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What Determines the Digital Transformation of SRDI Enterprises?—A Study of the TOE Framework-Based Configuration

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Abstract: SRDI enterprises are a strong engine for the high-quality development of the economy and an important implementation body for the construction of a strong digital country. With the booming development of digital economy, digital transformation is one of the effective paths to empower the high-quality development of small and medium-sized enterprises. However, the digital transformation of SRDI enterprises is not a simple stacked combination of elements, but rather a complex linkage system that contains many conditional elements. The cracking of the digital transformation of SRDI enterprises urgently needs to be explored by the academic community. In order to analyze the key success factors of digital transformation in SRDI enterprises, to determine whether individual elements constitute the necessary conditions for the digital transformation of an enterprise, and to explore which antecedent configurations are more conducive to the success of an enterprise's digital transformation, this study takes 39 "SRDI" enterprises in Zhejiang Province as samples and uses the Fuzzy Set Qualitative Comparative Analysis (fsQCA) method. Based on the "technology-organization-environment" framework, it examines the digital transformation path of "SRDI" enterprises from a configurational perspective. The following results were found in this study: the group patterns leading to high levels of digital transformation can be divided into the following four types: organization-environment linkage, pressure-strategy synergy, organization-led, and total-factor-driven. The group patterns leading to low levels of digital transformation can be divided into the following four types: total-factor-deficient, single-technology type, technology-biased, and organization-deficient. A digital strategy is an important condition for SRDI enterprises to realize high-level digital transformation, and the external environmental influences contribute to the realization of digital transformation and upgrading of enterprises, with the pressure of industry competition being more critical.

Keywords: SRDI enterprises; digital transformation; TOE framework; fsQCA

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1. Introduction

Small and medium-sized enterprises (SMEs) are an important mainstay of the national economy, and their development is crucial in stabilizing the economic growth rate, enhancing economic activity, ensuring the integrity of the production system, and stabilizing employment [1]. SRDI enterprises are those that are specialized, refined, distinctive, and innovational. They are considered the best among small and medium-sized enterprises (SMEs). They are enterprises with specialized production techniques or technologies and with excellent management characteristics, and are able to produce distinctive and innovative products [2]. With the booming development of new-generation information technology, the new round of technological changes triggered by the digital economy will enable SMEs to enter the rapidly expanding new economic sectors and promote the growth of core industries and spark a new round of economic growth. Digital transformation

becomes an inevitable requirement for the development of the digital economy, and an important embodiment of technological progress that promotes the transformation and development of SMEs. SRDI enterprises represent a high-quality group of SMEs, and their digital transformation serves as the direction of SMEs' digital transformation, which is of great significance in leading the entire group of SMEs in high-quality development, and in promoting the in-depth fusion of the digital economy and the real economy [3].

Around the emerging topic of digital transformation, many scholars have conducted many useful studies on its concepts, influencing factors and barriers to transformation, but little research has been conducted on the paths and driving mechanisms that drive transformation. It is worth noting that digital transformation of an enterprise is a complex systemic project, which is influenced by the interaction of multiple factors, such as systems, environments, organizations, and technology. However, most of the existing studies explore the influence of internal or external factors of an organization on the digital transformation of manufacturing enterprises based on a unidirectional net effect perspective. Therefore, considering the net effect of one factor alone cannot fully reveal the multiple paths affecting the digital transformation of enterprises and the interaction effects between different elements. Fuzzy set qualitative comparative analysis (fsQCA) can analyze the synergistic influence of each element on the digital transformation of SRDI enterprises' manufacturing process from a holistic perspective. In view of this, this paper uses fsQCA to construct a theoretical framework based on the Technology-Organization-Environment (TOE) theory to explore the influence of the digital transformation of manufacturing processes in SRDI enterprises, and find the multiple and complex drivers and paths that impact the level of digital transformation of manufacturing processes. The purpose of the research in this paper is to explore the following three questions: what are the critical success factors that influence the digital transformation of an enterprise? Do individual elements constitute the necessary conditions for an enterprise's digital transformation? Which antecedent configurations are more likely to contribute to the success of an enterprise's digital transformation? To address the three research questions mentioned above, this study focuses on SRDI enterprises and utilizes the FsQCA method to identify the driving pathways of digital transformation based on the TOE (Technological, Organizational, and Environmental) framework. The next chapter will introduce the construction of the model, while Section 4 will describe the research design, including research methods, variable design, selection of case companies, and data calibration, among other preliminary work. In Section 5, a rigorous discussion of the research results is presented. Finally, Section 6 concludes the study by summarizing the research findings and insights while also considering its limitations.

