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How to Improve an Enterprise's Innovation Capability from the Perspective of High- and Low-Level Enterprises Using Fuzzy-Set Qualitative Comparative Analysis

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Abstract: An enterprise's capability is based on the quantity and collocation pattern of the heterogeneous resources it possesses. Innovation resources are the source of enterprise innovation capability. However, there is still a "black box" problem of the impact of the intensity of government support on enterprise innovation. Therefore, it is necessary to study high- or low-level enterprise innovation capability by combining the internal and external factors of the enterprise—the background characteristics of R&D personnel and the degree of government support. Based on the configuration perspective, this study uses the qualitative comparative analysis (fsQCA) method to conduct a comparative analysis of the innovation capabilities of enterprises in five time windows over six years with the longitudinal database of China's industrial enterprises whose operating income exceeds RMB 20 million from 2010 to 2015. This paper summarizes two ways of realizing high-level enterprise innovation capability: female and highly educated R&D personnel type, and highly educated R&D personnel and high government investment type. The enterprise innovation capability is affected simultaneously by multiple conditional variables, and the impact of each conditional variable on enterprise innovation capability has a trend. Further, it analyzes the impact of every antecedent variable comparing high- to low-level enterprise innovation.

Keywords: R&D personnel backgrounds; government investment; high/low level enterprises; fs-QCA

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1. Introduction

The logic of corporate sustainability has been gaining prominence among companies and researchers have been studying corporate sustainability from a strategic perspective [1]. The variability, uncertainty, complexity, and ambiguity of the business environment constantly pose new challenges to the development of enterprises. Innovation is the only "antidote" and the main driving force of an enterprise's development in anthe uncertain environment [2]. Shumpeter put forward the concept of innovation in 1912. Innovation is the cornerstone of the sustainable development of an enterprise and is primary in its competitiveness. Innovationcan positively influence industrial firms by enhancing their competitiveness. Innovation must be viewed as a sustainable and continuous process of identifying and seizing opportunities in the ever-changing business environment [3]. Therefore, enterprises must commit to the sustainability of their overall innovation capability, which is the critical driver toward sustained competitive advantages. To some extent, firms have largely focused on improving their innovation capabilities in order to build their competitive strengths and improve the sustainability of their businesses [4]. The innovation capabilities of a firm represent the key assets for building and sustaining its competitive advantage. Enterprise innovation is a type of innovation activity including basic research, applied research and experimental development activities [5]. R&D activity is becoming more central in today's economy [6]. In this study, enterprise innovation capability mainly refers to the R&D capability of enterprises. Many scholars believe that enterprise patent data indicators can be used to measure enterprise innovation capability. Hsu et al. [7] stated that the number of patents, as a proxy for enterprise innovation capability, can more appropriately reflect innovation output, efficiency, and effect. Therefore, the annual number of patent applications of industrial enterprises above the designated size in each region is also used as a proxy to measure enterprise innovation capability. According to China Statistical Yearbook on Science and Technology in 2021, 379,409 enterprises above a designated size (enterprises whose operating income exceeds RMB 20 million) carried out innovative activities, accounting for 43.3% of all enterprises in China, and 278,548 enterprises above the designated size developed product or process innovation activities nationwide, 62.6% of which have achieved in-house R&D innovation. With the increase in the number of companies engaged in innovative activities, the patent application of enterprise has shown explosive growth. China ranked 14th based on the Global Innovation Index 2020. The effective patent implementation rate in China was 57.8% in 2020, an increase of 4.3% over the previous year. The industrialization rate of effective patents is 41.6%, an increase of 7.8% over the previous year (China Patent Survey Report of 2020). Therefore, R&D investment is the determinant of success or failure in enterprise innovation [8], and leads to better performance. The government participates in enterprise R&D activities as an 'investor' and not only encourages enterprises to carry out innovation activities but also shares some of the risks of technological innovation with enterprises [2]. Government investment in R&D is an important external innovation resource for enterprises [9] and can improve the innovation capability of enterprises [10,11]. Government support/investment in this study refers to government funds for the intramural expenditure on R&D of Chinese enterprises from various levels of government (China Statistical Yearbook on Science and Technology). Government funds accounted for 19.8% of the R&D funds in 2020. Moreover, the amount of government R&D investment in enterprises has increased from 1696.3 million yuan in 2010 to 4825.6 million yuan in 2020. On the other hand, the key to scientific and technological innovation is talent [12]. The enterprise innovation activities are closely related to the optimization of talent structure [13]. R&D personnel refers to personnel involved in research, management and support work of research and experimental development projects, including personnel directly related to R&D and personnel supporting R&D processes such as administrative and office staff and managers [14]. The R&D personnel were 7,552,986 persons in 2020 and 3,542,244 persons in 2010. Innovation is a complex phenomenon explained by multiple factors [15]. Investing in innovation resources, such as R&D personnel and funds, has the most direct impact on an enterprise's innovation performance [14,15]. R&D activities are characterized by large investment amounts, long cycles and high uncertainty of results, which will limit the enthusiasm of enterprises for R&D to a certain extent. As an innovation incentive policy, government capital investment can alleviate the problem of insufficient innovation motivation of enterprises [11,16]. The key to obtaining a competitive edge is to integrate internal and external heterogeneous resources, gradually building a collection of resource capabilities in a dynamic and orderly manner, enabling an enterprise to create more value based on the resource-based view. According to the above analysis, this paper aims to solve the questions of how the four internal and external factors interact with each other to influence the innovation capability of the enterprise and how to improve and obtain high-level innovation capability for enterprises.

