Research on the Configuration of High-tech Industry Innovation Performance under Digital Economy

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Abstract. Digital economy plays an important role for high technology industry innovation, in order to explore the digital economy under the high technology industry innovation performance before the condition of dynamic linkage mechanism, this paper is based on the 2013-2021 panel data, measure the digital economy development level in 31 provinces, with the help of dynamic fsQCA method, system to explore the digital economy, research and development investment, investment in talent input, market competition, government support and industrial structure optimization six elements of high technology industry innovation performance "synergy" and "interaction". The study found that the lack of r&d investment, talent investment and market competition are the necessary conditions leading to low innovation performance. Three paths driving high innovation performance have been identified: the eastern region is mainly "digital economy driven" and "innovation resource driven", while the central and eastern regions are mainly "industrial structure driven". The transformation of the development level of digital economy can promote the dynamic evolution of the innovation performance improvement path of high-tech industries. The combination of high R&D investment, high talent investment and high market competition is the "leading track", which plays an important role in driving the innovation performance of high-tech industries.

Keywords: Digital economy, High-tech industry innovation performance, Dynamic fuzzy set qualitative comparative analysis, Coordination mechanism

1 Introduction

In recent years, the scale of China's high-tech industry has continued to expand, with a good momentum of growth, and its innovation and development capacity has also been continuously enhanced. High-tech industries, represented by digital technology and electronic communication, provide a strong guarantee for enhancing the competitiveness of China's cutting-edge technologies and promoting the solution of the "bottleneck" problem. At present, China's economy has shifted from the stage of high-speed growth to the stage of high-quality development. Therefore, it is necessary to further explore the multiple causal relationships and multiple improvement paths of China's high-tech industry innovation capacity, so as to realize the efficient allocation of regional high-tech industry innovation resources and the overall improvement of China's innovation capacity. As the future development direction of the global economy, digital economy has become an important driving force for the development of regional innovation capacity in China [1]. With the continuous integration of digital economy and high-tech industries, the combination of the new generation of information technology with

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various industries to form digital productivity and digital economy, which is an important direction for the development of the modern economic system [2]. At present, the research of digital economy and high-tech industry is gradually emerging, but most of the research methods still use traditional regression analysis methods to study the net effect of single variables on the results, which fails to explain the influence of the interdependent interaction between the input elements of innovation performance in high-tech industry. This paper uses the panel data of 31 provinces in China from 2013 to 2021, on the basis of measuring the development level of provincial digital economy in China, based on the synergy theory [3], introduces fsQCA method to conduct the configuration analysis of the leading factors affecting the innovation performance of high-tech industries, and explores the collaborative mechanism of the innovation performance of various elements under the digital economy from the perspective of configuration. Based on the dynamic configuration theory, the time dimension is included in the configuration research, which responds to the scholars' call for including the dynamic thought in the configuration analysis. It not only reveals the dynamic evolution law of the path of driving innovation performance improvement, but also finds the "leading track" in the driving process, which can provide a reference for the timely adjustment of innovation policies in different regions.

2 Research method

2.1research design

The dynamic fsQCA method was used to explore the digital economy, r & d investment, talent investment, government support, market competition and industrial structure optimization six causal complex mechanism of high technology industry innovation performance, with 31 provinces and cities in China from 2013 to 2021 (not included in statistics due to missing data in 2017). The specific data sources are shown in Table 1. Referring to the existing literature, the lag period of innovation performance of high-tech industry is set to one year [4], and each case is characterized by the average data of three years, which can avoid the impact of [5] caused by random disturbance. Considering the influence of the time dimension, the independent variable study period was divided into two periods: 2013-2015 and 2019-2021, with the time span set to 3 years.