2. Literature Review

At present, the definition of enterprise digital transformation has not been unified in the academic community, and it can be found by combining the existing literature that scholars have mainly elaborated on from the technical level and the organizational change level. Hagberg and others [4] believed that digital transformation refers to the dynamic process in which a series of socio-economic changes is caused by the digital application of the production network. Vial et al. [5] proposed that enterprise digital transformation is the process of improving an entity by triggering significant changes in its attributes through a combination of information, computing, communication, and connectivity technologies. Chanias et al. [6] argued that digital transformation is an information systems-driven business transformation that involves structural and organizational transformations, information technology usage, and value creation for products and services, which triggers adjustments or entirely new business models. The impact of digital transformation is unprecedented, involving various industries and fields. Ladnar et al. conducted semi-structured interviews with 11 experts from different industries and companies in Germany to explore the impact of Corporate Venture Capital (CVC) activities on open innovation, digital agile leadership, and digital business transformation [7]. Wang et al. used a questionnaire based on the willingness of online second-hand consumers to construct a probability model and study

the influencing factors of digital transaction platforms [8]. Artik et al. conducted a survey of 100 practicing accountants in Istanbul, Turkey in 2023, emphasizing the importance of addressing digital infrastructure limitations and digital skills gaps for the development of electronic accounting practices [9]. Watkins et al. discussed the impact of digital development on the tourism industry, considering the advantages of information technology in promoting electronic tourism [10]. Agarwal et al. studied the significant efforts made by the U.S. healthcare system in digitization, suggesting that Information Technology (IT) can be a means to make healthcare systems safer, more cost-effective, and more convenient [11]. Katyeudo et al. proposed the TADEO method for use in basic subject courses in primary and higher education, believing that the digital transformation of the teaching process provides guidance and support through the integrated use of technological, human, organizational, and pedagogical driving factors [12]. Llopis-Albert et al. analyzed the impact of future digital transformation on business performance models and satisfaction of different stakeholders in the automotive industry's digital transformation process [13]. In any case, digital transformation is profoundly changing the strategic direction of enterprises to achieve technological change, for small and medium-sized enterprises (SMEs), with the in-depth integration of digital technology and data elements at the enterprise level and widespread application, digital transformation is no longer a question of "to be or not to be", but "how to turn".

The impact of digital transformation antecedents is intricate and complex, and the role played by different influencing factors in different contexts is heterogeneous; this paper is based on the TOE theory and divides into the driving factors of technology, organization, and the environment of the three categories for literature review.

On the technical level, Xiao et al. [14] used theoretical research methods to argue that the application of digital technology can provide enterprises with the capability of the whole process and thus bring about changes within the enterprise, accelerating the digital transformation of enterprises. Huang et al. [15] believed that enterprise digital transformation is based on the innovative application of data technology to empower the organization to completely change, so as to transform into a new digital enterprise, and create value based on new models, structures, and behaviors. Kong [16] used a binary choice model to find that enterprise innovation capability is the most critical factor for enterprise transformation and upgrading. Wang et al. [17] found that the key motivators for enterprises to make digital transformation decisions include factors such as the advanced nature of technology and equipment and digital innovation investment by establishing a two-layer factor identification model.

On the organizational level, Li et al. [18] found that SME decision makers exert effective leadership styles by establishing effective alignment between corporate strategy and digital technologies. Wang et al. [19] found that dynamic capabilities, especially innovation capabilities, can lead enterprises to complete digital transformation in terms of matching rhythms and capabilities through the fsQCA method; Yang et al. [20], based on the perspective of executive team experience, examined the specific impact of the academic experience of the executive team on the digital transformation of enterprises and its intrinsic mechanism. In addition, Proksch et al. [21] argued that digital strategy can support organizational transformation and achieve the desired goals of digital transformation, and companies need digital strategy to coordinate all mandatory resources to achieve and enhance competitiveness. On the contrary, the absence of digital strategy leads to poor decision-making and waste of resources [22].

On the environmental level, Zeng [23] found that the market competition mechanism, as an important external governance mechanism for enterprises, has an irreplaceable role in the change and development of enterprises. Niu [24] proposed that government subsidies can drive enterprise digital transformation by alleviating financing constraints and stimulating innovation investment. In addition, Chen et al. [25]—based on institutional theory and using a two-way fixed-effects regression model—found that the digital transformation

of enterprises is more likely to be influenced by industry digitization rather than regional digitization.

Regarding the transformation path, Li et al. [26] examined the group effect of six conditions, namely organizational inertia, human capital, prior performance, market environment, epidemic impact, and executive support, on the digital transformation of science- and technology-based SMEs at three levels: organizational, environmental, and managerial. Qi et al. [27] identified a combination of five types of elements, namely resources, innovation, business ecology, business process and management, and business model, through a multi-case analysis of state-owned enterprises. They constructed three types of digital transformation approaches: market-oriented, competence-oriented, and public-oriented. Zhang et al. [28] used the FsQCA methodology, which identifies the digital transformation in terms of both internal and external dynamic capability driving paths. Sebastian et al. [29] analyzed 25 large and established companies using technology investment as an entry point, and came up with two types of transformation strategies, customer engagement and digital solution. Tckic et al. [30] summarized four types of transformation paths from two dimensions, the use of digital technology and the readiness of digital operation business models: disruptive digital transformation, business-model-induced digital transformation, technology-induced digital transformation, and customized analog type, and further discusses the motivation for transformation, resources required, and risks faced.

Representative literature on the concept of digital transformation of SMEs, influencing factors, paths, etc., has launched a preliminary study and put forward reasonable suggestions for digital transformation in a targeted manner, but there are still the following shortcomings: first, in terms of the research object, although the study of digital transformation of enterprises has become a hot spot of academic research, there is not much literature focusing exclusively on the digital transformation of SMEs in SRDI. Second, in terms of research content, there are fewer studies that systematically study the factors influencing the digital transformation of SMEs and identify the key influencing factors and their influence paths. Digital transformation is not a simple stacked combination of individual elements, but a complex linkage system containing many conditional elements. By ignoring the overall set of elements of digital transformation, related studies have limitations in identifying joint effects and it is difficult for them to explain the complex coupling relationship between the elements and the digital transformation of enterprises. Through the research in this paper, we try to answer the following three questions: what are the conditions that promote the digital transformation of SRDI enterprises in a "different way"? Which conditions play a central role in the digital transformation of SRDI enterprises, and is there a phenomenon of "multiple concurrency" in the digital transformation path of SRDI enterprises?