According to the resource-based view, this study adopts the fuzzy set qualitative comparative analysis (fsQCA) method to analyze and investigate the innovation capability of industrial enterprises above a designated size by matching the internal and external resource configuration effects of enterprise innovation to explore how to reasonably allocate, train, and introduce R&D personnel with different backgrounds to improve the innovation capability of enterprises with the full combination of internal and external resources based on five time windows over six years with the longitudinal database of China's industrial enterprises whose operating income exceeds RMB 20 million from 2010 to 2015.

2. Theoretical Perspective and Literature Review

2.1. Theoretical Perspective

The knowledge-based views (KBVs) believe that the essence of innovation is knowledge innovation, and the essence of enterprise innovation is the process of managing and creating the acquired knowledge (Shan et al., 2021) [17]. R&D is beneficial to new knowledge creation [18] and should play a central role in knowledge diffusion processes [19]. Government support is beneficial to increasing the knowledge stock of enterprises and improving their own technological capabilities [20].

Drawing on the resource-based view, resources include a body composed of a series of inimitable tangible and intangible resources (i.e., assets, knowledge, processes, and capabilities among others), which are important factors affecting enterprise innovation. The investment of enterprise innovation resources mainly includes the human, financial and material resources that enterprises need to invest in innovation activities. Human resources involved with R&D, namely R&D personnel of an enterprise, have an important effect on the economic growth of countries, regions, and enterprise innovation activities [14]. The quantity and quality of R&D personnel are closely related to the innovation ability of enterprises in the era of the digital economy [21].The quantity and quality of R&D personnel refer to the amount and the educational level of R&D personnel, respectively. However, innovation activities have strong positive externality and high risks. If each innovation subject only relies on R&D resources to carry out innovation activities spontaneously, it may lead to disordered competition and market failure. Government investment is an important external innovation resource for enterprises, and obtaining external resources is an effective way for enterprises to obtain resources [22,23]. Therefore, enterprises can acquire diversified resources and make up for the lack of their own resources. The literature has shown that government financial support for innovation can help enterprises allocate more resources to R&D activities, increase R&D investment, and then improve their innovation capabilities [16]. Changes in the structure of R&D personnel will inevitably influence the knowledge creation and integration capabilities of enterprises, thereby promoting enterprise innovation [24].

2.2. Impacts of R&D Personnel Backgrounds on Enterprise Innovation Capability

In this study, we discuss the impacts of R&D personnel backgrounds on enterprise innovation capability from three perspectives—gender, education background, and division structure of labor of R&D personnel based on the upper echelon theory.

2.2.1. The Impact of Gender

The factor of gender is an important and emerging topic in innovation research, and the salient demographical attribute in R&D personnel (González-Moreno et al., 2018) [25]. Gender differences contribute to innovation and can help managers achieve their goals more effectively [25,26], but excessive heterogeneity may be detrimental to the activities of the R&D team [27]. In the high-tech or manufacturing industry, the proportion of female employees is relatively small, and there is a phenomenon of serious occupational gender segregation. The results of existing studies of gender diversity and enterprise innovation are not consistent regarding the positive and negative effects, and so on. This study specifically explores this relationship.

2.2.2. The Impact of Highly Educated R&D Personnel

Education is one important feature that enterprises sustain competition and innovation [28] and has a significant positive influence on the technological innovation of an enterprise [29]. The human capital theory holds that the most fundamental approach to improving human capital is education. Individuals with a higher education level can produce higher labor productivity, resulting in more profitability because human capital stock determines its unique value. Highly educated R&D personnel play a significant role in promoting enterprises' technological breakthroughs and innovations [2,30,31]. Innovation is considered the most knowledge-intensive process of enterprises. According to knowledge-based views, enterprises' capability to innovate is reliant on the educational level of staff [32].

