Comparative Study on Scientific and Technological Innovation Ability of High-Tech Parks From The Perspective of High-Quality Development Based on SFA Regression Method

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Abstract

China's economy has changed from a a high-speed growth stage to high-quality development stage. Innovation is the core driving force leading high-quality development, and national high-tech zones will be the main force and main position of innovation-driven development strategy. Using the methods of data envelopment analysis, cluster analysis and SFA regression, this paper compares and analyzes the technological innovation ability of national high-tech zones in Liaoning, Jiangsu, Guangdong and Shandong. The research shows that the comprehensive technological innovation ability of Liaoning Province is weaker than that of the other three provinces, and the scale efficiency of technological innovation ability of the four provinces needs to be improved, and there are obvious regional differences; Liaoning can enhance its technological innovation ability through the agglomeration of scientific and technological resources and production factors, the construction and improvement of collaborative innovation network, and the improvement of scientific and technological service system.

Keywords- *High-quality development; National high tech Zone; technological innovation Cluster analysis; SFA regression*

1. INTRODUCTION

With the entry of socialism with Chinese characteristics into a new era, China's economy has changed from a high-speed growth stage to a high-quality development stage. The key to high-quality development lies in innovation-driven development. As an important carrier for implementing innovation-driven development strategy, as a regional spatial unit with unique functionality and economy, national high-tech zones are the advantageous scales and carriers for China to participate in global competition and cooperation, and an important influencing factor to promote the change of global competition pattern. So far, Liaoning Province has established 8 national high-tech zones. In recent years, these high-tech zones have developed rapidly in all aspects. At the same time, some problems have become increasingly apparent, such as the ability of independent innovation to be strengthened, insufficient R & D investment, low innovation efficiency, unbalanced development among regions, etc. In the GDP ranking of 31 provinces and cities in 2020, Guangdong, Jiangsu, and Shandong ranked among the top three. Comparing Guangdong, Jiangsu, and Shandong, the national high-tech zones in Liaoning Province, is lacking of conductivity to solve the problems and promot the further development of high-tech zones, so as to further improve the regional technological innovation ability of Liaoning Province and lay a driving force for economic growth.

Innovation theory was first put forward by economist Schumpeter in 1912. Now it has become a hot topic all over the world. Ekinette M. Roger and Judyn K. Larsen (1985) were the first foreign scholars to conduct empirical evaluation research on high-tech zones. Qualitative analysis and research revealed the conditions for the formation of a "cohesive economic effect" in Silicon Valley [1]. Lofsten and Lindelof (2012) pointed out that the development of science and technology parks is inseparable from technological innovation [2]. Tian L, Li Y (2017) found that foreign cooperation and

technology spillover promote the cultivation of innovation ecological efficiency of high-tech zones [3]. With the proposal and practice of high-quality development, a high-quality development evaluation has been paid attention to. Based on the basic theory of economics, Jin Bei (2018) believes that innovation, efficiency, quality, sustainability, and other elements should be taken as the indicator for the evaluation of high-quality development status [4]. Du Chunli (2019) combined with the problems existing in the evaluation and assessment practice of development zones at all levels under the economic growth mode, constructed the evaluation and assessment index system of provincial economic development zones from the perspective of high-quality development [5]. Other scholars mostly put forward the construction of a high-quality development evaluation index system from the aspects of structural benefit, efficiency change, resource allocation, and innovation ability, but the focus is different [6-10]. There are more and more studies on the technological innovation ability of high-tech zones. Sun Qian (2013) and Wang Xia et al. (2014) established the evaluation index system for evaluating the innovation ability of national high-tech zones from three modules and using the factor analysis method [11-12]. Yang Jie et al. (2020) and Yuan Hang et al. (2018) respectively used the SOM network topology model and double-difference method to empirically analyze the comprehensive innovation efficiency of China's national high-tech zones [13-14]. Tian Zhilong et al. (2019), Xiong Bo et al. (2019), and Zhang Jixin et al. (2019) comprehensively evaluated the innovation efficiency, innovation ecological efficiency, and High-tech Zone carrier of China's information technology enterprises [15-17]. Zheng Xuhui et al. (2020) and Xiong ran et al. (2019) found the impact of trade on the innovation ecological efficiency of high-tech zones through the analysis of Two-stage DEA and dynamic super efficiency SBM model [18-19]. Measurement and Analysis of Technological Innovation Efficiency in National High-tech Zone of Liaoning Province.

