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Research Article

Research on the Driven Path of Ambidextrous Innovation of Science and Technology Enterprises: An Exploration Based on Fuzzy Set Qualitative Comparative Analysis

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Ambidextrous innovation is an essential way for enterprises to respond to environmental changes and create competitive advantage. This study constructs the "technology-organization-environment" (TOE) framework of enterprise ambidextrous innovation, aiming to explore the configuration effect of the linkage matching of technology, organization, and environment on enterprise ambidextrous innovation and the differentiated driving mode of enterprise ambidextrous innovation. In the study, the fuzzy set qualitative comparative analysis (fsQCA) is used to conduct an empirical study on the samples of 34 listed companies on the Science and Technology Innovation Board. The findings are as follows: (1) technical conditions (hardware facilities and software facilities), organizational conditions (human capital investment and R&D investment), and environmental conditions (market competition and government subsidies) are not necessary conditions for ambidextrous innovation individually; (2) there are three driven paths of ambidextrous innovation, namely, the technology-driven path under the pressure of market competition, the technology-promoted path under government support, and the resource-rich proactive change path. The conclusion has enlightening significance for guiding enterprises to attach importance to the technology and organizational conditions in the process of enterprise ambidextrous innovation.

1. Introduction

Scientific and technological innovation is an essential aspect of competition among countries [1]. Innovation-driven development is the core strategy for high-quality economic growth in China. In particular, the strategy of self-reliance in science and technology has received significant attention in China. As the core of the national innovation system, enterprises are the foundation of building an innovative country in China. Giving the full-play role of enterprise innovation is of great significance to the implementation of the innovation-driven development strategy at the micro-level. However, due to the characteristics of technological innovation of long cycle, high investment, and high risk [2], many small- and medium-sized enterprises in China have difficulties in innovation activities, such as low investment in innovation and inadequate R&D capital [3].

Enterprise's ambidextrous innovation takes into account both exploratory and exploitative innovation and has obvious advantages in increasing enterprise innovation output, improving enterprise performance, and enhancing the enterprise's competitive position [4–8]. On the one hand, the enterprise can acquire new knowledge, develop new products, open new markets, or meet unique customer needs through exploratory innovation. On the other hand, exploitative innovation can help enterprises improve existing products and expand product categories and functions to adapt to the complex and changeable competitive environment [5, 9]. Therefore, how to promote enterprises to carry out and maintain ambidextrous innovation is the key to promoting enterprises to obtain the competitive advantage in the long period, which is also an important issue to be explored in advancing the innovation-driven development strategy in China.

Summarizing the existing literature, scholars have extensively discussed the factors that affect the ambidextrous innovation of enterprises; for example, the internal factors that affect the ambidextrous innovation mainly include accumulated resources [10, 11], dynamic capabilities [8, 12], and technological diversification [13], and external environmental factors mainly include support from external organizations [11, 14], environment pressure [4, 15, 16], and information technology development [17, 18]; in general, most studies only focus on the "net effect" and single effect of internal and external factors such as technology, organization, and environment and do not consider the impact of the linkage combination of multiple factors on enterprise's ambidextrous innovation. However, in practice, an enterprise's ambidextrous innovation is a process of synergistic interaction of various factors, and it is difficult to give a comprehensive explanation by only considering the role of a single factor [19].

How to effectively drive ambidextrous innovation? What are the driving effects of technology, organization, and environment factors on the enterprise's ambidextrous innovation, and is there a matching and substitution relationship between different elements? Combined with the characteristics of the ambidextrous innovation, this study aims to build ambidextrous innovation "technology-organization-environment" (TOE) framework and to explore the driving path of ambidextrous innovation by using the method of fuzzy qualitative comparative analysis (fsQCA). The main contributions are as follows. (1) This study constructs the TOE analysis framework that influences the dual innovation of enterprises from three dimensions, namely, technical conditions (hardware facilities and software facilities), organizational conditions (human capital investment and R&D investment), and environmental conditions (market competition degree and government subsidy), which enriches and expands the theoretical research on the application of TOE framework in the field of ambidextrous innovation. (2) The fsQCA method is introduced into the research on ambidextrous innovation of enterprises, and the "configuration perspective" is used to explore the driven path of multifactors, such as technology, organization, and environment, synergistically promoting dual-innovation of enterprises, which provides a new perspective and a new method for the research on ambidextrous innovation of enterprises. (3) This study summarized three driven paths of enterprise ambidextrous innovation, namely, the technology-driven path under the pressure of market competition, the technology-promoted path under government support, and the resource-rich proactive change path. In addition, the empirical results verify that the ambidextrous innovation driving path of enterprises has the characteristics of ""All paths lead to the same destination."

This study is organized as follows. Section 1 presents the introduction. Section 2 sums up the literature and research framework. Section 3 presents the study design. Section 4 presents empirical results and analysis. Section 5 is about conclusions and implications.

2. Literature Review and Research Framework

2.1. Literature Review. Ambidextrous innovation refers to two kinds of innovation behaviors, namely, exploitative innovation and exploratory innovation [4, 9, 12, 20]. Exploitative innovation is a progressive innovation behavior that continuously improves and upgrades products based on existing knowledge and technology. Exploratory innovation is a radical innovation behavior that breaks away from the original technological track and aims to search for new knowledge, develop new products, and open up new business fields [4, 17, 20]. Exploratory innovation and exploitative innovation are both crucial in an enterprise, and to be focused on only one of them will lead enterprises to fall into the "failure trap" or "capability trap" [4, 20]. The excessive pursuit of exploitative innovation is beneficial to the short-term improvement of financial performance; however, in the long run, enterprises may fall into the "capability trap" relying on organizational inertia [7, 8]. Excessive emphasis on exploratory innovation is conducive to the improvement of industrial competitiveness, but the long time and extensive investment in research and development may affect the enterprise's normal operation, leading to the "failure trap." Thus, the enterprise needs to take into account these two kinds of innovation activities.

Regarding the driving factors of ambidextrous innovation, scholars have made a lot of beneficial exploration. Firstly, some studies focus on the impact of environmental dynamism, environmental competitiveness, fiscal and tax incentive policies, and other external environmental factors on ambidextrous innovation. For example, some scholars pointed out that, in the dynamic and competitive environment, enterprises need to carry out exploratory and exploitative innovation to reduce the risk and threat of obsolescence of products or services [4, 15, 16], which will help enterprises maintain their advantages and form new competitiveness; besides, some scholars also point out that fiscal and tax incentive policies, such as government subsidies and tax breaks, can reduce the cost of enterprise's R&D activities and stimulate enterprises to increase R&D investment [11, 14]. Secondly, some studies also focus on the influence of internal factors on ambidextrous innovation, such as accumulated resources and capacity. Based on the resource-based theory, some scholars point out that sufficient resources can avoid the competition for resources between exploratory and exploitative innovation and strengthen an enterprise's risk-taking [10], and rich resource support makes the enterprise more willing to R&D investment and high risk innovative experiments [10, 11]. Some scholars also believe that diversified organizational structure is conducive to promoting enterprise ambidextrous innovation [20, 21]; in addition, the dynamic capabilities and technological diversification of enterprise significantly improve the possibility of ambidextrous innovation [8, 13].