Table 1. Measurement variables and data sources

type	Measure selection	Measure variable	source
Result variable	High-tech industry innovation performance	Number of invention patent applications	China High-tech Industry Statistical Yearbook
Antecedent condition	Digital economy	Digital economy development index	China Statistical Yearbook Digital Financial Inclusion Index
	Talent input	R&D personnel equivalent full time equivalent	China High-tech Industry Statistical Yearbook
	R&d investment	R&D funds for internal expenditure	
	Market competition	The number of enterprises	

	Government support	Financial investment in science and technology	China Statistical Yearbook
	Industrial structure optimization	The proportion of secondary industry in GDP	

2.2 Measurements and calibration

This paper borrows the research method of Gu Youjin [6] et al. to measure the innovation performance of high-tech industry by the number of invention patent applications. Drawing on the measures of digital economy such as Du Jinzhu [7], Internet development and digital finance are selected as the first-level evaluation index, and the comprehensive index of digital economy development is measured through principal component analysis. Using the fsQCA method, the six antecedent conditions and one outcome variable were considered as a set, indicating the membership of each case in these sets. Data were converted to fuzzy membership scores by using the direct calibration method. Referring to the existing studies, the three calibration points of complete affiliation, intersection and complete nonaffiliation of the outcome variable and conditional variable were set as the standards of 90%, 50% and 10% of the sample data to calibrate the five previous conditions. And the same calibration method was adopted in the two periods [8].

3. empirical analysis

3.1 Essential conditions analysis

The necessity analysis of individual conditions was necessary to verify whether the individual condition variable constitutes the outcome variable [9]. In this paper, the necessity of a single condition is tested using fsQCA3.0 software, and we know that the low R&D investment, low talent investment and low market competition in the two stages are the necessary conditions for the low innovation performance of high-tech industries (consistency> 0.9), which means that these three variables will have a global impact on the outcome variables.

3.2 Sufficiency analysis

Table 2. Configuration analysis

Antecedent condition	High innovation performance configuration			Low innovation performance configuration	
	1	2	3	4	5
Digital economy	●		⊗	⊗	
Talent input	●	●	●	⊗	⊗
R&d investment	●	●	●	⊗	⊗
Government support			●		⊗

Market competition	●	●	⊗	⊗	⊗
Industrial structure		●	⊗		⊗
consistency	0.998	1	0.996	0.990	0.991
Original coverage	0.809	0.657	0.177	0.865	0.623
Unique coverage	0.188	0.039	0.011	0.231	0.036
Overall consistency	0.990			0.986	
Total coverage	0.888			0.929	

(Solid circles indicate existing conditions, hollow circles indicate no conditions; large circles represent core conditions, small circles represent edge conditions; blank space exists and does not affect the path)

In this paper, the consistency threshold is set to 0.85 to ensure the truth table of 0 and 1 in the results, and the PRI consistency threshold is set to 0.80, aiming to reduce the contradictory configuration of simultaneous subset relationships. In the qualitative comparative analysis, the researcher should analyze the results based on the consistency and coverage of [10]. Through fsQCA3.0 software operation, complex solution, intermediate solution and parsimony solution are different results. Referring to existing studies, the final configuration results are comprehensively interpreted by intermediate and parsimonious solutions. In this paper, the second period 2019-2021 is taken as the analysis object of the configuration, and the data from the first period 2013-2015 are used as the control group for the subsequent dynamic configuration analysis. As shown in Table 2, from the perspective of configuration, the consistency and total consistency of a single configuration solution are far above the threshold of 0.8, indicating that the five configurations in Table 2 meet the adequacy requirements. There were three groups of high innovation performance configurations with an overall coverage of 0.80, indicating that these three configurations explain about 80% of the high innovation performance. In this paper, three paths to improve innovation performance in high regions are obtained, and the coverage of the three paths is 0.80,0.65 and 0.17 respectively. The numerical difference is large, indicating that these three paths have a great difference on the efficiency of high innovation performance in driving high-tech industries.

Configuration 1 points out that high talent investment, high R&D investment and high market competition are the core conditions, and non-high digital economy as the marginal condition can produce high innovation performance. The typical case of this configuration is in Guangdong Province. The development of manufacturing industry in Guangdong is accelerating, and the growth of emerging industries is growing rapidly. Relying on the good basic innovation resources, the development of high-tech industry is more mature. Configuration 2 points out that high talent investment, high R&D investment and high market competition are the core conditions, and non-high industrial structure optimization as the marginal condition can produce high innovation performance. The typical case in this configuration is in Jiangsu Province. Since the 18th CPC National Congress, Jiangsu has contributed more than 10% to the national economic growth, showing strong resilience and

continuously improving the economic benefits of its enterprises. Jiangsu province not only has a solid foundation, but also maintains a high growth rate. The proportion of secondary industries has increased significantly, among which advanced manufacturing has a good growth momentum, and the industry is constantly moving towards the middle and high-end. Configuration 3 points out that high talent investment and high R&D investment are the core conditions, and non-high government support as the marginal condition can produce high innovation performance. The typical case of this configuration is in Tianjin Municipality. Tianjin new industry development momentum is good, as a manufacturing comprehensive strength of city, also as one of the world-class Beijing-Tianjin-Hebei city in China, Tianjin from manufacturing city to build a new development pattern, adhere to the manufacturing city, to promote the development of high quality as the theme, to deepen the reform of the supply side structural as the main line, with intelligent manufacturing as the main direction, unswervingly take the road of innovation drive.

