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Research on the Relevance of Chinese Industry Based on IO Model

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Abstract

Based on the latest input-output (IO) model data of China's 42 industries in 2018, this paper conducts industrial correlation research on 42 sectors of China's current national economy from the perspective of three quantitative indicators of industrial correlation, namely direct consumption coefficient, complete consumption coefficient and influence coefficient. Based on the data analysis results over the years, the paper explores the development and change rules of China's industrial association in 2017 and 2018, summarizes the experience of industrial development in combination with the current situation of China's economic and social governance, and analyzes the industrial association from the essential level, so as to provide policy reference for China's future industrial construction.

Keywords

IO Model, Direct Consumption Coefficient, Complete Consumption Coefficient, Influence Coefficient, Industry Correlation, China

1. Introduction

As China's economic and social development enters a new era, building a modernized economic system has put forward new requirements for industrial development. Such as carrying out structural reform on the supply side, building an industrial system led by innovation and coordinated development, etc., the improvements and changes in full swing have pointed out new directions to clarify the linkages and constraints among industries. Industrial linkage is the centralized embodiment of the linkage between social production factors, the study of industrial linkage is necessary and urgent for social and economic development, stable operation of the economy and society in all aspects, especially in

our country, the world today is in a century of unprecedented changes, economic globalization driven by the multipolarization of the world, social informatization, cultural diversity of the times across the juncture. The wave of global industrial chain is flourishing as the construction of global value chain becomes more and more rampant. Throughout our country, industrial linkage also becomes intricate and complex with the road of social development centered on economic construction, deepening the formation of organic state.

A deep understanding of the intrinsic nature of industrial linkages and the law of development is an important guarantee of China's economic and social operation. Different from analyzing the industrial structure and other industrial association elements by a specific industry, this article, based on the concept of global view and using MATLAB software, presents the nature of embodied industrial association quantitatively in terms of direct consumption coefficient, complete consumption coefficient and influence coefficient indicators, and conducts a study on China's industries in terms of industrial association in a holistic and systematic manner. The article is based on the latest input-output data in 2018, from the direct consumption coefficient. From the perspective of three quantitative indicators of industrial association, namely, complete consumption coefficient and influence coefficient, the industrial association study is conducted on 42 sectors of China's current national economy. And based on the results of data analysis in previous years, it explores the change pattern of industrial association development in China in 2017 and 2018, and summarizes the industrial development experience by combining the current situation of China's economic and social governance, so as to analyze industrial association from the essential level and provide policy reference for China's future industrial construction.

2. Theoretical Foundation and Literature Review

The input-output technique was first proposed by the American scholar Leon Tigers in the 1930s, and was created to describe the linkages between various sectors in the economic system and to illustrate the basic situation of economic operation. China's input-output table is officially published by the National Bureau of statistics of the People's Republic of China (NBSPRC), and currently, the NBSPRC website has different types of input-output for 2002, 2005, 2007, 2010, 2012, 2015, 2017 and 2018.

The national economy is a complex whole, and there are extensive and close technical and economic links between various industrial sectors, so any change in the production process of one industrial sector will have certain ripple effects on other industrial sectors through industrial linkages.

The input-output analysis method can quantitatively analyze the direct and indirect interdependent and mutually constraining technical and economic links formed by various industrial sectors of the national economy in the process of social reproduction within a certain period of time.

The single-region or multi-region input-output table reveals the interdepen-

dent and interrelated quantitative relationships between the input and output sectors in each region of the national economic system from the perspective of production technology. In essence, the input-output analysis model is a simplified model of the general equilibrium model, which can reflect the direct and indirect linkages between various sectors in each region (Chen et al., 2018). Therefore, input-output models are also widely used to study problems in economic and environmental fields.

