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Research on Management and Determination of Industrial Total Factor Productivity in China

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Abstract. Under the background of supply-side reform and industrial development realization 4.0, this paper studies China's overall industrial total factor productivity and tryt to provide a factual basis for the current management of national economic industries. Thus, this paper uses the panel data of 17 industrial industries in China (matched according to the 2017 China National Economic Industry Classification Standard and the International Industry Classification Standard) from 2000 to 2014, and uses the DEA Manmquist index method to measure the change of total factor productivity. The purpose of this paper is to deeply analyze its composition, evolution and law of total factor productivity and give factual support for current policy on the supply side reform and transformation of economic development mode. Research facts and conclusions can be drawn as follows: First, the overall total factor productivity gradually declines after 2008, indicating that the overall growth rate of China's industry slows down. Second, during the period 2000-2014,there are significant industry differences in total factor productivity. In the period from 2000 to 2008,the TFP of the industrial sector with low technical complexity increased rapidly, and the overall performance was better than other industries. Since 2008, the total factor growth rate of industries with high technical complexity has steadily increased, represented by pharmaceutical, machinery and equipment manufacturing, which are significantly higher than other industries. According to the empirical results, it is necessary to vigorously develop industries with high-precision industries and high R&D investment to promote the overall level of total factor productivity in the industrial sector and accelerate the transformation and upgrading of China's economy.

Introduction

Since 2014, China's economy has entered a period of transformation and shifting. The Chinese government has put forward a development strategy of "focusing on improving total factor productivity" to foster a new impetus for economic development. Even though the economic growth rate is lowered but the production efficiency is improved, the welfare of enterprises, governments and people can still maintain or approach the level of the period of rapid economic growth. It can be seen that under the background of China's economic development and upgrading, the research on the development of total factor productivity is particularly urgent. Many scholars have proposed that the core task of cultivating new impetus for economic development is to increase the efficiency of production and transform the economic growth model from factor input to total factor productivity. So how to accurately define total factor productivity? How to accurately measure the change in total factor growth rate? How should total factor productivity be decomposed? In this regard, the purpose of this paper is to decompose total factor productivity on the basis of accurately defining and measuring the growth rate of total factors, analyze the behind changes and give factual supports.

Research literature review

The most valuable study of total factor productivity is about growth rates, because the issue of growth has always been one of the core issues of national economic management[1].The fundamental task of total factor productivity estimation is to evaluate input-output efficiency. The first accepted measure of total factor productivity is the SR method proposed by Solow (1957), who derives the TFP growth rate expression under the assumption of full competition and constant scale returns[2]. The function was later called the "Solow residual".

Fare et al. (1994) measured the TFP by using data envelopment analysis combined with exponential method based on constructing DEA Malmquist index[3].The Malmquist index is designed to evaluate the efficiency of decision making for many different "input" and "output" variables. It constructs a DEA best effective production frontier from sample statistics to measure efficiency changes and technological changes. The advantage of this method is that overcomes the shortcomings of the strong theoretical assumptions in growth accounting, and it can also decompose total factor productivity into technological efficiency changes and technological advances, and further analyze the reasons for productivity changes.

Definition of total factor productivity

Solow (1957) pointed out that the growth rate of total output is determined by the growth rate of three factors of production, including capital, labor and technological changes; The part of "residual value" of production growth rate that cannot be explained by labor and capital growth rate, can be attributed to the result of technological change, that is "total factor productivity", and "residual value" is therefore called "Solow residual". Thus, total factor productivity in this paper refers to the additional productivity growth rate achieved when the input level of tangible production factors such as capital and labor are determined. The specific formula is as follows.

The production function can be expressed as:

$$Y = A * F(L, K, R) \tag{1}$$

Among them, the output indicator is Y, the input indicator is labor L, capital K and land resource R, and A indicator represents total factor productivity.

The proposal about TFP provides new ideas for analyzing the source of economic growth, and can help identify whether a country's economic growth belongs to “input-type growth” or “efficient growth”, and whether the quality of growth is sustainable and sustainable. Therefore, the importance of TFP has received increasing attention in recent years.

Determination of Total Factor Productivity - Data Envelopment Analysis

Decomposition of total factor productivity. In this paper, the DEA Mandquist index method constructed by Fare is used to measure the change of total factor productivity. The Malmquist Productivity Index (tfpch, TFP) can be decomposed into technical changes (techch, TC) and technical efficiency changes (effch, EC), which in turn can be further decomposed into pure technical efficiency changes (pech, PE) and scale efficiency changes (sech,SE), namely:

$$TFP = TC \times EC = TC \times PE \times SE \tag{2}$$

Among them, when the technical efficiency changes or the technical level changes by more than 1, it means that they are the source of TFP growth, and vice versa is the reason for the decline of TFP (the pure technical efficiency change and the scale efficiency change explain the same technical efficiency change).Scale efficiency reflects the gap between the actual size of the decision-making unit and the optimal production scale. Therefore, the change in scale efficiency measures the ability of the enterprise to adjust to the optimal production scale,namely the ability to approach the economies of scale,and reflects the impact of changes in firm size factors on its productivity.

