Analysis of the Relationship between Industrial Structure Optimization and Economic Growth in Shandong Province Based on VAR Model

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Abstract: The econometric model VAR model was used to explore the relationship between industrial structure optimization and economic growth in Shandong Province. Firstly, the Taier index and structural similarity coefficient are used to quantitatively analyze the rationalization and heightening of industrial structure in Shandong Province. Secondly, by constructing VAR model and analyzing the economic data of Shandong Province from 1978 to 2016, the relationship between industrial structure and economic growth is analyzed. The analysis results show that since the reform and opening, the rationalization and heightening of the industrial structure of Shandong Province have shown the characteristics of overall increase but staged fluctuations, both of which can promote economic growth. There is a mutual promotion between the rationalization of industrial structure and economic growth, and the one-way relationship between industrial structure heightening and economic growth, and the contribution of industrial structure rationalization to economic growth is much higher than heightening.

1. Introduction

As a major economic province in China, Shandong Province is also a large industrial province. However, in the development process of Shandong Province, the industrial structure shows that the heavy industry raw material industry develops rapidly, and the light industry, especially the high-end manufacturing industry and high-tech industry, is slow to develop. In recent years, the state of domestic economic growth has gradually changed from high-speed and high-volume to steady-structure growth. Under this background, the economic growth level of Shandong Province has changed from the original high-speed to the medium-high-speed growth, and the key to promoting economic stability and high-quality sustainable growth lies in Promote the adjustment of industrial structure and improve the efficiency of resource utilization, so as to drive the transformation of economic development power to realize the transformation of new and old kinetic energy. In this process, external highlighting and internal rationalization of industrial structure have different effects on the economic development. Therefore, objectively describing the relationship between industrial structure and economic growth through the method of econometrics from a scientific perspective is a major and urgent issue for the current and future period.

2. Model Construction and Data Selection

2.1. Construction of Rationalization Model of Industrial Structure.

As a common index to measure the income gap between individuals or regions, the Theil index can well evaluate the inequality among different subjects. One of the greatest advantages of using this index to measure inequality is that it can measure the contribution of the internal and inter-group disparities to the total disparity. Moreover, the index is restricted by strict conditions and the data collection is more convenient, so it can be used to measure the inequality. It is used to measure the different importance of three industries in the economy. TL stands for Theil index, below is his calculation formula:

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

Among them, Y_i/Y represents the proportion of output value of each industry, L_i/L represents the labor share of each industry, and Y_i/L_i represents the labor productivity of each industry.

In the process of calculating the rationality of industrial structure in Shandong Province, it is necessary to take into account the different importance of different industries, and to retain the mathematical basis and economic connotation of the degree of deviation. Therefore, we take the proportion of the three industrial output values to the total output value as the weight. The value of the Theil index ranges from 0 to 1. The smaller the calculation result, the lower the deviation of each industry, that is, the higher the rationalization among industries.

2.2. Construction of the Heightening Model of Industrial Structure.

The highlighting of industrial structure is the dynamic process of industrial structure upgrading. Combined with the specific characteristics of industrial structure upgrading in Shandong Province, this paper uses the structural similarity coefficient method proposed by Fu Linghui (2010), which is the angle cosine method to measure the index. In the process of calculation, the proportion of the three major industrial output values to GDP is calculated first, which is used as a component $X_0=(x_{1,0}\quad x_{2,0}\quad x_{3,0})$ in the space vector; Then define $X_1=(1\quad 0\quad 0)$、$X_2=(0\quad 1\quad 0)$、$X_3=(0\quad 0\quad 1)$ to indicate the evolution of the industrial structure from the primary industry to the tertiary industry; Finally calculate the angle θ_1、θ_2、θ_3 between the vector X_0 and the vector X_1、X_2、X_3. The index of the industrial structure is defined as W, and the calculation result of W is larger, indicating that the higher the level of industrial structure in Shandong Province , the W calculation results are determined by the following two formulas.

$$\theta_j=\arccos\left(\frac{\sum_{i=1}^{3}\left(x_{i,j}\bullet x_{i,0}\right)}{\left(\sum_{i=1}^{3}x^2_{i,j}\right)^{1/2}\bullet\left(\sum_{i=1}^{3}x^2_{i,0}\right)^{1/2}}\right),(j=1,2,3) \quad (2)$$

$$W=\sum_{k=1}^{3}\sum_{j=1}^{k}\theta_j \quad (3)$$

2.3. Construction of VAR Model.

In the process of analysis, this paper first quantifies the industrial structure of Shandong Province and the indicators of industrial structure and then constructs the VAR model, and uses Eviews8.0 software to empirically analyze the relationship between industrial structure optimization and economic growth in Shandong Province. The model establishment and analysis process is as follows:

Calculate the indicators TL and W that represent the rationalization and heightening of industrial structure in Shandong Province.

