



Research on the Driving Force of Technological Innovation on Industrial Upgrading Under the Guidance of Policy

Yang Zhao^(✉)

Shandong Management University, Jinan, Shandong, China
88092272@qq.com

Abstract. In 2018, Shandong Province proposed to implement replacing the old growth drivers with new ones, and lay out the new generation of information technology, high-end equipment, new energy and new materials, modern Ocean, health care and other emerging industries. Technological innovation plays a leading role in this transformation process. By analysing the relevant data of invention patents in Shandong Province from 2014 to 2020, this paper constructs an econometric model of patent application and economic growth, analyses the driving force of technological innovation guided by policy on industrial upgrading, and finds that technological innovation plays a strong role in promoting Shandong's economic growth, Electronic information industry is still the main field of innovation in Shandong Province, but the role of the top ten industries is not obvious.

Keywords: Technological Innovation · Industrial Policy · Patent Analysis · Driving Force of Technological Innovation

1 Introduction

Shandong is a major economic province in China, and its economy has long been at the forefront of the country. However, in the 21st century, as China's economic development enters a new stage, the drawbacks of Shandong's economic and industrial structure have gradually emerged, that it, Shandong's economy is large but not strong, and its industrial structure is dominated by traditional industries. In 2018, Shandong Province proposed a major project to replace the old growth drivers with new ones. This project will focus on cultivating the top ten "5 + 5" industries, and developing new industries such as the new generation of information technology, high-end equipment, new energy and new materials, modern marine technology, medical care and health care and other emerging industries. By 2022, the share of the top ten industries will reach 60%, forming a new pattern of economic development dominated by new drivers. The invention patent is an important form of technological innovation. By analysing the relevant data of invention patent, this paper studies the role of technological innovation under the guidance of policy in promoting industrial upgrading.

2 Literature Review

2.1 Research on Patent Quality

Li Chunyan and Shi Rong (2008) conducted an exploratory study on the evaluation of patent quality indicators. They divided patent indicators into six categories, including citation index, scientific index, content index, international index, time index and other indexes, for patent quality evaluation. Qiao Guiyin (2013) studied the patent quality index system, analyzed the main characteristics of patent quality, and designed four indexes reflecting patent quality, including content index, technical strength index, internationalization index, and market competitiveness index. Hu Die and Wang Yuandi (2015) integrated multiple indexes of patent novelty, creativity and practicability, determined the weight of each index by using principal component analysis, and constructed a comprehensive index reflecting the quality of patents of enterprises. They used the patent data of 355 listed companies on the Growth Enterprise Market to calculate the composite index of corporate patent quality. The research shows that according to the size of the listed companies, the patent quality of small companies is average, while the patent quality of large companies is in an inverted U-shaped segment, and the patent quality is seriously differentiated. Based on the Derwent Innovations Index, Xie Ping, Wang Xiuhong, and Lu Zhangping analyzed the strength of patentees and the competitiveness of patent technologies, and formulated a patent value evaluation system that includes 9 elements including the average patent citation rate [5].

2.2 Research on Patent Industrialization

Cao Yong and Zhao Li studied the mechanism of patent acquisition, patent protection, patent commercialization and technological innovation performance. The research showed that patent acquisition, patent protection, patent commercialization and technological innovation performance had significant positive effects [1]. Mao Hao, Liu Cheng, and Lin Han (2013) studied the patent implementation and industrialization of Chinese enterprises, and found that the patent industrialization rate of Chinese enterprises remained at about 39.9%. The characteristics of enterprises, patented technology, and the external environment had significant impacts on the implementation and industrialization of patents. Zhang Jinfan, Li Hanya, and He Hui (2017) studied the impact of corporate listing financing on corporate innovation. By constructing a sample of listed and non-listed companies, the research found that by alleviating corporate financing constraints, IPO can promote the construction of innovative talent team. The number of patent applications by enterprises with relatively difficult financing increased obviously after listing, and the number and efficiency of patent applicants of enterprises have been increased significantly after listing.

