Analysis of the industrial linkage effect of China's construction industry[1]

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Abstract: This study depicts the industrial linkages in China's construction industry utilizing input-output data from 2002 to 2017 and then provides an in-depth analysis of the industrial linkage effects of China's construction industry. The study found that China's construction industry has broad demand-pulled and supply-driven effects on other industrial sectors. In contrast to its limited supply-driven effect, the construction industry plays a significant demand-pulled role for other industries of the national economy. The construction industry, which is the backbone of the national economy, is still very solid. This study is important to provide a theoretical basis for promoting the integration of the traditional construction industry into new industries and ensuring the high-quality economic development of the construction industry.

Keywords: Industrial linkage, Demand-pulled, Supply-driven, High-quality development.

1 INTRODUCTION

Industrial linkages refer to the technological and economic linkages between industrial sectors through the input and output of products or services. Most industries in the national economy are interdependent with each other and with other industries. Analyzing the input-output relationship between industrial sectors is an important way to understand the position and function of an industry in the national economy.

Inter-regional comparison and inter-industry analysis are the two levels on which the current studies in the field of industrial linkage studies are focused. The analysis of the strength of industrial linkages within[1, 3, 6] or among countries[1-2] is the main objective of the regional comparative level. The main industries involved in the inter-industry analysis level are the production service industry[1], the steel industry[2], the digital economy industry[5], the distribution industry[9], the real estate industry[8], the environmental protection industry[7], and the tourism industry[10]. The majority of scholars use input-output analysis as their main basis and investigate the effect of industrial linkage utilizing mathematical statistics[1,3], comparative analysis[2], the non-complete hypothesis method[2], structural decomposition[5], the industrial network analysis method[4] and other research methods.

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Most of the relevant studies use cross-sectional data, which cannot reveal the dynamic trend of linkage between regions or industries, and the related studies around the construction industry have not received sufficient attention. Based on China's value-based input-output tables from 2002 – 2017, this paper reveals the linkage relationships and evolutionary trends between China's construction industry and related industries through inter-industry linkage effect analysis. And this provides a decision-making reference for the relevant policy formulation of structural adjustment and cross-industry synergistic development of China's construction industry.

The primary contribution and innovation of this study, when compared to previous studies, is to separate the industries related to construction activities from the national input-output table and use it as a basis to explore the interdependent and inter-constrained technical and economic links between the upstream and downstream related industries in China's construction industry. Further, this provides a reference basis for promoting the integration of the construction industry with multiple industries and the formulation of strategies for high-quality industrial development

2 INDUSTRIAL LINKAGE MODELS

The ripple effect, backward linkage effect, and forward linkage effect are the three types of industry linkage. The industry's demand-pulled effect on the national economy is reflected by the backward linkage effect, while the industry's supply-driven effect is shown by the forward linkage effect. The ripple effect illustrates the influence and sensitivity of the industry to the whole economy.

2.1 Demand-pulled Effect Model

The demand-pulled effect is analyzed by the backward direct linkage index and the backward complete linkage index to analyze the backward linkage effect of an industrial sector on its related industrial sectors.

(1) The backward direct linkage index

The backward direct linkage index reflects the direct techno-economic linkage between industries and is represented by a_{ij}. The larger the a_{ij}, the stronger the linkage effect. And the coefficient matrix is represented by A, as shown in Equations (1) and (2).

$$a_{ij} = \frac{X_{ij}}{X_j} \tag{1}$$

$$\sum_i a_{ij} = \frac{\sum_i X_{ij}}{X_j} (i, j = 1,2,\ldots,n) \tag{2}$$

X_{ij} is the consumption of industry j by industry i, X_j denotes the sum of inputs of industry j, and $\sum_i a_{ij}$ denotes the sum of backward direct linkage intensity of industry j.

(2) The backward complete linkage index

The backward complete linkage index, which is denoted as $b_{ij}(i, j = 1,2,\mathbf{L},n)$, measures the effect of both direct and indirect technical and economic linkages between industries. The larger the b_{ij}, the stronger the linking effect. As seen in Equation (3), the coefficient matrix is given as B.

$$B = (I - A)^{-1} - I \tag{3}$$

I is the unit matrix.

