Research on the Design and Analysis of the Improved Algorithm for Industrial Linkage Based on Input-Output Technology

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Abstract. The general measurement method of industrial linkage adopts the influence coefficient and the sensitivity coefficient to measure, and this method ignores the influence of the product structure of the current year when measuring the coefficient. In order to solve this problem, this research takes the Hainan Free Trade Port industry as an example, based on the input-output table of 42 sectors in the Hainan Free Trade Port in 2017, proposes an improved algorithm for measuring the degree of industrial linkage, derives the industrial influence coefficient and the sensitivity coefficient, and classifies and discusses the 42 industrial sectors in the Hainan Free Trade Port according to the relevant indices, evaluates the overall industrial linkage of the Hainan Free Trade Port and analyses the relationship between radiation and constraints of each industry. and analyses the relationship between the radiation and constraints of each industry. The conclusions drawn by the improved algorithm are more in line with reality, and the research results provide a theoretical basis for the adjustment and optimization of the industrial structure of the Hainan Free Trade Port. The empirical analysis results show that the improved algorithm for industrial linkage has the advantages of simple implementation and accurate calculation, and it is an effective method for analyzing industrial linkage.

Keywords: Input-output technology; Improved algorithm; Industrial linkage; Hainan Free Trade Port

1 Introduction

With the upgrading and rapid development of computer technology, accelerating the promotion and application of input-output technology, the national economy in the process of operation, there is a certain "input" and "output" relationship between the various industrial sectors, this relationship can be expressed as follows This relationship can be expressed as "the output of an industrial sector is the input of

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another industrial sector", and this relationship is the input-output relationship in the whole economic system [1-7]. Input-output technology was first proposed by Wassily Leontief in the mid-1930s, which is an important method of modern industrial linkage analysis, and is mainly embodied in the balanced relationship table between input sources and output flows of each industrial sector in the economic system, and mathematical models are established on the basis of the input-output table to express quantitative relationships between each industrial sectors, through the analysis of quantitative input-output relationships between industrial sectors. The association law between industries can be excavated by analyzing the quantitative input-output relationship between industrial sectors, which provides a theoretical basis for economic analysis, economic forecasting, industrial structure adjustment, industrial structure optimization, etc. [8-13].

Aiming at the shortcomings of the general measurement algorithm of industrial linkage, this paper proposes an improved algorithm of industrial linkage based on the data in the input-output table of 42 industrial sectors in the Hainan Free Trade Port, measures the influence coefficient and sensitivity coefficient of industrial sectors, This paper proposes an improved algorithm of industrial linkage based on the data in the input-output table of 42 industrial sectors in the Hainan Free Trade Port, measures the influence coefficient and sensitivity coefficient of the industrial sectors, explores the degree of linkage between each industry, analyzes the relationship between radiation and constraints of each industry, analyzes the degree of influence of the development of industries in the Hainan Free Trade Port on economic growth, and provides a theoretical basis for adjusting and optimizing the industrial structure of the Hainan Free Trade Port. At the same time, the improved measurement method provides a reference for the measurement and analysis of industrial linkage in other regions.

2 The basic principles of the input-output technology

2.1 Basic structure of an input-output table

In the process of national economic operation, the products and services of each industrial sector are consumed and used by which industrial sectors can be fully shown through the input-output table, not only that, the relationship between the consumption of products of various industrial sectors to other industrial sectors can also be interpreted through the input-output model.

Assuming that there are n industries, the variables in the input-output table are interpreted as follows:

X_{ij} denotes the value of products or services consumed by sector j in the economic system for sector i;

Y_i denotes the value of the product or service produced by sector i and consumed by final use;

X_i denotes the total value of products or services produced by sector i in the economic system;

V_j denotes the total value added generated by sector j in the economy.

The basic structure of the input-output table is shown in Table 1.

Table 1. The basic structure of the input-output table

Inputs \ Outputs		Intermediate use			Final use	Total outputs
		Sector 1	…	Sector n		
Intermediate inputs	Sector 1	X_{11}	…	X_{1n}	Y_1	X_1
	Sector 2	X_{21}	…	X_{2n}	Y_2	X_2
	…	…	…	…	…	…
	Sector n	X_{n1}	…	X_{nn}	Y_n	X_n
Added value		V_1	…	V_n		
Total inputs		X_1	…	X_n		

2.2 Industrial linkages indicators

2.2.1 Influence coefficient.

If the influence coefficient is greater than 1, it means that an increase in one unit of the final product in this sector has a demand effect on all other sectors of society that is higher than the average level of society, meaning that an increase in one unit of the final product in this sector has a demand effect on all other sectors of society that is higher than the average level of society. In other words, the production of this sector has a demand effect on all sectors of the national economy that is lower than the average level of society. If the influence coefficient is less than 1, it means that the increase of one unit of the final product in this sector has a demand effect on all sectors of society that is higher than the average level of society. If the influence coefficient is less than 1, it signifies that the demand pulls that an increase in one unit of the final product in the sector has on all societal sectors is weaker than that of society. The higher the influence coefficient, the greater the pull of the sector on other sectors.