2.2.3. The Impact of Researchers' Division Structure of Labor

According to the definition of OECD, R&D personnel fall into three types—researchers, technical and equivalent staff, and service support staff. The more R&D personnel, the higher the rate of technological progress [33]. An increase in skillful labor is conducive to technological innovation [34]. This study focuses on investigating researchers. Professional researchers not only have professional backgrounds but also have strong learning and research ability. R&D personnel are considered key resources for creating and sustaining enterprises' competitive advantage, as well as promoting innovation performance [33]. Shen concluded that factors such as the quality and quantity of enterprise researchers were the key determinants of successful enterprise innovation activities and an important source to maintain the core competitiveness of enterprises [35]. R&D researchers' division structure of labor is a very important resource for improving enterprise innovation capability. Therefore, researchers with heterogeneous characteristics are not only the core and dominant resources of enterprises but also the key to improving enterprise innovation capability.

2.3. Impacts of Government Support on Enterprise Innovation Capability

Both Keynes' economic theory and the technological innovation theory hold that the government plays a role in the innovation process of enterprises. Thus, it is essential for the government to strongly support enterprise innovation, which is one of the key factors for improving enterprise innovation performance [36]. The intensity of government support refers to the ratio of government subsidies received by an enterprise to its R&D expenditure, which reflects the degree of government support for the enterprise's technological innovation activities [37,38]. Scholars in China and other countries have not reached a consensus on this issue. However, there is still a "black box" problem regarding the impact of the intensity of government support on enterprise innovation. Some scholars believe that the intensity of government support can positively promote the innovation performance of enterprises [9], whereas others believe that the intensity of government support may negatively inhibit the innovation performance of enterprises [39]; other scholars also hold that the intensity of government support may have no significant impact on the innovation performance of enterprises [40,41] and may even have a significant inverted U-shaped effect [42]. The high-level innovation capability of enterprises refers to the high annual patent applications of enterprises.

Prior to the analysis, the theoretical model constructed in this study is depicted in Figure 1.

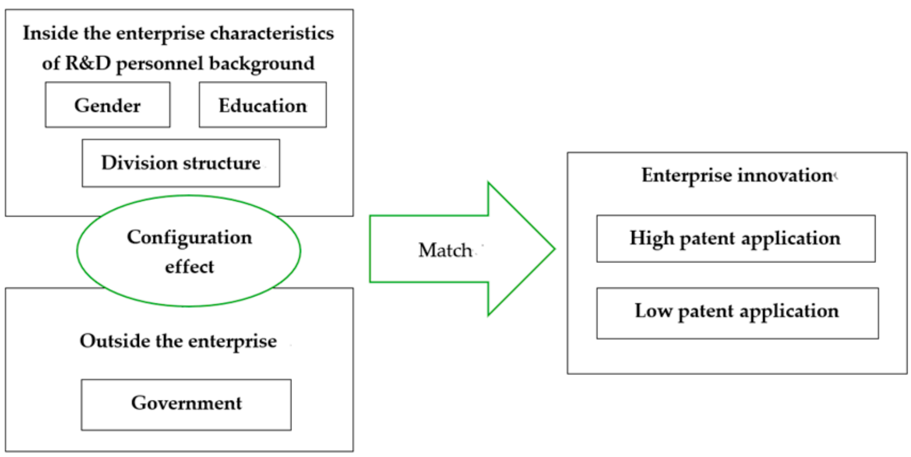

Figure 1. Theory model.

3. Methodology

QCA is a case-oriented methodology that combines case-based research with Boolean algebra and set theory, allowing systematic and formalized cross-case comparisons [43,44]. QCA integrates the advantages of qualitative and quantitative analyses, making studies in sociology, management, and other fields transform from linear analysis into an era of "set" analysis [44]. This study constructs a comparative analysis (QCA) of the innovation capabilities of enterprises in five time windows over six years with the longitudinal database of China's industrial enterprises whose operating income exceeds RMB 20 million from 2010 to 2015. These enterprises include many manufacturing for the environment that promote economic development while taking into account the protection and improvement of environmental quality. The sample size of every time window is 30, which does not meet the requirement of a 'large sample' in traditional quantitative research, so it is difficult to obtain ideal results. Thus, QCA is very suitable for solving the problems in this study.

Firstly, this study constructs a theoretical model (see Figure 1) based on the resource-based view and literature review. Secondly, fs-QCA was used to carry out configuration analysis from which it is believed that the collection of factors rather than the single factor itself plays a role in the results based on a holistic and systematic approach [45]. This method can not only accurately identify the sufficiency and necessity of the condition variables, but can also identify the primary and secondary relationships of different condition variables. In addition, the academic research applying the QCA analysis method usually uses cross-sectional data, while this study uses sequence data from 2010 to 2015 for model analysis. Through the core condition identification of sequence data, the trend of various configurations of this topic can be concluded.

In this study, a one-year lag analysis is conducted on enterprise innovation capability to investigate whether the investment in internal and external factors of industrial enterprises in the current period is related to the innovation capability of enterprises in the next period [46]. The one-year time lag aims to illustrate that it may take some time to give full play to the configuration effect [47]. As this study does not focus on changes in enterprise innovation capability, the value of using QCA on a longitudinal database is not to detect changes but to identify whether high- or low-performance configurations can stabilize over time, regardless of the continuous changes in the environment.

