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Innovation efficiency analysis of capital intensive manufacturing industry based on DEA and Malmquist index--Take Shaanxi Province as an example

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Abstract: *The innovation development of capital intensive manufacturing industry is an important driving force to promote the transformation of manufacturing industry in Shaanxi Province. In this paper, DEAP2.1 software and DEA-Malmquist model are used to make static analysis of innovation efficiency, pure technology efficiency and scale efficiency of five major capital-intensive sub-industries in Shaanxi Province during 2015-2020 from static and dynamic perspectives. And the dynamic analysis of efficiency change, technology change and their product total factor productivity of five major sub-industries is carried out to get the decomposition of capital intensive manufacturing industry in different industries and time in Shaanxi Province. Therefore, the research conclusion is drawn: the comprehensive innovation efficiency of capital intensive manufacturing industry in Shaanxi province is low, the innovation level is not high, and the scale efficiency value is low. The change of pure technical efficiency has a significant impact on the change of total factor productivity. Therefore, in order to improve the value of total factor productivity, theoretically speaking, we should always pay attention to the fluctuation of pure technical efficiency, and put forward suggestions for the development of capital intensive manufacturing industry in Shaanxi Province from the aspects of talent, technological innovation and resource allocation.*

Keywords: *DEA; Malmquist index; Innovation efficiency*

1. Introduction

Capital-intensive economy is characterized by the large proportion of investment needed in products, the small proportion needed in labor, the small consumption of resources, strong competitiveness and other advantages. It is one of the standards for measuring our social productive forces and one of the important ways to improve our social productive forces. The development of capital intensive industry is inseparable from the development of advanced production equipment, production technology and the enhancement of employee innovation efficiency. With the development of social economy in our country, overall improvement of education level and decrease of working-age population, labor-intensive manufacturing industry which was dominant gradually does not conform to historical development trend, then is gradually replaced by capital-intensive manufacturing industry which mainly produces with capital investment. Therefore, in the context of technology - and capital-intensive manufacturing, Vision 2035 calls for strengthening manufacturing, developing new models of manufacturing, promoting the transformation and upgrading of manufacturing, encouraging manufacturing enterprises to promote advanced technologies, and promoting the optimization and establishment of industrial clusters in key manufacturing industries. The Fifth Plenary Session of the 19th Central Committee of the Communist Party of China proposed to unswervingly build a strong manufacturing country, improve innovation, and build a strong country in science and technology.

At present, labor-intensive manufacturing industry still occupies a large proportion in Shaanxi's manufacturing industry. Under the background of scientific and technological innovation-driven development, the labor-intensive industrial structure is gradually not in line with the general trend of contemporary scientific and technological innovation and development. Innovation efficiency of capital intensive manufacturing industry refers to the output and innovation results obtained by input of certain production factors under the environment of innovation development of capital intensive manufacturing industry. Improving the innovation efficiency of capital-intensive manufacturing industry can speed up the transformation and upgrading of Chinese manufacturing industry and promote the improvement of

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innovation efficiency of capital-intensive manufacturing industry in Shaanxi province. Therefore, vigorously developing capital-intensive manufacturing industry is an important way to improve our social productive forces and enhance our international competitiveness among countries. According to statistics, in 2019, the income of industrial enterprises above designated size in Shaanxi Province was 2,496.157 billion yuan, and the number of patent applications was 10,182. However, the operating income created by the capital intensive manufacturing industry was 2,166.96 billion yuan, and the number of patent applications by the capital intensive manufacturing industry in Shaanxi Province was 9,455. They account for 87 percent of the revenue of industrial enterprises in Shaanxi Province and 93 percent of patent applications. It can be seen that the innovative development of capital-intensive manufacturing industry plays an important role in the economic development of Shaanxi Province. Therefore, under the environment of rapid economic development and changing customer and market demand, it is necessary to improve the innovation ability of manufacturing industry and the efficiency of input capital and output in order to effectively promote the transformation and upgrading of the economic structure and industrial structure of Shaanxi Province. By analyzing the innovation efficiency of capital intensive manufacturing industry in Shaanxi Province, we can find the deficiencies of the development of capital intensive manufacturing industry in Shaanxi Province at the present stage, and based on this, we can provide reference for the deficiencies of other industries. Therefore, this paper uses DEA method and Malmquist index model to study the innovation efficiency of capital intensive manufacturing industry in Shaanxi Province.

