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The impact of the change of trade pattern on China's energy industry——Based on the measurement of the upstreamness of production of the value chains

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Abstract

The natural monopoly of China's upstream industry and the vertical structure of industrial chain's upstream and downstream competition is an important feature of China's industrial economic structure, and the impact of the change of trade pattern on the energy industry, which located at the upstream of the China's value chain, has become an important issue in the industrial economy. Since China has entered into the WTO in 2001, we use it for event analysis based on 1987-2007 China input-output data. The study calculates the upstreamness of production of the value chain in various industrial sectors of China's energy industry every five years, and make correlation analysis of upstreamness of production and other economic indicators to check the characteristics of periodic inspection of China's industrial structure with the development of industrial economy and the change of trade pattern.

Keywords: Energy industry, industrial economic structure, upstreamness of production, trade pattern

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1. Introduction

Since the reform and opening up, the rapid development of China's economy and the unique mode of China's economic development have become the focus of scholars around the world. The adjustment of China's economic structure has largely affected the adjustment of the existing world economic structure, which has led to the study of China's industrial economy by many scholars. From the research progress at home and abroad, whether it is the research of value chain or the research of industrial location measurement in the value chain, the input-output model provides the necessary theoretical support for the research of the problem. Foreign literature can be divided into two types of research. The first category focuses on research in global value chains. The main focus of research is on how to choose a measurement method. Representative studies include Trade in Value-Added (TiVA) (Meng et al., 2012) based on Vertical Specialization (VS) (Hummels et al., 2001; Yi, 2003; Chen et al., 2005), based on the total export accounting framework (Wang et al., 2009; Koopman et al., 2010). The second category is based on the value chain research industry location measurement. The industry upstream index is constructed on the basis of measuring the relative production line position at the industrial level (Fally, 2011; Antràs et al., 2012). The research in this paper focuses on the second type of problem, that is, focusing on the measurement of industrial location in the value chain, especially in the energy industry in the monopoly market position. The research in this area is very rare in China, and the representative research is Gao (2013). Following Antràs et al. (2012), Gao (2013) proposed three methods for calculating the length of the export value chain in different industries. Then, he compared the different preconditions, applicable conditions and specific performance of the three manufacturing methods. However, no research has focused on the impact of changes in the trade pattern on the energy industry. The above research is generally based on a methodological discussion, but it is still rare to study how to study the industrial characteristics of different industries from within a country.

Obviously, the concept of the upstream is more important to understand the characteristics of the industry, rather than simple numerical calculations. Therefore, how to better link the upstream of the industry with other industrial characteristics is a more important issue. Based on this, this study will be based on China's 1987, 1992, 1997, 2002 and 2007 input-output tables, and conduct a more in-depth analysis of the upstream of different economic development stages and industries in China, while focusing on these issues. Discussion: First, is the industry with higher upstream more capital-intensive industries? Second, does the adjustment of China's trade pattern bring about the adjustment of the industrial structure of the energy industry, that is, China's accession to the World Trade Organization (WTO) in 2001 as an event research object, and whether the energy industry is relatively stable? The study of this series of issues will be of great significance for us to better understand the relationship between the industrial structure characteristics of China's energy industry and the industrial sector.

2. Methodology

2.1. Industry upstream measurement method

The calculation of the upstreamness of production of the industry is based on the study of Antràs et al. (2012). Under the open economy model, the output balance formula can be expressed as:

$$Y_i = F_i + \sum_{j=1}^{N} d_{ij} Y_j + X_i - M_i \quad (1)$$

Among them, i and j represent different industrial sectors; Y is the total output; F is the final product;

X_i and M_i represent the export value and import value of the output, respectively. d_{ij} measures the output value of industry i needed to produce the unit output value of industry j.

We need to point out that simply using the inter-industry commodity flow data to construct a country's input-output coefficient matrix does not distinguish between domestic product trade and international product trade. Therefore, although according to Equation (2), the total output share of industry i can be used as an intermediate product input of industry j (national or foreign). However, we do not know exactly the trade flows X_i and M_i between international industries in practice.

$$\delta_{ij} = \frac{d_{ij}Y_j + X_{ij} - M_{ij}}{Y_i} \quad (2)$$

Therefore, we use the hypothesis $\delta_{ij} = \frac{X_{ij}}{X_i} = \frac{M_{ij}}{M_i}$ of Antràs et al. (2012). Based on this assumption, the share of the export (import) used by industry i for production industry j is consistent with the share of output of industry i for production industry j.

