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The relationship between industrial structure upgrading, rationalization and total factor productivity

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Abstract: *Using the panel data of 31 provinces from 2000 to 2020, this paper first calculates the total factor productivity using LP method, and then calculates the industrial structure upgrading index and industrial structure rationalization index. The relationship between rationality of industrial structure, multilevel of industrial structure and total factor productivity is studied by using the vector autoregressive model. Finally, it is found that there is a two-way relationship between the upgrading of industrial structure, rationalization of industrial structure and total factor productivity. The upgrading of industrial structure and rationalization of industrial structure can promote the growth of TFP to some extent, but the upgrading of industrial structure that is too advanced is not conducive to the improvement of enterprise TFP and the coordination and development of industries.*

Keywords: *Industrial structure rationalization; Advanced industrial structure; Total factor productivity*

1. Introduction

Total factor productivity (TFP) is a very important index to measure economic production efficiency, which is mainly used to study the influence of other factors other than labor and capital input factors on the increase of output. From a macro perspective, there are two driving forces for TFP growth: the efficiency of technological progress and the efficiency of industrial restructuring. In the economic sense, the efficiency of technological progress refers to the relationship between input and output: it means that the output is maximized under the given input, or the input is minimized under the given production. The efficiency of industrial restructuring is also known as the efficiency of resource reallocation: due to the differences in productivity between different industrial sectors, in order to achieve the goal of optimal allocation of resources, factors need to be constantly flowing and allocated between different sectors, so as to promote the development of the entire economy in terms of output and quality. At present, China's three industries have basically realized the dual-driven development mode of the second industry and the third industry in terms of output value, but there is still a big gap between the rationalization level and the advanced level of industrial structure development and that of Western developed countries, which is highlighted for high-end industries that rely on technological innovation. Manufacturers on the market are often unable to provide the supply of products needed by consumers, and for those low-end industries that do not need core technology, there are often too many products to sell out. Therefore, as China's economic growth momentum has shifted from the pursuit of quantity to the pursuit of quality, insisting on quality first and efficiency first, effectively transforming the development mode, and exploring how to promote the improvement of total factor productivity through the optimization and upgrading of industrial structure has become an important issue for China to achieve sustainable development.

2. Literature review

In terms of the correlation between industrial structure and total factor productivity, since the high-quality development strategy was put forward, the existing literature has generally focused on the macro-economy and the industry as a whole in terms of research scope, focused on the country or region in terms of research object, and mostly focused on theoretical research such as policy recommendations and action paths in terms of research content. Domestic and foreign scholars have conducted research from different angles, which can be summarized as follows: First, most scholars have confirmed the existence of "structural dividend" in the process of industrial structure adjustment. For example, CAI Fang's research on China's economic growth since the reform and opening up shows that the main part of the total factor productivity shown in China's economic growth so far is the efficiency of industrial

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restructuring brought about by the transfer of labor from agriculture to non-agricultural industries.[1] Second, some scholars used different econometric models to measure the productivity respectively,[2] and selected appropriate indicators to reasonably measure the level of industrial structure rationalization and industrial structure upgrading, then studied the relationship between industrial structure and total factor productivity, and came to the conclusion that the importance of the impact of industrial structure changes on the growth of total factor productivity varies with the difference in development level.[3]

Therefore, this paper draws on existing literatures, uses LP method to measure China's total factor productivity index from 2000 to 2020, and builds a multivariate PVAR model on the basis of reasonable measurement of industrial structure changes, in order to discover the dynamic relationship between industrial structure and total factor productivity.

3. Research design

3.1. Index Selection

3.1.1. Total factor productivity

In this paper, lp method is used to calculate the total factor productivity of enterprises, and the model is set as follows:

$$\ln y_{it} = \beta_0 + \beta_w \ln w_{it} + \beta_s \ln s_{it} + f\{h(s_{i,t-1}, m_{i,t-1})\} + e_{it} \quad (1)$$

3.1.2. Measurement of industrial structure rationalization

Theil Index, also known as Theil fan, has been used by some scholars to study regional income disparities.[4] Theil Index is a good index to measure the rationality of industrial structure. The calculation formula is defined as follows:

$$TL = \sum_{i=1}^{n} \left(\frac{Y_i}{Y}\right) \ln\left(\frac{Y_i}{L_i} \Big/ \frac{Y}{L}\right) \quad (2)$$

In formula (2), Y represents output value, L represents employment, i represents industry, and n represents the number of industrial sectors.

3.1.3. Measurement of industrial structure upgrading

In this paper, the ratio of output value of tertiary industry to output value of secondary industry (briefly referred to as TS in this paper) is used as a measure of industrial structure upgrading.[5]

3.2. Data Description

All samples in this paper are 21 years of sample data from 31 provinces and cities from 2000 to 2020 (excluding Hong Kong, Macao and Taiwan). The data are derived from Historical Data of China's GDP Accounting (1952----2004), Compilation of Statistical Data of the past 60 Years of New China, Statistical Yearbook of China, statistical Yearbook of various provinces and websites of various statistical bureaus, etc. The output part is the gross domestic product, and the input includes labor input and capital input.