3. Model Construction

The TOE framework (technology-organization-environment) places the discussion of the conditions affecting technology adoption under the three levels of technology, organization, and environment. This analytical framework not only focuses on technology, but also incorporates organizational and environmental factors into consideration. It emphasizes the influence of multi-level technology application contexts on the effectiveness of technology adoption by enterprises. It is widely applicable because factors and variables can be varied according to research questions and contexts. As a general theory, the TOE framework allows for flexible adjustment of the factors and variables according to the research questions and context, and has broad applicability. With the rapid development of digital transformation and the widespread penetration of digital technologies, the business environment and management information systems are becoming increasingly complex, and the interdependence of technological, organizational, and environmental factors collectively determines the digital transformation of enterprises.

3.1. Technological Dimension

Based on Schumpeter's innovation theory, R&D investment is a planned creative research conducted by enterprises to obtain new technologies. Hitt MT et al. [31] found that R&D investment has a significant role in promoting technological innovation of enterprises. Technological investment is the preparatory link for enterprises to accelerate the construction of digitalization, and enterprises will moderately enhance the R&D investment to accelerate the transformation of technological achievements in order to enhance the innovation vitality and enhance the technological capability, thus adding impetus to the product and technological research and development. From the perspective of dynamic capability theory, enterprise innovation output helps to shape its own competitive advantage, thus creating potential opportunities for acquiring excess economic value. Yang et al. [32] have included the number of patent applications in the measurement index system of enterprise innovation. R&D input is the preparatory link, while innovation output is the key step, and both of them complement each other and jointly help the digital transformation of enterprises. Therefore, this paper selects technology input and innovation output as the representative variables to measure the technology level.

3.2. Organizational Level

Digital strategy refers to the master plan developed by SMEs in digital transformation, including the perception of personnel, funding, and digitalization. Soluk [33] conducted a study on the drivers of digital transformation in 15 family-owned companies in the U.S. and found that digital strategy and a common understanding of digital transformation are important factors that influence digital transformation. The degree of importance a company attaches to its digital strategy determines the degree of its resource commitment, and elevating the digital strategy to the corporate level will increase the likelihood of successful transformation. Based on the higher-order theoretical perspective, the executive team is a key factor in determining the direction of the enterprise, and its digital literacy and technological experience can help to optimize various types of resources to support the iterative updating required for the enterprise's digital transformation [34]. Based on this, this paper selects digital strategy and executive team as representative variables at the organizational level, considering the typicality of these variables and their difficulty in quantification.

3.3. Environmental Dimensions

Chen et al. [35] found that government support is an important factor in the success of enterprise digital transformation. The reason is that as digital transformation is a high-resource-consuming activity, enterprises can improve the efficiency of resource allocation and mobilize the enthusiasm of technological innovation through direct or indirect government subsidies, thus promoting enterprises to increase R&D investment. In addition, Jin et al. [36] found that in the era of digital economy, the level of industry digitization is an important support for the formation of competitive advantage. When enterprises face competitive pressure from the digital development of competitors and partners, they need to continuously innovate, improve the specificity of products and services, and meet the diversified needs of the market in order to occupy a dominant position in the industry. This enables them to better carry out R&D and innovation activities and promote the development of digital transformation. Therefore, in this paper, government subsidies and industry competitive pressure are selected as representative variables at the environmental level.

3.4. Construction of Digital Transformation Driver Model for SRDI Enterprises

Based on the literature review and TOE framework, six antecedent variables, namely, technology input, innovation output, company strategy, executive team, government subsidies, and industry competitive pressure, are taken as key influential influencing factors to construct the digital transformation driver model of SRDI enterprises, as shown in Figure 1.

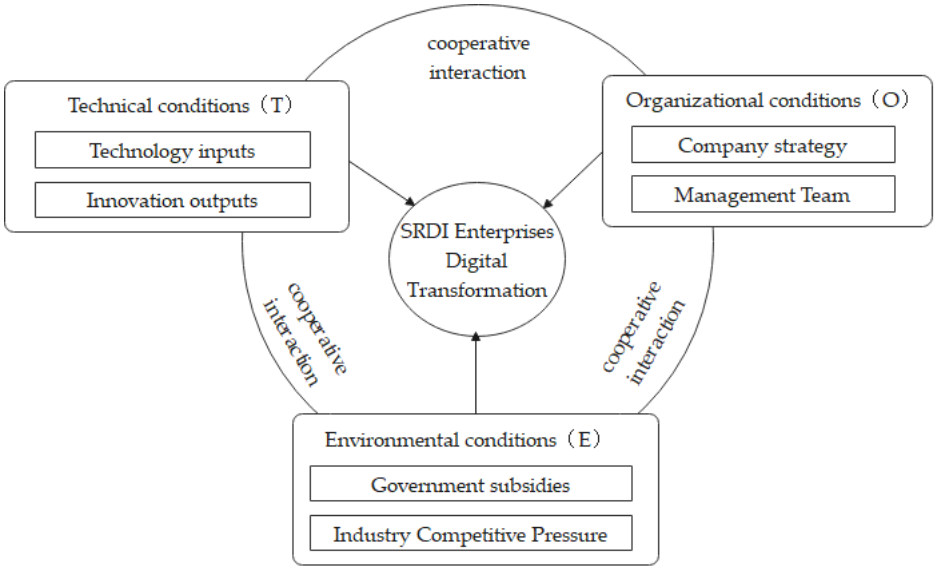


Figure 1. Research Models.