Based on this assumption, we can correct d_{ij} and get the upstream of the industry that can be measured directly by the input-output model:

$$\hat{d}_{ij} = d_{ij}\frac{Y_j}{Y_i - X_{ij} + M_{ij}} \quad (3)$$

It is worth emphasizing that the assumption of the derived Equation (3) is completely consistent with the specialization of the different parts of the country engaged in the value chain.

The input may come from inventory, so further modify Equation (3):

$$\hat{d}_{ij} = d_{ij}\frac{Y_j}{Y_i - X_{ij} + M_{ij} - N_i} \quad (4)$$

Here, N_i indicates the inventory change of the industrial department i.

Based on the modified Equation (4), construct a square matrix Δ whose molecule of the (i, j) element is $d_{ij}Y_j$, reflecting the precise value of the product i used in the production of j; the denominator is $Y_i - X_i + M_i - N_i$, and the economic meaning is the domestic absorption of the output in industry i. If we get square matrix Δ, we can finally calculate a column vector, that is, the industry upstream matrix $U_{i\times 1} = [I - \Delta]^{-1}\mathbf{1}$, where $\mathbf{1}$ is the column vector with element 1, and the i row of the resulting i matrix corresponds to the input-output model. The upstream value of F industries.

According to Equation (4) and input-output model, we construct square matrix Δ by the following method:

Molecular $d_{ij}Y_j$ is the $(i, j)th$ element in the matrix of intermediate inputs (or intermediate outputs) in the flow meter. We can directly calculate the data in the intermediate input (or intermediate output) matrix in the flow table. The denominator $Y_i - X_{ij} + M_{ij} - N_i$ is the total output obtained by summing the rows in the flow

meter, minus the net export and inventory. All data comes from "total output", "export", "import" [1] and "inventory increase" in the flow table. In this way, we can calculate the square matrix Δ, and then complete the measurement of the upstreamness of production.

2.2. Data description and processing

This paper is to study the characteristics of China's energy industry's industrial structure, especially the impact of industrial shocks brought about by changes in the trade pattern. Therefore, it is necessary to find an exogenous shock that changes China's trade pattern. In 2001, China's accession to the WTO provided an ideal exogenous shock for the study. In other words, the impact event, with China's accession to the WTO as a time node, analyzes the impact of changes in the trade pattern by comparing the changes in the upstreamness of production of energy industry production before and after China's accession to the WTO. Based on this, the data used in this study are the national input-output tables for a total of five years in 1987, 1992, 1997, 2002 and 2007, and the upstreamness of production of energy industry production is calculated according to the upstream construction method of the industry. [1]

However, since the statistical caliber of the five-year input-output tables in 1987-2007 has been adjusted with the development of the economy, the industrial names and industrial quantities of the five input-output tables are different. In order to consider the changes in industrial structure characteristics, we need to process the raw data and adopt two industrial sector classification standards.

The first category is rough division. In this paper, according to the research of Wang et al. (2012), all the industrial sectors are merged into eight categories. This paper re-created the eight departments' flow meter and calculated the upstream production level of each industry based on this flow meter. The second category is the refinement. This article refers to the classification criteria in the National Economic Industry Classification GBT4754-1994 and the National Economic Industry Classification GBT4754-2002, and reorganizes all industrial sectors into 30 sub-sectors, and adjusts the 30-part flow tables. Based on this flow meter, the upstreamness of production and other characteristics of each industry are calculated.

3. Analysis of upstream production of energy industry

Based on the industry sector classification criteria, we can directly calculate the upstream production of China's energy industry from 1987 to 2007 using the data in the input-output flow table. The calculation results are shown in Table 1.

Table 1
Production of the upstream sector of the 30 different industry sectors from 1987 to 2007

Unified department name	1987	1992	1997	2002	2007	Ranked standard deviation
Agriculture, animal husbandry and fishery	***2.0801***	***2.2735***	***2.4652***	***2.3518***	***3.2717***	
Agriculture, animal husbandry and fishery	1.9985	2.1394	2.3456	2.2677	3.1990	2.7928
Energy industry	***3.5158***	***3.9580***	***4.2534***	***3.7704***	***5.1039***	
Coal mining and washing industry	3.5528	4.0626	4.5540	3.9038	5.6371	0.4472
Oil and gas extraction industry	4.3467	4.6876	5.2055	4.6712	5.9025	0.4472

[1] The items in the flow charts in 1987 and 1992 were net exports, ie $X_{ij} - M_{ij}$.