Data selection and processing. In the analysis process, the per capita GDP value of Shandong Province since the reform and opening up is used as the economic growth index. In order to eliminate the influence of price fluctuation factors, the nominal per capita GDP is treated as a deflator to obtain the actual per capita GDP. In the application process of the VAR model, in order

to eliminate the heteroscedasticity phenomenon in the time series and enhance the data linearization trend, the natural logarithm of all the data is taken.

Carry out the stability test of the time series data industrial structure rationalization TL, the industrial structure heightening W, and the economic growth index PGDP. If the time series is not stable and there is the same order single integer, then it is necessary to continue to analyze the cointegration relationship between variables. , that is, whether there is a long-term equilibrium relationship between variables.

Analyze the relationship between industrial structure advancedization and economic growth through impulse response function.

Further analysis of the variance response analysis of the impulse response function results.

The model(the VAR model)used to analyze the relationship between industrial structure optimization and economic growth in Shandong Province is as follows:

$$\begin{pmatrix} \ln GDP \\ \ln TL \\ \ln W \end{pmatrix} = \Pi_1 \begin{pmatrix} \ln GDP_{t-1} \\ \ln TL_{t-1} \\ \ln W_{t-1} \end{pmatrix} + \Pi_2 \begin{pmatrix} \ln GDP_{t-2} \\ \ln TL_{t-2} \\ \ln W_{t-2} \end{pmatrix} + \ldots + \Pi_p \begin{pmatrix} \ln GDP_{t-p} \\ \ln TL_{t-p} \\ \ln W_{t-p} \end{pmatrix} + U_t \tag{4}$$

The dependent variable is the logarithmized economic growth, industrial structure rationalization and high-level indicators, and the explanatory variable is the p-order lag variable of the indicator; Π_p is the Pth square matrix to be estimated, and U_t is the white noise sequence column vector.

2.4. Data Selection.

In this paper, the nature of time series analysis and the reality of industrial structure development in Shandong Province are considered in the analysis process. Statistics from 1978 to 2016 are selected. The data mainly includes GDP per capita, output value of each industry, and the number of laborers in various industries.

3. Empirical Study on Industrial Structure Optimization in Shandong Province

3.1. Econometric Analysis of Industrial Structure Rationalization in Shandong Province.

This paper first uses the Theil index to measure and analyze the level of industrial structure rationalization in Shandong Province since the reform and opening up. The calculation results are shown in Figure 1.

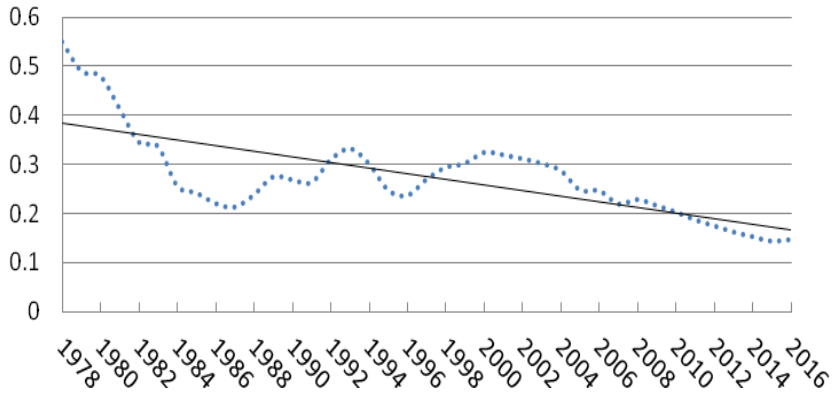

Figure 1. TL from 1978 to 2016 in Shandong Province

It can be seen from the figure that the Theil index generally shows a downward trend, but there is a staged phenomenon in the process of decline. This reflects that the industrial structure of Shandong Province has gradually developed towards rationalization since the reform and opening up, but there have been stage changes in the development process. We divided it into three phases

according to the changes in the Theil index, the first phase from 1978 to 1986, the second phase from 1987 to 2000, and the third phase from 2001 to 2016. In the first stage, due to reform and opening up, the planned economic system that originally restrained the development of productive forces was transformed into a market economic system, which greatly increased the input quantity and factor efficiency of production factors, and the level of rationalization of industrial structure in Shandong Province increased significantly; In the second phase, Shandong Province is in the transition period of Shandong's industrial structure. During the process of continuing to explore and effectively improve the industrial structure, there is a short-term fluctuation in the level of industrial structure rationalization; The third stage is in the new era of the 21st century. Shandong Province has entered the industrialization medium-term factor input structure more reasonable, but at this stage the level of industrial structure rationalization has risen slowly.