2.2.2 Sensitivity coefficient.

When a sector's products are in higher demand than the average for the entire economy, the sensitivity coefficient is greater than 1, which means that all economic sectors have increased their final consumption by one unit. In other words, the sector experiences more induction than the average for the entire economy; if the sensitivity coefficient is lower than 1, the sector experiences less induction than the average for the entire economy. The influence and sensitivity coefficients give a complete picture of the place and function of each sector in the economy.

In general, the sectors with greater influence coefficients serve as the foundation for the growth of the national economy, while the sectors with higher sensitivity coefficients serve as the backbone of that economy.

3 Improved algorithm for industry linkage

3.1 General measurement method

The influence coefficient is the extent to which the addition of a unit of final consumption in each sector causes a spill-over of demand to other sectors of the economy, and is calculated as follows:

$$IC_j = \frac{\sum_{i=1}^{n} b_{ij}}{\frac{1}{n}\sum_{j=1}^{n}\sum_{i=1}^{n} b_{ij}} \tag{1}$$

where $b_{ij} = (I - A)^{-1} - I$ is the full consumption factor, A is the matrix of direct consumption factors, I is the matrix of units.

The sensitivity coefficient is the extent to which a sector is fully demand-sensitive to the resulting change in the amount of output it must produce for other sectors for each additional unit of final consumption in each sector of the economy, and is calculated as follows:

$$SC_i = \frac{\sum_{j=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}} \tag{2}$$

3.2 Improved measurement method

In the calculation of the influence coefficient, calculation of the influence coefficient has been improved by amending the equally weighted average of the final products of the sectors to a weighted average with the physical share of the final products as weights. Similarly, the calculation of the sensitivity coefficient has been improved by amending the equally weighted sum of elements to a weighted sum with the sectoral structural share of intermediate consumption as weights, which gives a more reasonable result.

The improved influence coefficient is calculated as

$$\overline{IC_j} = \frac{\sum_{i=1}^{n} b_{ij}}{\sum_{j=1}^{n}\left(\alpha_j \sum_{i=1}^{n} b_{ij}\right)} \tag{3}$$

where $b_{ij} = (I - A)^{-1} - I$ is the full consumption factor, A is the matrix of direct consumption factors, I is the matrix of units, $\alpha_j = \frac{x_j}{\sum_{j=1}^{n} x_j}$ is the weighting factor and x_j is the final output for the year.

Similarly, the improved sensitivity coefficient is calculated as

$$\overline{SC_i} = \frac{\sum_{j=1}^{n} b_{ij}}{\sum_{i=1}^{n} \left(\beta_j \sum_{j=1}^{n} b_{ij} \right)} \tag{4}$$

where $\beta_j = \frac{y_j}{\sum_{j=1}^{n} y_j}$ is the weighting factor and y_j is the initial input for the year.

3.3 Algorithm design

This paper proposes to improve based on the general measurement method of industrial linkage, and when calculating the correlation coefficient, the weighted average method is used to consider the impact of the product structure of the current year, instead of simply equal-weighted average, and the specific algorithm is as follows:

Step 1: The data in the input-output tables are pre-processed and presented in a matrix.

Step 2: Based on the pre-processed data in the input-output tables, calculate the direct consumption coefficients between the different industry sectors and construct the direct consumption coefficient matrix.

Step 3: Based on the direct consumption coefficient matrix, calculate the full consumption coefficient between each industry and construct the full consumption coefficient matrix.

Step 4: Calculate the correlation coefficient according to the full consumption coefficient matrix and the improved measurement method proposed in this paper.

Step 5: Conduct a comprehensive analysis of each industrial linkage according to the correlation coefficient index, and draw the corresponding conclusions.

4 Empirical and results analysis

Based on the input-output table data of 42 industrial sectors of the Hainan Free Trade Port in the 2017 China Regional Input-Output Table, the influence coefficient of each industrial sector is measured and compared, and analyzed separately using the general measurement method and the improved measurement method, respectively, and the specific results are shown in Fig. 1 and Fig. 2. Similarly, the sensitivity coefficient of each industrial sector is measured separately, and the specific results are shown in Fig. 3 and Fig. 4.

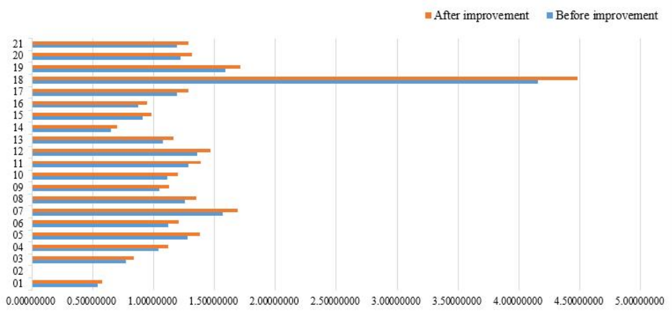

Fig. 1. Comparison of the influence coefficients for industrial sectors with industry code 1-21