1.1 Efficiency Measurement of Technological Innovation in National High-tech Zone in Four Provinces

1.1.1 Efficiency Measures

The innovation of high-tech zone is a dynamic and complex system with multi-factor input and multi-output, which involves many inputs of human, material, and financial resources in the whole process. The input index selects the full-time equivalent of R&D personnel, the number of enterprises, the internal expenditure of R&D funds, the funds for scientific and technological activities, the assets at the end of the year, the product sales income, the technical income, the patent authorization, the export earning foreign exchange and the total industrial output value as the output index.

Environmental variables are variables that are outside the observation sample and are not controlled by the sample but have an impact on the technological innovation efficiency of the sample. When carrying out SFA modeling, the attributes and development characteristics of technological innovation in high-tech zones are taken into account, the macroeconomic environment is measured by the per capita gross domestic product (GDP) of the region, the degree of opening to the outside world is measured by the total amount of foreign direct investment, the level of scientific education in the region is measured by the number of college students in ordinary colleges and universities, and the level of local policy support for technological innovation is expressed by the expenditure of finance on science and technology.

1.1.2 Data envelopment analysis

TABLE I.   MEASUREMENT OF TECHNOLOGICAL INNOVATION EFFICIENCY IN HIGH TECH ZONES

High-tech Zones	Name of Index		
	Integrated efficiency	Pure technical efficiency	Scale efficiency
Shenyang	0.315	0.392	0.805
Dalian	0.401	0.426	0.942
Nanjing	0.596	1	0.596
Suzhou	1	1	1
Guangzhou	0.45	1	0.45
Shenzhen	0.445	1	0.445
Jinan	0.459	1	0.459
Qingdao	0.469	0.675	0.695

As shown in Table 1, considering the influence of environmental factors and random factors, the average comprehensive technological innovation efficiency of Liaoning Hi-tech Zone in 2018 is 0.65, the average pure technical efficiency is 0.79, and the scale efficiency is 0.83. From the point of view of pure technical efficiency, Liaoning High-tech Zone is lower than the other three provinces, but the scale efficiency is generally superior to the other three provinces except for Benxi Hi-tech Zone. The reason is that the economic development of Jiangsu, Guangdong, and Shandong is good, and the investment in the related elements of technological innovation is much, which leads to the improvement of pure technical efficiency, but it can also reflect that the utilization rate of the elements is not enough, so the scale efficiency is low.

1.1.3 Cluster analysis

Using Python software to read the data, the abscissa is pure technical efficiency and the ordinate is scale efficiency; Then perform K-means clustering and define the optimal number of clusters as 3. The first category indicates that the pure technical efficiency and scale efficiency of the national high-tech zone are high, the second category indicates that the pure technical efficiency and scale efficiency of the national high-tech zone are poor compared with the first category, and the third category indicates that the pure technical efficiency and scale efficiency of the national high-tech zone are low, and then output the clustering label, For better cluster analysis, the following table is made:

TABLE II. THE THIRD STAGE MEASUREMENT OF TECHNOLOGICAL INNOVATION EFFICIENCY IN HIGH-TECH ZONE

Type	National high tech Zone
Type I	Shenyang, Dalian, Anshan, Suzhou, Nantong, Changzhou, Yuancheng, Dongguan, Yellow River Delta, Qin'an, Zhongshan, Shenzhen, Wuxi, Huizhou, Qingdao, Weihai, Zhanjiang, Taizhou, Jinan, Jining and Guangzhou
Type II	Fuxin, Liaoyang, Changshu, Yantai, Foshan, Weifang, Zaozhuang, Nanjing, Suzhou, Qingyuan, Changshu, Kunshan, Zhenjiang, Yantai, Jiangmen, Dezhou, Zibo
Type III	Benxi, Yingkou, Jinzhou, Suqian, Zhuhai, Shantou, Yangzhou, Wujin, Yancheng, Zhaoqing, Linyi, Xuzhou, Huai'an, Lianyungang, Maoming