At present, the rapid development of digital technology is impacting and reinventing the way of enterprise innovation, and it provides new impetus and opportunities for enterprise innovation [18, 22]. For example, Zhang and Long

[18] found that digital technology application has significantly improved the level of enterprise's exploratory innovation; Chen et al. [17] found that digital technology not only can guide enterprise to carry out the exploratory innovation across the technological track but also can improve and reorganize organizational business processes by exploitative innovation. In addition, some scholars explored the path of enterprise innovation activities based on the perspective of configuration; Zhao et al. [23]studied the configuration effect of government presubsidies and post-subsidies on enterprise innovation efficiency; Wu and Fan [24] studied the influence of market, system, organization, and executive team on enterprise green innovation from the perspective of configuration; Zhuang and Wang [25] constructed the research framework of industry, system, and resources to explore the new path of driving high-quality technological innovation of science and technology enterprises.

To sum up, most of the existing studies have explored the "net effect" of a particular dimension of factors such as technology, organization, and environment on enterprise's ambidextrous innovation. Although some studies have focused on the driving effect of different factor combinations on enterprise innovation from the perspective of configuration, the impact of the linkage of relevant factors on enterprise ambidextrous innovation has not been thoroughly investigated. As an essential way for enterprises to deal with external environment changes and improve competitive advantages, ambidextrous innovation is a process of synergistic interaction of multiple factors, and it is difficult to give a comprehensive explanation only considering the role of a single factor [19]. Therefore, this study constructs the "technology-organization-environment" (TOE) framework of enterprise ambidextrous innovation and explores the driven path of enterprise ambidextrous innovation.

2.2. Theoretical Framework Construction. TOE framework was proposed by Tornatzky and Fleischer, which is used to analyze the influence of technology, organization, environment, and other factors on the adoption of new technologies [26]. Technical factors are mainly about the characteristics of information technology innovation, such as the achievement of existing technology, comparative advantage, cost, and complexity [27]; organizational factors refer to the features of the organization, including enterprise's scale, structure, corporate resources, and system arrangement. [28]; environmental factors refer to the external environment of an organization, such as the market structure, competitive environment of the industry, and the policy and system environment [27]. Based on the TOE framework, this study constructs the analysis framework of ambidextrous innovation from three dimensions, namely, technology condition (hardware facilities and software facilities), organization condition (human capital investment and R&D investment), and environment condition (market competition and government subsidy) to explore the influence factors and drive path of enterprise ambidextrous innovation; the analysis framework is shown in Figure 1.

2.2.1. Technical Conditions. The application of software and hardware facilities can enhance the organization's ability of information search, resource acquisition, and resource reorganization and then promote the enterprise's innovation activities. Firstly, with the help of digital technology, the organization and individuals can continuously absorb, activate, and update knowledge, which speeds up the updating of an organization's knowledge base and promotes the cross-fusion of heterogeneous knowledge [29]. Compared with exploitative innovation, exploratory innovation needs more support from heterogeneous knowledge, so the application of software and hardware facilities has a stronger role in promoting exploratory innovation. Secondly, digital technology helps enterprise collect more abundant and diverse resources and accurately obtain the relevant information on customer needs and customer psychology. The enterprise can actively explore new knowledge and technology through exploratory innovation and develop new products to maximize customer needs [18]; at the same time, the digital technology can promote utilization innovation by discovering new functions of different products, optimizing the factor input structure in the production process. Thirdly, digital technology can carry out a virtual simulation on the process of product design, production, and use, which shortens the research and development cycle to some extent, and the innovation efficiency of enterprise can be further improved [22]. In addition, with the development and application of digital technology, the innovation boundary and organizational boundary of enterprises are further expanded so that more and more innovation subjects such as customers, suppliers, and other innovation subjects can join in the innovation activities of enterprises [30]. Therefore, this study measures the technical conditions from the two aspects of hardware facilities and software facilities.

2.2.2. Organizational Conditions. Organizational conditions mainly include corporate scale, organizational resources, and institutional arrangement. [31]. As the "booster" of enterprise innovation, the abundant human capital largely determines the quality of an enterprise's products or services and directly affects innovation activities [32–34]. The richer the human capital of the enterprise, the deeper the excavation of the original knowledge of the organization. Therefore, the human capital of the enterprise is conducive to deepening the understanding of the original knowledge, enhancing the knowledge application ability of the enterprise, and promoting the organization to carry out utilization innovation [33]. At the same time, R&D capital, as another vital resource of the organization, has played an essential role in promoting the output of innovative achievements, enhancing innovation capabilities, and forming core market competitiveness [35, 36]. Although short-term R&D capital investment increases the cost of enterprises, the sufficient R&D capital investment provides

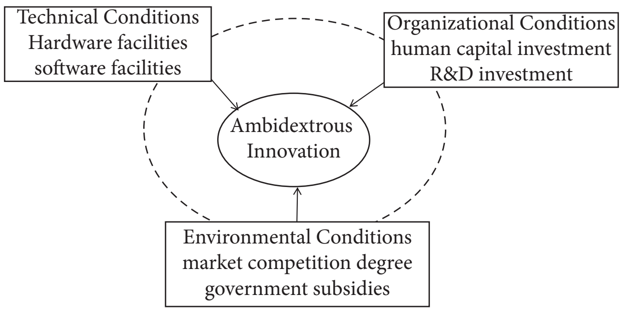


Figure 1: Theoretical analysis framework.

necessary support for exploratory and exploitative innovation in the long-term [36] and can mobilize the enthusiasm of R&D personnel. At the same time, innovation activities will not be delayed or interrupted due to a lack of funds, and enterprises are more confident to try various innovation activities [37]. Therefore, this study measures organizational conditions from two aspects, namely, human capital investment and R&D capital investment.

2.2.3. Environmental Conditions. In the fierce market competition, the speed of imitation and diffusion of advanced technology among competitors is accelerated, and the update speed of products and services is accelerated, which conveys a "competitive threat signal" to enterprises [24]. In order to avoid competitive threats and market risks, enterprises often increase their R&D investment and enhance their innovation capabilities [25]. Exploratory innovation can change the performance of original products by developing heterogeneous products and form product competitive advantages, which will distance it from other competitors and stand out in existing or emerging markets. In addition, in the fierce market competition, enterprises may have threats and risks such as reduced competitive advantage, loss of market share, bankruptcy, and liquidation [25], which will further increase the dependence of enterprises on technological innovation, and enterprises will try their best to search and use all available resources to carry out innovation activities [10].

