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On the Innovation Efficiency of High-tech Industries in 28 Provinces and Cities in China based on DEA-Malmquist Index

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Abstract

Based on the panel data of high-tech industries in 28 provinces and cities in China from 2017 to 2021, this paper uses DEA-Malmquist index method to measure the innovation efficiency of high-tech industries from a dynamic perspective in the overall and regional perspectives. Research has found that the innovation efficiency of China's high-tech industries has maintained a stable upward trend, with a good development trend. However, the contribution of technological efficiency to innovation efficiency is relatively low, which is the main limiting condition. There are significant differences in the development of innovation efficiency among 28 provinces and cities, specifically manifested in the fact that the level of innovation efficiency in the eastern region is generally higher than that in the western region. At the same time, China's overall dependence on technological resource investment to develop innovation efficiency is excessive, and most provinces and cities have not utilized scale effects to promote the development of innovation efficiency. The conclusion of this article is that scientific research provides corresponding inspiration and suggestions for promoting innovation in China's high-tech industry.

Keywords

DEA-Malmquist Index; High Tech Industry; Innovation Efficiency; Technical Efficiency.

1. Introduction

Against the backdrop of the century long upheaval in world politics and economy, the international environment has become increasingly complex, with the world economy showing a downward trend and unstable factors significantly increasing. Countries have strengthened technological innovation, hoping to gain more voice and competitive advantages through tough technological advantages, and to stand firm in the trend of technological prosperity. The 14th Five Year Plan of China once again emphasizes the importance of building a country through science and technology, and the plan includes "adhering to innovation driven development and comprehensively shaping new advantages for development" as one of the 19 outlines. Technological innovation is the strategic support for enhancing national comprehensive competitiveness in today's world. High tech industries are the core influencing factors of national strategic security and competitiveness. Industrial innovation leverages the unique

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advantages of scale efficiency and iterative upgrading, and is an important driving force for national economic development. In China's current economic system, high-tech industries play an important role in technological innovation. The Chinese government has also proposed the strategic goal of becoming one of the top innovative countries by 2035, and has made technological self-reliance and self-improvement an important strategic support for national development. As an important strategy for the economic development of various countries, high-tech industries have become the focus of global competition and a key support for many countries to achieve economic transformation and upgrading. How to break through the blockade of foreign technology chains, fill the gaps in the development of high-tech industries, and achieve phased results in this field has become an important issue faced by national governments, enterprises, and academia. Therefore, this article will be based on this background to analyze the current situation of innovation efficiency development in China's high-tech industry and analyze the key factors affecting innovation efficiency development, providing reference opinions for the development layout of China's high-tech industry.

The research on innovation efficiency in high-tech industries has always been a hot topic of discussion among scholars. Innovation efficiency is an important indicator for evaluating China's overall innovation capability. In terms of measuring the innovation efficiency of high-tech industries, scholars are good at using traditional DEA models or unexpected SBM models to measure the efficiency of input and output indicators. Scholars such as Yang Rong used the three-stage DEA model to calculate the innovation efficiency of China's high-tech industries from 2009 to 2019, and found that the overall level of innovation efficiency in China is not high; Cao Li [2] and other scholars used the modified generalized DEA model to measure and analyze the high-tech innovation efficiency of 18 provinces and regions along the "the Belt and Road" from 2012 to 2016, and found that the average innovation efficiency in these five years did not reach the standard value, and the overall development level was not high; Scholars such as Liu Fengchao [3] calculated the innovation efficiency of high-tech industries in the three northeastern provinces of China based on a two-stage DEA model, and found that there is a significant gap in innovation efficiency between the three provinces and other provinces and cities. Scholars such as Song Qiuyun [4] used the traditional DEA model CCR-BCC model to calculate the static efficiency of the six central provinces from 2012 to 2015, and the results showed that the innovation efficiency development level of the six central provinces was not high; Scholars such as Chen Yingwen [5] used an improved two-stage DEA model to calculate the innovation efficiency of high-tech industries, and found that the overall level of innovation efficiency development in China is not high. Scholars Liu Hedong and Xie Ting [6] calculated the efficiency of high-tech industry research and development based on the three-stage DEA model, and found that the improvement of total factor productivity in research and development mainly relies on technological investment. Liu Bingsickle [7] used the non consensus output SBM-DEA model to calculate high-tech industries, and found that with the investment of innovation factors, the overall R&D efficiency in China is decreasing year by year.