2. Literature review

The innovation efficiency of manufacturing industry has been concerned by academic circles for many years. At present, the evaluation index of manufacturing innovation efficiency is mainly divided into two aspects: regional selection division and index system framework division. At present, the research field of manufacturing innovation efficiency mainly focuses on the dynamic research of manufacturing input-output efficiency. For example, Georgia Makridou conducts a two-stage analysis of five capital-intensive manufacturing industries in EU countries.[1] The first stage is based on DEA methods that allow the differentiation of efficiency and technology over time. In the second stage, the cross-classification and multi-level model is used, and according to the DEA analysis results, the department efficiency is comprehensively improved within a certain period of time. Diaz Ricardo F analyzed the innovation efficiency of the pharmaceutical industry during 2010-2018, selected the data types of different types, different sizes and different European companies, and calculated the annual enterprise efficiency score through non-parametric data enveloping analysis technology, and reached the conclusion that during 2010-2018, The efficiency of large manufacturing companies is significantly higher than that of small and medium-sized companies and the average efficiency has been declining. [2] Chenyang and Chenyang analyzed the innovation efficiency value of China's regional equipment manufacturing industry with cluster analysis, and concluded that innovation is an important condition to promote the development of manufacturing industry, and the market has a very obvious influence on the innovation efficiency value of China's manufacturing industry. Peng Xiaojing applied DEA-Malmquist method to analyze the input-output efficiency values of large-scale manufacturing industries in the manufacturing industry of Hebei Province from 2014 to 2017, and concluded that from the static point of view, the average innovation efficiency of the 27 sub-industries is lower than 1, indicating that the comprehensive technical efficiency is not high, but the value is still growing and has a certain space for development. From the dynamic point of view, the change range of each sub-industry of manufacturing industry in Hebei Province is quite different, the overall trend is rising, but the overall level of innovation is not high, there is still room for further development. Fu Sen conducted industry and time decomposition of manufacturing sub-industries in Ningxia Hui Autonomous Region from 2009 to 2018 and concluded that innovation efficiency of manufacturing industry in Ningxia Province still maintained growth on the whole, but it still had a certain degree of adverse impact on productivity due to factors such as scale combination and backward technology.[3]Therefore, the government should actively guide the manufacturing industry in Ningxia to develop in the right direction, let enterprises actively research and development, learn to innovate, and promote the "production, education and research" at the same time. He Yanzi evaluated and analyzed the innovation efficiency of manufacturing industry in Hunan Province from 2011 to 2019 and concluded that, from the static point of view, the R&D level of most sub-industries in Hunan Province is low and the efficiency of resource allocation is relatively unreasonable. From the dynamic point of view, the improvement of the manufacturing industry in Hunan Province is a fluctuating situation, and the scale efficiency values of several sub-industries are all greater than 1. Therefore, the manufacturing industry in Hunan Province still needs to enhance the awareness of innovation to promote sustainable development.