3.2. Econometric Analysis of the Heightening of Industrial Structure in Shandong Province.

The angle of cosine method is used to measure the heightening of industrial structure in Shandong Province. The calculation results are shown in Figure 2.

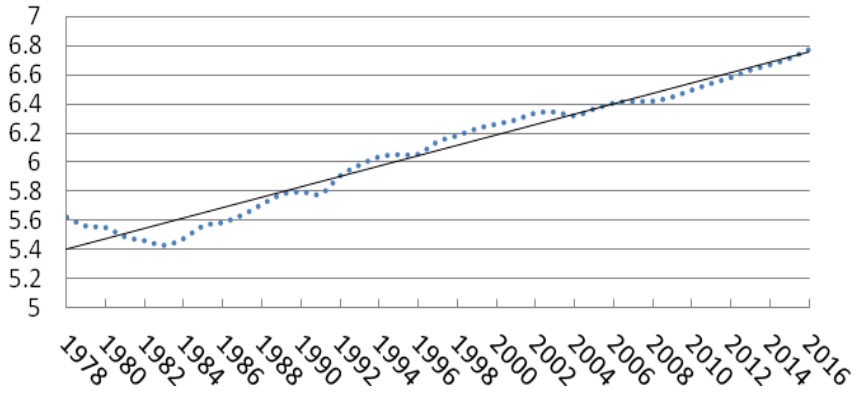

Figure 2. W from 1978 to 2016 in Shandong Province

It can be seen from Figure 2 that the level of the heightening of industrial structure in Shandong Province is generally on the rise. Similar to the level of rationalization of industrial structure, the level of heightening is still staged. According to calculation results of the heightening of industrial structure in Shandong Province, we divided it into three stages: 1978-1990 first stage 1978-1990, second stage 1991-2003, and third stage 2004-2016. From the analysis results, the stages of industrial structure upgrading in Shandong Province are postponed in various stages of rationalization. In the following, we will explain the reasons for this phenomenon in Granger causality analysis. The first stage belongs to the second industry in the early stage of industrialization in Shandong Province, and there is a slight fluctuation in the level of high level in this stage; The second phase is at a time when industrialization continues to be promoted. The deep-seated systemic contradictions in the reform are gradually emerging, causing the level of industrial structure to rise in volatility; In the third stage, with the continuous development of the new industrialization road, the industrial structure is highly stable and shows a steady upward trend.

4. An Empirical Analysis of the Relationship between Industrial Structure Optimization and Economic Growth in Shandong Province

4.1. Feasibility Analysis of VAR Model Construction.

This paper tests the stability of Shandong's economic aggregate GDP and industrial structure through the ADF test, and confirms the long-term stable relationship between Shandong's industrial structure and economic growth through the Johansen Test. The analysis results are shown in Table 2

and Table 3.

Table 2 ADF stationarity test

variable	Prob value	1% threshold	5% threshold	10% threshold	conclusion
LnPGDP	0.9021	-3.626784	-2.945842	-2.611531	non-stationary
lnTL	0.4621	-3.621023	-2.943427	-2.610263	non-stationary
lnW	0.9939	-3.615588	-2.941145	-2.609066	non-stationary
△LnPGDP	0.0139	-3.626784	-2.945842	-2.611531	stationary
△lnTL	0.0016	-3.621023	-2.943427	-2.610263	stationary
△lnW	0.0010	-3.621023	-2.943427	-2.610263	stationary

Table 3 Johansen Cointegration Test Results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.489723	37.98628	29.79707	0.0046
At most 1	0.315979	13.76542	15.49471	0.0896
At most 2	0.002603	0.093834	3.841466	0.7593

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

4.2. Granger Causality Test.

The results of the Granger causality test calculated by Eviews 8.0 are shown in Table 4.

Table 4 Granger causality test results

Null hypothesis	F statistic	Prob value	Conclusion
LnTL does not Granger Cause LnPGDP	2.32336	0.0426	Refuse
LnPGDP does not Granger Cause LnTL	5.44614	0.0018	Refuse
LnW does not Granger Cause LnPGDP	1.01558	0.0433	Refuse
LnPGDP does not Granger Cause LnW	3.57387	0.0143	Accept
LnW does not Granger Cause LnTL	3.21170	0.0225	Refuse
LnTL does not Granger Cause LnW	1.30433	0.3004	Accept

From the results of the Granger causality test in the table, there is the following causal relationship between the rationalization ,heightening and economic development in Shandong Province: there is a two-way Granger causality between the rationalization of industrial structure and GDP per capita in Shandong Province .The relationship between them is mutually reinforcing; there is a one-way Granger causal relationship between the heightening of industrial structure in Shandong Province and per capita GDP, and the heightening can promote per capita GDP growth, but per capita GDP growth is not the cause of industrial structure upgrading; the rationalization and heightening of industrial structure in Shandong Province is also a one-way Granger causal relationship. The rationalization and high degree of industrial structure in Shandong Province is also a one-way Granger causal relationship. The industrial structure is highly rationalized, the opposite is not true. This also verifies the phased inconsistency presented by the rationalization and heightening of the industrial structure in Shandong Province.

