Industrial Engineering and Innovation Management (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/ieim.2023.060804
ISSN 2522-6924 Vol. 6 Num. 8

Research on the Evaluation and Enhancement Path of Science and Technology Innovation Capability of Manufacturing Industry in Jinjiang City

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Keywords: Evaluation of scientific and technological innovation ability, JinJiang city, industrial innovation, scientific and technological innovation, manufacturing industry

Abstract: Technological innovation is an important support to promote regional economic development and industrial transformation. Manufacturing is the pillar industry of economic growth, and improving its scientific and technological innovation capability is of great significance to promote economic development. This study takes Jinjiang's manufacturing industry as the research object and uses the entropy method to evaluate its scientific and technological innovation ability. The results show that Jinjiang's scientific and technological innovation ability in 2016—2020 is generally fluctuating and rising rapidly, with high intensity and efficiency. In terms of each sub-dimension, innovation input contributes the most to the improvement of science and technology innovation capability, innovation output is the second and innovation environment is the lowest. To improve the scientific and technological innovation ability of the Jinjiang's manufacturing industry, the following suggestions are put forward: optimize the environment of enterprise scientific and technological innovation; give full play to the support of intellectual property rights to scientific and technological innovation; promote continuously the integration of industry, academia and research; build a high-quality and efficient talent training system.

1. Introduction

In 2016, the "National Innovation-driven Development Strategy Outline" was released, and "science and technology", "innovation" and "innovation-driven" have been gradually became popular words in China. Under the leadership of the Chinese government, China's Science and technology innovation strategy has been fully implemented, and the ability of science and technology innovation has been greatly improved. Jinjiang city is located in Quanzhou city, Fujian Province, China. Since the reform and opening up, it has relied on its more developed traditional manufacturing industry and active private economy to take the initiative to integrate into the global production

network system and achieve the continuous and rapid development of the manufacturing industry. However, for a long time, extensive economic growth has made Jinjiang city have problems such as low industrial level, obvious overcapacity, low technical content and added value of products, and lack of innovative talents, which have obviously restricted the pace of scientific and technological innovation. Since the introduction of the "Made in China 2025" strategy, the goal of building a strong manufacturing country has been elevated to a national strategy. Jinjiang city has followed the pace and opened the pace from Jinjiang's "manufacturing" to Jinjiang's "intelligent manufacturing", trying to explore a high-quality development path of manufacturing industry with technology, intelligence and cracking industrial structural contradictions.

Science and technology innovation capability is an important indicator to measure the level of science and technology of a region, and many scholars at home and abroad have studied it, such as [1] have made a comprehensive evaluation of the scientific and technological innovation ability of China's industrial enterprises. [2] evaluated the scientific and technological innovation ability of Hefei High-tech Zone from the perspective of scientific and technological input and output capacity. [3] constructed an evaluation index system from the perspectives of industrial scale, innovation input, output performance, and market environment, and analyzed the growth ability of high-tech industries in China's eastern, central, and western regions in detail. [4] identified three high-tech industry indicators: production and operation of the manufacturing industry, fixed asset investment in the location, and R&D activities of enterprises. [5] assessed China's manufacturing technology innovation capability from four perspectives: innovation investment funds, innovation production technology, innovation support, and innovation resource integration. In terms of evaluation methods, most studies have adopted comprehensive evaluation methods, such as factor analysis [6] and entropy weight method [7,8]. Some studies also combine multiple methods for evaluation, for example, [9] used factor analysis and cluster analysis based on diamond theory to comprehensively evaluate the level of science and technology innovation in China's provincial regions. [10] used the entropy TOPSIS method to comprehensively evaluate the scientific and technological innovation capacity of Gansu Province. As for the path of science and technology innovation capacity enhancement, [11] argued that science and technology innovation performance within a region is not influenced by the regional concentration of resources, and that science and technology innovation capacity needs to be enhanced through rational allocation of science and technology innovation resources and improvement of science and technology innovation efficiency. [12], on the other hand, argues that an open environment has a significant positive effect on innovation.

In general, research on the evaluation and improvement path of China's science and technology innovation capability started late, and there is a lack of research on innovation capability at the small regional scale. Therefore, based on the current situation of manufacturing science and technology innovation industry development in Jinjiang city, this study establishes an evaluation index system of science and technology innovation capability from multiple dimensions to comprehensively investigate and analyze the science and technology innovation development capability of manufacturing industry in Jinjiang city, and provide effective countermeasures and suggestions for promoting high-quality development of manufacturing industry in Jinjiang city.