4. Research Design

4.1. Research Method: fsQCA

The purpose of this study is to explore the group effects of multiple factors of digital transformation in SMEs. As digital transformation is a complex and challenging issue, and a deep understanding of digital transformation is lacking in both theory and practice, the effects of each influencing factor on digital transformation are not necessarily independent, and there may be causal asymmetry. Using traditional qualitative and quantitative methods may not explain the digital transformation path of enterprises well. The Fuzzy Set Qualitative Comparative Analysis (fsQCA) method adopts a holistic perspective, which can effectively cope with the complexity of the antecedents of the research problem, and the method integrates the advantages of qualitative and quantitative research methods, which can adequately deal with the group effect of multiple antecedent elements on the resultant elements. In addition, the fsQCA method is suitable for both small-sample (case number of 10 or 15 or less), medium-size sample (case number of 10 or 15 to 50), and large-size sample (case number of 100 or more) studies with overall analysis of conditional groupings at the case level. Therefore, in this paper, we choose the fsQCA method to identify the driving paths of digital transformation based on the TOE framework from the three aspects of "technology-organization-environment".

4.2. Variable Design

4.2.1. Outcome Variables

Enterprise digital transformation level (DTL). This paper refers to the research results of Wu et al. [37] to measure the level of digital transformation by text analysis; the method has been widely used by the academic community. Based on specific keywords of digital transformation obtained, the statements and word frequency in annual reports of listed enterprises that contain these keywords are counted. The data are then screened through manual reading, and the resulting word frequency is categorized and combined to obtain the final total word frequency. The logarithmic transformation of the final total word frequency plus 1 characterizes the level of enterprise digital transformation.

4.2.2. Conditional Variables

Technology Input (TI). Referring to the research of Qi et al. [38] and Yan [39], the technological input of enterprises is measured by the mean value of the proportion of R&D investment and the proportion of R&D personnel.

Innovation output (IO). Referring to Wang [40] and other domestic and international scholars to measure corporate innovation, the innovation output dimension is measured by the logarithm of the total number of corporate patent applications plus one.

Corporate Strategy (CS). Referring to the research of Chen and other scholars [41], the measurement criterion mainly involves reviewing the management discussion and analysis sections in the externally disclosed corporate annual reports of each case enterprise in FY2022 to determine if they have a digital strategy. The options are divided into four categories: none, ready to start, already have but less, and already have and more, with corresponding scores of 1, 2, 3, and 4 points, respectfully.

Executive Team (MT). The educational backgrounds of the executive team play a key role in influencing a firm's decision on whether to undergo digital transformation. This paper draws on the research results of Xue [42] to measure the education level of the executive team. As defined in the study, other education is assigned a value of 1, college education is assigned a value of 2, a bachelor's degree is assigned a value of 3, and postgraduate education is assigned a value of 4. The sum of the weights of the educational assignments of the executive team is calculated and divided by the total number of people to obtain the average, which characterizes the education level of the executive team.

Government Subsidies (GS). In this paper, the government's digital input subsidy data are mainly from the annual report of the enterprise manually screened government subsidies and digitization-related data collated, and finally logarithmic processing of the collated data [43].

Industry Competitive Pressure (CP). Referring to the measurement of competitive intensity by Wang [43] and Cai [44], the Herfindahl index (HHI) is used to measure the competitive pressure of the industry, which is calculated as follows:

$$HHI = \sum_{i=1}^{n} \left(\frac{x_i}{x} \right)^2 \quad (1)$$

where, n indicates the number of enterprises, x_i is the business income of enterprises, x represents the total business income of the industry in which the enterprise is located. The inverse of *HHI* reflects the degree of competition in the industry, and the larger the value, the higher the degree of competition in the industry in which the enterprise is located.

4.3. Case Selection

Zhejiang Province is deeply implementing the "Project No. 1" of digital economy, ranking first in the country in terms of comprehensive development level of digitalization, and leading the country in the number of SRDI enterprises. The SRDI enterprises in Zhejiang Province are not only the strongest among SMEs, but also the leader of digital transformation, which makes the conclusions drawn from this sample more representative and inspiring. Since the FsQCA method follows theoretical sampling rather than random sampling, in order to ensure the heterogeneity of the sample data, enterprises in different industries are selected through manual testing, and 39 sample enterprises are selected. The research data are obtained from the Cathay Pacific database (CSMAR) and Sina Finance. The CSMAR database contains more comprehensive data of listed companies, including their operating revenues, operating costs, and net operating profits. Sina Finance contains the annual reports of listed companies, which can uncover the corporate strategy, business status, and industry development direction of the companies. This study mainly uses 2022 annual report data audited by certified public accountants, and the relevant data are highly feasible.