4. Configuration Analysis

4.1. Data Collection

The sample data in this study are selected from the longitudinal database of industrial enterprises above the designated size in 30 provinces, autonomous regions, and municipalities directly under the Central Government from 2010 to 2015. Based on the comprehensiveness and availability of data, the data on Tibet, Hong Kong, Macao, and Taiwan are not included in the statistics of this study. All data are from the *China Statistical Yearbook on Science and Technology*, *China Statistical Yearbook on Industry*, and *China Statistical Yearbook*.

4.2. Variable Measurement

1. Regarding gender (rf), we use the ratio of female R&D personnel in industrial enterprises above the designated size to R&D personnel (full-time equivalent) in the region.
2. Regarding higher educational level (rdm), we use the ratio of R&D personnel (full-time equivalent) with a master's degree and PhD degree in industrial enterprises above the designated size to R&D personnel (full-time equivalent) in the region [48].
3. Regarding the division structure of labor (rnr), we use the ratio of R&D personnel to full-time staff as a measurement indicator [49].
4. Regarding government investment (rdg), we use the ratio of government subsidies received by enterprises to the R&D expenditures of enterprises [50,51].
5. Regarding enterprise innovation capability (lnpa), we use the total patent applications of enterprises as a measurement indicator. Compared with other measurement indicators, the number of annual patent applications is more widely applied and

operational [7]. The specific calculation method is to take the logarithm after adding 1 to the number of patent applications [52]. The high-level innovation capability of enterprises refers to the high annual patent applications of enterprises. The low-level innovation ability of enterprises is just the opposite.

4.3. Analysis

4.3.1. Variable Calibration and Descriptive Statistics

Table 1 lists the calibration thresholds and descriptive statistical results in each of the five (one-year lag) time windows for the main variables of the model, including the mean, standard deviation, minimum, and maximum. As both the background characteristics of R&D personnel (rf, rdm, and rnr) and government investment (rdg) are continuous variables, this study uses the calibration function Calibrate (x, n1, n2, n3) in the fsQCA3.0 software to convert the original data into membership values within the range of (0,1). The three anchor points for four conditional variables and enterprise innovation capability are set to 75%, 50%, and 25% quantiles of the sample data as the thresholds for complete membership, intersection, and complete non-membership, respectively. To avoid theoretical difficulties arising from membership scores of 0.5, we added a constant of 0.001 to causal conditions under one [45,53].

Table 1. Fuzzy-set membership calibrations and sample descriptives.

Year	Variables	Fuzzy Set Calibrations			Mean	S.D.	Min	Max
		Fully In	Crossover	Fully Out				
2010–2011	lnpa	9.476	8.661	7.455	0.505	0.422	5.130	11.195
	rf	0.250	0.222	0.196	0.466	0.396	0.160	0.297
	rdm	0.126	0.102	0.078	0.492	0.395	0.055	0.233
	rnr	0.536	0.437	0.379	0.490	0.372	0.252	0.640
	rdg	0.081	0.046	0.027	0.502	0.399	0.018	0.161
2011–2012	lnpa	9.913	8.967	7.694	0.497	0.410	5.375	11.375
	rf	0.240	0.211	0.191	0.530	0.398	0.170	0.295
	rdm	0.140	0.113	0.100	0.496	0.415	0.067	0.248
	rnr	0.519	0.389	0.345	0.520	0.381	0.246	0.645
	rdg	0.078	0.038	0.026	0.499	0.373	0.018	0.164
2012–2013	lnpa	9.863	9.124	7.832	0.525	0.416	5.814	11.479
	rf	0.248	0.216	0.186	0.492	0.384	0.167	0.287
	rdm	0.150	0.116	0.102	0.481	0.413	0.066	0.232
	rnr	0.466	0.38	0.323	0.511	0.380	0.200	0.609
	rdg	0.072	0.039	0.029	0.481	0.403	0.019	0.189
2013–2014	lnpa	10.002	9.203	7.847	0.523	0.410	5.953	11.658
	rf	0.249	0.210	0.186	0.518	0.390	0.173	0.320
	rdm	0.162	0.124	0.103	0.479	0.394	0.067	0.271
	rnr	0.484	0.372	0.304	0.483	0.376	0.190	0.587
	rdg	0.073	0.043	0.029	0.495	0.397	0.019	0.203
2014–2015	lnpa	9.995	9.126	7.858	0.534	0.416	5.724	11.695
	rf	0.233	0.202	0.185	0.507	0.388	0.137	0.271
	rdm	0.166	0.124	0.112	0.525	0.402	0.068	0.332
	rnr	0.424	0.356	0.293	0.487	0.402	0.169	0.570
	rdg	0.072	0.040	0.025	0.523	0.400	0.017	0.197

4.3.2. Necessity Analysis

Table 2 lists the test results of the necessary conditions for enterprise innovation capability for each of the five (one-year lag) time windows. In this study, the consistency threshold is set to 0.8; the proportional reduction in inconsistency (PRI) is set to 0.70; and the frequency threshold is set to 1 [45]. The configuration analysis indicates that when the consistency level of a conditional variable is greater than 0.9, the conditional variable is considered a necessary condition for the outcome variable. In other words, when the outcome variable occurs, the conditional variable will inevitably occur. As presented in Table 2, the maximum value for the consistency level of the conditional variables (including non-sets) of all time windows is 0.794, which is less than 0.9. This indicates that none of the conditions alone can constitute the necessary conditions for enterprise innovation capability. Therefore, it is necessary to explore their impacts on outcome variables with a combination of conditional variables.