Indicator setting and processing of total factor productivity. According to the 2017 China National Economic Industry Classification Standard and the International General Industry Classification Standard, a total of 17 industrial sectors have been matched(Specific industry matching is shown in Table 1), including 15 manufacturing industries, the mining industry and the utilities supply industry. According to the DEA method, the total output value of the industry (unit: 100 million yuan) is taken as the output index, and the total industrial assets (unit: 100 million yuan), the average annual number of employees (unit: 10,000 people) and the total energy consumption (10,000 tons of standard coal) are respectively input indicators. The data period is from 2000 to 2014 from the China Statistical Yearbook and the China Industrial Statistical Yearbook.The research objects are 17 industrial sectors.

Table 1 17 sub-industry matching tables

Code	Industry	Code	Industry
C05-09	Mining and quarrying	C24	Basic metals
C10-12	Food products, beverages and tobacco	C25	Fabricated metal products, except machinery and equipment
C13-15	Textiles,wearing appare,leather and Related Products	C26	Computer, electronic and optical products
C16-18	Wood,paper,pringting and peproduction of recorded media	C27	Electrical equipment
C19	Coke and refined petroleum products	C28	Machinery and equipment n.e.c.
C20	Chemicals and chemical products	C29-30	Motor vehicles, trailers,emi-trailers and Other transport equipment
C21	Pharmaceuticals, medicinal chemical and botanical products	C31-33	Furniture, other manufacturing and repair, and installation of machinery and equipment
C22	Rubber and plastic products	C35-39	Electricity, natural gas and water supply; sewage treatment, waste management and remediation activities
C23	Other non-metallic mineral products		

Analysis of China's industrial TFP results

In this paper, the DEA-Malmquist index method is used to measure total factor productivity,and the results are directly derived from DEAP2.1 software. Table 2 visually shows total factor productivity for each year from 2000 to 2014:

Table 2 TFP index and growth of China's 17 industrial segments in four specific years

	TFP				TFP growth rate		
Industry	2000	2007	2008	2014	Mean	Max	Min
C05-09	1.551	1.001	1.078	1.037	-0.0013	0.2777	-0.4242
C10-12	1.036	1.135	1.076	1.008	0.0026	0.1762	-0.2359
C13-15	1.09	1.065	1.037	0.992	-0.0059	0.0758	-0.0731
C16-18	1.025	1.132	1.059	1.027	0.0024	0.0969	-0.1667
C19	1.65	1.021	1.083	0.996	-0.0259	0.2122	-0.3521
C20	1.158	1.089	1.052	0.976	-0.0081	0.0893	-0.2074
C21	1.032	1.17	1.053	1.11	0.0085	0.1319	-0.1199
C22	1.048	1.09	1.049	0.982	-0.0027	0.0963	-0.1254
C23	1.375	1.148	1.069	0.986	-0.0137	0.2211	-0.2698
C24	1.107	1.068	1.063	0.974	0.0011	0.2949	-0.2225
C25	1.074	1.07	1.052	0.932	-0.0077	0.0766	-0.1561
C26	1.133	0.947	0.973	1.016	0.0069	0.612	-0.2471
C27	1.108	1.092	1.016	1.075	0.013	0.6359	-0.2433
C28	1.055	1.058	1.048	1.053	0.0416	0.6101	-0.6031
C29-30	1.043	1.178	0.995	1.081	0.0173	0.5583	-0.2466
C31-33	1.011	1.049	1.066	0.978	0.0352	1.0872	-0.3495
C35-39	1.086	1.175	1.057	1.073	0.0051	0.2852	-0.2385

From Table 2 above, the following facts can be obtained:

First,after 2008, the total factor productivity of the whole industry has gradually become smaller, especially in 2014, the change in total factor growth rate of most industries is less than one.

Second,during the period of 2000-2014, the TFP indices of 17 industries vary greatly, and the annual average is different.Mining, agricultural and sideline food processing, wood bamboo and rattan brown grass products, petroleum coal The total factor productivity of the fuel processing industry showed a downward trend; the total factor productivity of the two industries of electrical machinery manufacturing and equipment manufacturing was the most stable; the most outstanding performance of the pharmaceutical manufacturing industry was the highest in the total factor growth from 2008 to 2014.