The heat of industry-linked research has continued unabated in the historic wave of supply-side reform. Guan and Wang (2002)'s research on industrial linkages, as the authoritative foundational work in the field of industrial linkage research, reflects the practicality and importance of industrial linkage research by applying the results of industrial linkage research in practice to the selection of leading regional industries. Prior to this, Li et al. (2001) analyzed industry linkages and industry ripples with specific tourism industries, which are also works in the field of industry linkage research and represent the research direction of analyzing industry linkages with specific industries. Later, with the further development of the economy, more and more scholars began to study industrial linkages. At the same time, also with the increasing compilation of China's input-output tables, research on industry linkages has been enriched. For example, Xu et al. (2006) based on the 2002 China Input-Output table combined with the influence and induction coefficients, provides a general review of industrial linkages in China. Wang et al. (2007) analyzed the input-output characteristics of China's industries in terms of industrial structure and put forward policy recommendations for the reform and development of China's industrial system. Chen et al. (2015) combined the new direction of spatial distribution and made a corresponding analysis for the industrial association within specific manufacturing industries. Wang and Xiao (2016) similarly choose a specific industry, namely the marine industry, based on an input-output model, to illustrate the intrinsic relationship and characteristics of the linkage between the sea and land industries in China. The latest research is equally remarkable. He and Zhu (2020) systematically and summarily elaborate the laws of association of industrial development and layout in China, raising the history of industrial development to a logical level of scientific abstraction in order to enable a better grasp of the nature and development laws of industrial association.

3. Data Selection and Model Construction

According to whether the intermediate input component of the production sector distinguishes between domestic and imported products, the input-output model is divided into competitive and non-competitive models (Ye et al., 2019), and the mainstream follows the non-competitive input-output model.

Therefore, in order to study the industrial correlation in China and to improve the calculation accuracy, the article adopts the non-competitive input-output model. The data are obtained from the NBSPRC.

The basic form of the non-competitive input-output model is as follows:

output input			Intermediate use			End Use			Total output/imports
			Sector 1	…	Sector n	Sector 1	…	Sector n	
Intermediate Inputs	National Products	Sector 1	z_{11}	z_{1j}	z_{1n}	y_{11}	y_{1j}	y_{1n}	X_1
		…	z_{i1}	z_{ij}	z_{in}	y_{i1}	y_{ij}	y_{in}	X_i
		Sector n	z_{n1}	z_{nj}	z_{nn}	y_{n1}	y_{nj}	y_{nn}	X_n
	Imported products	Sector 1							
		…							
		Sector n							
Value Added									
Total input			X_1	X_i	X_n				

Because this paper uses non-competitive input-output tables and focuses on identifying our industrial affiliation, the intermediate inputs are not involved in the part of imports horizontally, i.e., our industrial affiliation is considered from the perspective of national products. However, whether the end use is domestic use or export, it is the output characteristic of our industry, so the export part of the end use is not excluded to ensure the complete balance of the input-output table.

The input-output table has the following balancing relationship, which is combined into the article as follows:

Total output = Total intermediate use + Total end use;

$$x_i = z_i + y_i = \sum_{j(j\neq i)} z_{ij} + \sum_{j(j\neq i)} y_{ij} + z_{ii} + y_{ii} \tag{1}$$

where $i, j = 1, 2, \cdots, n$, X_i denotes the total output of sector i, divided into two parts, one for this sector and the other for other sectors. $\sum_{j(j\neq i)} z_{ij}$ indicates that the output of sector i is allocated to sector j as an intermediate product; y_{ii} indicates that the output of sector i is allocated to this sector as a final product; $\sum_{j(j\neq i)} z_{ij}$ indicates that the output of sector i is allocated to sector j as an intermediate good; $\sum_{j(j\neq i)} y_{ij}$ indicates that the output of sector i is allocated to the sector as final product.

$$a_{ij} = \frac{z_{ij}}{x_j} \tag{2}$$

a_{ij} denotes the direct consumption coefficient of sector i to sector j, reflecting the amount of product of sector j in country r consumed directly in the production process per unit of product of sector i in country r. Bringing Equation (2) to Equation (1):

$$x_i = \sum_j a_{ij} x_j + \sum_j y_{ij} \tag{3}$$

That is, total inputs = total intermediate inputs (including imports) + value

added;

Write Equation (3) in the form of a matrix:

$$X = AX + Y \tag{4}$$

That is, total input = total output.

$$X = (I - A)^{-1} Y \tag{5}$$

A is the direct consumption matrix, Y is the end-use matrix and I is the unit matrix. Let $L = (I - A)^{-1}$, L is the Leontief inverse matrix of a non-competitive input-output table as a chunked array, Where the embedded element l_{ij} represents the complete consumption of products and services of sector i for each additional unit of end use in sector j. That is, complete consumption = direct consumption + indirect consumption.