2.3 Research on the Replacement of the Old Growth Drivers with New Ones

Wang Xinjuan, Li Mi, and Wang Yuanhua explained how to promote the replacement in Shandong province through consciousness innovation, entrepreneurial activities, and

value creation [4]. By using the analytic hierarchy process and fuzzy comprehensive evaluation method, Sun Xiumei and Hou Shiqi selected 19 factors from 4 aspects: quality and efficiency, innovation and development, opening to the outside world, and environmental protection and people's livelihood, and constructed a performance evaluation index system for the replacement of the old growth drivers with new ones [3]. The results showed that Shandong Province's performance evaluation is good, and the score is slightly lower than that of Jiangsu province and Zhejiang province, and higher than that of Hebei province. Fan Qiufang, Luo Qianwen, and Han Zhiye studied the relationship between innovation drive and the replacement of the old growth drivers with new ones, and found that among the factors that affect innovation drive, the correlation degree with the replacement of the old growth drivers with new ones is ranked from high to low in the following order: Patent and technology > capital investment > enterprise innovation investment > number of scientific researchers and university talents [2].

3 Research Design

3.1 Research Ideas

To sum up, the current research on patents is concentrated on two areas. One is the research on patent quality, that is, the evaluation of patents, which evaluates the quality of patents through the attributes of patents. The second is the research on the transformation of patent applications. The research on patent application and industrialization mainly starts from the external environment in which patents are generated, and analyzes which external factors have positive effects on the industrialization of patents. The research on the replacement of the old growth drivers with new ones is currently focused on the influencing factors, countermeasures and the effect of the replacement. Patent and technology have the highest correlation with the replacement of the old growth drivers with new ones.

Patent is the embodiment of human creation, invention and knowledge. The replacement of the old growth drivers with new ones is a shift from the traditional resource-input industry characterized by high energy consumption and high pollution to the high value-added, high-tech industry characterized by innovation. In the process of replacement, along with the rise of new emerging industries characterized by innovation, it will inevitably be reflected in patent applications. Based on the data of patent from 2014 to 2020 in Shandong province, this paper analyses the replacement effect of top ten industries in Shandong province, and puts forward corresponding policy recommendations.

3.2 Patent Application in Shandong Province

From the perspective of the number of patent applications, in 2020, the number of invention patent applications in Shandong province was 66,741, an increase of 23% compared with 2014, with an average annual growth of 3.89%. The number of invention patent applications has experienced a trend of first increase and then decline. The turning point appeared in 2018. In 2018, the number of invention patent applications reached a staged

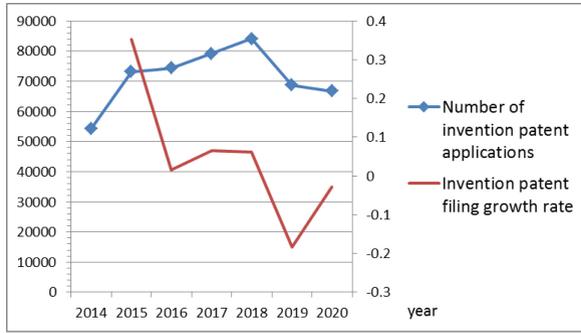


Fig. 1. Invention Patent Application in Shandong Province, 2014–2020.

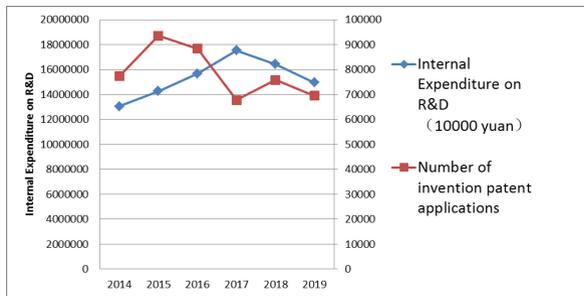


Fig. 2. Research and Development Personnel, Number of Units with Research and Development Activities, 2010–2019.

maximum. Since 2019, the number of invention patent applications has been declining continuously. If we analysed from the perspective of the growth rate of invention patent applications, from 2014 to 2020, the growth rate of invention patent applications in Shandong province has gradually declined, and the growth rate of patent applications in 2019 and 2020 has dropped to a negative value. (Fig. 1).