2.2 Supply-driven Effect Model

The forward linkage of an industry to adjacent industries is examined using the forward direct linkage index and the forward complete linkage index to examine supply-driven effects.

(1) The forward direct linkage index

h_{ij} represents the forward direct linkage index, which measures the direct impact of an industry on the downstream industry. The degree of linkage is determined by the value of the h_{ij}. As seen in equations (4) and (5), H represents the coefficient matrix.

$$h_{ij} = \frac{X_{ij}}{X_i}(i, j = 1,2,\mathbf{L},n) \tag{4}$$

$$\mathbf{å}_j h_{ij} = \frac{\mathbf{å}_j X_{ij}}{X_i}(i, j = 1,2,\mathbf{L},n) \tag{5}$$

H denotes the sum of direct linkage strengths.

(2) The forward complete linkage index

The forward complete correlation index, which is represented by $w_{ij}(i, j = 1,2,\mathbf{L},n)$, expresses the cumulative effect of an industry's direct and indirect effects on downstream industries. The degree of linkage increases as w_{ij} increases in value. As indicated in Equation (6), the coefficient matrix is expressed by W.

$$W = (I - H)^{-1} - I \tag{6}$$

2.3 Ripple Effect Model

The ripple effect is divided into two aspects, which are the influence and sensitivity of the industry in the national economy.

(1) The influence coefficient

The influence coefficient is an indicator of the ripple effect and is denoted by y , as shown in equations (7) and (8).

$$l_j = \sum_j l_{ij} (i, j = 1,2,\cdots,n) \tag{7}$$

$$y = \frac{l_j}{\frac{1}{n}\sum_j l_j} (j = 1,2,\cdots,n) \tag{8}$$

l_{ij} is the element in the matrix $(I - A)^{-1}$, l_j is the sum of its j-th column elements, and the average of the sum of the elements in each column of the matrix $(I - A)^{-1}$ is $\frac{1}{n}\sum_j l_j$. The greater the W, the greater the industry's demand pull.

(2) The sensitivity coefficient

The sensitivity coefficient, denoted by the letter h , measures the degree to which the growth of one industry is influenced by changes in the development of other industries. as demonstrated by equations (9, 10).

$$q_i = \sum_j q_{ij} (i, j = 1,2,\cdots,n) \tag{9}$$

$$h = \frac{q_i}{\frac{1}{n}\sum_i q_i} (i = 1,2,\cdots,n) \tag{10}$$

q_{ij} is the element in matrix $(I - H)^{-1}$, and q_i is the sum of its i-th row elements. $\frac{1}{n}\sum_i q_i$ is the average of the sum of the elements in each row of matrix $(I - H)^{-1}$. The larger h indicates the stronger supply-driven effect of the industry.

3 EMPIRICAL RESEARCH

3.1 Data sources

The input-output tables for 2002, 2007, 2012, and 2017 were chosen as the base data in this study due to the availability of the data. The industrial classification in the input-output table of each year has some differences; in order to facilitate vertical comparison and analysis. According to the needs of the study, this paper compiles them into a consistent caliber of 42 industry sector data. Among them is the lack of "No. 24 repair service" in 2002, "No. 22 other manufacture," and "No. 24 repair service" in 2007.as shown in Table 1.