Table 2. Necessity test for the number of patent applications.

Year	Variable	High Patent Application		Low Patent Application	
		Consistency	Coverage	Consistency	Coverage
2010–2011	Rf	0.487	0.528	0.521	0.553
	~rf	0.587	0.556	0.555	0.515
	Rdm	0.636	0.652	0.451	0.454
	~rdm	0.467	0.465	0.654	0.638
	Rnr	0.389	0.401	0.704	0.711
	~rnr	0.719	0.712	0.407	0.395
	rdg	0.417	0.419	0.673	0.664
	~rdg	0.665	0.675	0.411	0.409
2011–2012	rf	0.556	0.522	0.586	0.556
	~rf	0.527	0.557	0.496	0.530
	rdm	0.559	0.561	0.535	0.543
	~rdm	0.544	0.537	0.567	0.565
	rnr	0.379	0.362	0.777	0.751
	~rnr	0.739	0.767	0.340	0.356
	rdg	0.489	0.487	0.615	0.619
	~rdg	0.617	0.613	0.490	0.492
2012–2013	rf	0.483	0.516	0.610	0.589
	~rf	0.615	0.636	0.498	0.465
	rdm	0.565	0.617	0.473	0.467
	~rdm	0.512	0.518	0.612	0.560
	rnr	0.359	0.369	0.788	0.732
	~rnr	0.739	0.794	0.321	0.312
	rdg	0.487	0.532	0.574	0.566
	~rdg	0.603	0.610	0.525	0.480
2013–2014	rf	0.519	0.525	0.648	0.597
	~rf	0.601	0.652	0.484	0.479
	rdm	0.537	0.586	0.523	0.520
	~rdm	0.560	0.563	0.584	0.535
	rnr	0.376	0.407	0.739	0.730
	~rnr	0.751	0.760	0.400	0.369
	rdg	0.473	0.500	0.625	0.602
	~rdg	0.623	0.646	0.481	0.454
2014–2015	rf	0.459	0.483	0.676	0.621
	~rf	0.640	0.694	0.437	0.413
	rdm	0.537	0.546	0.619	0.549
	~rdm	0.556	0.626	0.489	0.480
	rnr	0.397	0.435	0.707	0.677
	~rnr	0.705	0.734	0.410	0.372
	rdg	0.472	0.482	0.677	0.604
	~rdg	0.612	0.685	0.418	0.409

Note: "~" indicates the negation of a condition.

4.4. Configuration Results

Tables 3 and 4 illustrate the analysis results using fsQCA3.0 software. The configuration analysis is associated with high and low levels of enterprise innovation capability in each of the five (one-year lag) time windows.

Table 3. Configurations generating high-level enterprise innovation capability.

Condition	Configuration 2010–2011			Configuration 2011–2012		Configuration 2012–2013		Configuration 2013–2014		Configuration 2014–2015	
	A	B	C	D	E	C	E	F	G	F	H
RF	●		•		⊗	•	⊗		⊗		⊗
RDM		●	●	⊗		●			●		●
RNR	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	•	⊗	●
RDG	⊗	⊗		⊗	⊗		⊗	⊗	●	⊗	●
Consistency	0.857	0.962	0.964	0.872	0.811	0.901	0.95	0.890	0.830	0.935	0.922
Raw coverage	0.238	0.302	0.228	0.353	0.300	0.376	0.241	0.542	0.193	0.502	0.185
Unique Coverage	0.095	0.159	0.085	0.159	0.106	0.273	0.139	0.454	0.105	0.421	0.104
solution Consistency	0.914			0.850		0.907		0.868		0.927	
solution Coverage	0.482			0.458		0.515		0.647		0.606	

Note: Black circles (●) indicate the presence of a condition, and circles with "X" (⊗) indicate its absence. Large circle; core condition. Small circle; peripheral condition. Blank space; "don't care" condition.

Table 4. Configurations generating low-level corporate innovation capability.

