

Empirical Study on the Relationship Between Industrial Structure and Economic Growth

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Abstract—Industrial structural changes include two aspects: rationalization and supererogation. In the "new normal" economy, these two aspects are increasingly the focus of government and theoretical circles. In order to research the interrelation among the rationalization, supererogation and economic growth, rationalization and supererogation of industrial should be measured. On the basis of constructing vector auto-regressive model, the mutual influences between these two industrial structure indicators and economic growth are analyzed. The research result shows the effect of rationalization is positive and remarkable, while the effect of supererogation is poor. Therefore, when formulating industrial policies, the government should vigorously promote the rationalization, and pay attention to coupling input and output structure. In addition, the supererogation and the transformation of industry-oriented structure into service-oriented industrial structure should be promoted in a moderate way.

Keywords—*rationalization of industrial structure; supererogation of industrial structure; economic growth*

I. INTRODUCTION

China's economy has entered the new stage, accompanied by shifting growth drivers and changing development mode. The economic growth has slowed and the potential structural problems have emerged. The imbalance of industrial structure has always been one of the hot problems discussed in the academic circle. The advantages of traditional industries are gradually disappearing. The domestic demand is not enough and the market system is not sound. The above factors can restrict the industrial transformation and upgrading in China. At the new stage, adjusting the industrial structure and promoting the long-term sustainability have become the key tasks. This paper aims to research the correlation between industrial structure and economic growth. Industrial structure consists of rationalization and supererogation. We use GDP per capita for analysis. Therefore, the influence of the two aspects of industrial structure on GDP per capita is analyzed.

The theory about industrial structure can be traced back to the 17th century. Petty first found that the industrial structure was important for the national income. Petty (1672) pointed out that the added value of industry was higher than that of agriculture, and the income gap between industries

promoted the transfer of labor forces from low-income industries to high-income industries. Later, many scholars extended such theory. Colin Clark and Kuznets mainly analyzed the general rules between industrial structure and economic growth through statistical methods. Colin Clark's theory further supported the view of Petty. According to the three divisions of industry put forward by Fisher in 1935, Colin Clark (1940) sorted and compared the input and output data of each department in 40 countries and regions, and came from primary industry to secondary industry and tertiary industry with the increase of national income per capita. Kuznets (1971) argued that the structure of labor force and output value changed with economic growth. Technological innovation, income demand elasticity and international trade comparative advantage were decisive factors for structural transformation. With the acceleration of global economic integration, more and more scholars combined the theory of industrial structure with the actual economic situation. There were different opinions on the influence process. Related researches mainly concentrated on three aspects.

The first research is from the perspective of the proportion of output value or employment. For example, Buera and Kaboski (2009) explored the service industry growth in the United States for nearly half a century and found that specialized and highly skilled labor had made a prominent contribution to economic growth. Namely, economic growth was driven by technology-intensive services rather than low-skilled jobs. Jorgenson and Timmer (2011) found the service industry dominated the economy and became an important force to improve the total productivity through the statistical data of various countries from 1980 to 2005. Ye and Cao (2003) found that the secondary industry contributed as much as 65.7% to the total economic growth in China in the 1990s.

The second kind of research is from the perspective of "structural dividend". For example, through a comparative study of China and Russia, Sachs (1994) found that industrial structure transformation was important factor. Springer (1988) found the adjustment of industrial structure resulted in the transfer of labor force across regions and sectors, thus improving the overall economic efficiency. He (2014) believed that labor force shifting to industry and service led to the "structural dividend", which could promote

economic growth. Liu and Zhang (2008) separated the total factor productivity. The effects of industrial structure change and net technological progress within TFP from 1986 to 2002 were measured in five stages. The results showed that, with the improvement of marketization degree in China, the effect of industrial structure changes was gradually weakening, and the impact of technological progress became greater.

The third kind of research is from the perspectives of the two indicators, rationalization and supererogation. Li and Ping (2014) found the influence of rationalization was greater than that of supererogation. Fu (2010) proposed a new method to measure the supererogation and found that the economic growth promoted the supererogation. However, the supererogation of industrial structure could not promote economic growth. Chen and Mu (2014) found there was a linkage between the rationalization and economic growth, but both the positive and negative impacts were not stable. Based on GMM model, Liu (2015) found that both indicators are beneficial for economic growth, and the rationalization played a more important role. Gan et.al (2011) divided China's development process since 1978 into four stages, and found that rationalization is positive and stable. Based on the fixed effect model, Tao and Fang (2016) found there were differences among different regions as to the influences.

II. MEASUREMENT OF INDUSTRIAL STRUCTURAL CHANGE

A. Rationalization of Industrial Structure and Its Measurement

The rationalization aims to describe the balance degree. It refers to the balance degree among the various industrial sectors or the balance degree between supply and demand. In essence, the indicator reflects the utilization of resources. Current researchers generally use the structural deviation degree to describe the rationalization level.

$$E = \sum_{i=1}^n \left| \frac{Y_i / L_i}{Y / L} - 1 \right| = \sum_{i=1}^n \left| \frac{Y_i / Y}{L_i / L} - 1 \right| \quad (1)$$

Where, E represents the deviation degree. Y represents output, and L represents employment, i represents each industrial sector. Let Y/L be the labor productivity. When the economy is balanced, $Y_i / L_i = Y / L$, which means the labor productivities of all industrial sectors are the same, $E = 0$. Since Y_i / Y refers to output structure and L_i / L refers to employment structure, E also reflects the coupling degree between output and employment structure. The larger value of E means the larger deviation from equilibrium state, so the more unreasonable the industrial structure is. This paper takes the $1/E$, denoted as R to measure the rationalization.