Comparing the number of invention patent applications with the internal expenditures of R&D funds and the number of personnel participating in research and experiment during the same period, it can be seen that they are positively correlated (Fig. 2) (Fig. 3).

3.3 The Characteristics of Patent Application of the Top Ten Industries in Shandong Province

In 2018, Shandong province set 10 industries as top ten, including new generation information technology, high-end equipment, new energy and materials, modern Marine technology, medical care and health care, high-end chemical industry, modern and efficient agriculture, cultural creativity, boutique tourism, and modern financial services. These ten industries are the breakthrough point and development direction for the replacement of the old growth drivers with new ones. Based on the top ten industries, the author set 11

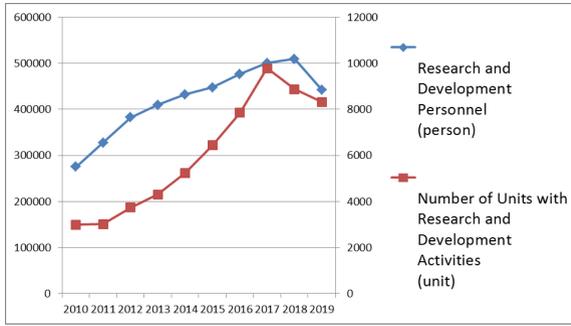


Fig. 3. R&D Expenditure and Invention Patent Application.

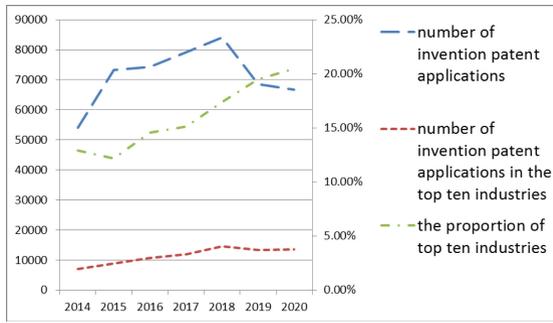


Fig. 4. Invention Patent Applications of Top Ten Industries in Shandong Province.

keywords, including equipment, chemical industry, information, new energy, new materials, marine, agriculture, cultural creativity, medical and health, tourism, and finance, to screen the invention patents from 2014 to 2020. The study found that from the perspective of development trends, although the number of invention patent applications in Shandong province has begun to decline since 2018, the number of invention patent applications in the top ten industries has not decreased significantly, and the proportion has been increasing. It indicates that with the implementation of replacement of the old growth drivers with new ones, the innovation power of the top ten industries is constantly increasing (Fig. 4).

From the analysis of the composition of invention patent applications in the top ten industries, we found that the number of invention patent applications for the new generation information technology has increased significantly since 2014, and accounted for more than 60% in the total applications, indicating that the electronic information industry is still the main field of innovation in Shandong province. According to IPC classification, G06 electronic computer and information technology patents account for 51% and H04 communication technology patents account for 17%. The patent application covers 99% of the categories of class H physics and class G electricity. The proportion of invention patent applications in medical and healthcare industry has been continuously increasing, showing that the innovation of the medical and healthcare industry has been

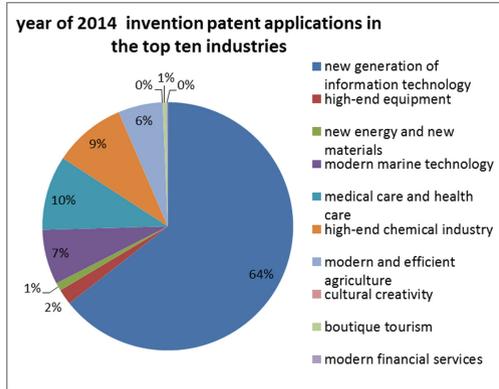


Fig. 5. Invention patent Application in the top ten industries of 2014.