Condition	Configuration 2010–2011	Configuration 2011–2012			Configuration 2012–2013			Configuration 2013–2014			Configuration 2014–2015
	I	J	K	L	K	L	M	K	L	M	N
RF		⊗	●	●	●	●	⊗	●	●	⊗	●
RDM	⊗	⊗	⊗	●	⊗	●		⊗	●		⊗
RNR		●		●		●	●		●	●	●
RDG	●		●	⊗	●	⊗	●	●	⊗	●	●
Consistency	0.810	0.836	0.838	0.889	0.846	0.857	0.862	0.936	0.883	0.900	0.805
Raw coverage	0.523	0.328	0.222	0.222	0.197	0.223	0.333	0.245	0.215	0.315	0.192
Unique Coverage	0.523	0.223	0.114	0.162	0.040	0.176	0.176	0.070	0.143	0.140	0.192
solution Consistency	0.810	0.847			0.852			0.886			0.805
solution Coverage	0.523	0.615			0.549			0.528			0.192

Note: The notation is the same as in Table 3.

4.4.1. High-Level Enterprise Innovation Capability

Table 3 indicates that eight different configurations of high-level enterprise innovation capability are identified in the study of the five time windows over six years, some of which occurred more frequently within the six years. Three configurations (Configurations A, B, and C) were produced in 2010–2011. The overall solution consistency and coverage were, respectively, 0.914 and 0.482. Two configurations (Configurations D and E) were produced in 2011–2012. The overall solution consistency and coverage were, respectively, 0.850 and 0.458. Two configurations (Configurations C and E) were produced in 2012–2013. The overall solution consistency and coverage were, respectively, 0.907 and 0.515. Two configurations (Configurations F and G) were produced in 2013–2014. The overall solution consistency and coverage were, respectively, 0.868 and 0.647. Two configurations (Configurations F and H) were produced in 2014–2015. The overall solution consistency and coverage were, respectively, 0.927 and 0.606. The overall solution consistency and coverage in every time window indicate that these configurations are reliable. In particular, the coverage of solutions gradually increased from 2010 to 2015.

Particularly, Configurations C, E, and F occurred twice in the analyzed years. Table 3 presents the trend for the combination mode of the conditional variables of high-level enterprise innovation capability. Over time, industrial enterprises above the designated size in various regions gradually transform from low-level R&D personnel allocation and low-level government investment (Configuration A, B, C, D, E, and F) to the combination mode of increasing the degree and proportion of R&D personnel and researchers, as well as striving for high government investment (Configurations G and H). Five configurations (A, B, D, E, and F) are the logical non-sets of the researchers' division structure of labor and government investment. Obviously, R&D personnel and high government investment were absent as a core condition in the years analyzed, which are the main antecedent variables hindering the further improvement of enterprise innovation capability.

The ways of realizing high-level enterprise innovation capability can be divided as follows:

(1) Female and highly educated R&D personnel type. Configurations A, B and C indicate that the more females in the R&D personnel and the more highly educated R&D personnel, the stronger the innovation capability of the enterprises. Gender proves to be a factor that benefits innovation in enterprises [27], and females have the added advantage of improving diversification and innovation in the management practices of enterprises [54]. The higher the education level of the R&D personnel, the stronger their cognitive ability and learning ability, thereby further improving the technological innovation level of enterprises [55]. In this type of configuration, highly educated R&D personnel is a core factor, and female R&D staff is a peripheral factor. The combination of two kinds of resources can result in a high level of innovation capability.

(2) Highly educated R&D personnel and high government investment type. Configurations G and H indicate that enterprises with more highly educated R&D personnel and higher government investment have higher innovation ability. Both are core condition variables. Government subsidies are conducive to promoting enterprises' innovative output [39,56]. The heterogeneity in knowledge inputs is crucial to innovation [30], and the high education level of R&D personnel is an important and crucial resource for the innovation of an enterprise. Though R&D researchers' division structure of labor is a very important resource for improving enterprise innovation capability, it is a peripheral factor in Configuration G and a core factor in Configuration H. In this type of configuration, the cooperation between two kinds of main resources (R&D personnel higher education and higher government investment) and peripheral resources (researchers' division structure of labor) can lead to a high level of innovation capability.

4.4.2. Low-Level Enterprise Innovation Capability

According to Table 4, six different configurations of low-level enterprise innovation capability were identified in the six-year study, some of which occurred more frequently over the six years. In the analyzed years, Configurations K and L occurred three times, whereas Configuration M occurred twice. Only one configuration (Configuration I) was produced in 2010–2011. The overall solution consistency and coverage were, respectively, 0.810 and 0.523. Three configurations (Configurations J, K and L) were produced in 2011–2012. The overall solution consistency and coverage were, respectively, 0.847 and 0.615. Three configurations (Configurations K, L and M) were produced in 2012–2013. The overall solution consistency and coverage were, respectively, 0.852 and 0.549. In 2013–2014, Three configurations (Configurations K, L and M) were produced. The overall solution consistency and coverage were, respectively, 0.886 and 0.528. Just one configuration (Configuration N) was produced in 2014–2015. The overall solution consistency and coverage were, respectively, 0.805 and 0.192. In the configuration analysis from 2010 to 2014, the consistency of the overall result was greater than 0.8, and the coverage of the overall result was greater than 0.5. This indicates that the changes in Configurations K, L, and M can well explain the trend of the combination mode of conditional variables for low-level enterprise innovation capability.