B. Supererogation of Industrial Structure and Its Measurement

There are three aspects of the supererogation. The first is the optimization of industries, that is, the labor force is gradually transferred from the primary industry to the tertiary industry. The second is the optimization of the secondary industrial structure. The industries tend to transform from light, raw materials and general industries to heavy, assembly and technology-intensive industries. The third is the optimization of resource-intensive industries. In essence, the supererogation of industrial structure aims to measure the productivity. If resources are transferred to those with high productivity, the overall economic efficiency is improved. This paper adopts the method proposed by Fu (2010) to measure the supererogation of industrial structure, denoted by W. According to the method, GDP is divided into three industries.

The added value of each industry as a share of GDP is a component of space vector, and thus a set of three dimensional vectors is constituted, which is denoted

as $X_0 = (x_{1,0}, x_{2,0}, x_{3,0})$. Calculate the angles between X_0 and $X_1 = (1,0,0)$, $X_2 = (0,1,0)$, $X_3 = (0,0,1)$ separately, the three angles are denoted as $\theta_1, \theta_2, \theta_3$.

$$W = \sum_{k=1}^3 \sum_{j=1}^k \theta_j \quad (2)$$

W reflects the supererogation of industrial structure and k means the industry.

III. EMPIRICAL ANALYSIS

A. Variables Selection and Model Setting

This paper uses R and W to represent the rationalization and supererogation of industrial structure respectively. Also, GDP per capita is used to measure economic. Meanwhile, population growth rate G and CPI are introduced as exogenous variables. For better analysis, this paper took logarithms of these data and obtained LNGDP, LNW, LNE, LNG and LNCPI. The data come from China statistical yearbook from 1978 to 2017. Vector auto-regression model is used to investigate the impact of the two indicators on economic growth. The model is shown in equation (3).

$$Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + HX_t + \varepsilon_t \quad (3)$$

Where, Y_t is the endogenous variable column vectors with k dimension, X_t is the exogenous variable column vectors with d dimension, $\Phi_1, \Phi_2, \dots, \Phi_p$ and H are the coefficient matrix, ε_t is the random error term.

$$Y_t = (LNGDP_t, LNW_t, LNR_t)'$$

$$X_t = (LNG_t, LNCPI_t)'$$

B. Unit Root Test

Eviews8.0 is used to analyze the stability of LNGDP, LNW and LNR. The unit root tests include PP test, ADF test, LLC test and other methods. The ADF test is used in this paper. (See "Table I")

TABLE I. UNIT ROOT TEST

Variables	(c,t,k)	ADF	5% Value	Conclusion
LNGDP	(c,t,1)	-2.814	-3.540	unstable
Δ LNGDP	(c,0,1)	-3.313	-2.948	stable
LNW	(c,t,2)	-3.221	-3.544	unstable
Δ LNW	(0,0,0)	-3.617	-1.950	stable
LNR	(c,t,2)	-2.018	-3.544	unstable
Δ LNR	(0,0,0)	-4.100	-1.950	stable

C. VAR Model

The VAR model is established by taking LNG and LNCPI as exogenous variables and LNGDP, LNW and LNR as endogenous variables. The model is shown in equation (4).

$$Y_t = \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} \cdots + \Phi_k Y_{t-k} + HX_t + \varepsilon_t \quad (4)$$

$$Y_t = \begin{bmatrix} LNGDP \\ LNW \\ LNR \end{bmatrix}_t$$

Where, $\Phi_1, \Phi_2, \dots, \Phi_k$ and H are coefficient matrices; ε_t is the white noise vector, k is the lag order of auto-regression. Using AIC and SC criterion, the optimal lag order of is 3. Next, the stability of the model is tested, as shown in "Fig. 1", so the model is stable.

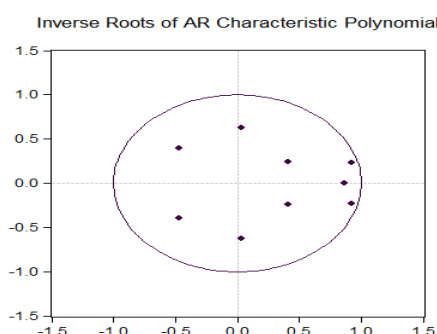


Fig. 1. Inverse roots of ar.