Electricity, gas and water production and supply industry	3.4175	3.9249	3.9759	3.6082	5.1188	1.3416
Petroleum processing, coking and nuclear fuel processing industry	3.3123	3.7906	4.1009	3.8817	4.9147	1.1402
Mining	***3.0478***	***3.6221***	***4.0755***	***3.7525***	***4.8415***	
Metal mining industry	4.3769	4.6738	5.0821	4.6643	5.6147	0.7071
Nonmetallic mining and dressing industry	2.7636	3.4358	3.6842	3.2110	4.2655	1.4832
Light manufacturing	***2.2626***	***2.5719***	***2.6599***	***2.6457***	***3.3097***	
Food manufacturing and tobacco processing	1.6314	1.8010	1.9164	1.9647	2.5740	0.5477
Textile industry	2.9906	3.4601	3.9556	3.3246	5.1388	2.4900
Clothing, leather, down and its products industry	1.6888	1.7681	1.9062	1.9472	2.4958	1.3038
Wood processing and furniture manufacturing	2.4571	2.8087	2.8071	2.9302	3.5081	1.1402
Paper making, printing and stationery manufacturing industry	2.9269	3.1803	3.6740	3.4733	4.3584	1.5811
Heavy manufacturing	***2.6561***	***3.1355***	***3.3661***	***3.2152***	***3.9668***	
Chemical industry	3.2550	3.5877	4.0596	3.7861	4.7834	1.5811
Non-mental mineral product industry	2.4710	2.9576	2.7342	2.7280	3.0531	2.1909
Metal smelting and calendaring processing industry	3.2306	3.7826	4.1602	3.7112	4.6045	2.0000
Metal product industry	2.5304	2.9404	3.2572	3.2173	4.1284	2.6077
General purpose and special equipment manufacturing industry	1.9674	2.4679	2.8248	2.5167	3.1019	2.1679
Transportation equipment industry	2.0017	2.7466	2.6302	2.7317	2.7518	2.0736
Electrical machinery and equipment manufacturing industry	2.2255	2.7532	2.9409	3.0227	3.3177	1.3416
Communications equipment, computers and other electronic equipment manufacturing industry	2.0158	2.4179	3.1096	3.0482	4.1611	4.6368
Instrumentation and culture, office machinery manufacturing industry	2.4954	3.1625	3.2801	3.0506	3.7165	0.7071
Other manufacturing	***3.2889***	***3.7862***	***3.3735***	***3.0229***	***3.8194***	
Other manufacturing	3.2566	3.8989	3.5276	3.1664	3.9878	3.3166
Construction	***1.0000***	***1.1059***	***1.1543***	***1.1537***	***1.0730***	
Construction	1.0000	1.0921	1.1372	1.1427	1.0655	0.7071
Service	***2.0680***	***2.5427***	***2.5229***	***2.3184***	***2.6121***	
Transport, storage and post	2.4262	3.1626	3.3170	3.2061	3.6155	2.5495
Wholesale and retail trades	2.7832	3.0380	3.1488	2.9670	2.9522	3.3166
Hotels and catering services	1.0000	1.0000	2.4954	2.1566	2.6148	2.9496
Financial insurance and real estate industry	3.5308	3.9031	2.7312	2.4339	2.7927	9.8082
Social services	1.4441	2.6928	2.7159	2.6221	2.9021	2.0736
Science, culture, education, health and social security industry	1.4429	1.5759	1.4648	1.4041	1.7808	0.5477
Public management and social organization	1.0000	1.0000	1.0000	1.0000	1.0277	0.0000

Average upstreamness of production of 30 sectors	2.5180	2.9304	3.1247	2.9253	3.6362
Standard deviation of upstreamness of production of 30 sectors	0.9162	1.0074	1.0420	0.8955	1.2694

First of all, we focus on the upstream production of the eight categories of industries shown in Table 1. The results of the upstreamness of production in Table 1 show that the industry differs greatly in terms of the average position of the production line. Taking the upstream of the sectors in 2007 as an example, the average upstreamness of production of 30 sectors is 3.6362, and the standard deviation is 1.2649. That is, the average industry has experienced 2.5 stages in the production and use process before final consumption or investment. However, as mentioned above, the classification of the eight major categories of industrial sectors is relatively rough, and the more detailed calculation of the upstream production of the 30 sectors will help us understand the changes in the industrial structure of China's energy industry over time and the changes in the trade pattern.