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In the process of evaluating DEA innovation efficiency of manufacturing industry, there are great differences in the construction of index system among different industries. For example, Zhang Qiqi measured the innovation efficiency of Chinese pharmaceutical industry by taking the personnel input and internal expenditure of 140 samples from 28 provinces and cities during 2014-2018 and the number of enterprises of research institutions as input indicators, and patent applications and sales as output indicators.[4] When Wang Xue measured the input-output efficiency of Chongqing real estate, he took the existing fund situation, the existing constructable area and the total purchased area as the input index, and the total sales amount and the total completed area as the output index. [5] When Wang Qi conducted DEA financial efficiency research on new energy vehicles, because inventory could not be directly used as a measurement index of financial investment efficiency research, he took input financial scale and inventory turnover as input indicators respectively, and the growth rate of total assets and annual operating income as output indicators.[6] When Gu Shixiang measured the efficiency of water resources utilization in central Yunnan and constructed the index system, he considered water consumption, area and population, and finally took the input index as agricultural water consumption, total planted area of agricultural products and total population engaged in agriculture.[7] The output index is the final number of annual agricultural products harvested. When Li Na analyzes the efficiency of the logistics industry along the Belt and Road, she takes the number of employees in the logistics industry and the investment expenditure for the logistics industry as the input index, and the sales volume, passenger volume and turnover of the logistics industry as the output index based on the experience of previous scholars and the consideration of personnel, capital and distance. When Wang Rui conducted research on the efficiency measurement of scientific research funds in universities, he took the input of funds, full-time staff and the number of projects as the input indicators, and the number of patents granted, the number of annual income and the number of published papers as the output indicators.When LAN Hai studied the efficiency of scientific and technological innovation in Qinghai Province, the input index was set as the number of input capital and input personnel, and the output index was set as the final income and the number of patents and papers applied.

At present, Chinese academic circles have studied the innovation efficiency and the problems existing in the digital transformation of the input-output of labor - and technology-intensive manufacturing industry to a certain extent, but there are few studies on the innovation efficiency of capital-intensive manufacturing industry. Based on this, this paper analyzes five representative capital-intensive manufacturing sub-industries in Shaanxi Province. This paper finds out the main factors affecting the development of capital intensive manufacturing industry in Shaanxi province, and puts forward countermeasures based on the analysis and the development status of capital intensive manufacturing industry in Shaanxi Province, so as to promote the transformation and development of manufacturing industry and improve the innovation efficiency and production efficiency.

3. Research methods

3.1. DEA theoretical model

DEA model is a method that can be used to measure the input-output efficiency of various industries. It was proposed by A. Charnes and his colleagues in 1978. Its main purpose is to study the efficiency of various industries with more input and more output. It is mainly to obtain the optimal input-output efficiency through comparison, list the inequality set, and take it as an indicator when the front surface is obtained according to the results. If it is within the index, DEA is effective; if it is not within the index, DEA can be regarded as invalid. Then, the final efficiency value can be calculated by calculating the distance between the DEA invalid point and the previously measured index. Finally, the weighted calculation is carried out to obtain the ratio as the conclusion value. Because the capital-intensive manufacturing industry in our province can use the index of more input more output to measure the efficiency value, so this is an extremely efficient way to evaluate the capital-intensive manufacturing industry in our province. At the current stage, in view of the different assumptions made under different conditions, CCR and BCC model are set as two sub-models of DEA model. Therefore, when the return to scale is variable, the advantages of BCC can be shown at this time. Generally speaking, BCC model can be obtained by perfecting CCR model.

Malmquist index analyzes the changes of the research object from the perspective of horizontal and vertical dynamics. In this paper, Malmquist index is used to analyze the time and industry change decomposition of capital-intensive manufacturing industry in Shaanxi Province from the dynamic perspective.

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3.2. Index selection

In recent years, many scholars have disagreed on the evaluation index of innovation efficiency. This paper is based on the opinions of scholars Xiao Meidan (2019), [8]Yang Yang (2020) [9]and Shi Wen (2021), and capital-intensive manufacturing industry is characterized by high input and strong innovation. In combination with the enterprise innovation research and development and transformation process, this paper takes personnel and fund input as the input index. The number of converted patents obtained and income are output indicators. Input and output indicators are selected according to the experience of most previous scholars and combined with science, availability and accuracy.

Input index: This paper evaluates the innovation efficiency of capital-intensive manufacturing industry, and studies the innovation efficiency from the main direction of personnel and capital, which has certain representativeness. When evaluating the innovation efficiency of manufacturing industry, the index can be generally selected as the full-time equivalent of R&D personnel. At the same time, the internal expenditure of R&D funds can be selected as the capital index to measure the investment in manufacturing industry. Therefore, considering the accessibility and comprehensibility of data, the most representative indexes representing the innovation efficiency of capital intensive manufacturing industry in Shaanxi Province are the internal expenditure of R&D funds and the total number of R&D personnel, because these indexes represent the intensity of investment of funds with a certain degree of practicality and accuracy.