First, Configuration K indicates that enterprises with more female R&D personnel and more government investment but less highly educated R&D personnel will have lower innovation ability. Configuration L demonstrates that enterprises with more female R&D personnel, more highly educated R&D personnel, and a higher proportion of R&D personnel but less government investment will have a lower innovation ability. Configuration M shows that enterprises with more R&D personnel and higher government R&D investment but a low proportion of female R&D personnel also have a low innovation ability. Second, highly educated R&D personnel were the least frequent (Configurations I, J, K, and N), which is the main antecedent for the low-level enterprise innovation capability. The common feature of the four configurations is that the enterprises lack R&D personnel with high education qualifications. Finally, unlike what is presented in Table 3, in these six configurations, government investment and R&D personnel exist as core conditions (Configurations M and N); however, enterprises have a low level of innovation capability. On the one hand, enterprises will reduce their investment in innovation after receiving more subsidies from the government, which reduces their innovation ability to some extent [42]. On the other hand, females have a different influence on the innovation of enterprise [57].

5. Discussion

This paper uses the fs-QCA method and aims to solve the question of how the four internal and external factors interact with each other to influence the innovation capability of the enterprise. According to the research results, this study finds the trend and ways of changing conditional variables in the configuration to improve the innovation ability of enterprises.

Firstly, highly educated R&D personnel, as a crucial and important resource, is a core factor in improving the innovation capability of enterprises according to Table 3. In Table 4, only the core factor of Configuration L is highly educated R&D personnel; the other five configurations (Configurations I, J, K, M, and N) are default. Innovation (for example, new product development) is considered the most knowledge-intensive process of enterprises [30]. The knowledge-based view of the firm emphasizes the importance of the absorptive ability of knowledge interplay, and believes that the core competitiveness of the enterprise stems from tacit knowledge [58]. The scholar finds that the innovation capability of enterprises depends on the staff's educational level, connecting knowledge capabilities and innovation [29,59]. The resource-based view of the firm highlights human capital as a crucial resource to firm performance [60,61], and says that human capital with a higher level of education has a better capability to create a pathway to the evolution of new knowledge, further increasing the enterprise's innovation [32].

Secondly, compared to the eight configurations in Table 3 and the six configurations in Table 4, if an enterprise is overly reliant on government investment (see Table 4), it is difficult for them to improve their innovation capability, for example, Configurations I and K. However, once this factor is the default, the innovation capability of the enterprise is bound to be low, such as in Configuration L. Eight configurations of Table 3 prove that high government investment was absent as a core condition in the years analyzed; it is the main antecedent variable hindering the further improvement of enterprise innovation capability. Government investment is an important external innovation resource for enterprises to innovate continuously based on the resource-based view [22,23]. Government support is beneficial to increasing the knowledge stock of enterprises and improving their own technological capabilities [16]; it can help enterprises allocate more resources to R&D activities, increase the R&D investment of enterprises, and then improve their innovation capabilities [20]. Government financial support can positively promote or inhibit the innovation performance of enterprises, and sometimes even has no effect on the innovation performance of enterprises. How to make good use of government investment is crucial for enterprises to enhance their innovation ability.

Thirdly, according to Tables 3 and 4, the proportion of female R&D personnel gradually becomes a marginal condition in each time window. This factor is viewed as a core conditional variable in three configurations (Configurations A, K, and L). As far as the enterprise is concerned, the factor has different impacts on corporate R&D investment in females and males because innovation is a high-risk activity [62]. Gender can negatively or positively affect the probability of innovating [54,63], and there is even an inverted U-shape relationship between R&D personnel gender diversity and enterprise innovation. As the most salient demographical attribute of R&D personnel [25], the factor of gender implies increasing knowledge and a higher probability of new ideas, which benefits innovation in enterprises. Moreover, the gender of R&D personnel has received little attention compared to gender diversity in top management teams [33].

Finally, the structure of R&D personnel can be considered a core factor in Configuration H and a peripheral factor in Configuration G. It is absent as a core factor of innovation in six other configurations in Table 3. This factor is considered a core condition variable in Configurations J, L, M, and N in Table 4, but it is an antecedent variable hindering the further improvement of enterprise innovation capability. The structure of R&D personnel is an important source to maintain the core competitiveness of enterprises based on a resource-based view [35], and it will inevitably influence the knowledge creation and integration capabilities of enterprises, thereby promoting enterprise innovation [24]. Although the quantity of R&D personnel is important for successful enterprise innovation activities, it does not play a decisive role. It is necessary to determine the structure of R&D personnel according to the scale of the enterprise, industry prospects and product characteristics.