Table 1: China's 42 industries and numbers

No.	Industry	No.	Industry	No.	Industry
1	Agriculture	15	Metal Products	29	Wholesale and Retail Trades
2	Coal	16	General Purpose Machinery	30	Transport,Storage and Post
3	Petroleum and Natural Gas	17	Special Purpose Machinery	31	Hotels and Catering
4	Metal Ores	18	Transportation and Transport Equipments	32	Information Technology
5	Nonmetal Ores and Other Ores	19	Electrical Machinery and Apparatus	33	Financial Intermediation
6	Foods, Beverages and Tobacco	20	Electronic Equipent	34	Real Estate
7	Textile	21	Instruments and Machinery	35	Leasing and Business Services
8	Wearing Apparel and Related Products	22	Other Manufacture	36	Scientific and Technical
9	Timber and Fumoture	23	Utilization of Waste Resources	37	Management of Public Facilities
10	Manufacture of Culture and Education Products	24	Repair Service	38	Other Services
11	Petroleum, Coking and Nuclaer Fuel	25	Electricity and Heat	39	Education
12	Chemical Products	26	Gas	40	Health and Social Service
13	Non-metallic Mineral Products	27	Water	41	Culture,Sports and Entertainment
14	Smelting and Pressing of Metals	28	Construction	42	Public Management

3.2 Analysis of Linkage Effects in China's Construction Industry

(1) Demand-pulled effect

The demand-pulled effect is the backward linkage effect. The backward direct linkage index and the backward complete linkage index, respectively, measure the backward direct linkage effect and backward complete linkage.

In 2002, 2007, 2012, and 2017, the total backward direct linkage coefficients of China's construction industry with other industrial sectors were measured to be 0.7656, 0.7681, 0.7345, and 0.7583, while the average values were 0.0187, 0.0192, 0.0175, and 0.0181. And the total values of the backward complete linkage coefficients of China's construction industry for the nation's various industrial sectors were 2.0335, 2.4836, 2.4053, and 2.1584, respectively; the corresponding mean values were 0.0495, 0.0621, 0.0573, and 0.0514. Specifically, as shown in Figure 1.

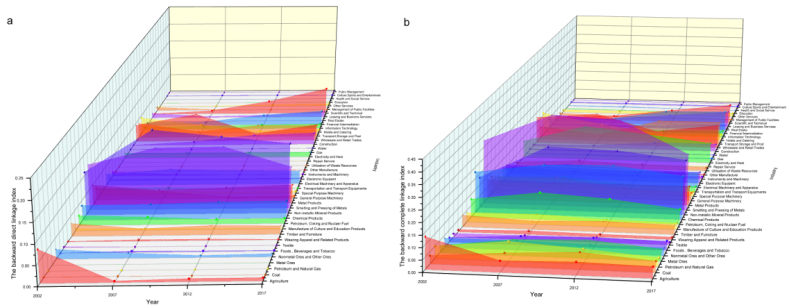

Figure 1: The backward linkage coefficients

Figure 1 illustrates the backward linkage effects of the construction industry on various industrial sectors of the national economy in 2002, 2007, 2012, and 2017. Around 80% of the total coefficient is made up of the backward direct or complete linkage coefficients of the top 10 industries that have the strongest backward linkage effect with the construction industry. The primary backward-linked industries of the construction industry are the smelting and pressing of metals, non-metallic mineral products, transportation, storage, posting, chemical products, electrical machinery and apparatus, metal products, and other industries. These industries supply the most fundamental means of production for the growth of the construction industry. According to the time series analysis, the backward linkage coefficients of the construction industry to the majority of other industries exhibit a dynamically increasing trend. This demonstrates that the industry's ability to pull in demand is continuing to grow over time while maintaining its status as a pillar of the national economy and further consolidating and strengthening it.

Meanwhile, it can be seen from Figure 1 that the backward correlation effect of the construction industry on the tertiary industries such as scientific research, technical services, and finance shows an upward trend. This is in accordance with the "14th Five-Year Plan," which aims to establish deep integration of the construction industry with new science and technology, resulting in new business models and development objectives.

(2) Supply-driven effect

The supply-driven effect is the forward linkage effect. The forward direct linkage index and the forward complete linkage index, respectively, measure the forward direct linkage effect and forward complete linkage.

The forward direct linking coefficients of China's construction industry to other industries in 2002, 2007, 2012, and 2017 were 0.0653, 0.0319, 0.0625, and 0.0459, respectively; the corresponding mean values were 0.0016, 0.0008, and 0.0015, details can be seen in Figure 2a. The forward complete linkage coefficients had total values of 0.5290, 0.0566, 0.1279, and 0.0655 and mean values of 0.0129, 0.0014, 0.0031, and 0.0016, details can be seen in Figure 2.