Scientific and technological innovation is the key driving high-quality economic development, and the improvement of innovation performance not only needs its efforts but also depends on policy support [14]. From the perspective of innovation compensation, innovation activities are more uncertain and riskier than other business activities. Government subsidy can directly increase the capital reserve of enterprises, improve the risk resistance ability of enterprises, and reduce enterprise's R&D cost, which has the "resource compensation" effect [38, 39]. Meanwhile, enterprises receiving government subsidies are labeled as "government certification" [40, 41], and the "good reputation signal" is conducive to enterprises obtaining more financial support from the capital market and alleviating innovation financing constraints [39]. This study measures environmental conditions from two aspects, namely, market competition and government subsidy.

3. Research Design

3.1. Research Methods. Qualitative comparative analysis (QCA) is an analytical method for small- and medium-sized sample case studies that emerged from social science research in the late 1980s. QCA was first proposed by American sociologist Charles C. Ragin, who introduced QCA in his book "Comparative Methods: Beyond Qualitative and Quantitative Strategies," published in 1987. Based on the principles of set theory and Boolean algebraic algorithms, this approach emphasizes the construction of causality of research topics from small sample data through continuous dialogue between empirical data and relevant theories. According to the different forms of sets, QCA applications are mainly divided into csQCA (qualitative comparative analysis of clear sets), mvQCA (qualitative comparative analysis of multivalues), and fsQCA (qualitative comparative analysis of fuzzy sets). Among them, csQCA is a dichotomous variable that converts variables into "0" or "1;" FsQCA allows a partial membership score between "0" or "1," that is, the degree of membership between "full membership" and "no membership at all."

QCA analysis combines the advantages of case orientation and variable orientation, aiming to find out the causal relationship between condition configuration and results through the comparison of cases and answer the questions such as "which configuration of conditions can lead to the desired results and which configuration causes the result not to appear?" [42, 43]. The method has the following characteristics. ① The traditional statistics methods mostly focus on the "net effect" of explanatory variables on the explained variables [19], while qualitative comparative analysis focuses on the "configuration effect" analysis, exploring the influence of the combination of various antecedent variables on the outcome variables, which helps to reveal multiple concurrent relationships between multiple elements. ② This method is not only suitable for the study of large case samples but also for the analysis of small samples [43]. ③ According to the variable type, QCA can be divided into fsQCA (fuzzy set qualitative comparative analysis), csQCA (clear set qualitative comparative analysis), and mvQCA (multivalue qualitative comparative analysis). Compared with csQCA and mvQCA, fsQCA has wide application scope and universality [43].

3.2. Data Description

3.2.1. Selection of Data and Variables. The Science and Technology Innovation Board is the backbone of fostering new innovative enterprises and promoting the development of emerging strategic industries. The Science and Technology Innovation Board enterprises have higher innovation enthusiasm and representation of R&D innovation. Therefore, 70 companies listed on the Science and Technology Innovation Board in 2019 were selected as research samples in this study. To ensure the validity of case data, we screened the initial cases and excluded all enterprises with zero patents in 2019 and data missing. Finally, 34 enterprises of the Science and Technology Innovation Board were retained as study cases. The data mainly come from the China Stock Market and Accounting Research (CSMAR) database, Wind database, and China Patent database. The specific variable measures are as follows:

(1) Ambidextrous Innovation (DIB). There are four relationships between exploratory innovation and exploitative innovation, namely, competition and opposition, difference and differentiation, integration and coordination, and balance and complementarity [21]. This study argues that maintaining a balance between exploratory and exploitative innovation is conducive to giving full play to the advantages of each type of technological innovation and enabling enterprises to get better innovation performance [8, 20, 44]. Referring to the research of Chen et al. [14] and Wang et al. [44], this study uses the number of invention patent applications to measure the level of exploratory innovation and the number of utility models, designs patent applications to measure the level of utilization innovation, and then calculates the degree of balance between the two to measure the enterprise's ambidextrous innovation degree(DIB). The calculation formula is as follows: $\mathrm{DIB} = 1 - |x - y|/x + y$, where x represents exploratory innovation and y represents exploitative innovation. The closer the value in this formula to 1, the higher the level of ambidextrous innovation of the enterprise.

(2) Technical Conditions Include Hardware Facilities (HI) and Software Facilities (SI). This study believes that the application of digital technology is based on the corresponding software and hardware investment, so this study reflects the application of digital technology through investment in hardware facilities and software facilities. Referring to the research of Liu and Tian [45], the hardware facility (HI) is measured by the ratio of the net value of computers, electronic equipment, communication equipment, etc., in fixed assets to the total assets. Software infrastructure (SI) is measured by the ratio of software net worth to total assets in intangible assets.

(3) Organizational Conditions Include Human Capital Investment (SQ) and R&D Investment (R&D). Referring to the research of Shang et al. [46] and Feng [37], this study uses the ratio of the number of employees with a bachelor's degree or above to the total number of employees as the proxy of human capital investment (SQ). R&D investment (R&D) is measured by the ratio of R&D investment to operating income.

(4) Environmental Conditions Include Market Competition (MC) and Government Subsidy (GS). Referring to the research of Xie and Wei [10], Herfindahl–Hirschman Index (HHI) is adopted to measure the degree of market competition (MC), and the higher the value is, the lower the degree of market competition is. The calculation formula is $\mathrm{HHI} = \sum (X_i/X)^2$, where X_i represents the main business income of enterprise i, and X represents the sum of the primary business income of the industry to which enterprise i belongs. Considering the different scales of enterprises, the number of government subsidies is significantly different, and the ratio of government subsidies in the nonoperating income details to total assets is used to measure government subsidies (GS).

3.2.2. Variable Calibration. To avoid the influence of sample differences on the results, this study calibrates the variables according to the thresholds of full membership, the crossover point, and full nonmembership. Referring to the research of Fiss [19], this paper sets three anchor points of ambidextrous innovation, hardware facilities, software facilities, human capital investment, R&D investment, and government subsidy, according to the upper quartile, median, and lower quartile of the sample data. In addition, referring to the research of Xie and Wei [10], the market competition degree is calibrated against the median of the HHI index. If the market competition degree of the industry in which the enterprise is located is greater than 0.1261, it is regarded as a low market competition degree, and the value is 0. Otherwise, the value is 1. The anchor point setting of each variable is shown in Table 1.