In fact, factors influencing the innovation capability of the enterprise do not appear alone or in all, but in the form of logical combination. Therefore, according to the above analysis, the fs-QCA method is used to analyze the configuration of the influencing factors, find out the matching rules of the influencing factors that improve the innovation capability of enterprises, and identify core and peripheral factors among antecedent variables. This paper summarizes two ways of realizing high-level enterprise innovation capability: female and highly educated R&D personnel type, and highly educated R&D personnel and high government investment type. The enterprise innovation capability is affected simultaneously by multiple conditional variables, and the impact of each conditional variable on enterprise innovation capability has a trend. However, the role of gender and the structure of R&D personnel has not been effective. Government investment inhibits the innovation ability of enterprises. Undoubtedly, the impact of each conditional variable on high- or low-level enterprise innovation capability is asymmetric. It is necessary and important for enterprises to have a moderate R&D personnel scale, not rely too much on government investment, and further enhance their innovation ability.

6. Conclusions and Implications

6.1. Conclusions

From the perspective of configuration, this study uses the fs-QCA analysis method to conduct a comparative analysis of the internal and external factors affecting enterprise innovation capability in five time windows in six years with the longitudinal database of China's industrial enterprises above the designated size from 2010 to 2015 and finds several configuration modes, finding high- and low-level enterprise innovation capability and their configuration development trends as well as their main influencing factors. This paper summarizes two ways of realizing high-level enterprise innovation capability and analyzes every antecedent variable compared to high- or low-level enterprise innovation. Despite the limitations, this study is still meaningful and provides a theoretical basis and practical case for future research.

In addition, the configuration analysis of enterprise innovation ability and the relationship between enterprise sustainable development are as follows: On the one hand, the configuration (Configurations C, H, etc.) of high enterprise innovation ability can promote enterprises to continuously enhance their investment in conditional variables so as to make it easier for enterprises to achieve sustainable, long-term and stable development. On the other hand, enterprises can also conduct QCA configuration analysis based on more time series data so as to obtain the path of how to improve the innovation ability of enterprises and further promote the sustainable and stable development and improvement of enterprises.

6.2. Contributions of This Study

This study makes the following main contributions to the literature. First, this study reveals the configuration mechanism for enterprise innovation capability. Although previous studies on enterprise innovation capability are relatively abundant, they were all conducted with case analysis or measurement methods; only a few were carried out from the perspective of configuration. Second, relatively, there is a lack of research that focuses on the impact of R&D personnel on enterprise innovation capability. Innovation is the primary driving force for enterprise development. Therefore, it is necessary to study enterprise innovation capability by combining the internal and external factors of the enterprise—the background characteristics of R&D personnel and the degree of government support. Third, this study divides the six-year longitudinal database into five time windows to conduct a comparative analysis of the conditional variables of enterprise innovation capability rather than just using one-year cross-sectional data. Through the analysis of the configurations of high- and low-level enterprise innovation capability in five time windows, targeted consultative opinions and suggestions for improving both high- and low-level enterprise innovation capability at different stages are obtained.

6.3. Implications for Management

Based on the above research and analysis, this study also has certain implications for management practices in the process of improving enterprise innovation capability. First of all, in terms of the background characteristics of R&D personnel in enterprises, introducing, cultivating, and improving the division of labor structure of researchers is crucial for enterprises with high-level innovation capabilities. Researchers with heterogeneous characteristics, such as scarcity, creativity, and dominance, are the core and dominant resources of enterprises and the key to improving enterprise innovation capability. The more R&D personnel, the faster the rate of technological progress and the higher the patent output efficiency. For enterprises with low-level innovation capability, the most important thing is to introduce, train, and improve the educational level of R&D personnel. Highly educated personnel not only have stronger technology absorption capacity but also play a significant role in promoting technological breakthroughs and innovations in enterprises. Second, the results of the analysis show that government investment is an external factor that hinders high-level innovative enterprises from further enhancing their innovation capabilities. This does not mean that this factor is not important to enterprises with low-level innovation capability, but the government should maintain support for these enterprises. Therefore, the government had better formulate corresponding R&D investment policies to enhance the innovation capabilities of enterprises and promote their long-term development in the future.

6.4. Limitations and Prospects

This study has the following limitations. First, based on the resource-based theory and upper echelon theory, this study analyzes four conditional variables, including three background characteristics of R&D personnel in enterprises and an external factor, without covering all antecedent variables. Therefore, the generality of the conclusions needs to be further improved, and more antecedent variables can be added and expanded in future research. Second, this study only focuses on industrial enterprises above the designated size in China, without analyzing and investigating other types of enterprises, so the investigation scope of samples can be expanded in future research. Third, although based on the resource-based theory, resource dependence theory, and upper echelon theory, this study analyzes enterprise innovation capability from the configuration perspective, and it cannot perfectly reveal the essence of enterprise innovation capability. Therefore, it is necessary to develop and deepen the theories of enterprise innovation capability in the future.

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