4.4. Data Calibration

The Boolean logic of qualitative comparative analysis requires the calibration of continuous variables to fuzzy set variables between 0 and 1. First, three anchor points, namely, totally unaffiliated, cross-affiliated, and totally affiliated, were identified, followed by converting all data into corresponding fuzzy affiliation scores through fsQCA3.0 software.

Referring to the study of Du et al. [45], the three anchor points were set to 95%, 50%, and 5% of the descriptive statistics of the sample, and the calibration values of each variable are shown in Table 1. In addition, 0.001 was added to the affiliation scores of cases whose affiliation was at the 0.5 intersection to avoid the sample cases from being eliminated and ensure the accuracy of the analyzed results.

Table 1. Data Calibration Anchors.

Variable Dimension	Variable	Full Affiliation	Intersection Point	Completely Unaffiliated
Outcome variable	Degree of digital transformation (DTL)	5.26	3.58	2.17
Technical Dimension	Technology inputs (TI)	0.20	0.10	0.07
	Innovation outputs (IO)	5.72	4.19	1.52
Organizational dimensions	company strategy (CS)	4	3	1
	Management Team (MT)	3.79	3.25	3.0
Environmental dimension	Government subsidies (GS)	16.80	15.73	12.90
	Industry Competitive Pressure (CP)	9.33	3.06	1.23

As shown in Table 1, taking the degree of digital transformation (DTL) as an example, its fully affiliation point, intersection point, and completely unaffiliated point are 5.26, 3.58, and 2.17, respectively. This means that when calibrating the values of the digital transformation variable to the range of 0 to 1, if the indicator value for a sample company is 5.26, it indicates that the digital transformation degree of that company reaches 95%. If the indicator value is 3.58, then the company's digital transformation degree is 50%, and if the indicator value is 2.17, the company's digital transformation degree is only 5%. Other variables follow a similar pattern.

5. Empirical Analysis

5.1. Necessary Condition Analysis

Referring to the study of Cheng et al. [46], the necessary condition analysis was conducted before the Group analysis, and when the consistency of the condition variable to the outcome variable reaches 0.9 or more, it can be assumed that this factor is a necessary condition for the generation of this result. The consistency scores of each single variable to the outcome variable were obtained by consistency analysis through fsQCA3.0 software.

In Table 2, the abbreviations and their meanings are as follows: TI represents high technological inputs, ~TI represents non-high technological inputs. IO represents high innovation outputs, ~IO represents non-high innovation outputs. CS represents high company digital strategy, ~CS represents non-high company digital strategy. MT represents high management team education background, ~MT represents low management team education background. GS represents high government subsidies, ~GS represents non-high government subsidies. CP represents high industry competitive pressure, ~CP represents non-high industry competitive pressure.

As can be seen from Table 2, the consistency scores of each conditional variable on the outcome variable of transformation and upgrading do not exceed 0.9, i.e., there is no condition in which one of them is a necessary condition for transformation and upgrading. The weak explanatory power of a single antecedent variable on digital transformation is also a side evidence that the digital transformation of SRDI enterprises has a certain complexity, which cannot be explained by a single factor, so it is necessary to carry out the next step of group analysis.

Table 2. Analysis of necessary conditions.

Conditional Variable	High Digital Transformation		Low Digital Transformation	
	Consistency	Coverage	Consistency	Coverage
TI	0.582819	0.597048	0.584604	0.633781
~TI	0.642509	0.593753	0.628314	0.614476
IO	0.678258	0.634282	0.618282	0.611893
~IO	0.584985	0.591522	0.630464	0.674663
CS	0.731665	0.86857	0.300133	0.377058
~CS	0.475246	0.390859	0.865383	0.779312
MT	0.696674	0.794736	0.356331	0.430178
~MT	0.500487	0.423542	0.829972	0.743308
GS	0.684866	0.628992	0.60692	0.589891
~GS	0.553461	0.570902	0.618282	0.674936
CP	0.688116	0.833486	0.352032	0.451253
~CP	0.546961	0.443712	0.870099	0.74699

5.2. Conditional Grouping Analysis

In this paper, fsQCA3.0 was used to analyze the sample data by grouping, referring to the practice of Fiss [47]. The threshold of consistency was set to 0.8 and the threshold of case frequency was set to 0.7. The consistency of PRI was also set to 0.7. The conditional variables were all selected as "Present or Absent", resulting in the formation of a truth table. According to the principle of "intermediate solution as the main solution and parsimonious solution as the secondary solution", four types of groupings of SRDI enterprises with high digital transformation and four types of groupings with non-high digital transformation were identified. The results are presented in Table 3.

Table 3. Results of configuration analysis for digital transformation.