4. Empirical Results' Analysis

4.1. Necessity Analysis. Before the configuration analysis through the truth table of fuzzy sets, it is necessary to analyze the necessity of all antecedent variables and their nonsets. Table 2 presents the results for the necessity of antecedent variables. Table 2 shows that the consistency of all antecedent variables affecting enterprise ambidextrous innovation is below 0.9, and none of the variables alone constitutes a necessary condition for enterprise ambidextrous innovation. In other words, it shows that any single variable in technical conditions (hardware facilities and software facilities), organizational conditions (human capital investment and R&D investment), and environmental conditions (market competition and government subsidies) has a relatively weak explanatory power for ambidextrous innovation, and the analysis based on the configuration perspective is necessary. Therefore, this study will explore the linkage effect of "technology + organization + environment" on ambidextrous innovation.

4.2. Configuration Analysis. This study takes 34 companies on the Science and Technology Innovation Board as samples to analyze the conditional configuration that promotes the ambidextrous innovation of enterprises by using the fsQCA software. Specifically, referring to the views of scholars such as Fiss [19], Du, and Jia [43], the frequency threshold is set to 1, the consistency threshold is set to 0.8, and the proportional reduction in inconsistency (PRI) is set to 0.7. At the same time, when using the fsQCA method for configuration analysis, three solutions will be formed, namely, complex solution, parsimonious solution, and intermediate solution. We mainly focus on the intermediate solution and parsimonious solution to interpret the results. If a specific antecedent variable appears in these two solutions

Table 1: Calibration anchors for variable.

Main variables	The full membership	The crossover point	The full nonmembership
Ambidextrous innovation (DIB)	0.6667	0.1151	0.0000
Hardware facilities (HI)	0.0105	0.0040	0.0015
Software facilities (SI)	0.0032	0.0014	0.0007
Human capital investment (SQ)	81.4650	59.1500	33.8275
R&D investment (R&D)	19.5650	14.6800	8.3900
Market competition (MC)	1.0000	—	0.0000
Government subsidy (GS)	0.0124	0.0080	0.0050

Table 2: Necessity test results of the single anterior dependent variable.

Antecedents	Consistency	Coverage
Hardware facilities	0.5235	0.5169
~Hardware facilities	0.5841	0.5476
Software facilities	0.6073	0.6156
~Software facilities	0.4514	0.4130
Human capital investment	0.5480	0.5209
~Human capital investment	0.5205	0.5065
R&D investment	0.3804	0.3733
~R&D investment	0.7162	0.6753
Market competition	0.5572	0.3961
~Market competition	0.4428	0.6582
Government subsidy	0.5572	0.5378
~Government subsidy	0.5554	0.5322

simultaneously, it is recorded as the core condition; if it only appears in the intermediate solution, it is recorded as the marginal condition [43]. The results of empirical analysis are shown in Table 3.

There are five ambidextrous innovation configurations in Table 3. Among the five configurations, the consistency of the single solution (configuration) and the overall resolution is higher than the acceptable minimum standard of 0.8. Among them, the consistency value of the overall solution is 0.9271, indicating that the five configurations explain 92.71% of the enterprise's high ambidextrous innovation; the coverage value of the overall solution is 0.3810, indicating that 38.1% of the high ambidextrous innovation cases of enterprises can be explained. In this study, these five configurations are summarized into three high-level ambidextrous innovation driven paths of enterprises, namely, the technology-driven path under the pressure of market competition, the technology-promoted path under government support, and the resource-rich proactive change path.

4.2.1. The Technology-Driven Path under the Pressure of Market Competition. This path corresponds to configuration $1(\mathrm{hi}^* \times \mathrm{SI}^* \times \mathrm{r\&d}^* \times \mathrm{MC}^* \times \mathrm{gs}^*)$. Software facilities and market competition as the core conditions exist, while hardware facilities, R&D investment, and government subsidies as the core conditions are missing in configuration 1. It shows that the perfect software infrastructure can promote enterprises to actively respond to the fierce market competition to carry out ambidextrous innovation. Therefore, this study named it as " the technology-driven path under the pressure of market competition." Meanwhile, among all the configurations, the original coverage of configuration 1 is the highest, which is 0.1505, and it shows that the technology-driven path under the pressure of market competition plays a dominant role in the implementation process of ambidextrous innovation. The main reason is that the speed of knowledge circulation among the enterprises is accelerated and the updating cycle of products and services is shortened in the fierce market competition. Therefore, enterprises have to innovate actively to gain competitive advantages and adapt to the law of the "survival of the fittest" [25]. At the same time, the application of digital technologies and related office software such as the Internet and 3D printing can reduce the cost of enterprise communication and speed up the resource integration [18]; it is conducive to improving the dilemma of innovation and supporting enterprises to carry out ambidextrous innovation.

Typical examples of this driven path include Shanghai Bright Power Semiconductor Co., Ltd., Jiangsu BioPerfectus Technologies Co., Ltd., and Shanghai Medicilon Inc. For these enterprises, although resources are relatively limited, the fierce market competition and the support of technical conditions such as software facilities will promote enterprises to carry out ambidextrous innovation. Taking Shanghai Bright Power Semiconductor Co., Ltd. (referred to as "BPSemi") for example, it is the leading enterprise of the LED lighting driver chips in the world, with a market share of about 30%. There are many enterprises in this industry, and the market competition is fierce. Compared with the major domestic and foreign LED lighting companies (Philips, OPPLE Lighting Co., Ltd., etc.), there is still a significant gap in the technological innovation level of BPSemi. Therefore, to form its competitive advantage in the harsh market environment, continuous innovation has become BPSemi's focus. BPSemi continues to expand new technology fields and add new product lines to meet the diversified downstream market needs and improve comprehensive competitiveness.

Combined with the case analysis of the core conditions of configuration 1, this study puts forward Proposition 1; that is, under the circumstance of low R&D investment, perfect software facilities and fierce market competition drive enterprise ambidextrous innovation.

4.2.2. The Technology Promoted Path under Government Support. This path corresponds to configuration *2a* $(\mathrm{SI}^* \times \mathrm{SQ} \times \mathrm{R\&D} \times \mathrm{mc}^* \times \mathrm{GS}^*)$ and configuration *2b*

Table 3: Configurations for enterprise ambidextrous innovation.

Variables	Configuration				
	Configuration 1	Configuration 2a	Configuration 2b	Configuration 3a	Configuration 3b
Hardware facilities (HI)	⨂		•	⬤	⬤
Software facilities (SI)	⬤	⬤	⬤	⊗	⊗
Human capital investment (SQ)		•	⊗	⬤	⬤
R&D investment (R&D)	⨂	•	⊗	⨂	⨂
Market competition (MC)	⬤	⨂	⨂	⊗	•
Government subsid (GS)	⨂	⬤	⬤	•	⊗
Consistency	0.8786	1	1	1	0.8071
Raw coverage	0.1505	0.0930	0.0483	0.0685	0.0691
Unique coverage	0.1297	0.0777	0.0330	0.0563	0.0483
Overall solution consistency			0.9271		
Overall solution coverage			0.3810		

Black circles indicate the presence of a condition, and circles with "X" indicate its absence. Large circles indicate core conditions; small circles indicate peripheral conditions. Blank spaces indicate "do not care".