Output index: Generally speaking, the most direct income representing the output efficiency of the manufacturing industry is sales income. In view of the availability of data and the difficulty in obtaining alternative indicators through comprehensive analysis, this paper also selects patents as output indicators. Due to the strict conditions of patent application, it is of certain target value to select patents as output indicators. Patent generally represents the current enterprise innovation and output. Is the most direct output reflecting the level of innovation. At the same time, the putting into use of innovative achievements is ultimately reflected as the income obtained for the enterprise, so the sales income of new products can also be used as an indicator of innovation output. The results are shown in Table 1.

Table 1: Technical innovation efficiency index of capital-intensive manufacturing industry

Counter Type	Counter code	Indicates the counter
The input index	X1	R&D personnel is equivalent to the full-time equivalent
	X2	Internal expenditure of R&D funds
Output index	Y1	Output index patent applications
	Y2	Y2 new product sales revenue

3.3. Sources of data

Jia Zhangke's film aesthetics has always been in a dynamic process of change, from "underground production" to "mainstream society", from the first film "Xiao Shan Goes Home" to "Three plays in Hometown", from the "World" after release to the "Mountains May Depart", Jia Zhangke's film style has always maintained concern for the real society. However, with the constant changes of society, Jia zhangke's career and thoughts also change with The Times and social development. He said, "I am not immutable. I should take pictures of myself at this moment, even if I am not thoughtful and not fully understood."

4. Empirical analysis

4.1. DEA-BCC was analyzed annually

In this paper, data of five major industries of capital intensive manufacturing industry in Shaanxi Province during 2016-2020 are selected as samples to calculate DEA innovation efficiency value, and then DEAP2 is used. 1. Specific calculations are made and the results are as follows:

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Table 2: Innovation efficiency value of capital-intensive manufacturing industry in Shaanxi Province from 2015 to 2020

		crste	vrste	scale	
Equipment manufacturing industry	2015	0.928	1	0.928	drs
	2016	0.791	0.812	0.975	irs
	2017	0.535	0.653	0.819	irs
	2018	0.313	0.321	0.974	irs
	2019	0.559	0.77	0.726	drs
	2020	0.324	0.327	0.991	irs
	The average value	0.575	0.647	0.902	
Electrical machinery and equipment manufacturing	2015	0.790	1	0.928	drs
	2016	1	1	1	
	2017	0.952	1	0.952	drs
	2018	0.69	1	0.69	drs
	2019	0.626	1	0.626	drs
	2020	1	1	1	
	The average value	0.843	1	0.866	
Automobile manufacturing industry	2015	1	1	1	
	2016	1	1	1	
	2017	1	1	1	
	2018	1	1	1	
	2019	1	1	1	
	2020	1	1	1	
	The average value	1	1	1	
Automobile manufacturing industry	2015	1	1	1	
	2016	0.266	1	0.266	irs
	2017	1	1	1	
	2018	1	1	1	
	2019	1	1	1	
	2020	1	1	1	
	The average value	0.878	1	0.878	
Electricity, heat, production and supply industries	2015	1	1	1	
	2016	0.693	1	0.693	irs
	2017	0.893	1	0.893	irs
	2018	0.294	0.339	0.868	irs
	2019	0.389	0.452	0.859	irs
	2020	1	1	1	
	The average value	0.712	0.8	0.89	

Table 2 mainly analyzes the calculated values of the five representative industries of capital-intensive manufacturing industry in the past six years, which are successively the value of innovation efficiency, followed by the value of pure technical efficiency and scale efficiency. From the perspective of comprehensive innovation efficiency, the comprehensive innovation efficiency value of these five industries during 2015-2020 is not high. This indicates that the comprehensive innovation efficiency value of capital-intensive manufacturing industry in Shaanxi Province is not high, the capital innovation resource efficiency of Shaanxi province is low, and the resource utilization is unreasonable. From the perspective of comprehensive innovation efficiency, the equipment manufacturing industry has the lowest innovation efficiency value, which is only 0.575, followed by power production, heat supply industry, electrical machinery manufacturing and device and material manufacturing industry, which are 0.712 and 0.843, respectively. The fields with the highest comprehensive innovation efficiency value are