	High Digital Transformation Antecedents Configuration				Non-High Digital Transformation Antecedents Configuration			
Parameterization	**Grouping 1**	**Grouping 2**	**Grouping 3**	**Grouping 4**	**Grouping 5**	**Grouping 6**	**Grouping 7**	**Grouping 8**
TI		⊗	⊗		⊗	●	●	●
IO	⊗	•	⊗	•	⊗	•	⊗	⊗
CS	●	●	●	●	⊗	⊗	⊗	⊗
MT	●	⊗	●	●	⊗	⊗	•	⊗
GS	⊗	⊗	•	•		⊗	⊗	•
CP	●	●	⊗	●	⊗	⊗	⊗	•
Raw coverage	0.3457	0.2471	0.2904	0.4043	0.432	0.3787	0.2202	0.1945
Unique coverage	0.1258	0.0499	0.0543	0.1291	0.0583	0.0521	0.0565	0.0102
Consistency	0.9193	0.9661	0.9470	0.9163	0.8719	0.8852	0.8776	0.9406
Solution coverage		0.6429				0.6357		
Solution consistency		0.9352				0.8543		

Note: ● indicates that the core condition exists; • represents the presence of an auxiliary condition; ⊗ indicates that core conditions are missing; ⊗ indicates that the marginal condition is missing; blank indicates that this condition is optional.

5.2.1. Analysis of Groupings with High Digital Transformation

As can be seen from Table 3, the consistency of all four groupings is much higher than 0.75, which indicates that each grouping is a sufficient condition for realizing the digital transformation of SRDI enterprises. The overall consistency level of the solution is 0.9352, which indicates that 93.52% of all sample cases of digital transformation that satisfy these five groupings have achieved a higher level of digital transformation in the case firms. In addition, the overall coverage level of the solution is 0.6429 shows that these four groupings can explain 64.29% of the case companies with high digital transformation.

(1) Organization-environment linkage. Organizational-environmental linkage type refers to the linkage matching between organizational and environmental conditions jointly contributing to the digital transformation of SRDI enterprises. Grouping 1 (~IO∗CS∗MT∗~GS∗CP) shows that SRDI firms with a digital strategy, a high-quality executive team, and high industry competitive pressure can achieve a high level of digital transformation despite the lack of innovation output and government subsidies. About 34.57% of the case firms can be explained by Grouping 1. When SRDI firms face intense industry competitive pressure, the executive team will develop a digital strategy that is in line with the industry development trend. Even if the lack of government subsidies does not provide financial support for the firm's R&D and innovation activities and the firm's innovation output is not satisfactory, the SRDI firms can also achieve a high level of digital transformation; because the firms themselves have certain market share and product uniqueness and their market position is difficult to be replaced, they can also achieve a high level of digital transformation.

(2) Pressure-strategy synergy. Pressure-strategy synergistic type refers to the linked match between industry competitive pressure and company strategy together to help the digital transformation of SRDI firms. Grouping 2 (~TI*IO∗CS∗~MT∗~GS∗CP) shows that SRDI firms with digital strategies complemented by certain innovation outputs when facing high industry competitive pressures can achieve a high level of digital transformation even in the absence of a high-quality executive team and government subsidies. Approximately 24.71% of the case firms can be explained by Grouping 2. SRDI firms can also contribute to a high level of digital transformation when faced with high industry competitive pressure, guided by the company's digital strategy and complemented by certain innovative outputs.

(3) Organization-led. Organizational dominant refers to the synergy between the executive team and the organizational conditions such as the firm's strategy for the digital transformation of SRDI firms. Grouping 3 (~TI*~IO∗CS∗MT∗GS∗~CP) suggests that even facing lower competitive pressure in the industry, SRDI firms with high-quality executive teams, which formulate their digital strategies based on the future development trend of the industry, supplemented by specific government subsidies, can achieve a high level of digital transformation. About 29.04% of the case firms can be explained by Grouping 3. When SRDI firms are facing lower industry competitive pressure, high-quality executive teams can foresee the future development trend of the industry and prioritize key resources and funds to ensure the implementation of the company's digital strategy. At the same time, government subsidies also provide enterprises with certain support for digital transformation funds to alleviate the pressure on enterprise funds and stimulate enterprises to achieve a high-level of digital transformation.

(4) All-factor-driven. All-factor-driven refers to the linkage and matching between technology, organization, and environmental conditions that jointly help manufacturing firms' digital transformation. Grouping 4 (IO∗CS∗MT∗GS∗CP) suggests that SRDI firms with a digital strategy, a high-quality executive team, and facing high industry competitive pressures, complemented by higher innovation output and government subsidies, are better able to achieve a high level of digital transformation. About 40.43% of the case firms can be explained by Grouping 4. When SRDI firms face intense industry competitive pressure, the executive team develops a digital strategy that is aligned with the industry development trend. At the same time, government subsidies provide financial support for R&D and innovation activities, and under the leadership of a top team with a strong digital sensibility, digital inputs and R&D results are rapidly transformed, thus more effectively facilitating enterprises to achieve a high level of digital transformation.

By comparing the above four combined paths, it was found that corporate strategy appeared in all four paths, and the executive team and industry competitive pressure appeared three times in all four paths, reflecting the importance of digital strategy, the

executive team, and industry competitive pressure in the process of digital transformation of SRDI companies.

5.2.2. Grouping Analysis of Non-High Digital Transformation

As can be seen from Table 3, there are also four groupings for non-high digital transformation, and the overall consistency of the solutions is 0.8543, which is greater than 0.75 and meets the consistency requirement of the sufficient condition test; additionally, the overall coverage of the four groupings' solutions is 0.6357, which suggests that the four groupings are able to explain the reasons for the non-high digital transformation of 63.57% of the case companies.