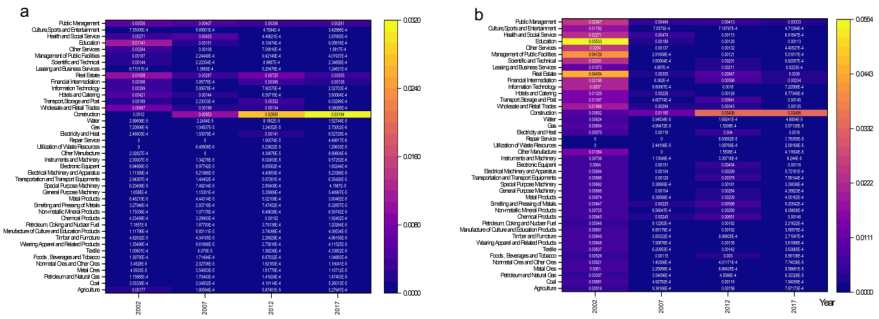

Figure 2: The forward linkage coefficients

More than 80% of the total coefficients in 2002, 2007, 2012, and 2017 can be observed in the sum of the forward direct or complete linkage coefficients of China's construction industry for ten industries, including public management, wholesale and retail trades, real estate, transportation, storage, post, etc. This indicates that the construction industry continues to have a stabilizing overall driving effect on other national economic sectors and plays a key role in determining how the tertiary industry's production is distributed. The supply-driven effect of the construction industry on various industries of the national economy basically remains stable. The forward correlation effect of the construction industry is minimal compared to the backward correlation effect, and the forward correlation utility to each industry is more evenly distributed.

(3) Ripple Effect

In order to more intuitively compare the influence and sensitivity of the construction industry and other industries on the national economy, this paper constructs a cross-coordinate system with the influence coefficient as the X-axis, the sensitivity coefficient as the Y-axis, and the intersection of the two (1,1) as the origin to judge the position of each industry in the national economy, as shown in Figure 3.

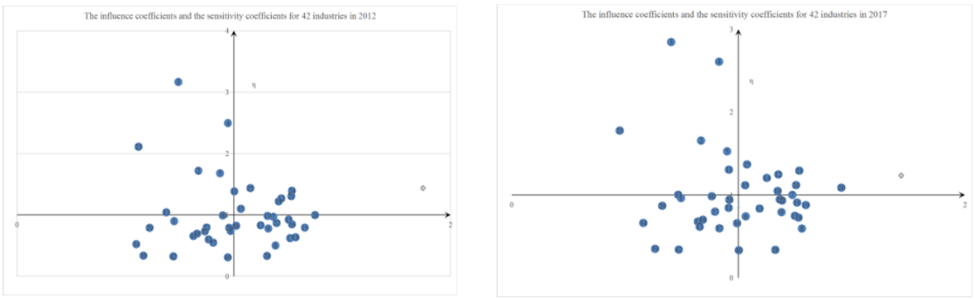

Figure 3: The influence coefficient and the sensitivity coefficient

As can be seen from Figure 3, the industrial structure of our country has been in a stable state over the years. Take the year 2017 as an example. Nine industries are located in the first quadrant, including chemicals, metal smelting and rolling products, electricity, heat, etc. And their influence and sensitivity coefficients are both greater than 1. These industries belong to the "strong-strong" demand-driven and supply-driven industries, and their level of demand induction and ripple effects transcend the average of society, providing significant momentum for national economic development. Seven industrial sectors are located in the second quadrant, including petroleum and natural gas, metal ores, etc. They have influence coefficients less than one and sensitivity coefficients greater than one, indicating that these industrial sectors mostly prosper by virtue of their strong driving force on other industrial sectors, and they belong to the "weak-strong" type of demand-driven and supply-driven industries. The third quadrant has the most industries, with 14, including real estate, education, wholesale and retail, and so on. Their both coefficients are less than 1, indicating that the demand induction and ripple effects of these sectors on other industrial sectors are smaller than the social average; they belong to the "weak-weak" type of demand-driven and supply-driven industries. The fourth quadrant has 12 industries, such as special-purpose machinery, transportation and transport equipment, construction, etc. They only have an impact coefficient greater than 1. These industries have a strong demand for production in all sectors of the national economy and are "strong-weak" demand-driven and supply-driven industries.