($HI \times SI^{*} \times sq \times r\&d \times mc^{*} \times GS^{*}$). Configuration 2*a* indicates that the configuration with high software facilities, high government subsidies, high human capital investment, high R&D investment, and low market competition can promote an enterprise's ambidextrous innovation. Configuration 2*b* indicates that the configuration with high software facilities, high government subsidies, high hardware facilities, low investment in human capital, low investment in R&D, and low market competition can promote enterprise's ambidextrous innovation. Through comparison, it is found that the core conditions of configuration 2*a* and configuration 2*b* are the same; that is, software facilities and government subsidies are both core conditions, which shows that, in the case of weak market competition, government subsidies and relatively perfect software facilities can stimulate enterprises' ambidextrous innovation actively and avoid "enjoy wealth and honor" because of the comfortable market environment. Therefore, this study names it as " the technology-promoted path under government support." Through further analysis, we find that high human capital investment and high R&D investment play a supporting role in configuration 2*a*, which indicates that sufficient internal R&D investment can strengthen the promotion effect of government support and software infrastructure on an enterprise's ambidextrous innovation. The reason is that enterprises' willingness to innovate is relatively low due to the characteristics of long innovation cycle and large investment scale [2], while government subsidies can produce the effect of "resource compensation" to alleviate the shortage of funds and improve the enthusiasm of enterprises for innovation [14]. In addition, when an enterprise obtains government subsidies, it sends a positive signal to the capital market that the government supports enterprises, and the enterprises that receive government subsidies can raise more funds for R&D from the capital market. In addition, the application of digital technology brings changes of business models, makes the management mechanism of organizations more flexible, improves the adaptability of enterprise, and thus enhances the innovation level of enterprise [18].

Typical examples of this driven path include Suzhou TZTEK Technology Co., Ltd., Suzhou Harmontronics Automation Technology Co., Ltd., and KINGSEMI Co., Ltd. Taking Suzhou TZTEK Technology Co., Ltd. (referred to as "Harmontronics Automation") for example, it is an intelligent manufacturing equipment enterprise characterized by scientific and technological innovation in China. The enterprise has many innovative achievements in mechanical design, industrial vision, and information technology. On the one hand, relying on the platform development environment, Harmontronics Automation has developed a software system to open up the data chain of the whole factory and provide technical support for innovation activities. On the other hand, government subsidies also send a positive signal to the capital market; before the IPO (initial public offering of shares), Harmontronics Automation has obtained multiple rounds of financing, which provides sufficient financial support for enterprises to carry out innovation activities.

Combined with the case analysis of the core conditions of configuration 2*a* and 2*b*, this study puts forward Proposition 2; that is, when the market competition environment is relatively stable, the support of government subsidies and internal software facilities are crucial to enterprise ambidextrous innovation.

4.2.3. The Resource-Rich Proactive Change Path. The path corresponds to configuration 3*a* ($HI^{*} \times si \times SQ^{*} \times r\&d^{*} \times mc \times GS$) and configuration 3*b* ($HI \times si \times SQ^{*} \times r\&d^{*} \times MC \times gs$). Different from the previous two driven paths, the resource-rich proactive change model is mainly affected by the enterprise's conditions; that is, the technical conditions and organizational conditions of the enterprise are relatively abundant, which provides an essential foundation

Table 4: Configuration views and typical cases of enterprise ambidextrous innovation.

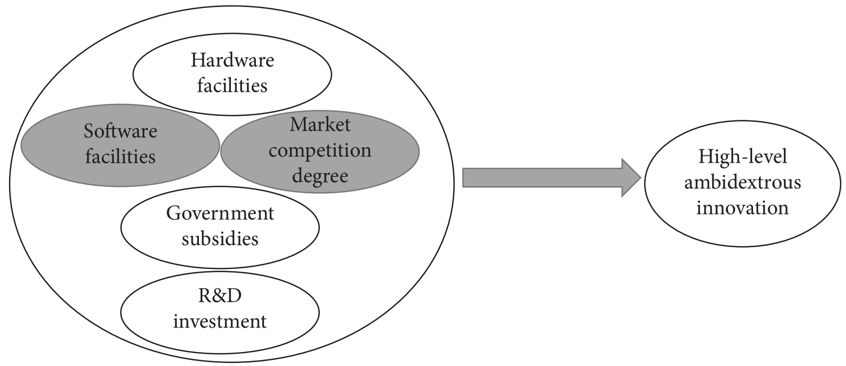
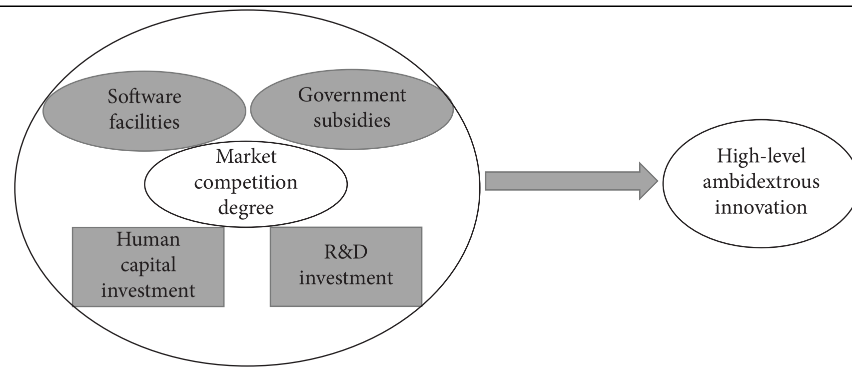
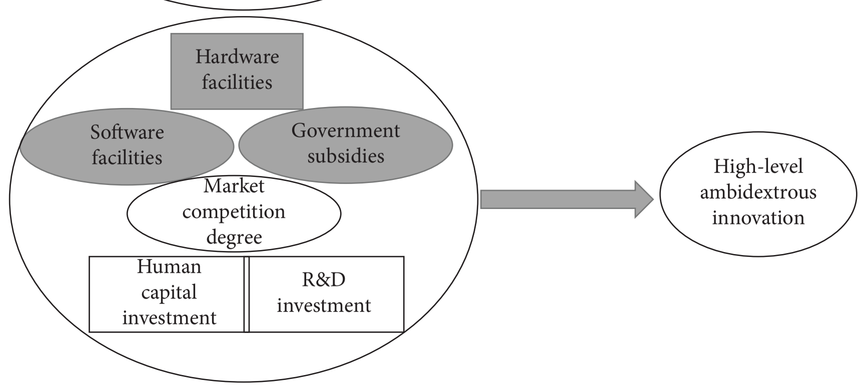
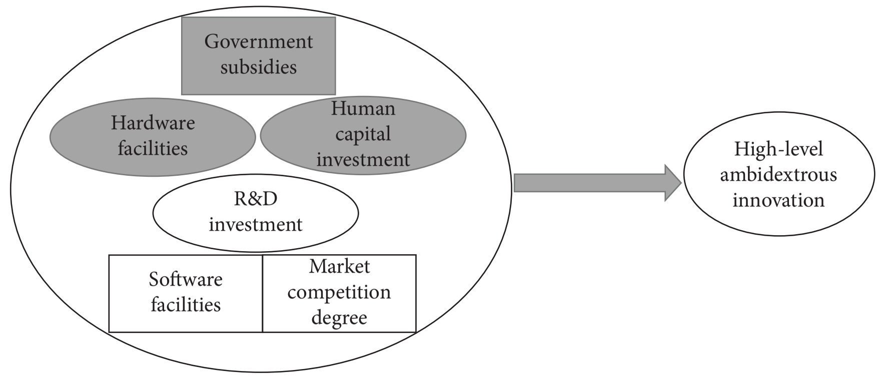
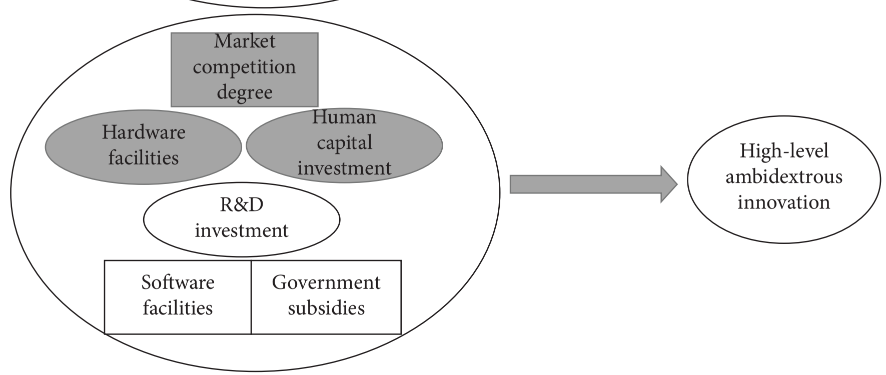
Ambidextrous innovation path	Configuration view	Typical cases
The technology-driven path under the pressure of market competition		Shanghai Bright Power Semiconductor Co., Ltd. Jiangsu Bioperfectus Technologies co., ltd. Shanghai Medicilon Inc.
The technology-promoted path under government support		Suzhou TZTEK Technology Co., Ltd. KINGSEMI Co., Ltd.
		Suzhou Harmontronics Automation Technology Co., Ltd.