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oil and gas mining industry and automobile manufacturing industry, 0.878 and 1, respectively. The development of automobile manufacturing industry is the most stable, the comprehensive innovation efficiency value is always 1, followed by natural gas and oil underground mining industry, except for 0.266 in 2016, the rest are all 1. The remaining three sub-industries have a large fluctuation range, showing a wave wave.

The relationship among the three efficiency values is analyzed according to the formula comprehensive innovation efficiency = pure technical efficiency * scale efficiency. From the perspective of the automobile manufacturing industry, the pure technical efficiency and scale efficiency of the automobile manufacturing industry during 2016-2020 are both 1, and the comprehensive innovation efficiency of each year is also 1. Therefore, the average value of comprehensive innovation efficiency of automobile manufacturing industry is also 1, indicating that comprehensive innovation efficiency is not only affected by scale efficiency, but also greatly affected by pure technical efficiency. It can be seen from the table that the scale efficiency in 2016 was 0.266, and the pure technical efficiency was 1 during 2016-2020. The average value of comprehensive innovation efficiency was the same as that of pure technical efficiency except that it was 0.266 in 2016. This shows that the oil and gas mining industry is mainly affected by scale efficiency. In the electrical appliances and equipment manufacturing industry, the pure technical efficiency is always 1. With the change of scale efficiency, the comprehensive innovation efficiency value also changes, which indicates that the change of the comprehensive innovation efficiency value of the electrical appliances and equipment manufacturing industry is consistent with the scale efficiency. The electric power production and thermal production and supply industries are affected by both pure technical efficiency and scale efficiency changes in a wavy manner. Scale efficiency and pure technical efficiency of equipment manufacturing industry have been relatively low during 2016-2020, with an average value of less than 1, which is at a low level. Therefore, innovation efficiency is related to scale efficiency and pure technical efficiency to a certain extent. As can be seen from the chart, the innovation efficiency values of the five sub-industries all show a trend from high to low to high, which indicates that the capital-intensive manufacturing industry in Shaanxi Province is still in the stage of rapid development and still has a large space for innovation. The innovation efficiency value is mainly affected by the change of scale efficiency, indicating that the low scale efficiency is an important factor affecting the development of innovation efficiency.

4.2. Malmquist index decomposition

Table 3: Malmquist index and breakdown table of capital-intensive manufacturing industry in Shaanxi Province from 2015 to 2020

year	effch	techch	pech	sech	tfpch
2015-2016	0.724	0.562	0.990	0.731	0.407
2016-2017	1.255	2.185	0.957	1.311	2.743
2017-2018	0.675	1.033	0.699	0.965	0.697
2018-2019	1.164	1.373	1.262	0.923	1.598
2019-2020	1.189	0.915	0.987	1.205	1.088
The average value	0.968	1.098	0.962	1.006	1.062

Total factor productivity (Tfpch) = efficiency change (effch) * Technology change (techch). If the value of Tfpch is larger than 1, it indicates that the ratio of capital input to total factor output is higher; if the value of total factor productivity is smaller than 1, it indicates that the capital input total factor productivity of capital-intensive manufacturing industry in Shaanxi Province decreases. Table 3 shows that the average annual total factor productivity of the capital-intensive manufacturing industry in Shaanxi Province from 2016 to 2020 is 1.062, and most of the annual total factor productivity is greater than 1, indicating that the total factor productivity has been significantly improved in the past five years, and the capital-intensive manufacturing industry in Shaanxi Province has achieved good development and enhanced sustainability. However, at the same time, the mean value of technological change is 1.098>1, while the mean value of efficiency is 0.968<1, indicating that the improvement of total factor production efficiency is mainly affected by technological change. The development of capital-intensive manufacturing industry in Shaanxi Province from 2016 to 2020 benefits from technological progress, while low efficiency restricts the improvement of production efficiency of capital-intensive manufacturing industry in Shaanxi Province. Therefore, In the development of capital intensive manufacturing industry in Shaanxi Province, we should focus on improving scale efficiency and production innovation.