In summary, domestic scholars mostly explore the development status of high-tech innovation efficiency from different spatial dimensions, such as the three northeastern provinces and the six central provinces. At the same time, scholars often use traditional CCR, BCC models, or improved two-stage or three-stage models to calculate and analyze innovation efficiency, but traditional DEA models cannot break through the limitations of cross-section. Therefore, this paper uses DEA-Malmquist index method to measure and analyze the innovation efficiency of high-tech industries in 28 provinces and cities in China. DEA-Malmquist index method conducts panel data analysis on selected indicators, which can better see the development level of China's high-tech industry innovation efficiency in different years over the years and the different development situation of 28 provinces and cities in China, which is conducive to providing

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development suggestions according to the different situations of provinces and cities in the future.

2. Research Methods

2.1. DEA Model

Envelopment analysis is currently the most commonly used method for measuring data efficiency. Data envelopment analysis (DEA) and its models have been widely used in different research fields since the famous American operations research scientists A. Charnes and W.W. Cooper proposed them in 1978. The CCR model and BCC model are the basic models of DEA. The CCR model is based on the principle of assuming constant returns to scale. The BCC model is improved by Banker et al. on the basis of the CCR model, while the BCC model assumes that returns to scale are variable.

The calculation principles of the CCR model are as follows:

$$min[\beta - \varepsilon\,(e^T s^- + e^T s^+)]$$

$$s.t.\begin{cases} \sum_{k=1}^{n} \lambda_k x_k + S^+ = \beta x_0 \\ \sum_{k=1}^{n} \lambda_k y_k - S^- = \beta y_0 \\ \lambda_k \geq 0, S^+ \geq 0 \end{cases} \tag{1}$$

The calculation principles of the BCC model are as follows:

$$min[\beta - \varepsilon\,(e^T s^- + e^T s^+)]$$

$$s.t.\begin{cases} \sum_{k=1}^{n} \lambda_k x_k + S^+ = \beta x_0 \\ \sum_{k=1}^{n} \lambda_k y_k - S^- = \beta y_0 \\ \sum_{k=1}^{n} \lambda_k = 1 \end{cases} \tag{2}$$

2.2. Maimquist Index Method

Traditional DEA models, such as CCR and BCC models, conduct effective data analysis on multiple input indicators and multiple output indicators according to linear programming, which is conducive to data analysis of multiple inputs and outputs, and the data need not be dimensionalized. However, the traditional DEA model is difficult to break through the limitation of cross section, and can only carry out static analysis, which is not conducive to panel data analysis. The DEA-Maimquist index was first proposed by Malmquist Sten, so it was named Maimquist index. The Maimquist index method can break through the section limit of DEA to conduct panel data analysis, and it is also conducive to studying the dynamic changes of relative efficiency. It can be used to analyze the efficiency changes in different regions at different time stages. According to the Maimquist decomposition method proposed by R. Färe et al. (1992) expresses the Maimquist productivity index as follows:

$$M(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{\mathrm{D}^{t+1}(x_{t+1}, y_{t+1})}{\mathrm{D}^{t}(x_t, y_t)} \times [\frac{D^t(x_{t+1}, y_{t+1})}{D^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D^t(x_t, y_t)}{D^{t+1}(x_t, y_t)}]^{\frac{1}{2}} \tag{3}$$

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3. Indicator Selection and Data Sources

The research on innovation efficiency in high-tech industries has received considerable attention from scholars both domestically and internationally. The selection of input and output indicators is becoming increasingly mature. The selection of indicators in this article draws on the research results of scholars such as Ye Dan [8] and Hu Yan [9]. The selection of indicators is shown in the table below.