Table 4: Continued.

Ambidextrous innovation path	Configuration view	Typical cases
The resource-rich proactive change path		China National Electric Apparatus Research Institute Co., Ltd.
		Shenzhen Qingyi Photomask Limited

Note. Black circle indicates the core condition exists, and the white circle indicates the core condition is absent. Black squares indicate that the peripheral condition exists, and white squares indicate that the peripheral condition is missing.

Table 5: Robust test of adjusting consistency thresholds.

Variables	Configuration			
	Configuration a	Configuration b	Configuration c	Configuration d
Hardware facilities (HI)	⨂		●	●
Software facilities (SI)	●	●	●	⊗
Human capital investment (SQ)	⨂	•	⊗	•
R&D investment (R&D)	⨂	•	⨂	⨂
Market competition (MC)	●	⨂	⨂	⨂
Government subsid (GS)	⨂	●	●	•
Consistency	0.9603	1	1	1
Raw coverage	0.0887	0.0930	0.0483	0.0685
Unique coverage	0.0887	0.0777	0.033	0.0563
Overall solution consistency	0.9866			
Overall solution coverage	0.2709			

for the enterprise's ambidextrous innovation. In configuration 3*a*, hardware facilities and human capital investment are the core existence conditions, government subsidies are the marginal existence conditions, R&D capital investment is the core absence condition, and software facilities and market competition are the marginal absence conditions. In configuration 3*b*, hardware facilities and human capital investment are the core existence conditions, market competition is the marginal existence condition, R&D capital investment is the core absence condition, and software facilities and government subsidies are the marginal absence conditions. We find that the core conditions of configuration 3*a* and 3*b* are the same, indicating that abundant resources such as human capital input and hardware facilities are essential sources for enterprises to carry out innovation activities. The larger the scale of enterprise's disposable resources, the stronger their willingness and ability to engage in high-risk innovation projects, and the easier it is to carry out technological innovation [10, 11, 25]. So, configurations 3*a* and 3*b* are named as "the resource-rich proactive change path" in this study.

Typical examples of this driven path include Shenzhen Qingyi Photomask Limited and China National Electric Apparatus Research Institute Co., Ltd. Among them, taking China National Electric Apparatus Research Institute Co., Ltd. (referred to as "CEI"), for example, as an innovative technology enterprise, the reserve of high-precision talents and excellent technical conditions are essential supports for CEI to carry out continuous innovation. CEI has a research and development team mainly composed of doctors, masters, various academic and industry leaders, and professional technical personnel accounting for more than 70% of the total number of employees. Therefore, rich human capital and excellent technical conditions provide the premise guarantee and core advantages for the ambidextrous innovation of CEI.

Combined with the case analysis of the core conditions of configuration 3*a* and 3*b*, this study puts forward Proposition 3; that is, rich technical conditions and human capital investment are the powerful guarantee for enterprises to carry out ambidextrous innovation.

To facilitate understanding and comparison, Table 4 summarizes the abovementioned analysis graphically from the perspective of research propositions, typical cases, and configuration.

4.3. Robust Test. To improve the reliability of the research results, this study uses the method of adjusting the consistency level to conduct a robustness test. If changing the consistency level results in a clear subset relationship between the configurations, the results can be considered robust, even if the configurations look radically different. Otherwise, it is not robust. We adjust the consistency level from 0.8 to 0.85, keep the frequency threshold unchanged, and adopt a stricter consistency threshold to analyze and test cases, and the results are shown in Table 5. Compared with the results in Table 3, the overall solution consistency and coverage have slight changes. The consistency of the overall solution increases from 0.9271 to 0.9866, and the overall solution coverage decreases to 0.2709. From the set relationship among the configurations, Table 5 contains four configurations. It shows that Configuration *a* is a subset of Configuration 1 in Table 3; Configuration *b* is entirely consistent with Configuration 2*a* in Table 3; Configuration *c* contains exactly the same conditions as Configuration 2*b*, Configuration *d*, and Configuration 3*a* in Table 3. Therefore, it is found that the conclusion of the study is still robust after adjusting the consistency threshold of the model.