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Technical efficiency is affected not only by the change of pure technical efficiency, but also by the change of scale efficiency. The relationship between the three can be expressed as scale efficiency sech multiplied by the result of pure technical efficiency pech as the technical efficiency value. It can be seen from Table 3 that the mean value of pure technical efficiency change is 0.962, the value of scale change efficiency is 1.006, while the mean value of efficiency change is 0.968 and the mean value of efficiency change is less than 1, which indicates that the low efficiency of capital-intensive manufacturing industry in Shaanxi Province from 2016 to 2020 is mainly due to the low efficiency of pure technical change. Therefore, In order to improve the innovation efficiency of capital intensive manufacturing industry in Shaanxi province, we should focus on the level of pure technical efficiency. At the same time, the innovation efficiency of capital intensive investment should be improved, and the technological development level should be improved to really apply the technological innovation to the development of capital intensive manufacturing industry in Shaanxi Province, so as to reduce the efficiency loss rate.

Table 4: Malmquist index and breakdown table of capital-intensive manufacturing industries in Shaanxi Province from 2015 to 2020

Industry	effch	techch	pech	sech	tfpch
Equipment manufacturing industry	0.81	1.049	0.799	1.013	0.85
Electrical and Equipment Manufacturing	1.048	1.162	1.032	1.016	1.218
Automobile Manufacturing Industry	1	1.218	1	1	1.218
Oil and Gas Extraction	1	1.032	1	1	1.032
Electricity and Heat Production and Supply Industry	1	1.041	1	1	1.041
The average value	0.968	1.098	0.962	1.006	1.06

As can be seen from Table 4, the industries whose total factor productivity index is larger than 1 include electrical manufacturing, appliance and material manufacturing, automobile manufacturing, oil and gas underground mining, and power and heat production and supply. However, only one industry is smaller than 1, which is equipment manufacturing industry, with a value of 0.85 and an average annual reduction of 15%. Moreover, the pure technical efficiency change index has an obvious impact on the change of total factor productivity of this industry. Except the technical efficiency change index of equipment manufacturing industry, which is less than 1, the other four industries are all greater than 1. It shows that technical efficiency change index has great influence on the negative change rate of total factor production in equipment manufacturing industry. The indexes of electrical manufacturing, appliance and material manufacturing are all greater than 1, and the technological progress change index has the most obvious influence, with a value of 1.162. In addition to the average increase of the technological progress change index of the automobile manufacturing industry is 21.8%, the other three decomposition indexes are basically unchanged, all of which are 1, so the automobile manufacturing industry has a good development trend. The electric power and thermal generation industry, oil and natural gas underground mining industry, and these two industries are all stable, with an average of 1. The analysis shows that the rate of change of technological progress plays the biggest role in the total factor productivity growth of each industry, except that the technological progress change index increases by 3.2% and 4.1% respectively.

5. Conclusions

Based on the DEA-Malmquist model, this paper calculates the 2015-2020 data of the capital-intensive manufacturing industry in Shaanxi Province, and draws the comprehensive innovation efficiency, scale efficiency, pure technical efficiency and dynamic changes of the capital-intensive manufacturing industry in Shaanxi Province, and draws the following conclusions according to the calculated results:

First, from the static point of view, the comprehensive innovation efficiency of capital-intensive manufacturing industry in Shaanxi province is low. The ranking of innovation efficiency is automobile manufacturing industry, oil and gas underground mining industry, electrical appliance and material manufacturing industry, electric power production and supply industry, and equipment production and manufacturing industry. The comprehensive innovation efficiency value of all industries differs greatly, and the innovation efficiency value of automobile manufacturing industry is the highest, which is 1. The comprehensive innovation efficiency value of equipment manufacturing industry is the lowest, and