It can be seen from the above table that compared with the other three provinces, the national high-tech zones in Liaoning Province are in the third category, accounting for a large proportion, and only Shenyang, Dalian, and Anshan national high-tech zones are in the first category, Through the comparison, it can be seen that the innovation ability of other national high-tech zones in Liaoning Province has a lot of room for progress compared with the national high-tech zones in other three provinces. In order to promote the overall development of national high-tech zones in Liaoning Province, it is the key to making up the shortboard. How to make up for it needs SFA regression analysis.

1.1.4 SFA regression

TABLE III. SFA REGRESSION ANALYSIS OF TECHNOLOGICAL INNOVATION EFFICIENCY IN HIGH TECH ZONES

Project	R & D personnel	Number of enterprises	R & D funds
Constant term	-53.52	-526.95	-343688.07
Macroeconomic environment	108.47	420.8	214392.97
Regional openness	3.42	329.34	-106761.78
Science education level	-551.88	282.08	-109924.24
Policy support	-2656.1	-1189	-166368.09
sigma-squared	6968404.2	3240451	2.46152E+11
gamma	0.99996	0.89999	0.7967
LR	45.17	49.19	26.77

The regression in the above table shows that the LR values of the three inputs are greater than the critical value, indicating that it is suitable for random frontier analysis. The regression coefficients of relaxation variables of regional per capita GDP to all input factors are positive, indicating that per capita GDP has a stimulating effect on input redundancy. The regression coefficients of the relaxation variables of regional openness to the internal expenditure of R & D funds of high-tech zones are negative, indicating that the more foreign capital is utilized, the less capital investment of high-tech zones is. With the improvement of science education level, the higher the quality of graduates, which has stimulated the redundancy of the number of enterprises in the high-tech zone, and pay more attention to the matching degree of posts. The regression coefficient of the relaxation variable of the government's expenditure on science and technology and the investment in human and capital of the high-tech zone is negative. Because technological innovation requires a lot of human and material resources, the government's financial expenditure on technological innovation of the high-tech zone will reduce the investment in human and capital of the High-tech Zone, and the new area needs the support of the government. Findings

1.2 Research conclusion

For innovation input variables, the impact of R & D funds on innovation output is greater than that of R & D personnel, and the redundancy of R & D personnel input is vulnerable to changes in environmental factors. Therefore, the key to improving innovation output is to continuously improve the scientific and technological work system, attract and cultivate high-level technical talents, and create a good soft and hard environment for scientific research while increasing R & D capital investment, fully mobilizing the enthusiasm and creativity of scientific and technological personnel.

There are obvious regional differences in the innovation ability of Liaoning high-tech zones, especially in terms of scale efficiency. Compared with Benxi, Jinzhou, and other cities, Shenyang and Dalian high-tech zones have more scale effect, which is inseparable from the establishment and development of Shenyang University National Independent Innovation Demonstration Zone. In order to promote the interactive and coordinated development of high-tech zones in Liaoning Province in terms of scientific and technological innovation, industrial docking, achievement transformation, and resource sharing, it is necessary to support national high-tech zones to establish scientific and technological exchange institutions and achievement transfer institutions in Shenyang and Dalian national high-tech zones, give full play to the advanced driving role of Shenyang and Dalian high-tech zones and

realize the innovation and linkage development of national high-tech zones in Liaoning Province, Promote the improvement of innovation ability.