3.3 Dynamic configuration analysis

Table 3. Comparative analysis of two phases

Antecedent condition	First period			Second period		
	1	2	3	4	5	
Digital economy		●		●		⊗
Talent input	●	●	●	●	●	●
R&d investment	●	●	●	●	●	●
Government support		⊗	●			●
Market competition	●		●	●	●	⊗
Industrial structure		●	●		●	⊗
consistency	0.983	0.949	0.993	0.998	1	0.996
Original coverage	0.847	0.363	0.533	0.809	0.657	0.177
Unique coverage	0.273	0.004	0.009	0.188	0.039	0.011
Overall consistency	0.946			0.990		
Total coverage	0.876			0.888		

In this study, the configurations of the two periods are compared to explore the dynamic evolution law of the innovation performance improvement path in different periods. As shown in Table 3, in the configuration of the two periods, the R & D investment and talent investment are in a "existence state" and play a core role. Combined with the necessity analysis, it shows that the r & d investment and talent investment are the necessary conditions for the innovation performance of high-tech industry. Among the sufficient conditions, the variable of "market competition" is not absent, indicating that it is always a positive factor to improve innovation performance. Combining configuration 1 and configuration 4, on the basis of other conditions being the same, digital economy changes from existence to "existence" variable, indicating that

for regions with solid innovation foundation, the positive role of digital economy will gradually emerge over time. Looking at the configuration of the two periods, it can be found that the conditional combination of high R&D investment, high talent investment and high market competition appeared steadily in the two periods, indicating that the change trajectory is "dominant trajectory" and plays an important role in driving the innovation performance of high-tech industry.

4 Research conclusions and enlightenment

4.1 Study Conclusions

Innovation foundation plays an irreplaceable role in driving the innovation performance of high-tech industries. The lack of r & d investment, talent investment and market competition are the necessary conditions to lead to low innovation performance. The research has identified three paths to drive high innovation performance: digital economy-driven, innovation resource-driven and industrial structure-driven. Among them, the eastern region mainly adopts the strategy of "digital economy driven" and "industrial structure optimization driven", while the central and eastern regions mostly adopt the "innovation resource-driven" strategy. In addition, the development of digital economy can significantly improve the innovation performance of high-tech industries, and the driving role of high innovation performance is gradually highlighted with time evolution. For some regions, R & D investment, talent investment and market competition do not exist simultaneously, but market competition has always been a positive factor in the driving process.

4.2 Research enlightenment and deficiencies

The coordination and linkage between innovation elements reflects the complexity of the innovation performance of high-tech industry. Each region should base on its own development advantages and characteristic endowment conditions, build efficient and high-quality innovation policies, and create a characteristic environment suitable for the development of high-tech industry through the synergistic influence of various factors. R & d investment, talent investment and market competition are the basic guarantee to drive innovation performance. Local governments should give priority to ensuring the adequate supply of R & D funds and human resources, and vigorously develop high-tech industries. In addition, the development of the digital economy can also indirectly consolidate the foundation for innovation. With the help of digital economy, to some extent, it can also reduce the cost of innovation, improve the profits of innovation subjects, so as to increase the investment in research and development activities, and further enhance the competitiveness of electronic and communication equipment manufacturing industry. Local governments should optimize the innovation environment in real time according to their own development status, so as to provide a strong guarantee for the follow-up development of regional high-tech industries.

There are also some deficiencies in the research process: firstly, although the digital economy is included due to the complexity of the regional high-tech industry innovation; secondly, through the comparative analysis of multiple periods, only the "dominant track" is found, and the subsequent study can explore the "turning track" and "mixed track"; thirdly, this study only studies the innovation level of high-tech industry at the regional level, providing detailed

empirical analysis on the subdivision of high-tech industry in the future.

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