Table 1. Innovation Efficiency Evaluation Indicator System

Tier 1 indicators	Secondary indicators
Inputs	R&D funding
	R&D staff equivalent full time equivalent
	Expenditure on new product development
Output	Number of valid invention patents
	Number of new product development projects
	Revenue from new product sales

The innovation efficiency of high-tech industries is divided into two dimensions: innovation input and innovation output. The selection of indicators for measuring innovation efficiency investment is mainly considered from two perspectives: talent resources and capital investment. Talent resources are the backbone of innovation activities in high-tech industries. Scholars at home and abroad generally believe that the quantity and quality of talent resources directly determine the strength of technological innovation capabilities. Therefore, this article reflects the investment of innovative talent resources by converting R&D personnel into full-time equivalents. Capital investment is a necessary guarantee for innovation activities. Scholars such as Zhang Lijie believe that enterprise research and development funds or government funding support can significantly affect the innovation efficiency development level of high-tech industries. Therefore, this article uses R&D funds and new product development funds as indicators for capital investment. Among them, the development expenditure of new products is the main investment indicator to measure the innovation efficiency of China's high-tech industry

In the selection of output indicators, it is mainly considered from two dimensions: innovation achievements and economic output. The measurement of innovation achievements is the main indicator reflecting the innovation output of high-tech industries. China divides patents into three categories: design patents, utility model patents, and invention patents. Considering that invention patents can better reflect the output of innovation activities in a region, this article selects the number of effective invention patents and the number of new product development projects as representative variables in terms of innovation achievements. Economic output is the data that most intuitively reflects the output level of innovation activities. The higher the sales revenue of new products is, the higher the efficiency of input-output conversion is. Therefore, this article selects new product sales revenue as a representative variable in terms of economic output. Among them, the number of new product development projects and the sales revenue of new products are the main output indicators for measuring innovation efficiency.

The indicator data in this article is sourced from 28 provinces and cities in the 2017-2021 China National Statistical Yearbook (Hainan, Xinjiang, and Tibet were discarded due to some missing data)

4. Empirical Analysis

This article studies the dynamic analysis of the innovation efficiency of high-tech industries in 28 provinces and cities using the DEA-Malmquist index method. Based on the output orientation, the DEA model with variable returns to scale (VRS) is selected to obtain the total factor productivity change (TFPCH) of 28 provinces and cities in China from t to t+1. The decomposition method of R. Färe et al. (1992) and the decomposition method of R. Färe et al. (1994) obtained the Technical Efficiency Change Index (EFFCH) and the Technical Progress Change Index (TECH). The Technical Efficiency Change Index (EFFCH) can be further decomposed into Pure Technical Efficiency Change (PECH) and Scale Efficiency Change (SECH). Among them, the change in total factor productivity (TFPCH), also known as the M index, reflects the degree of productivity change in a certain decision-making unit from the t period to the t+1 period. When M>1, it indicates an upward trend in productivity from period t to period t+1; When M<1, it indicates a downward trend in productivity from period t to period t+1.

In summary, the change in total factor productivity (TFPCH) can be expressed as:

$$TFPCH=EFFCH\times TECH=PECH\times SECH\times TECH$$

The six input-output indicators in this article were calculated using software DEAP2.1 to obtain the national M index and mean values of each decomposition term for China's high-tech industry from 2017 to 2021, as well as the M index and mean values of each decomposition term for high-tech industry in 28 provinces and cities across the country, as shown in Tables 2 and 3.

Table 2. DEA-Malmquist Index and Decomposition of Innovation Efficiency in China's High tech Industry by Year

Year	EFFCH	TECHCH	PECH	SECH	M Index
2017-2018	1.007	0.988	0.980	1.027	0.995
2018-2019	0.953	1.084	0.979	0.974	1.033
2019-2020	0.999	1.081	0.992	1.007	1.079
2020-2021	1.037	0.975	1.039	0.998	1.011
Mean	0.999	1.030	0.997	1.001	1.029

According to the calculation results in Table 2, the M index of China's high-tech industry from 2017 to 2018 is 0.995<1. In terms of technical efficiency, the calculation result is 1.007>1. In terms of scale efficiency, the calculation results are 1.027>1. In terms of technological progress and pure technological efficiency changes, the calculation results are 0.988<1 and 0.980<1. The contribution of the M index in 2017 mainly relies on the progress of technological efficiency and scale efficiency. Between 2018 and 2019, the M index of China's high-tech industry was 1.033>1. The changes in pure technological efficiency, scale efficiency, and technological efficiency showed a significant downward trend between 2017 and 2018, all of which were less than the standard value of 1, with only a technological progress change index of 1.084>1. The M index in China between 2018 and 2019 showed a significant increase compared to the previous year, indicating that the increase in innovation efficiency between 2018 and 2019 mainly relied on the increase in industrial technology investment to improve the technological progress change index, which led to the rise of the M index. However, increasing technological investment has also led to a decrease in technological efficiency, further leading to a significant decrease in pure technological efficiency and scale efficiency. This may be because although the investment in technology has increased, China has not properly allocated the resources invested, resulting in a decrease in technological efficiency. Between 2019 and 2020, the M index was 1.079>1, showing an upward trend compared to the previous year. In terms of technical efficiency, the calculation result is 0.999<1; In terms of pure technological efficiency changes, the calculated result is 0.992<1. In terms of technological progress, the calculated result is 1.081>1; In terms of changes in scale efficiency, the calculation result is 1.007>1. Explain the promoting effect of technological progress and scale efficiency progress on the rise of the M index in China from 2019 to 2020. Between 2020 and 2021, the M index was 1.011>1.