First, we use the average of the upstream production levels of all industries as the cut-off point between upstream and downstream. The sector that defines the upstream value of the upstreamness of production greater than 30 sectors is the upstream industry, and the sector with the upstreamness of production less than the upstream average of the 30 sectors is the downstream industry, and the energy industry is located upstream. Taking the 2007 data as an example, the average upstream production of all industries is 3.6362.

Second, by observing the five industries in the most upstream and downstream of the past years, this paper finds that almost all of the output in the most downstream industries, including Construction, Services, Light manufacturing, flows directly to the end users. On the other hand, the most upstream industries are generally related to energy and raw materials, including the Energy industry, Mining industry.

Third, the upstream production of industrial production in different sub-sectors in China has shown significant stability. That is to say, the position of most industrial sectors in the industrial value chain has not changed with time, nor has it changed structurally because China joined the WTO in 2001. We ranked 30 sectors from small to large according to the upstream value. We calculated the standard deviation of the five-year industrial chain position ranking, and the calculation results are shown in the last column of Table 1. It can be seen that 87% of the industry's position in the production value chain has not changed much with time, and only a few of the four industries have changed to some extent.

We focus on two industries with characteristics:

Financial insurance and real estate industry. This is the sector with the largest change in industrial position. Its ranked standard deviation of sorting changes to 9.8082, and the industrial position shifts from upstream to downstream. We think this is due to changes in the real estate industry. Specifically, the real estate industry is closer to the final use. Moreover, China has began to reform the housing system since 1998. China's urban housing system has undergone a fundamental transformation. The original welfare housing system was changed to consumers who can buy and sell houses freely in the real estate market. The liberalization of the real estate market has accelerated the rapid development of the real estate industry during 1997-2007, thus lowering the overall upstream production of the Financial insurance and real estate industries.

Communications equipment, computers and other electronic equipment manufacturing industry. In these industries, the ranked standard deviation reached 4.6368, which was continuously shifted upstream. This result shows that the supply-related sectors of the information industry in the information age are increasingly driving the supply of other sectors, and the production stage is increasing. This is consistent with our intuition. At the same time, it is also in line with the overall strategic decision of China's strategy of rejuvenating the country through science and education, with science and technology as the primary productive force.

4. Correlation between upstreamness of production and industrial characteristics

Next, we hope to explore the relationship between upstreamness of production and factor density and verify whether the capital of the upstream industry is dense. Capital Expenditure is often used as an indicator of

physical capital intensity based on the assumption that production has only two inputs of labor and capital, such as Cole and Elliott (2005). Following the method in the literature, we define the material capital intensity as the added value of non-labor remuneration, so that the material capital intensity of the industry can be calculated directly using the data in the input-output table. The equation is as follows:

$$PCI_i = 1 - V_i / TVA_i \quad (5)$$

Among them, PCI indicates that the material capital intensity is from labor compensation, TVA is the total value added, and i indicates the i_th industrial sector.

Based on Equation (5), the calculation results are shown in Table 2. From the overall material capital intensity of the 30 sectors, the average has been decreasing since 1987-1997 and has rebounded since 2002. The material capital intensity of energy industry has been more than 0.7 in 1987-2007, including Petroleum and natural gas extraction industry, Electricity, gas and water production and supply, Petroleum processing, coking and nuclear fuel processing industries (all located in the most upstream industries).