The influence factor F_j for sector j is calculated as follows.

$$F_j = \frac{\frac{1}{n}\sum_{i=1}^{n} l_{ij}}{\frac{1}{n^2}\sum\sum l_{ij}} = \frac{\sum_{i=1}^{n} l_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}} (j = 1, 2, \cdots, n) \tag{6}$$

Direct consumption coefficient a_{ij} reflects the economic linkage between various industrial sectors and is the most important and basic data for industry linkage analysis (Yang & Hou, 2011). The influence coefficient F_j reflects the degree of ripple effect of an industry on other industries.

Generally speaking, industrial sectors with larger impact coefficients have a greater radiative power on social production.

4. Empirical Analysis

4.1. China Industry Correlations 2018

After the above calculation, from the point of view of the direct consumption coefficient of each industry (Table 1, Figure 1), it is found that thesum of direct digestion coefficient of the textile industry is the highest, which is 0.794, which is the most direct consumption to other industries in our country. That is, the textile industry consumes the largest amount of other industries, including its own intermediate investment. This is related to the essential characteristics of the textile industry. For example, agriculture, forestry and fishery products and services industries provide intermediate products such as cotton fabric produced from cotton as a source of raw materials for the textile industry. The textile industry is more about the production of finished textile products rather than the most raw materials needed to produce textiles. Located in the second place of the direct consumption coefficient is also the textile series of textile, clothing, footwear, leather and down and its products industry, so the principle is similar, and is determined by the nature of the characteristics of the textile series of industries.

The industry with the lowest direct consumption of intermediate products is the real estate business, with the lowest direct consumption coefficient among the 42 industries in China, at 0.257. This is also highly relevant to the essential

Table 1. Direct and indirect consumption coefficients and impact coefficients of China's 42 industries.

Industries	Code	Direct consumption factor and	Complete consumption factor and	Impact factor
Agriculture, forestry and fishery products and services	1	0.383	1.849	0.798
Coal Mining Products	2	0.482	2.098	0.906
Oil and gas extraction products	3	0.294	1.688	0.729
Metal ore mining products	4	0.438	2.019	0.872
Non-metallic and other ore mining products	5	0.537	2.275	0.983
Food and Tobacco	6	0.719	2.525	1.090
Textiles	7	0.794	3.011	1.301
Textile, clothing, shoes, hats, leather, down and other products	8	0.782	3.119	1.347
Woodworking products and furniture	9	0.716	2.748	1.187
Paper printing and stationery and sporting goods	10	0.680	2.643	1.141
Petroleum, coking products and processed nuclear fuel products	11	0.402	1.775	0.767
Chemical products	12	0.681	2.609	1.127
Non-metallic mineral products	13	0.675	2.608	1.127
Metal Smelting and Rolling Products	14	0.640	2.428	1.049
Metal Products	15	0.722	2.761	1.193
General Purpose Equipment	16	0.714	2.796	1.208
Specialized equipment	17	0.688	2.718	1.174
Transportation equipment	18	0.713	2.819	1.218
Electrical machinery and equipment	19	0.725	2.797	1.208
Communication equipment, computers and other electronic equipment	20	0.570	2.339	1.010
Instrumentation	21	0.567	2.366	1.022
Other manufacturing products and scrap waste	22	0.349	1.801	0.778
Metal products, machinery and equipment repair services	23	0.752	2.888	1.247
The production and supply of electricity and heat	24	0.654	2.540	1.097
Gas production and supply	25	0.483	1.926	0.832
Water production and supply	26	0.517	2.232	0.964
Architecture	27	0.752	2.832	1.223
Wholesale and retail	28	0.339	1.720	0.743
Transportation, storage and postal	29	0.538	2.165	0.935
Accommodation and Dining	30	0.637	2.417	1.044
Information transmission, software and information technology services	31	0.493	2.064	0.891
Finance	32	0.425	1.889	0.816
Real Estate	33	0.257	1.533	0.662
Leasing and Business Services	34	0.628	2.429	1.049