5. Conclusion and Enlightenment

5.1. Research Conclusions. Based on the configuration perspective, this study explores the path configuration that drives the enterprise's ambidextrous innovation from the technical conditions, organizational conditions, and environmental conditions. It draws the following conclusions: (1) by using fsQCA3.0 software to test the necessary conditions of enterprise ambidextrous innovation, it is found that technical conditions, organizational conditions, and environmental conditions cannot constitute the essential conditions of enterprise ambidextrous innovation alone, but the combination configuration of different factors has a significant impact; (2) three driven paths of enterprise ambidextrous innovation are summarized as follows: the technology-driven path under the pressure of market competition, the technology-promoted path under government support, and the resource-rich proactive change path. Among them, the technology-driven path under the pressure of market competition is the main driven path of ambidextrous innovation, and the path is the corresponding Configuration 1. In addition, it indicates that, under the circumstance of low R&D investment, perfect software facilities and fierce market competition drive enterprise ambidextrous innovation. The technology-promoted path under government support is the corresponding Configuration 2*a* and Configuration 2*b*, and the path indicates that when the market competition environment is relatively stable; the support of government subsidies and internal software facilities are crucial to enterprise ambidextrous innovation. The resource-rich proactive change path is the corresponding Configuration 3*a* and Configuration 3*b*, and the path indicates that rich technical conditions and human capital investment are a powerful guarantee for enterprises to carry out ambidextrous innovation.

5.2. The Enlightenment. The primary enlightenment is shown in the following aspects:

(1) From the perspective of enterprises, enterprises must realize the importance of ambidextrous innovation. The rapid development of the digital economy intensifies market competition and impacts the external living environment of enterprises [22, 29]. Enterprises should not only focus on the existing technology but also have the courage to explore new technology fields. In other words, the enterprises need to carry out ambidextrous innovation and explore new capabilities to adapt to the new environment [8]. The enterprises should formulate the corresponding ambidextrous innovation strategy according to the external environment (market competition degree and government subsidies), its technical conditions (hardware facilities and software facilities), and organizational conditions (investment in human capital and R&D investment). In addition, the enterprises should establish core competitive advantages through developing new technology and product, to ensure that enterprises have an invincible position in future development. Besides, enterprises should pay attention to the enabling effect of digital technology application for ambidextrous innovation. By integrating digital technologies such as the Internet, big data, and artificial intelligence into enterprises, enterprises can actively build an innovation system under the digital context and promote the deep integration of product and service innovation and digital technology [22].

(2) From the perspective of the government, the government should continue to play the supporting role of government subsidies for innovation activities [11]. The study finds that government subsidies play an essential role in promoting high-level ambidextrous innovation of enterprises, so the government should continue to play the role of government subsidies in correcting market failure and promoting enterprises to improve the innovation ability. At the same time, governments should also be aware of companies' innovation strategies in detail when handing out subsidies, make targeted subsidy measures, and design incentive policies accurately according to the current situation of enterprises. In addition, this study finds that market competition plays a vital role in promoting enterprises to increase innovation input and enhance the ambidextrous innovation. Therefore, the government should create a healthy competitive market environment, give full play to the role of the market in optimizing the allocation of innovation resources, and allow market competition to stimulate the innovation vitality of enterprises.