Table 2

Material capital intensity of the industry from 1987 to 2007

	1987	1992	1997	2002	2007
Petroleum and natural gas extraction industry	0.9688	0.9326	0.8100	0.8062	0.7709
Electricity, gas and water production and supply	0.9161	0.8788	0.7223	0.7657	0.7458
Petroleum processing, coking and nuclear fuel processing industry	0.9485	0.8718	0.7875	0.7016	0.7080
Average material capital intensity of 30 sectors	0.6725	0.6557	0.5240	0.5578	0.6207
Correlation coefficient	0.5616***	0.5168***	0.5004***	0.4760***	0.4184**
	[0.0012]	[0.0035]	[0.0049]	[0.0078]	[0.0214]

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Focusing on the correlation coefficient between material capital intensity and upstreamness of production, the results in Table 2 show that upstreamness of production is significantly positively correlated with the material capital intensity, but the correlation is weakened year by year. That is, the correlation coefficient of 1987-1997 has been around 0.5, and the correlation coefficient decreased slightly after 2002. This shows that the material capital of the upstream industry is relatively dense, but the degree of this tendency is decreasing year by year.

5. Conclusion

Keqiang Economics mentioned “promoting structural reforms and exchange short-term pain for long-term sustainable development”. So how do you change the way, adjust the structure, and promote development? This requires us to have a good understanding of the status quo and characteristics of the industrial economy. This paper systematically sorts out the characteristics of industrial structure. The input-output model based on the complete linkage between various industrial sectors can more comprehensively reveal the relationship between consumption, investment, exports, imports and total output, value added and intermediate products of various industrial sectors. Therefore, based on the calculation method of the upstreamness of production by Antràs et al. (2012), this paper uses the current five-year input-output table of 1987-2007 in China to calculate the relative position of China's industrial sector in the industrial value chain. The basic conclusions of this study

are as follows:

First, if the upstream and downstream industries are defined by the average of the upstreamness of production in all industries. The industries located downstream are Construction, Service, Agriculture, animal husbandry and fishery and Light manufacturing. Located upstream are the Energy industry, Mining, Heavy manufacturing and Other manufacturing industries. Moreover, the industries with the highest upstream production of industrial production are generally related to energy or raw materials, showing the characteristics of natural monopoly.

Second, the relative positions of various industrial sectors in the industrial value chain showed significant stability without structural changes between 1987 and 2007. The liberalization of the real estate market brought about by the reform of the housing system in China has promoted the transfer of Financial insurance and real estate industry from upstream industries to downstream industries. And the overall strategic decision-making of science and technology as the primary productive force promotes and accelerates the development of Communications equipment, computers and other electronic equipment manufacturing industry which continues to shift to upstream industries.

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References

[1] Antràs, P., Chor D., Fally T., et al. Measuring the upstreamness of production and trade flows. American Economic Review: Papers & Proceedings 2012; 102(3): 412-416.

[2] Chen, Hogan, Matthew Kondratowicz, and Kei-Mu Yi. Vertical specialization and three facts about U.S. international trade. North American Journal of Economics and Finance 2005; 16(1): 35–59.

[3] Cole, M. A., Elliott, R. J. FDI and the capital intensity of ‘dirty’ sectors: a missing piece of the pollution haven puzzle. Review of Development Economics 2005; 9(4): 530-548.

[4] Fally, T. On the Fragmentation of Production in the U.S. Mimeo; 2011.

[5] Gao Jingfeng. Evolvement and mechanism of export value chain in China. Finance & Trade Economics 2013; 1(4): 98-110. (In Chinese)

[6] Hummels, D., J. Ishii, and K. Yi. The nature and growth of vertical specialization in world trade. Journal of International Economics 2001; 54(1): 75–96.

[7] Koopman, R., Powers, W., Wang Zhi et al. Give credit where credit is due: tracing value added in global production chains. NBER Working Paper No. 16426; 2010.

[8] Li, Xi, Liu, Xuewen and Wang, Yong. A model of China’s state capitalism. Available at SSRN: http://ssrn.com/abstract=2061521 or http://dx.doi.org/10.2139/ssrn.2061521; October 2012.

[9] Meng, B., N. Yamano and Y. Fang. China’s regional economies and value chains: An interregional Input-Output analysis. IDE Discussion Paper No. 359; 2012.

[10] Wang Zhi, Powers, W and Wei Shang-jin. Value chains in East Asian production networks-An international Input-Output model based analysis. United States International Trade Commission Working Paper; 2009.

[11] Wang Dong, Pan Wenqing, Liu Qing, Gao Xudong. Factors decomposition of CO2 emission in China's industries: Based on LMDI model. Systems Engineering-Theory & Practice 2012; 32(6): 1193-1203.

[12] Yi, Kei-Mu. Can vertical specialization explain the growth of world trade? Journal of Political Economy 2003; 111(1): 52–102.