There is still a certain gap between the development of Liaoning high-tech Zone and that of Guangdong, Jiangsu, and Shandong. From the perspective of provincial capital cities, Nanjing high tech Zone focuses on cultivating innovative leading enterprises, and promotes the development of overall technological inn , high enterprise recognition ovation through policies such as enterprise R & D organization performance, high enterprise recognition, and warehousing reward, industrial-technological innovation alliance, and R & D fee inclusive for scientific and technological small and medium-sized enterprises. Shenzhen high-tech Zone allows innovation subjects that meet the industrial access conditions, simplifies the procedures related to scientific and technological innovation land, and provides convenience for the development of scientific research institutions and enterprises. Jinan high tech Zone will build a number of international scientific and technological achievements transfer and transformation centers integrating technological achievements trading, offshore incubation, high-level talent exchange, joint research, enterprise investment, and industry-university research cooperation, create a new highland for export-oriented regional scientific and technological innovation and achievements transformation, and improve the development level of openness and innovation. As the capital city of Liaoning Province, Shenyang has superior platform and policy advantages. Combined with characteristic advantageous industries, facing the needs of the full integration of the manufacturing industry and the Internet, Shenyang improves the technological innovation ability of Liaoning National High-tech Zone through platform development, so as to further improve the overall high-quality development level.

From the perspective of cities with better economic development, Suzhou, Dalian, Shenzhen, and Qingdao play an important role in the economic development of their respective provinces. It can be found that the comprehensive efficiency of the Dalian high-tech Zone is lower than that of the other three cities, mainly due to the low pure technical efficiency. By increasing the investment in science and technology activities, Suzhou high tech Zone has promoted the exchange of science and technology service institutions, new R & D institutions, science and technology enterprises, and technology brokers, to improve the technological innovation and development ability of Suzhou high tech Zone. Shenzhen high tech Zone has increased the investment of assets and the supervision and implementation of scientific research funds at the end of the year, so that the technological innovation efficiency of Shenzhen high-tech zone develops rapidly and with High-quality. Relying on the advantages of characteristic industries, Qingdao high tech Zone cultivates an

international fishery science and technology cooperation base and a national and local joint Engineering Research Center for Mariculture equipment and biological breeding technology. As a city with better economic development in Liaoning Province, Dalian has excellent universities such as Dalian University of Technology, Northeast University of Finance and economics, and Dalian Maritime University, provides a large number of R & D talents, and has close cooperation with many enterprises and R & D institutions in the high tech Zone. Through the intelligent development of new kinetic energy and new industries, we can improve the technological innovation ability of national high-tech zones in Liaoning Province, to further improve the overall high-quality development level.

2. CONCLUSIONS

This study uses data envelopment analysis, cluster analysis and SFA analysis, and collects the sample data of 20 yearbooks, so as to compare and analyze the gap in technological innovation ability between 8 national high-tech zones in Liaoning Province and advanced high-tech zones in Jiangsu, Guangdong and Shandong. The empirical results show that: (1) in data envelopment analysis, from the perspective of pure technical efficiency, Liaoning high tech Zone is lower than the other three provinces, but the scale efficiency is generally better than the other three provinces except Benxi high tech Zone. (2) In the cluster analysis, compared with the other three provinces, the national high-tech zones in Liaoning Province account for a large proportion. (3) In SFA regression analysis, after considering environmental factors, there are common problems of redundant investment and insufficient product R & D and sales. The overall innovation capability of advanced high-tech zones in Jiangsu, Guangdong and Shandong is close to the efficient frontier of innovation, while the innovation capability of 8 national high-tech zones in Liaoning Province is far from the efficient frontier. We can establish or introduce R & D institutions with strong influence through multiple channels, encourage enterprises to cooperate in R & D, and strengthen cooperation with well-known universities inside and outside the province; We will accelerate the gathering of a number of high-tech talents to enhance the ability of technological innovation. At the same time, we should clarify our own advantages, and then implement the differentiated innovation ability improvement strategy according to the action mechanism and influence path of relevant innovation elements, so as to promote the transformation of scientific and technological achievements, so as to improve the overall high-quality development level.

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