D. Johansen Co-integration Test

It can be seen from the above analysis that LNGDP, LNW and LNR are unstable first-order sequences. Johansen co-integration test is used to determine the co-integration relationship among the three variables, so as to explore the

long-term equilibrium. LNG and LNCPI are regarded as exogenous variables. Based on AIC and SC, the optimal lag order is 2. (See "Table II")

TABLE II. JOHANSEN CO-INTEGRATION TEST

Hypothesized No. of CE(s)	Eigenvalue	T	0.05 value	P**
None*	0.651	66.712	42.915	0.000
At most 1*	0.446	29.818	25.872	0.015
At most 2	0.230	9.135	12.518	0.172

"Table II" shows that there are two co-integration relationships among LNGDP, LNW and LNR. A standard co-integration equation is as follows:

$$LNGDP = -115.238LNW + 1.951LNR + 0.059TREND \quad (5)$$

According to equation (5), the effect of the rationalization is positive and the coefficient is 1.951. However, the effect of the supererogation is negative and the coefficient is -115.238. In contrast, the negative influence of the supererogation is larger than the positive influence of the rationalization.

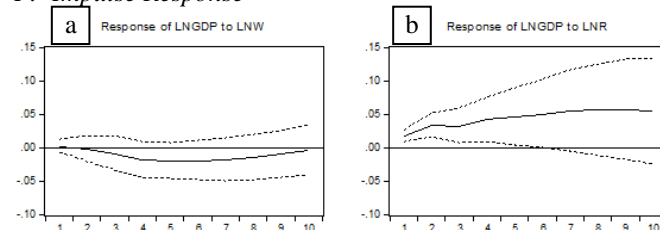
E. Granger Causality Test

At the significance level of 5%, both the rationalization and supererogation of industrial structure are Granger reasons for GDP per capita, while GDP per capita is neither the Granger reason for the rationalization nor the Granger reason for the supererogation of industrial structure. (See "Table III")

TABLE III. GRANGER CAUSALITY TEST RESULT

Null hypothesis	F	P	Conclusion
LNW is not the Granger cause of LNGDP	16.174	0.001	reject
LNR is not the Granger cause of LNGDP	8.631	0.035	reject
LNGDP is not the Granger cause of LNW	4.519	0.211	accept
LNR is not the Granger cause of LNW	2.527	0.471	accept
LNGDP is not the Granger cause of LNR	4.242	0.237	accept
LNW is not the Granger cause of LNR	9.061	0.030	reject

F. Impulse Response



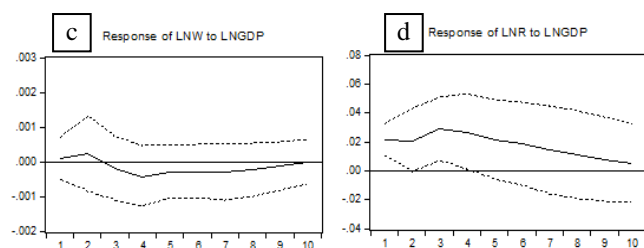


Fig. 2. Graphic output of impulse response.

Note: the solid line is the impulse response path of 1 unit impulse, and the dotted lines on both sides are the confidence interval paths within 2 standard deviations.

Figure (a) shows the impact of LNW on LNGDP. According to the response path of LNGDP, its impulse effect gradually decreases from the 1st stage to the 6th stage, and increases gradually after the 6th stage. When it reaches the 10th stage, the impulse effect almost disappears, and economic growth returns to the initial state. On the whole, the rise of the supererogation level is not conducive to GDP per capita. However, the minimum value of impulse response is only -0.02, indicating that the negative impact is small. Figure (b) shows the impulse response path of LNGDP impacted by LNR. The response path is always positive, and its pulse influence gradually increases from the 1st stage to the 7th stage, and tends to be stable after the 7th stage, indicating that the improvement of the rationalization is conducive to the growth of GDP per capita, and finally the impact tends to be stable. Figure (c) shows the impact of LNGDP on LNW. The response path of LNW fluctuates around 0, indicating that economic growth has no significant effect on the supererogation. Figure (d) shows the impact of LNGDP on LNR. The values of impulse response are always positive, indicating that GDP per capita is beneficial to the industrial structure rationalization, but the positive influence wane over time.

IV. CONCLUSION

Industrial structural changes include two aspects: rationalization and supererogation. In the paper, VAR model is built to research the mutual relationship between industrial structure changes and economic growth with China's statistical data from 1978 to 2017. Through the empirical analysis, this paper proves that the two indicators have different influence on economic growth.

It approves that the government should emphasize the rationalization and moderately promote the supererogation when making industrial structure policies. Currently, the government should attach importance to the optimization of industrial structure and economic quality improvement. In this paper, two policy suggestions are put forward. On the one hand, since the central government proposed the supply-side structural reform, the local authorities have responded to the reform actively. Some local authorities vigorously develop the tertiary industry, paying too much attention to the supererogation and neglecting the rationalization, which is not conducive to the long-term sustainability. Therefore, the local authorities should formulate industrial adjustment

policies according to local conditions. In addition, the state should focus the coupling of input and output structures. At present, the labor force structure and industrial structure match poorly. High-level labors are in short supply and labor-intensive manufacturing needs to be upgraded. Therefore, it is necessary to strengthen investment in education so as to increase the supply of high-level labors. Certain labor-intensive industries should be maintained to absorb low-level workers and enhance the coupling degree of labor and output.

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