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Although the M index was greater than 1, it showed a slight decrease in the level of improvement in innovation efficiency compared to the previous year.

Table 3. Malmquist Index and Decomposition of High tech Industry Innovation Efficiency in 28 Provinces and Cities of China in 2021

Region	EFFCH	TECHCH	PECH	SECH	M Index
Beijing	1.000	1.150	1.000	1.000	1.150
Tianjin	1.000	1.024	1.000	1.000	1.024
Hebei	1.081	1.016	1.055	1.025	1.098
Shanxi	1.027	0.968	1.026	1.001	0.994
Inner Mongolia	0.981	1.000	0.981	1.000	0.981
Liaoning	1.023	1.030	1.023	0.999	1.053
Jilin	1.000	1.047	1.000	1.000	1.047
Heilongjiang	1.040	1.107	1.040	1.000	1.150
Shanghai	0.928	1.093	0.976	0.951	1.014
Jiangsu	1.019	1.017	1.000	1.019	1.037
Zhejiang	1.000	1.102	1.000	1.000	1.102
Anhui	0.999	1.009	1.000	0.999	1.008
Fujian	0.985	1.045	0.969	1.016	1.030
Jiangxi	0.994	1.043	1.000	0.994	1.036
Shandong	1.062	1.023	0.998	1.065	1.086
Henan	1.018	0.949	0.975	1.044	0.966
Hubei	1.027	0.972	1.008	1.019	0.998
Hunan	0.981	1.010	0.959	1.023	0.990
Guangdong	1.000	1.043	1.000	1.000	1.043
Guangxi	1.000	1.016	1.000	1.000	1.015
Chongqing	0.979	1.042	0.975	1.005	1.021
Sichuan	0.973	1.049	0.969	1.004	1.020
Guizhou	0.983	0.996	0.994	0.989	0.979
Yunnan	0.975	1.032	0.982	0.992	1.006
Shaanxi	1.004	1.063	1.001	1.003	1.066
Gansu	1.070	1.007	1.075	0.995	1.078
Qinghai	0.934	1.053	1.000	0.934	0.983
Ningxia	0.901	0.972	0.929	0.969	0.875
Mean	0.999	1.030	0.997	1.001	1.029

In terms of technical efficiency, the calculation result is 1.037>1. In terms of pure technical efficiency changes, the calculation result is 1.039>1. In terms of technological progress, the calculated result is 0.975<1; In terms of changes in scale efficiency, the calculated result is 0.998<1. From 2020 to 2021, the decrease in technology investment in China has suppressed the rise of the M index. The development of the M index mainly relies on the progress of technological efficiency. At the same time, from the perspective of technological efficiency, it can be seen that the improvement of pure technological efficiency is the main reason for the increase in technological efficiency, while the scale efficiency shows a downward trend. This may be because pure technological innovation has squeezed out a portion of technologically backward enterprises, leading to a decrease in scale efficiency. From an overall analysis, China's high-tech industry maintained a stable upward trend from 2017 to 2021, with the average performance of the M index being 1.029>1. The contribution of technological progress to China's high-tech industry is greater than that of technological efficiency progress, indicating

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that at present, China's high-tech industry relies on technological investment to promote the development of innovation efficiency, and technological efficiency has not been effectively applied. In the process of technological research and development, improving scale efficiency is a key means to develop the technological efficiency of high-tech industries. At the current stage in China, high-tech industries should strengthen technological innovation and not overly rely on investment in funds and talent resources to promote the development of innovation efficiency. At the same time, in the stage of technological research and development, attention should be paid to industrial structure reform, strengthening the intensity of technological innovation, learning from excellent management methods from abroad, and allocating resources reasonably.