Industrial TFP Index Decomposition and Policy Suggestions

Total factor productivity decomposition. According to the decomposition principle of Eq. 2, we obtain the TFP decomposition results as shown in Table 3:

In the first part, the first five columns of table 3 are the TFP and its decomposition of the industry as a whole from 2000 to 2014. We can see that the annual index of the TFP column is greater than 1, indicating that the total factor productivity of the industry is increasing every year. However, for each decomposition index, the SE of the scale efficiency index is the smallest and less than 1; the TC average of the technical change index is the largest, and the pure technical efficiency index PE is the second. Explain that China's industry as a whole, the scale effect has not been well played, and the economic benefits brought about by the expansion of scale have not been realized in industrial production.

In the second part, the last five columns of table 3 are the TFPs of 17 industrial segments and their decomposition. It can be seen that there is a big difference in TFP in each industry. For example, the TFP of the C35-39 industry reaches 1.138, and the TFP of the C25 industry is only 1.033, indicating that there is difference in the total factor productivity of each industry. The TFP index of the C27, 28, and 29 industries is at a medium-high level, indicating that the production efficiency of these industries with high technical complexity shows a steady growth trend every year.

Table 3 Decomposition of China's industrial sector by year and by industry TFP index

Year	EC	TC	PE	SE	TFP	Industry	EC	TC	PE	SE	TFP
2000	0.985	1.157	0.993	0.992	1.139	C05-09	1.01	1.076	1.006	1.004	1.087
2001	0.994	1.062	0.992	1.002	1.056	C10-12	1.008	1.064	1.000	1.008	1.072
2002	1.005	1.092	1.012	0.993	1.098	C13-15	1.004	1.043	1.000	1.004	1.048
2003	0.958	1.149	0.979	0.978	1.101	C16-18	1.016	1.043	1.015	1.001	1.06
2004	1.061	1.053	1.11	0.956	1.117	C19	1.000	1.108	1.000	1.000	1.108
2005	1.006	1.076	0.981	1.026	1.083	C20	1.01	1.052	1.025	0.986	1.062
2006	0.947	1.132	0.989	0.958	1.072	C21	1.013	1.073	1.000	1.013	1.086
2007	1.14	0.952	1.062	1.073	1.086	C22	1.007	1.042	1.007	1.000	1.049
2008	1.023	1.025	1.009	1.014	1.048	C23	1.022	1.05	1.022	1.000	1.074
2009	1.029	1.012	1.026	1.003	1.041	C24	1.014	1.053	1.038	0.977	1.067
2010	0.998	1.065	1.001	0.997	1.063	C25	0.996	1.041	0.997	0.998	1.037
2011	1.005	1.082	1.004	1.001	1.087	C26	1.000	1.054	1.000	1.000	1.054
2012	0.991	1.034	1.004	0.986	1.024	C27	1.008	1.058	1.000	1.008	1.067
2013	1.024	1.02	1.007	1.017	1.044	C28	1.016	1.061	1.016	1.000	1.078
2014	1.006	1.01	1.006	1.000	1.016	C29-30	1.027	1.069	1.026	1.001	1.098
						C31-33	0.999	1.034	1.000	0.999	1.033
						C35-39	1.031	1.105	1.038	0.993	1.138
Mean	1.011	1.06	1.011	0.999	1.071		1.011	1.06	1.011	0.999	1.071

Conclusions. According to the results of the calculation and decomposition of total factor productivity,the conclusions are as follows:

First,The industry as a whole is in a state of uneconomic scale, and the scale effect is the key factor to curb the increase of total factor productivity; therefore, supply-side reform should be vigorously carried out at present, the industrial investment structure should be adjusted, the invalid investment should be reduced, and the scale effect should be suppressed.

Second,After 2007, the overall technical efficiency is improving, which is mainly due to the reform of production enterprises, organizational forms and the accumulation of human capital.

Third,Industrial technology has made remarkable progress. The improvement of total factor productivity is mostly caused by technological changes. It can be seen that the production technology of Chinese industry has been greatly improved.

The scale effect of China's industrial input-driven growth model is not prominent, making the total factor productivity, which is one of the important sources of economic growth, unable to improve, and the factor-driven growth mode is difficult to continue. In the future, China's industrial economic growth must achieve a virtuous circle, and it is necessary to vigorously carry out supply-side reforms and adjust the input structure of factors.It is urgent to use the national industrial innovation center as a fulcrum and cultivate a new engine for industrial development to realize the rational layout of the national economy industry.

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