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Research and Experimental Development	35	0.540	2.272	0.981
Integrated Technical Services	36	0.588	2.349	1.015
water conservancy, environment, and public facilities management	37	0.576	2.292	0.990
resident services, repair, and other services	38	0.465	2.032	0.878
education	39	0.277	1.599	0.691
health and social work	40	0.566	2.373	1.025
culture, sports, and entertainment	41	0.458	2.042	0.882
public management, social security, and social organizations	42	0.379	1.855	0.801
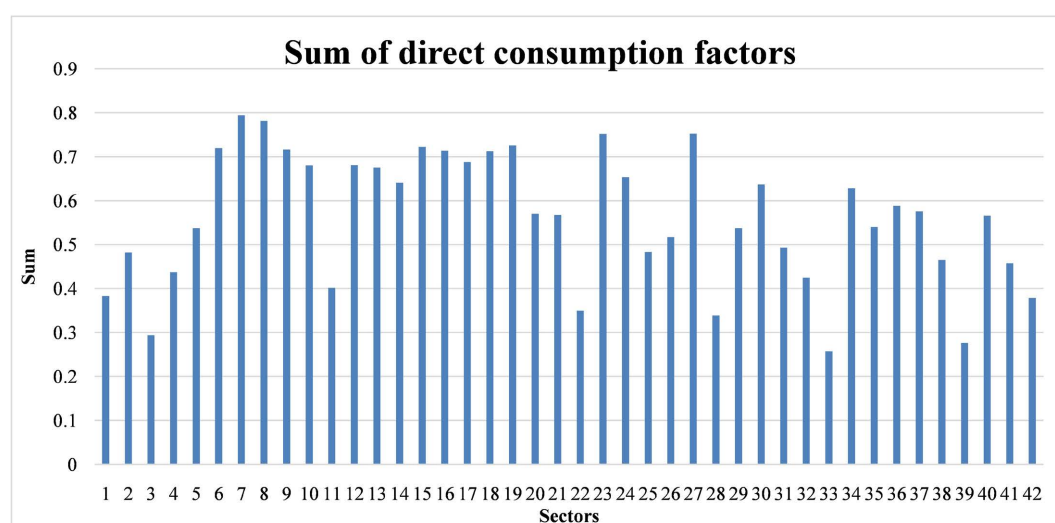
Figure 1. Direct consumption coefficients by industry in China.

characteristics of the real estate industry. The products that the real estate industry relies more on and consumes, such as steel and cement, are the final finished products, one of the main reasons why the real estate industry has the lowest direct consumption coefficient.

From the perspective of the complete consumption coefficient (Table 1, Figure 2), the highest complete consumption coefficient is in the textile industry and the lowest is in the real estate industry, whose quantitative results of industrial association and direct consumption coefficient results have the same nature.

When the influence coefficient of a sector is greater than 1, it means that the degree of the ripple effect of the sector's production on other sectors is higher (lower) than the average social influence level, i.e. the average of the ripple effects generated by each sector. The larger the influence coefficient, the greater the pulling effect of the sector on other sectors.