From Table 3, it can be seen that the overall innovation efficiency of 28 provinces and cities in China's high-tech industry is showing a stable upward trend, with an average M index of 1.029>1. At the same time, the data also reflects that the M index of innovation efficiency in China's high-tech industries is less than 1 in 8 provinces, namely Shanxi, Inner Mongolia, Henan, Hubei, Hunan, Guizhou, Qinghai, and Ningxia. If the M index of these 8 provinces and cities is less than 1, it indicates that the development of innovation efficiency is not objective and shows an overall downward trend. The following will conduct a specific analysis of these 8 provinces:

According to TFPCH=EFFCH × TECH knows that the M index of innovation efficiency is influenced by the level of technological efficiency and progress. Taking Inner Mongolia, Henan, and Hubei as examples, the innovation efficiency M index of these three provinces is less than 1, while the technological efficiency change index is greater than 1, and the technological progress change index is less than 1. This indicates that the level of technological innovation investment in these three provinces is relatively low, which can be manifested as insufficient talent resources, economic investment, etc., leading to lower overall innovation efficiency and a downward trend. The M index of innovation efficiency in Hunan and Qinghai is also less than 1, but their situation is opposite to the above three provinces. The index of technological progress change in Hunan and Qinghai is greater than 1, while the index of technological efficiency change is less than 1, indicating that the overall decline in innovation efficiency in the two provinces is due to the inadequate development of technological efficiency. The development level of technical efficiency can be decomposed into pure technical efficiency and scale efficiency. The pure technological efficiency change index in Hunan is less than 1, while the scale efficiency change index is greater than 1, indicating a lack of technological innovation activities in Hunan. The pure technological efficiency change index in Qinghai just reaches the standard value, while the scale efficiency change index is less than 1, indicating that the scale efficiency level of high-tech industries in Qinghai is relatively low. This may be due to Qinghai being located in the northwest of China, with underdeveloped economy and fewer large-scale enterprises, failing to leverage the scale effect to promote the development of technological efficiency. The M index of innovation efficiency in high-tech industries in Guizhou and Ningxia is less than 1, while the index of technological efficiency change and technological progress change are both less than 1, indicating that both technological efficiency and technological progress limit the development of innovation efficiency in these two provinces. This may be due to the fact that Guizhou is located in the southwest region and Ningxia is located in the northwest region. These two provinces have underdeveloped economies, resource shortages, and low technological investment. At the same time, large and medium-sized enterprises in these two regions are scarce, unable to leverage economies of scale to promote the development of innovation efficiency. It is also worth noting that the M index of innovation efficiency in high-tech industries in Ningxia is the lowest among 28 provinces and cities, with a value of 0.875<1. Based on reality, Ningxia Autonomous Region is constrained by historical reasons such as talent shortage, resource shortage, and economic backwardness. The government should provide policy support to Ningxia, introduce talents to absorb excellent management methods from other provinces, and introduce large enterprises to leverage economies of scale.

From Table 3, it can be seen that although the M index of innovation efficiency in high-tech industries in Shanghai, Anhui, Fujian, Jiangxi, Chongqing, Sichuan, and Yunnan provinces and cities is greater than 1, their technological efficiency change index is all less than 1, indicating that these seven provinces and cities have not played the role of technological research and development and excessively rely on technological resource investment to promote the development of innovation efficiency. These seven provinces and cities, during the technology research and development stage, did not make reasonable use of resources to carry out technological innovation activities, and their pure technological efficiency change index was generally lower than 1. Taking Shanghai as an example, considering the actual situation, Shanghai's economic investment and high-quality and highly educated talent resources are relatively sufficient, with a technological progress change index of 1.093>1. The level of technological resource investment is relatively high, but in the technology research and development stage, resources are not reasonably applied, and the technological efficiency change index is low. Shanghai should learn excellent management methods to allocate resources reasonably, while strengthening the intensity of technological innovation to promote the development of technological efficiency.