(1) Grouping 5 represents the "all-factor absence type" (~TI*~IO∗~CS∗~MT∗~CP), meaning that when factors such as technology, organization, environment, and others are all missing, it often leads to low digital transformation. Approximately 43.20% of the case companies can be explained by Grouping 5. In cases where SRDI companies face intense industry competition pressure, their executive teams fail to focus on industry development trends in a timely manner, lack necessary guidance for digital transformation strategies, and do not invest in the required technology. This can easily result in digital transformation failure.

(2) Grouping 6 represents the "single-technology type" (TI*IO∗~CS∗~MT∗~GS∗~CP), where companies in this grouping focus solely on technological factors such as research and development investment, while neglecting the impact of organizational environment factors like corporate strategy, executive teams, government subsidies, and industry competition pressure. This also leads to a non-high level of digital transformation. Approximately 37.87% of the case companies can be explained by Grouping 6. In cases where SRDI companies face intense industry competition pressure, their executive teams fail to seize digital transformation opportunities, formulate digital transformation strategies, and lack government subsidy support. Even if there is significant technological investment and some innovation output, it becomes challenging to achieve successful digital transformation.

(3) Grouping 7 represents the "technology-oriented type" (TI*~IO∗~CS∗MT∗~GS∗~CP), where in this configuration, if the executive team focuses solely on research and development investment and neglects the influence of external factors such as industry trends, without formulating a digital strategy, it can also lead to significant challenges in digital transformation. Approximately 22.02% of the case companies can be explained by Grouping7. In cases where SRDI companies face high industry competition pressure, even if the executive team can foresee future industry trends and increase technological investment, the lack of a clear digital strategy results in superficial digital transformation efforts. Digital transformation often requires substantial financial support, and in the absence of government subsidies, it often leads to digital transformation failure for businesses.

(4) Grouping 8 represents the "organizational absence type" (TI*~IO∗~CS∗~MT∗GS∗CP), and approximately 19.45% of the case companies can be explained by Grouping 8. This configuration indicates that even though industry competition pressure and government subsidies may stimulate companies to increase their research and development investment, the lack of a high-quality executive team means that when the wave of the digital economy arrives, the company fails to formulate a digital strategy that adapts to industry trends. This ultimately leads to digital transformation failure.

From the above four-group analysis, it is not difficult to find that digital transformation is difficult to succeed with the support of only a single factor. The reasons for this may be the following: Firstly, in the absence of competitive pressure and when there is a weak sense of digitalization, it is difficult to generate innovative activities in the general market of similar manufacturing enterprises. Secondly, the lack of government financial support causes internal resources and funds to be mostly invested in production and business activities, resulting in a lack of digital investment. Thirdly, when the senior team lacks

keen market insight and digital change awareness, it is difficult for the organization's internal innovation activities to continue, making it even more difficult to transform the results of research and development, resulting in the inability to achieve transformation and upgrading. The above analysis also proves that digital transformation is the result of a combination of factors, and it is difficult to rely on a single factor to achieve success; the enterprise's digital transformation will be especially difficult when the enterprise lacks a high-quality management team and a clear digital strategy.

5.3. Robustness Analysis

In this paper, two robustness tests were performed on the results: the consistency threshold was adjusted from 0.8 to 0.85, and other conditions remained unchanged. The PRI threshold was adjusted from 0.7 to 0.75, and other conditions remained unchanged. After analyzing and comparing the results, it was found that the adjusted grouping results remained basically unchanged, so the present results show good robustness.

6. Conclusions and Policy Implications

6.1. Discussion and Conclusions

Using the SRDI listed enterprises in Zhejiang Province as a sample, this study uses fsQCA3.0 software to analyze and explore the grouping effects of six antecedent conditions, such as the enterprise R&D investment, innovation output, corporate strategy, executive team, government subsidies, and industry competitive pressure, on the enterprise digital transformation. Current research on digital transformation often relies on qualitative or quantitative single-method approaches. However, the FsQCA (Fuzzy Set Qualitative Comparative Analysis) method differs from previous research methods in examining the net effects of independent variables on dependent variables. It not only combines the advantages of quantitative and qualitative analysis but also investigates how the synergistic interactions of various antecedent factors affect the outcome. This provides a more precise basis for practical insights. The configurational thinking underlying the FsQCA method challenges and complements the mainstream quantitative research perspective, offering a holistic view to understand and explain the causal complexity of digital transformation. The study found that the success of digital transformation of SRDI firms is not driven by a single factor, but by a combination of internal and external elements. The different combinations among the antecedent elements form four equivalent paths of high digital transformation and non-high digital transformation paths for SRDI enterprises. The groupings that lead to high digital transformation can be divided into the following four types: organization-environment linkage, pressure-strategy synergy, organization-driven, and all-factor-driven. The groupings that lead to low digital transformation of manufacturing processes can be divided into the following four types: all-factor-deficient, single-technology, technology-biased, and organization-deficient. Based on comparing the above eight paths, the following conclusions can be obtained:

(1) A clear digital strategy is a necessary condition for enterprises to realize high-level digital transformation of manufacturing processes. By comparing the groups, it can be seen that the realization of a high level of digital transformation of enterprises has formulated a clear and explicit digital strategy (Grouping 1–Grouping 4); on the contrary, a low level of digital transformation of enterprises has not formulated a digital strategy (Grouping 5–Grouping 8). The new round of scientific and technological revolution and industrial change is developing rapidly, the global economy has shifted from incremental development to stock-based competition, the rigid constraints of resources and environment are increasing, and the development environment of enterprises is becoming more and more complex and changeable, with both opportunities and challenges. Comprehensively enhancing the sustainable development capability of enterprises and resolving uncertainties with digital transformation are the core of the current strategic transformation. To carry out digital transformation, the first and foremost task is to formulate a digital transformation strategy and make it an

important part of the development strategy, incorporating the data-driven concepts, methods, and mechanisms in the overall development strategy. Focusing on the vision, goals, business ecology blueprint, and other broad strategic directions put forward in the overall development strategy of the enterprise, the digital transformation strategy is systematically designed, and the goals, directions, initiatives, and resource requirements for digital transformation are put forward. By connecting business, technology, management, and other related contents, and organically integrating with functional strategy, business strategy, and product strategy, it effectively supports the realization of the overall development strategy of the enterprise. Secondly, the formulation and implementation of a digital strategy essentially depends on the enterprise strategy management team, and to a certain extent, the decision logic, decision-making style, and risk preference of the executive team's strategic decisions have a decisive impact on the effectiveness of the enterprise's strategic decisions. Based on the theory of senior echelon, the gender, age, education, personal experience, and other characteristics of the executive team have a far-reaching impact on corporate strategic decision-making, and it is no exception for the strategic decision-making of enterprise digital transformation.

(2) The external environment helps enterprises realize digital transformation, and industry competitive pressure plays a key role. From Grouping 1, Grouping 2, and Grouping 4, we can find that the three groupings of high digital transformation are faced with more intense industry competitive pressure. The higher the degree of competition in the industry, the more it can promote the digital transformation of enterprises. Specifically, the degree of competition in the industry is closely related to the performance of the enterprise, and higher industry competition will compress the profit margin of the enterprise, prompting the enterprise to improve the degree of product differentiation through digital transformation to reduce operating costs and improve business performance to meet the needs of business operators and owners. The higher the degree of competition in the industry, the greater the homogenization of products in the market. The more competitors in the industry, the higher the business risk due to the pressure of survival; in order to stabilize the market scale and ensure survival and development, enterprises tend to accelerate the digital transformation to enhance their competitiveness. In addition, government subsidies are an important policy tool for governments to influence micro-economic agents to carry out digital transformation. According to the theory of government intervention, governments have implemented targeted policy interventions, including financial subsidies, tax incentives, and the establishment of dedicated funds, to promote the digital development of enterprises. On one hand, government grants directly provide financial support to enterprises, making them willing to invest funds in high-risk, long-cycle digital transformation projects. On the other hand, it helps enterprises to release positive signals to the outside world, optimizes the external financing environment, strengthens investor confidence, improves enterprise risk tolerance, and helps managers to choose high-risk investment projects such as digital transformation.

6.2. Research Implications

(1) Theoretical Insights. Firstly, previous research has conducted many useful studies on the drivers of digital transformation, but they are mostly limited to single-factor net effects. This paper uses the fsQCA method to explore the antecedent configuration of digital transformation and the synergistic relationship between factors, which complements the theoretical research on the drivers of enterprise digital transformation to a certain extent. Secondly, distinguishing from the previous digital transformation focusing on traditional manufacturing industries, this paper takes SRDI enterprises as the research object, further subdividing the types of transformation and studying the digital transformation of enterprises based on the TOE framework, which

enriches the perspective of theoretical research and expands the understanding of the transformation and upgrading of enterprises from the micro level.

(2) Practical insights. On the one hand, enterprises need to actively embrace the digitalization process and develop a clear and explicit digital strategy. From the four grouping paths of high-level digital transformation, it is easy to see that a clear and definite digital strategy is an important influencing factor contributing to the digital transformation of SRDI enterprises. In addition, the cognition and action of top managers on digital transformation will influence the formulation of the enterprise digital strategy, and the role of top managers should be fully emphasized. As top managers, they should understand the importance of the digital transformation strategy in terms of cognition, match the resources needed for digital transformation in terms of action, and lead the promotion of the digital transformation strategy to the ground. On the other hand, in the context of the global digital economy, enterprises need to actively respond to the impact of digital change on the industry and enhance the long-term competitiveness of the industry through digital transformation. In addition, as most enterprises in China are in the exploration and development stage of digital transformation, the government needs to provide sufficient funds and liberal policies to improve the financing environment for enterprises to realize digital transformation and give them the momentum for digital transformation.

6.3. Research Limitations and Prospects

This study also has some shortcomings that require further in-depth research in the future: Firstly, the limitation of antecedent elements selections. Digital transformation is a very complex phenomenon, and there are many elements that affect the digital transformation of SRDI enterprises. This paper, based on the TOE framework, selects six antecedent conditions, and there are many possible influences that are not included in the model. Secondly, digital transformation is a continuous and profound dynamic process; this study explores the group effect that affects the degree of digital transformation, and does not take into account the effect of time—a next step could be including the factor of time in the analysis framework. Thirdly, the data source of this study is mainly the company's annual report disclosed to the public by the enterprise, and there is no on-site visit to the enterprise, which fails to analyze the process of digital transformation of the enterprise in great detail. Based on the results of the current study, case studies can be further integrated in the future to provide in-depth analysis of the drivers and paths of digital transformation of different enterprises.

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