2. Evaluation of the Technological Innovation Ability of the Manufacturing Industry in Jinjiang City

2.1. The Evaluation Index System Construction

To fully understand the current situation of the scientific and technological innovation ability of the manufacturing industry in Jinjiang city, according to the principles of scientificity, comprehensiveness, and availability, this paper constructs the evaluation index system of scientific

and technological innovation in Jinjiang city from three dimensions of innovation input, innovation output, and innovation environment. The details are shown in Table 1.

Table 1: Jinjiang city science and technology innovation ability evaluation index system

Target layer	Main-dimension	Sub-dimension	Specific indicators
Science and technology innovation ability	Innovation investment	Investment in science and technology	Total R&D internal expenses
		Science and technology investment intensity	Total R&D internal expenses as a percentage of GDP
		Investment in technological transformation	Total investment in technological transformation
	Innovation output	Economic output	High-tech enterprise output value accounted for the proportion of industrial value added above the scale
		Patent Output	Number of invention patents per 10,000 people
		Project Output	Number of key technological transformation projects implemented
	Innovation Environment	Percentage of High and New Technology Enterprises	The number of high-tech enterprises accounted for the proportion of the number of manufacturing enterprises above the scale
		R&D institutions	Number of new provincial-level R&D institutions

2.2. Research Method and Data Sources

2.2.1. Research Method

Based on the strong objectivity of the research data, the study adopts the entropy method to measure the science and technology innovation capability of Jinjiang city, and its specific steps are as follows:

Assuming that there are *m* evaluation objects and *n* evaluation indexes, the original matrix (X_{ij}) *m*n* is formed. Further standardize the data, using the standardized formula of the positive index:

$$x'_j = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} (i = 1, 2, \ldots, n) \quad (1)$$

After data standardization, entropy is calculated for the next program. The information entropy of each index is obtained by the entropy method: the lower the information entropy, the lower the degree of disorder, the higher the utility value of the information, and the higher the index weight.

We calculate the weight of the *j-th* index value in the *i* year by the following equation:

$$Y_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \quad (2)$$

We calculate the information entropy of the index e_j by the following equation:

$$e_j = -k\sum_{i=1}^{m}\left(Y_{ij} * lnY_{ij}\right), (k = \frac{1}{lnm}) \tag{3}$$

We calculate the index weight W_i by the following equation:

$$W_i = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{4}$$

Then,

$$d_j = 1 - e_j \tag{5}$$

X_{ij} indicates the value of the *j-th* marker in the *i-th* year.
The results of the weights of each indicator are shown in Table 2.

2.2.2. Data Sources

The main data for this study were obtained from official data reports such as the 2016-2020 Statistical Bulletin of National Economic and Social Development of Jinjiang city and the Work Report of Jinjiang Municipal Government.

Table 2: The weight results of each index of scientific and technological innovation ability.

Main-dimension dimension	Sub-dimension	Weight
Innovation Investment	Investment in science and technology	0.168
	Science and technology investment intensity	0.161
	Investment in technological transformation	0.151
Innovation Output	Economic output	0.072
	Patent Output	0.080
	Project Output	0.178
Innovation Environment	Percentage of High and New Technology Enterprises	0.114
	R&D institutions	0.076

2.3. Analysis of Results

After calculating the weight, the comprehensive score results are obtained:

Table 3: Comprehensive evaluation result.

Years	2020	2019	2018	2017	2016
Innovation input	0.480 07	0.098 33	0.053 56	0.156 72	0.010 92
Innovation output	0.298 92	0.107 49	0.090 11	0.205 38	0.067 92
Innovation environment	0.189 81	0.127 44	0.092 29	0.050 44	0.000 02
Overall score	0.968 80	0.333 25	0.235 95	0.412 54	0.078 86

According to Table 3, Jinjiang city has an overall fluctuating and rapid upward trend of science and technology innovation capacity from 2016 to 2020, with a high enhancement intensity and fast enhancement efficiency. Compared with 2016, Jinjiang's science and technology innovation capacity in 2020 has obviously improved in all aspects, which is due to the introduction of the "Made in China 2025" strategy, Jinjiang city has introduced a series of relevant policies focusing on improving the science and technology innovation capacity of the manufacturing industry, which has achieved effective results. In terms of each sub-dimension, innovation input contributes the most to the

improvement of scientific and technological innovation capability, innovation output is the second and innovation environment is the lowest. In the current context of accelerating the trend of intelligent transformation of the manufacturing industry, production factor input is the most important link and is the main driving force to enhance the ability of science and technology innovation. From each year, 2017 is the sub-peak of manufacturing science and technology innovation capacity, mainly because of the large number of key technological reform projects and high investment amount in 2017, which is second only to 2020 in terms of innovation input and innovation output. The innovation environment sub-dimension score has gradually increased over the past 5 years, mainly due to the increasing number of high-tech enterprises and R&D institutions driven by an improved innovation climate.