3.3. Model Setting

Since In TFP, ln x1 and ln x2 are all first-order single integral sequences, this paper establishes PVAR model for the first-order difference of each variable. According to BIC criterion, AIC criterion and QIC criterion, the maximum lag period of the model is determined to be 2. The VAR(2) model with three variables is represented as follows:

$$y_t = \mu + A_1 y_{t-1} + A_2 y_{t-2} + \varepsilon_t \quad (3)$$

In the formula, y_t = (dln TFP, dln x1, dln x2), t is the year, A_1 and A_2 both represent the 2×2 maintenance matrix, μ is the 2-dimensional intercept term coefficient matrix, and ε_t is the 2-dimensional "white noise" disturbance term.

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4. Empirical results and analysis

4.1. Determination of lag order

Table 1: Determination of lag order.

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	0.9999911	139.289	9.46E-06	-323.7449	-10.71096	-100.7578
2	0.9999973	74.49345	0.0139194	-234.1959	-25.50655	-107.5378
3	0.9999997	30.54511	0.2045259	-123.7995	-19.45489	-60.47051

As shown in Table 1, according to BIC criteria, AIC criteria and QIC criteria, the maximum number of hysteretic periods of the model is determined to be 2.

4.2. Stability test of PVAR model

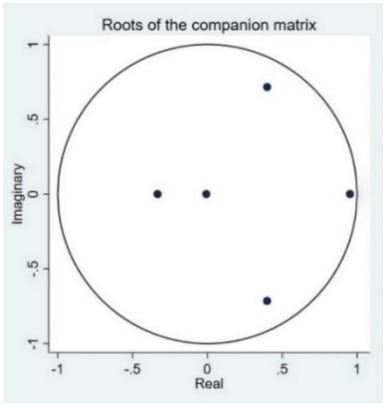

Figure 1: Stability test of the model.

As shown in Figure 1, all the unit roots are inside the unit circle, indicating that the model passes the stability test.

4.3. Granger causality test

Table 2: Granger causality test.

null hypothesis	chi2	df	Prob>chi2	conclusion
In TFP is not a Granger cause for ln x1	1.3800	2	0.000	reject
In TFP is not a Granger cause for ln x2	1.4160	2	0.0003	reject
In x1 is not a Granger cause for In TFP	0.7940	2	0.0002	reject
In x1 is not a Granger cause for ln x2	2.2730	2	0.2210	accept
In x2 is not a Granger cause for In TFP	11.6590	2	0.0000	reject
In x2 is not a Granger cause for ln x1	11.9640	2	0.2311	accept

As can be seen from the test results in Table 2, there is a two-way causal relationship between the upgrading of industrial structure, the rationalization of industrial structure and the total factor productivity. It shows that the adjustment and upgrading of industrial structure will lead to the change of total factor productivity to a certain extent, and the change of total factor productivity will also react to the industrial structure to a certain extent.

4.4. Impulse response analysis

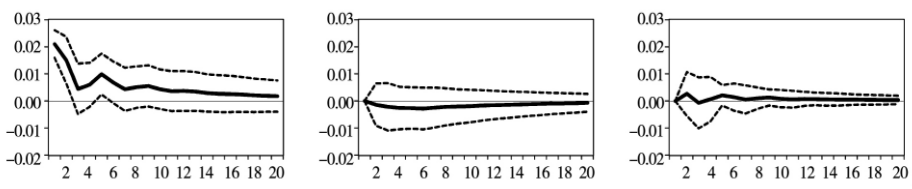

Figure 2: Response of ΔIn TFP, Δln x1, Δln x2 to ΔIn TFP.

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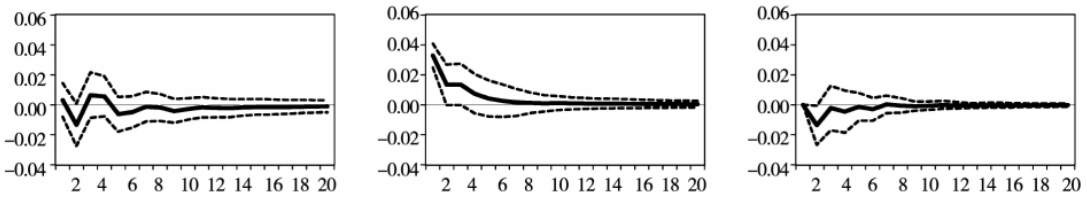

Figure 3: Response of ΔIn TFP, Δln x1, Δln x2 to Δln x1.