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except the comprehensive innovation efficiency value of automobile manufacturing industry is 1, the other four major capital intensive manufacturing industries are all less than 1, so it can be seen that the overall innovation efficiency of capital intensive manufacturing industry in Shaanxi province is not high, and the resource allocation is unreasonable. The main reason for this situation is the impact of scale efficiency, which ranks automobile manufacturing industry > equipment manufacturing industry > electric power production and supply industry > oil underground mining industry > electrical appliance and material manufacturing and production industry. Besides, except automobile manufacturing industry, the scale efficiency of the other four major capital-intensive manufacturing industries in Shaanxi Province is about 0.9, indicating low scale utilization efficiency. But generally speaking, the development situation of each industry is good, there is still a large space for development.

Second, according to Malquist time decomposition, the development of technology-intensive manufacturing industry in Shaanxi Province is mainly affected by technological changes, and the total factor productivity is developing in a wavy way, but the overall trend is rising. However, the low scale efficiency indicates that the overall resource allocation efficiency of capital-intensive manufacturing industry in Shaanxi Province is low and the resource allocation is unreasonable. This indicates that although Shaanxi Province has invested a large amount of new technology and new equipment in the capital-intensive manufacturing industry of Shaanxi Province, it has not realized the scale allocation of resources according to the development situation of the industry.

Third, according to Malquist industry decomposition, the total factor productivity of capital intensive manufacturing industry in Shaanxi Province ranks in the following order: appliance and material manufacturing industry = automobile manufacturing industry > electricity and thermal supply industry > underground natural gas mining industry > heavy industry equipment manufacturing industry. Except for the negative growth of total factor productivity of equipment manufacturing industry, The other four industries all achieved a certain degree of growth. The equipment manufacturing industry was mainly restricted by the development of technical efficiency, while the other four industries all achieved a certain degree of development under the influence of technological progress.

It can be analyzed from the conclusion that in order to promote the better development of capital-intensive manufacturing industry in Shaanxi Province, it is necessary to introduce talents, improve the comprehensive allocation efficiency and increase the investment in technological innovation. The suggestions are as follows:

First, strengthen talent introduction. Innovation and development cannot be separated from the promotion of high-tech talents. If we want to make progress in the field of independent innovation, we must take measures to introduce talents. First, we should cooperate with scientific research universities to establish a service platform for production, education and research, so as to continuously push advanced scientific and technological talents to the manufacturing sector. The second is to strengthen the allocation of scientific research funds, take certain incentive measures to retain the capital intensive manufacturing industry, and improve the internal control system of funds.

Second, rational allocation, planning and utilization of resources. Low comprehensive innovation efficiency is mainly affected by scale efficiency. Rational allocation of resources to optimize resource utilization, improve resource scale allocation efficiency, and improve resource innovation utilization level are important ways to improve the comprehensive innovation efficiency of manufacturing industry. To improve the efficiency of resource utilization innovation, not only the society needs to pay attention to the efficiency of resource utilization innovation, but also the government needs to guide. First, we should give full play to the government's macro-control, strengthen guidance, and guide the allocation of resources according to the development of industries in various regions of the market. Second, we will encourage the flow of resources. Strengthen the exchange and transaction of resources, make the mutual flow of resources in various industries to achieve the optimal surplus value, so as to rationally allocate resources and improve scale efficiency.

Third, increase investment in technological innovation. The development of capital-intensive manufacturing industry depends on technological innovation to a large extent, increase the investment of capital and talents in each sub-industry of technology-intensive manufacturing industry, and promote the development of capital-intensive manufacturing industry in Shaanxi Province to the direction of independent innovation. Improve the research and development capacity and innovation capacity of each sub-industry of Shaanxi Province's own intensive manufacturing industry. However, since each sub-industry has different requirements for technological development, it is required to invest according to the actual situation of technology-intensive manufacturing sub-industries, and blind research and development should be avoided.

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