3. Conclusions and Policy Recommendations

3.1. Conclusions

This study constructed a science and technology innovation capability evaluation index system as a way to assess the overall science and technology innovation capability of Jinjiang city from 2016 to 2020. The main research findings are as follows: Jinjiang's scientific and technological innovation ability in 2016—2020 is generally fluctuating and rising rapidly, with high intensity and efficiency; In terms of each sub-dimension, innovation input contributes the most to the improvement of science and technology innovation capability, innovation output is the second and innovation environment is the lowest; Production factor input is the most important link and the main driving force to enhance science and technology innovation capability.

3.2. Policy Recommendations

3.2.1. Optimize the Enterprise Science and Technology Innovation Environment

First of all, we can connect high-tech from different industries, departments, and functions to the large-scale manufacturing network of manufacturing enterprises, guide manufacturing enterprises to use modern science and technology, focus on building manufacturing intelligent production data resources and production service platforms and emphasize the leading position of manufacturing enterprises in scientific and technological innovation. At the same time, the government should increase the relevant investment in the scientific and technological innovation funds of the manufacturing industry in Jinjiang city, increase the proportion of the scientific and technological innovation funds of the manufacturing industry in the relevant funds of the city, and enhance the intensity of support for the scientific and technological innovation research of manufacturing enterprises. Secondly, the government should accelerate the reform of the system and mechanism of scientific and technological innovation, optimize the management and service mode in the field of scientific and technological innovation, further strengthen the incentive management system, and coordinate the innovation environment. Focusing on key industries such as information technology, new materials, intelligent equipment, and machinery manufacturing, we will promote the implementation of high-tech projects, strengthen the government services of a business as a policy, and promote breakthroughs in the technical bottlenecks of related industries. Finally, manufacturing enterprises should improve the absorption demand of scientific and technological innovation of enterprises, ensure the investment of strengthening the introduction cost and upgrading cost of scientific and technological innovation technology, and promote the ability to transform their own scientific and technological innovation technology into landing projects, to realize the combination of "importing" and "going out" of science and technology innovation.

3.2.2. Play the Support of Intellectual Property Rights to Scientific and Technological Innovation

Jinjiang city should deepen the close relationship between policy, technology, and enterprises, establish and improve the relevant patent property rights protection system, strengthen the construction of property rights policies and regulations on patents related to scientific and technological innovation in the Jinjiang's manufacturing industry, and establish patent property rights protection laws and regulations according to local conditions. At the same time, manufacturing enterprises in Jinjiang should increase investment in innovation resources, strengthen the support of each element of scientific and technological innovation for industrial development, vigorously promote the agglomeration of high-tech industries, generate a series of positive externalities such as external economies of scale, so that they can produce self-reinforcing mechanisms and accumulate cycles of various innovation resources for manufacturing industries in Jinjiang.

3.2.3. Promote Continuously the Integration of Industry, Academia and Research

The government should further break the logjam of collaborative R&D among science and technology innovation organizations, universities and manufacturing enterprises. At the same time, it will promote cooperation projects between universities, research institutes and manufacturing enterprises in Jinjiang, and guide the joint cultivation of potential talents between universities and manufacturing industries. Secondly, supply and demand docking channels for manufacturing industry should be established to promote the in-depth cooperation of intellectual property rights among enterprises, universities and research institutes, and to guide the development of order-based R&D and delivery innovation. Finally, universities and research institutes are encouraged to set up professional branches and institutes in industrial clusters to give full play to their professional and technological advantages, and to promote key technology research and development.

3.2.4. Build a High-quality and Efficient Talent Training System

On the one hand, relevant departments should focus on introducing enterprises and talent teams with strong scientific and technological innovation capabilities, and establish and improve the human resources development system to ensure the employment needs of manufacturing enterprises. On the other hand, we should vigorously strengthen the cultivation of local talents, upgrade the way of educating people with the times, aim at the actual employment needs of manufacturing enterprises, improve the mechanism of apprenticeship training, professional setting, and employment linkage, and realize the precise docking of specialty and industry. Improve the school-enterprise collaborative education method, and dynamically adjust the school specialty. Based on the industrial demand, conduct in the right direction in the training of industrial field engineers and local high-quality skilled talents, and transport talents for the high end of the industry.

Acknowledgment

This work was supported in part by a grant from Social Science Planning Research Project of Fujian Province (FJ2022C096) and Natural Science Foundation of Fujian Province (2021J05184).

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