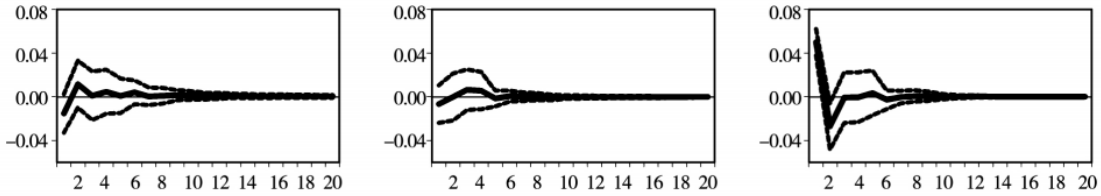

Figure 4: Response of ΔIn TFP, Δln x1, Δln x2 to Δln x2.

The impact response of total factor productivity to itself and the rationalization and upgrading of industrial structure is shown in Figure 2. The response of total factor productivity to its own shock is always positive, and it decreases rapidly after reaching its peak in the first period, and slightly weakens between the third and ninth periods, and approaches 0 in the 20th period. The impact effect of one standard deviation of industrial structure rationalization on total factor productivity shows a weak negative effect of gradually decreasing trend. After a positive impact on the upgrading of industrial structure, the total factor productivity fluctuated slightly in the first 8 periods, and declined to 0 around the 10th period. This shows that in the long run, total factor productivity has a self-cumulative promotion effect; The optimization and adjustment of industrial structure is a cyclic and gradual process, and the excessive pace of industrial structure adjustment will cause irreversible negative effects on the growth of total factor productivity. The upgrading of industrial structure has a continuous positive effect on the growth of total factor productivity.

The impact response of industrial structure rationalization to itself, total factor productivity and industrial structure upgrading is shown in Figure 3. The impact response of industrial structure rationalization to itself has always been positive, weakened after reaching a peak in the first stage, and approached 0 in the eighth stage. After the positive impact of one standard deviation on the total factor productivity, the rationalization of industrial structure showed a decline trend of positive and negative fluctuation in the first 5 periods, and approached 0 in the 10th period. The impact effect of one standard deviation of industrial structure upgrading on the rationalization of industrial structure shows a weak negative effect of declining trend. In other words, in the long run, the improvement of the rationalization level of industrial structure has a self-promotion mechanism.

The impact response of industrial structure upgrading to itself, total factor productivity and industrial structure rationalization is shown in Figure 4. Different from the first two, the impact of the upgrading of industrial structure on itself is not always a positive response. Specifically, the fluctuation range of the first two periods is sharp, and it is at the highest point at the beginning of the impact, and then it quickly falls to the lowest negative point in the next period, and then gradually adjusts to the zero value. The impact of one standard deviation of total factor productivity on the upgrading of industrial structure immediately reaches the negative lowest point at the beginning, and then quickly adjusts to the positive highest point in the next period, and then fluctuates slightly, approaching 0 in the 10th period. After a shock to the rationalization of industrial structure, the industrial structure advanced gradually adjusted from negative to positive, weakened after reaching a peak in the 4th phase, and approached 0 in the 8th phase. In the long run, the upgrading of industrial structure does not have self-reinforcing inertia; The rationalization of industrial structure and total factor productivity have similar effects on the upgrading of industrial structure, both of which have short-term fluctuations and long-term promotion effects.

5. Conclusion and enlightenment

This paper empironally analyzes the impact of industrial structure change on total factor productivity and draws the following conclusions: 1) The rationalization of China's industrial structure and the growth rate of total factor productivity have the characteristics of path dependence, while the upgrading of

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industrial structure has the form of "creative destruction". 2) The growth rate of total factor productivity has different influence paths on the rationalization and upgrading of industrial structure. The effect of the growth rate of total factor productivity on the improvement of the rationalization level of industrial structure is manifested as a positive promotion mechanism to a negative inhibition mechanism, while the latter is the opposite. 3) The interaction between the rationalization of industrial structure and the upgrading of industrial structure has asymmetric characteristics, that is, the rationalization of industrial structure has a short-term restriction effect on the optimization and upgrading of industrial structure and a long-term promotion effect, while the advanced service of industrial structure has been unfavorable to the improvement of the rationalization level of industrial structure.

Based on the above research conclusions, this paper puts forward the following suggestions: 1) Promoting the transformation and upgrading of China's industrial structure is of great benefit to improving the overall economic quality of China, and the upgrading of industrial structure is the key to improving China's total factor productivity, which should be placed in a more important position. 2) To realize the transformation and upgrading of industrial structure in China, we should not only further promote the improvement of labor market and capital market, but also optimize the allocation of resources among industries; At the same time, it is also necessary to increase investment in research and development and promote the continuous upgrading of China's industrial structure with technological innovation as the driving force. 3) The rationalization of industrial structure is the basis of the upgrading of industrial structure, and the optimization and upgrading of industrial structure is a dynamic process; Therefore, in the process of China's industrial structure adjustment, we should follow the objective law of economic service, pay close attention to the interaction and stability of the service industry and industry and agriculture, and be alert to the advance development of the service industry, so as to effectively promote the improvement of total factor productivity and achieve quality economic growth.

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