According to Figure 3, textile, clothing, footwear, leather, down and their products, textiles, metal products, machinery and equipment repair services, construction, transportation equipment, electrical machinery and equipment, general
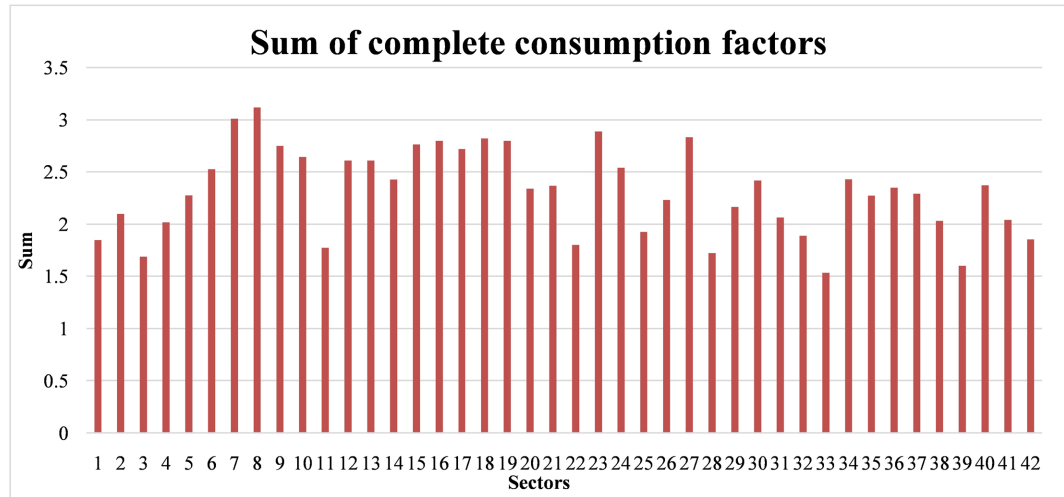
Figure 2. Graph of complete consumption coefficient of each industry in China.
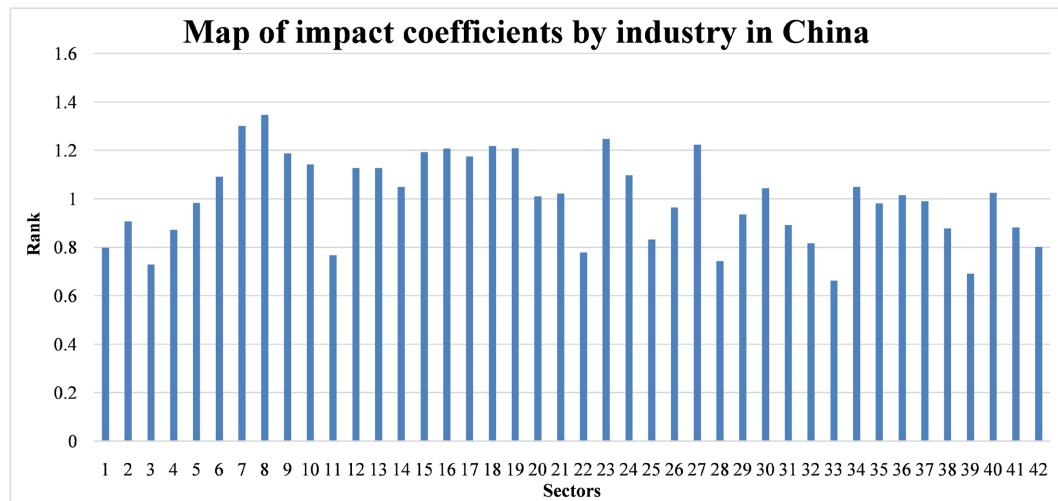

Figure 3. Impact factor diagram.

equipment, metal products, woodworking products and furniture, special equipment, paper printing and cultural and educational supplies, chemical products, non-metallic mineral products, production and supply of electricity and heat, food and tobacco, rental and business services, the Metal smelting and rolling processing products, accommodation and catering, health and social work, integrated technology, communications equipment, computers and other electronic equipment and other 22 industries with an impact factor greater than 1 and in decreasing order. Among them, textiles, clothing, footwear, hats, leather, down and their products have the largest impact coefficient of 1.347229. followed by textiles and metal products, machinery and equipment repair services with impact coefficients of 1.301 and 1.247 respectively. from the data of each industry in 2018, there are no industries with impact coefficients higher than 1.5, nor lower than half of the social average impact i.e. industries with an impact coefficient of 0.5, with values fluctuating between 0.662 and 1.347.