Analyzing the M index of innovation efficiency in high-tech industries in 28 provinces and cities in China, it was found that the change index of technological progress is generally greater than the change index of technological efficiency. Currently, the development of innovation efficiency in high-tech industries in China mainly relies on technological progress, with low technological efficiency. From the perspective of technological efficiency, it can be seen that some provinces in China, such as Beijing and Hebei, have a change index of technological efficiency greater than the standard value of 1, indicating that the resource allocation in these regions is reasonable and the degree of resource conversion is high. However, the change index of technological efficiency in some provinces and cities such as Shanghai and Anhui is less than the standard value of 1, indicating that the resource allocation in these regions has a relatively low promoting effect on technological efficiency, has not played its due role, has insufficient resource conversion capacity, and lacks the implementation of innovative activities, resulting in a low level of technological research and development. From the perspective of technological progress, it can be seen that the change index of technological progress in most provinces and cities in China is greater than 1, indicating that technological progress in China has a promoting effect on the innovation efficiency of high-tech industries, and the level of technological investment is relatively reasonable. According to R The decomposition method of R. Färe et al. (1994) further decomposes the technical efficiency to obtain EFFCH=PECH×SECH. From the perspective of pure technological efficiency, it can be seen that only 7 provinces and cities in China have a change index of pure technological efficiency greater than the standard value of 1. The overall level of pure technological efficiency in China is relatively low, indicating that pure technological efficiency in various provinces and cities has a inhibitory effect on innovation efficiency. 28 provinces and cities should improve resource utilization, introduce excellent management methods, increase the ability to allocate resources reasonably, and promote resource transformation and technological innovation. From the perspective of scale efficiency, it can be seen that the scale efficiency change index of 10 provinces and cities in China is less than 1. This may be due to China's recent industrial structure reform and technological innovation activities, which have squeezed out some technologically backward enterprises. However, over time, technological innovation and resource investment play a role, and scale efficiency will begin to rise. At the same time, some regions have underdeveloped economies and lack capital to introduce enterprises to improve scale efficiency and promote economies of scale. This may also lead to a change in scale efficiency index less than 1, indicating that the

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government should play a leading role in providing policy advantages to attract large-scale enterprises to settle and promote the development of scale efficiency.

5. Conclusion and Suggestions

This article uses software DEAP2.1 to analyze the input and output indicators of 28 provinces and cities in China using the DEA-Malmquist index method. Based on the above analysis, the following conclusions and suggestions are drawn:

The overall innovation efficiency of China's high-tech industry showed an upward trend from 2017 to 2021. At present, China mainly relies on technological progress, that is, technological investment to promote the development of innovation efficiency. The conversion rate of resource investment is not high, so the level of technological efficiency is relatively low. Further analysis of technological efficiency reveals that the development level of pure technological efficiency and scale efficiency in China's high-tech industries is not high, which limits the development of innovation efficiency. Although China has put forward the development slogan of technological innovation in recent years and further increased investment in talent resources and research funds, the management methods of China's high-tech industry are outdated, and there is no reasonable allocation of resources to carry out technological innovation activities, resulting in waste of resources and low conversion rate of resource achievements. At the same time, the high-tech industry also needs high-quality and highly educated scientific research and innovation talents. The lack of innovative talents makes it difficult to convert scientific research achievements into new product development projects and sales revenue, which limits the overall development of innovation efficiency. China's high-tech industry should take the path of independent innovation, absorb excellent management methods from both domestic and foreign sources, strengthen the exchange of experiences between provinces and cities that promote high and low innovation, allocate resources reasonably, carry out technological innovation activities to develop economies of scale, and not overly rely on technological investment to promote the development of innovation efficiency. At the same time, the government should strengthen investment in higher education, cultivate more high-quality and highly educated innovative talents, and further improve the conversion rate of scientific research achievements.

There are significant differences in the development of high-tech industry innovation efficiency among 28 provinces and cities in China. Economically developed provinces and cities in the eastern region, such as Beijing, Shanghai, Guangdong, and Jiangsu, rely on regional conditions and policy support to obtain excellent technology investment resources. The investment of technology resources ensures that the innovation efficiency of these provinces and cities in the eastern region maintains a high-quality development level. However, due to historical reasons, western regions such as Yunnan and Ningxia have a shortage of talents and backward economy, resulting in insufficient investment in technological resources. This is an important reason for their low level of innovation efficiency and development. Therefore, the government should introduce supportive policies for these backward provinces, increase technological investment in western backward areas, utilize policy advantages to attract enterprises to develop economies of scale, introduce high-quality and highly educated talents, and carry out innovation activities to promote the efficient and effective development of high-tech industry innovation.

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