4.3. Impulse Response Function Analysis.

Figure 4 shows the results of the impulse response analysis.

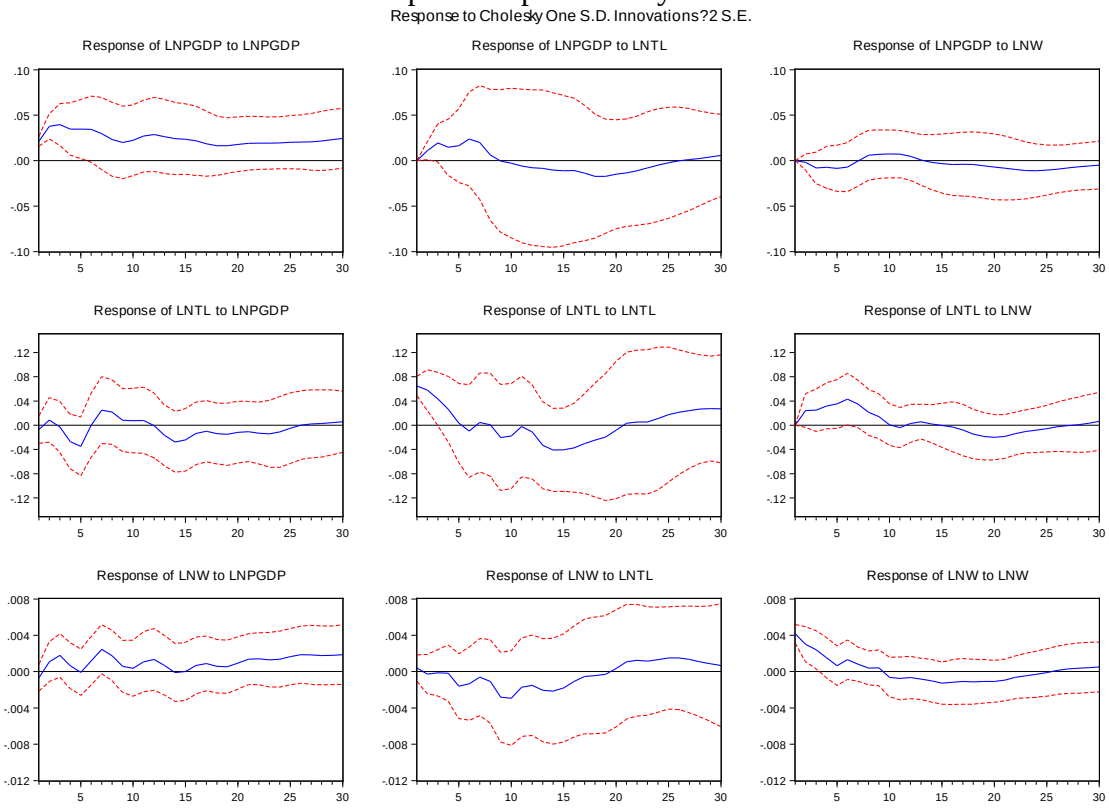

Figure 4. Impulse response function image

From the pulse analysis chart, the actual per capita GDP, the rationalization and heightening of the industrial structurecan all have a strong impact on pGDP, and the per capita GDP index pGDP reflects more quickly. From a unilateral point of view, the per capita GDP index is subject to its own large impact and lasts for a long time, and the impact state is stable; the rationalization and heightening of the industrial structure in Shandong Province has also had a positive effect on per capita GDP and has a long duration. The comparison shows that the rationalization of industrial structure has a stronger driving force for economic development. Overall, the development of Shandong's economic level is not only affected by its own economic scale, but also by the rationalization and heightening of industrial structure in the region, and the rationalization of industrial structure in the short term has a greater impact on economic growth. From the second and third lines in the picture, we can easily see the relationship between the advanced industrial structure and economic growth in Shandong Province. Therefore, Shandong Province should pay more attention to the promotion of industrial structure rationalization in the process of economic development.

5. Conclusion

The analysis results show that since the reform and opening, the rationalization and heightening of the industrial structure of Shandong Province have shown the characteristics of overall increase but staged fluctuations, both of which can promote economic growth. There is a mutual promotion between the rationalization of industrial structure and economic growth, and the one-way relationship between industrial structure heightening and economic growth, and the contribution of industrial structure rationalization to economic growth is much higher than heightening.

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