Table 2. China's industrial influence ranking.

Industries	Code	2017 Influence Rank	2018 Influence Rank
Agriculture, forestry and fishery products and services	1	34	36
Coal Mining Products	2	28	28
Oil and gas extraction products	3	39	40
Metal ore mining products	4	29	32
Non-metallic and other ore mining products	5	23	24
Food and Tobacco	6	14	15
Textiles	7	2	2
Textile, clothing, shoes, hats, leather, down and other products	8	1	1
Woodworking products and furniture	9	10	9
Paper printing and stationery and sporting goods	10	11	11
Petroleum, coking products and processed nuclear fuel products	11	35	38
Chemical products	12	13	12
Non-metallic mineral products	13	12	13
Metal Smelting and Rolling Products	14	16	17
Metal Products	15	9	8
General Purpose Equipment	16	6	7
Specialized equipment	17	5	10
Transportation equipment	18	8	5
Electrical machinery and equipment	19	7	6
Communication equipment, computers and other electronic equipment	20	22	22
Instrumentation	21	19	20
Other manufacturing products and scrap waste	22	38	37
Metal products, machinery and equipment repair services	23	3	3
The production and supply of electricity and heat	24	15	14
Gas production and supply	25	30	33
Water production and supply	26	26	26
Architecture	27	4	4
Wholesale and retail	28	40	39
Transportation, storage and postal	29	27	27
Accommodation and Dining	30	18	18
Information transmission, software and information technology services	31	33	29
Finance	32	36	34
Real Estate	33	42	42
Leasing and Business Services	34	17	16
Research and Experimental Development	35	24	25

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Integrated Technical Services	36	21	21
water conservancy, environment, and public facilities management	37	25	23
resident services, repair, and other services	38	31	31
education	39	41	41
health and social work	40	20	19
culture, sports, and entertainment	41	32	30
public management, social security, and social organizations	42	37	35

The industry with the lowest influence coefficient is real estate, which indicates that the production of the real estate industry has a smaller degree of influence on the remaining 41 industries in the country. Above, it also shows that the most influential industries are generally those in the manufacturing sector.

4.2. China Industry Correlation Study by Year

Due to data availability, the analysis of the calendar year is based on the input-output table data of 2017 and 2018. According to the area chart of the influence ranking of each industry in China (Table 2, the top the ranking, the greater the influence), it can be concluded that the influence of each industry changed less in 2017 and 2018, and the change is more prominent in 2018, the influence ranking of the special equipment industry (code is 17) changed from The influence of information transmission, software and information technology services industry (code 31) changed from 33rd to 29th, up 4 places, and the influence coefficient rose from 0.853 to 0.891. This phenomenon is in line with the development of our current economy, that is, the production of information transmission, software and information technology services industry to increase the degree of influence on other industries in our country, while some specialized equipment with the development of economic productivity, its production to reduce the degree of influence on the industries.

5. Conclusion

Through a series of calculations and analysis of direct consumption coefficient, complete consumption coefficient and influence coefficient, we have a deeper understanding of industrial association.

Although the industrial linkage, with the operation and development of the economy and society, presents a more intricate and complex, more closely linked, but in terms of its specific industries, the decisive factor of the linkage with other industries is the essential characteristics of the industry. This shows that in the industrial system construction, the most important thing is to grasp the essential characteristics of industry and its development law, in line with the law of historical development, in line with the interests of the people.

The focus of industrial association changes and develops with the develop-

ment of society. For example, today is the age of information technology, the production activities of the information series of industries have risen in influence on other industries. Whether it is direct consumption or complete consumption, it is unified with the changing times of industrial association. This means that it is necessary to trace the roots of the industry linkage as well as the main characteristics of the times. The industrial development strategy and other related strategies are considered in multiple aspects.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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