Data Availability

The data used to support the findings of this study are available from the China Stock Market and Accounting Research (CSMAR) Database (http://cndata1.csmar.com/), Wind Database(https://www.wind.com.cn/), and China Patent Database(http://cnki.scstl.org/kns55/brief/result.aspx?dbPrefix=SCPD).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] Y. Z. Chen and Y. X. Ge, "Self-reliance and self-improvement in science and technology based on leading innovation," *Studies in Science of Science*, vol. 39, no. 5, pp. 770–773, 2021.
[2] Y. Guo, "Signal transmission mechanism of government innovation subsidy and enterprise innovation," *China Industrial Economics*, vol. 9, pp. 98–116, 2018.
[3] J. Z. Wang and M. H. Gao, "Anti-corruption, entrepreneurial competencies and enterprise Innovation," *Journal of Business and Management*, vol. 39, no. 6, pp. 35–52, 2017.
[4] J. J. P. Jansen, F. A. J. Van Den Bosch, and H. W. Volberda, "Exploratory innovation, exploitative innovation, and performance: effects of organizational antecedents and environmental moderators," *Management Science*, vol. 52, no. 11, pp. 1661–1674, 2006.
[5] Y. Li and Y. H. Si, "Exploratory innovation, exploitative innovation, and performance: influence of business strategies and environment," *Nankai Business Review*, vol. 5, pp. 4–12, 2008.
[6] Q. Cao, E. Gedajlovic, and H. Zhang, "Unpacking organizational ambidexterity: dimensions, contingencies, and synergistic effects," *Organization Science*, vol. 20, no. 4, pp. 781–796, 2009.
[7] C. Peng, R. X. Li, H. Yang, and P. Yu, "Research on the relationship between dual innovation and sustainable development of enterprises in dynamic and competitive environment," *Science & Technology Progress and Policy*, vol. 37, no. 15, pp. 70–79, 2020.
[8] H. Jiao, "The road to establishing the competitive advantage of the dual type of organizations: founded on the case study theory of the dynamic capabilities," *Management World*, vol. 11, pp. 76–91+188, 2011.
[9] M. J. Benner and M. L. Tushman, "Exploitation, exploration, and process management: the productivity dilemma revisited," *Academy of Management Review*, vol. 28, no. 2, pp. 238–256, 2003.
[10] W. M. Xie and H. Q. Wei, "Market competition, organizational slack and corporate R&D investment: evidence from China," *China Soft Science*, vol. 8, pp. 102–111, 2016.
[11] X. F. Bi, S. P. Zhai, and B. Q. Jiang, "The effects of government subsidy and financial redundancy on dual innovation of high-tech enterprises," *Accounting Research*, vol. 1, pp. 46–52+95, 2017.
[12] Z. Q. Jian, N. Liu, and R. Y. Huang, "Research on the relationship between dynamic capability, firm size and dual innovation: an empirical analysis based on fsQCA method," *Science & Technology Progress and Policy*, vol. 37, no. 19, pp. 77–86, 2020.
[13] B. X. Yang, Y. R. Wang, and X. G. Li, "The impact of technological diversification on the performance of dual innovation: from the perspective of formal and informal institutional environment," *Science of Science and Management of Science and Technology*, vol. 42, no. 12, pp. 145–162, 2021.
[14] H. Chen, Y. Zhang, and D. X. Liu, "Government subsidies, tax breaks and enterprise's innovation performance: an empirical study on different life cycle stages," *Nankai Business Review*, vol. 22, no. 3, pp. 187–200, 2019.
[15] C. Peng, D. Q. Cao, and R. X. Li, "The impact of environmental dynamism and competitiveness on ambidextrous innovation synergy: the mediator of resource bricolage and the moderator of organizational emotional ability," *Science & Technology Progress and Policy*, vol. 38, no. 20, pp. 11–19, 2021.
[16] D. Q. Cao, C. Peng, and C. L. Lv, "The influence of the environmental dynamism and competitiveness on dual innovation of enterprises: moderation role of entrepreneurial orientation," *Journal of Management*, vol. 34, no. 1, pp. 56–66, 2021.
[17] Q. J. Chen, M. F. Wan, and Y. M. Wang, "Digital technology applied to the dual innovation - based on the influence of organization life cycle of the empirical test," *China Soft Science*, vol. 35, no. 11, pp. 92–98, 2021.
[18] J. C. Zhang and J. Long, "How does digital technology applications drive enterprise breakthrough innovation," *Journal of Shanxi University of Finance and Economics*, vol. 44, no. 1, pp. 69–83, 2022.
[19] P. C. Fiss, "Building better causal theories: a fuzzy set approach to typologies in organization research," *Academy of Management Journal*, vol. 54, no. 2, pp. 393–420, 2011.
[20] Z. L. He and P. K. Wong, "Exploration vs. Exploitation: an empirical test of the ambidexterity hypothesis," *Organization Science*, vol. 15, no. 4, pp. 481–494, 2004.
[21] B. B. Dong, S. S. Cheng, and L. Zhang, "Ambidexterity innovation: review and future research agenda," *Journal of Management*, vol. 19, no. 2, pp. 308–316, 2022.
[22] J. Chen, S. Huang, and Y. H. Liu, "Operations management in the digitization era: from empowering to enabling," *Management World*, vol. 36, no. 2, pp. 117–128+222, 2020.
[23] W. Zhao, Y. J. Li, and H. H. Zhao, "Can government R&D subsidies improve the innovation efficiency of enterprises?—a study based on fsQCA," *R & D Management*, vol. 32, no. 2, pp. 37–47, 2020.
[24] J. Z. Wu and H. L. Fan, "Corporate green innovation driving model based on configuration perspective," *R & D Management*, vol. 33, no. 4, pp. 41–53, 2021.
[25] Y. M. Zhuang and L. Wang, "Who drives the technological innovation of science and technology enterprises," *Science Research Management*, vol. 43, no. 3, pp. 46–54, 2022.
[26] L. G. Tornatzky and M. Fleischer, *The Processes of Technological Innovation*, Lexington Books, Lexington, MA, 1990.
[27] Y. X. Ding, N. N. Xu, and J. H. Guo, "Empirical study on influencing factors of government e-service capability based on TOE framework," *E-government*, vol. 1, pp. 103–113, 2020.
[28] H. B. Tan, Z. T. Fan, and Y. Z. Du, "Technology management capability, attention distribution and local government website construction:a configurational analysis based on the TOE framework," *Management World*, vol. 35, no. 9, pp. 81–94, 2019.
[29] G. Q. Chen, D. J. Zeng, and Q. Wei, "Transitions of decision-making paradigms and enabled innovations in the context of big data," *Management World*, vol. 36, no. 2, pp. 95–105+220, 2020.
[30] X. W. Zhang, "Research on evolution of innovation model under the condition of digital economy," *Economist*, vol. 7, pp. 32–39, 2019.
[31] Z. Q. Qiu, "Technology and Organization: themes and theoretical trends in sociology and other disciplines," *Sociology Study*, vol. 32, no. 4, p. 167, 2017.
[32] J. Alegre, R. Lapiedra, and R. Chiva, "A measurement scale for product innovation performance," *European Journal of Innovation Management*, vol. 9, no. 4, pp. 333–346, 2006.

[33] J. Lin and J. He, "A study on the impact paths of intellectual capital on incremental and radical technology innovation," *R & D Management*, vol. 23, no. 1, pp. 90–98, 2011.
[34] Y. L. Hu and Y. Li, "The influence of configuration effect of intellectual capital on enterprise ecological innovation—an empirical analysis based on fsQCA method," *Science & Technology Progress and Policy*, vol. 38, no. 10, pp. 95–104, 2021.
[35] B. H. Hall, F. Lotti, and J. Mairesse, "Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms," *Economics of Innovation and New Technology*, vol. 22, no. 3, pp. 300–328, 2013.
[36] H. Sun and H. Wang, "Government subsidy, R&D investment and enterprise innovation performance—an empirical study based on the gem high tech enterprises," *Science and Technology Management Research*, vol. 37, no. 12, pp. 111–116, 2017.
[37] W. N. Feng, "A correlation analysis on High-tech enterprise R&D input and innovation output: the experience proof come from high-tech enterprises in Shandong province," *Economic Problems*, vol. 9, pp. 74–78, 2010.
[38] N. Hewitt-Dundas and S. Roper, "Output additionality of public support for innovation: evidence for Irish manufacturing plants," *European Planning Studies*, vol. 18, no. 1, pp. 107–122, 2010.
[39] X. Wang, Y. D. Yang, and L. Wang, "From "No target" to "considerations": research on the impact of government subsidies on green innovation from the perspective of information disclosure," *Science & Technology Progress and Policy*, vol. 37, no. 15, pp. 135–143, 2020.
[40] F. Überbacher, "Legitimation of new ventures: a review and research programme," *Journal of Management Studies*, vol. 51, no. 4, pp. 667–698, 2014.
[41] H. L. Gao, L. Li, and J. H. Chen, "Does government's R&D support have an influence on external financing of high-tech firms? A Study Based on Organizational Legitimacy Theory," *Nankai Business Review*, vol. 20, no. 6, pp. 178–189, 2017.
[42] C. Zhang, X. J. Zheng, and F. B. Wang, "The application of qualitative comparative analysis(QCA)in configuration research in business administration field: commentary and Future Directions," *Foreign Economics & Management*, vol. 39, no. 4, pp. 68–83, 2017.
[43] Y. Z. Du and L. D. Jia, "Configurational perspective and qualitative comparative analysis (QCA): a new approach to management research," *Management World*, vol. 6, pp. 155–167, 2017.
[44] F. B. Wang, J. X. Chen, and Y. Yang, "An analysis of the effect of the explorative and exploitative innovations and their balance," *Management World*, vol. 3, pp. 96–112+188, 2012.
[45] F. Liu and G. L. Tian, "Does information technology replace employment?— evidence based on China's kisted companies," *Finance and Economics*, vol. 7, pp. 95–107, 2019.
[46] Y. M. Shang, F. Q. Zhou, and L. Lin, "Impact of open innovation on the innovation performance of energy-saving and environmental protection enterprises," *Science & Technology Progress and Policy*, vol. 38, no. 10, pp. 114–122, 2021.