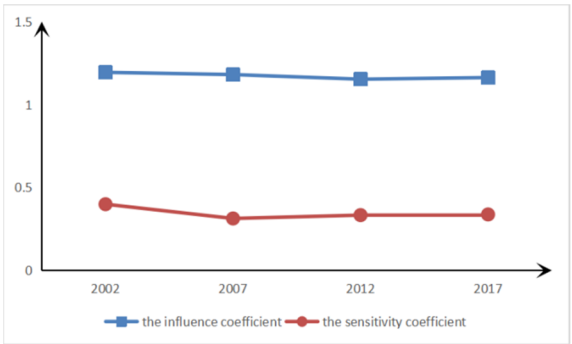

Figure 4 Ripple effects of the construction industry, 2002-2017

Figure 4 makes it clear that the construction industry's influence coefficient from 2002 to 2017 is much higher than its sensitivity coefficient. Construction is an industry with a higher

radiation and fewer restrictions, but its demand-pulled effect on the national economy is stronger than its supply-driven effect. The aforementioned amply demonstrates the importance of revitalizing China's pillar industries, such as the construction industry, at this time and actively pursuing new economic development points. This plays both a guiding and supporting role in the development of various industries in the national economy and is a major national development strategy issue.

4 CONCLUSION

China's construction industry has a wide range of pulling and driving effects on other industries through a combination of backward and forward connections as well as ripple effects. It can encourage deep integration and coordinated cross-industry development, as well as promote the growth of several industries upstream and downstream of the supply chain. On the one hand, the growth of industrial integration is focused on analyzing the broad influence of the construction industry on other industries. On the other hand, it is most important to clarify the synergistic development relationship with the construction industry and its deeply related industries so that the construction industry's economic quality development planning is more scientific and rational.

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REFERENCES

[1] Cheng D (2008) Development Level,Structure,and Impact of Producer Services in China:An International Comparison Based on Input-Output Approach. Economic Research Journal. 01):76-88.
[2] Huang G-t and Xu H (2018) The Correlation Effects of China's Iron and Steel and International Comparison: Based on Input-output Table. On Economic Problems. 11):1-8.
[3] Midmore P, Munday M and Roberts A (2006) Assessing industry linkages using regional input–output tables. Regional Studies. 40(3):329-343.
[4] Shen X, Wu S and Liu L (2022) Analysis on Correlation Effect of China’s Digital Economy and National Economy. Statistics & Decision. 38(04):27-32.
[5] Tian J-f, Li H-p, Zhang W and Xue R (2022) Research on the Association and Pulling Effect of Digital Economy Industry in China. Journal of Statistics and Information. 37(05):12-25.
[6] Wang H-y and Sun Q-m (2016) Research on Identification and Comparison of Key Industries in Beijing-Tianjin-Hebei Region—Based on the Complex Network Model. East China Economic Management. 30(12):77-85.
[7] Wang Y, Tian Y and Wu Y (2017) Input-output Analysis on the Correlation Effect of Environmental Industry in China. Chinese Journal of Environmental Management. 9(04):39-45.
[8] Wei W-x and Yuan P-f (2009) Comparative analysis of the industrial relationship and status of real estate industry:The cases of the situation in Beijing,Shanghai and Xiamen city. Systems Engineering-Theory & Practice. 29(05):98-105.
[9] Zhao X (2012) Industrial Linkage and Dynamic Comparison between China’s Circulation Service Industry and Manufacture Industry. Journal of Business Economics. 11):5-14.
[10] Zuo B and Yang Y (2021) Structural Linkage and Economic Contribution of Tourism Industriy:The Case of Guangdong Province in China. Tourism Tribune. 36(04):14-30.