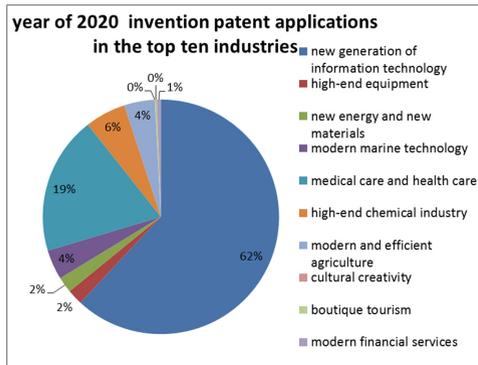


Fig. 6. Invention patent Application in the top ten industries of 2020.

continuously increasing in recent years. The number of invention patent applications in the high-end chemical industry is relatively stable, with a decline in the proportion. The number of invention patent applications for modern high-efficiency agriculture has increased, but its proportion has remained stable at about 5%. The number and proportion of patent applications in other industries are relatively low. All in all, except information industry and medical care and health care industry, other industries do not have significant innovation motivation (Fig. 5) (Figs. 6 and 7).

3.4 Analysis on the Driving Force of Technological Innovation on Industrial Upgrading Under the Guidance of Policy

Based on the above analysis, this paper constructs an analysis model of the driving force of technological innovation on industrial upgrading. The model uses the number of patent applications to represent the strength of technological innovation and GDP to represent the implementation effect of industrial upgrading:

$$\text{Ln}(\text{Gdp}) = \alpha \cdot \text{Ln}(\text{Patent}) + \beta \tag{1}$$

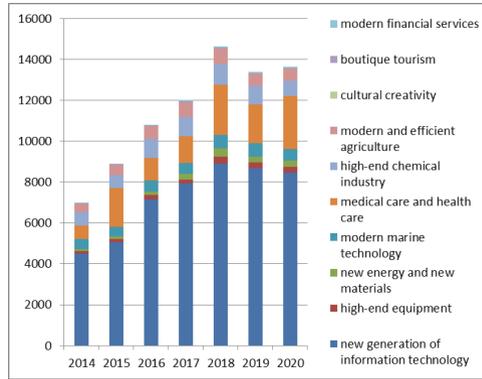


Fig. 7. Invention patent Application in the top ten industries, 2014 to 2020.

Table 1. Regression results.

Dependent Variable:GDP				
Method:Least Squares				
Date:03/01/22 Time:20:52				
Sample:2014 2020				
Included observations:7				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PATENT	1.521767	0.321305	4.736206	0.0052
C	33539.34	6301.414	5.322510	0.0031
R-squared	0.817729	Mean dependent var		62593.79
Adjusted R-squared	0.781275	S.D.dependent var		8149.528
S.E.of regression	3811.379	Akaike info criterion		19.56433
Sum squared resid	72633046	Schwarz criterion		19.54887
Log likelihood	-66.47514	Hannan-Quinn criter.		19.37331
F-statistic	22.43165	Durbin-Watson stat		1.490120
Prob(F-statistic)	0.005167			

Gdp is the gross domestic product of Shandong Province from 2014 to 2020, and Patent is the number of patents authorized from 2014 to 2020. Eviews is used to analyse the model. The results are as follows:

$$Gdp = 1.521767 * Patent + 33539.34 \tag{2}$$

R-squared was 0.817729 and prob (F-statistic) was 0.005167, which showed that patent could explain 81% of the change of GDP, $P < 0.05$ (Table 1).

4 Conclusion and Suggestions

By analysing the data of invention patent application in Shandong province in recent years, the author finds that the impetus for innovation in Shandong province is generally weakening due to the decrease of R&D expenditures and the decline in the number of R&D personnel participating in experimental research. However, judging from the proportion of patent applications in the top ten industries, the replacement of the old growth drivers with new ones is beginning to bear fruit. The development of the top ten industries is uneven. The information technology industry is still the focus of innovation. The development of the medical and healthcare industry is gradually accelerating, and the development of other industries is not satisfactory. Therefore, on the whole, technological innovation plays a strong role in promoting the economic growth of Shandong Province, but the top ten industries determined by the policy of replacement of the old growth drivers with new ones have not yet formed a strong support for the province's economic transformation and upgrading. In the next step, Shandong province should strengthen its support for innovation in the top ten industries, increase the research and experiment expenditures in the top ten industries, especially other industries other than information technology and medical and health care industries, improve the overall innovation capacity of the industries.

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