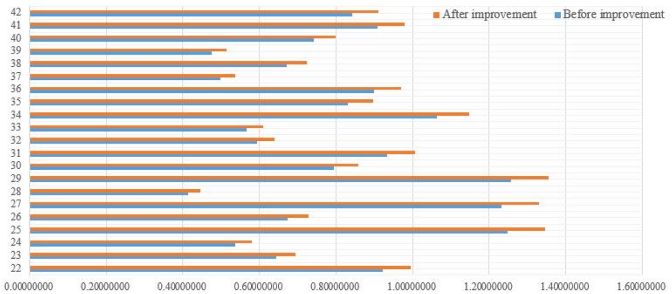

Fig. 2. Comparison of the influence coefficients for industrial sectors with industry code 22-42

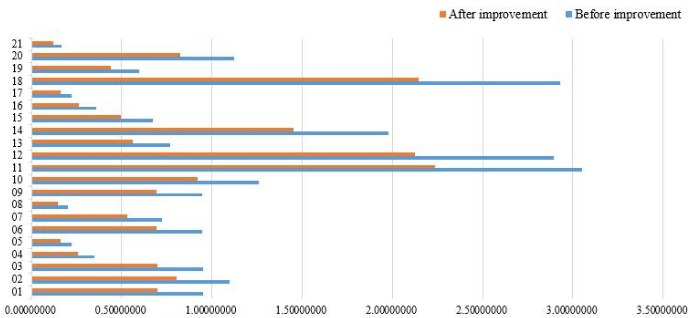

Fig. 3. Comparison of the sensitivity coefficients for industrial sectors with industry code 1-21

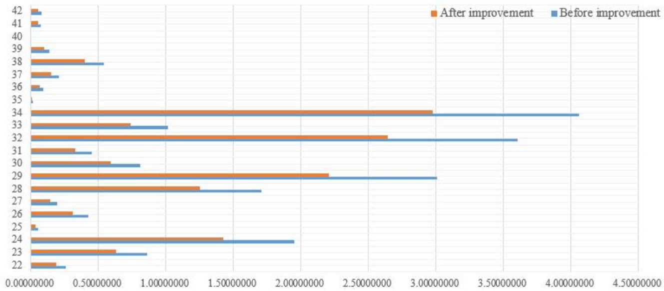

Fig. 4. Comparison of the sensitivity coefficients for industrial sectors with industry code 22-42

From Fig. 1 to Fig. 4, there is a high correlation between the influence coefficient and the sensitivity coefficient before and after the improvement. In 2017, the 12 important pillar industries of the Hainan Free Trade Port are shown in Table 2, and the 12 important basic industries are shown in Table 3. The analysis results of the improved algorithm are more consistent with the actual situation of the Hainan Free Trade Port, with an accuracy rate of 91.67%, which shows that the improved algorithm is effective.

Table 2. Important pillar industries

Industry code	National economic sectors	Improved influence coefficient
18	Transportation equipment	4.48224754
19	Electrical machinery and equipment	1.71409770
07	Textiles	1.69122713
12	Chemical products	1.46669194
11	Petroleum, coking products, and processed nuclear fuel products	1.38722370
05	Non-metallic and other mineral extraction products	1.38218151
29	Transportation, storage and postal	1.35514637
08	Textile, clothing, shoes, hats, leather, and down and their products	1.35377418
25	Gas production and supply	1.34551133
27	Construction	1.32939127
20	Communication equipment, computers, and other electronic equipment	1.31676642
17	Special equipment	1.28785815

Table 3. Important basic industries

Industry Code	National economic sectors	Improved sensitivity coefficient
34	Leasing and business services	2.98057899

32	Finance	2.64456149
11	Petroleum, coking products, and processed nuclear fuel products	2.23815640
29	Transportation, storage and postal	2.20683576
18	Transportation equipment	2.14724394
12	Chemical products	2.12378116
14	Metal smelting and rolling products	1.45176573
24	Electricity, heat production, and supply	1.43026306
28	Wholesale and retail	1.25432749
10	Paper printing and stationery and sporting goods	0.92206311
20	Communication equipment, computers, and other electronic equipment	0.82413615
02	Coal mining products	0.80548093

5 Conclusions

Aiming at the deficiencies of the general measurement method of industrial linkage, this paper proposes an improved algorithm for measuring industrial linkage and takes the industry of the Hainan Free Trade Port as an example to verify the effectiveness and feasibility of the improved algorithm. By comparing the results of the general measurement method and the improved measurement method, the results calculated by the improved measurement method are more reasonable and more in line with reality. According to the influence coefficient and sensitivity coefficient calculated by the improved measurement method, it can objectively evaluate and analyze the degree of industrial linkage of the Hainan Free Trade Port, and analyze the radiation and constraints between various industries, and the comprehensive evaluation results are more in line with the actual situation, and the results of the analysis can provide theoretical guidance for the adjustment and optimization of the industrial structure of the Hainan Free Trade Port. In addition, the improved algorithm of industrial linkage measurement proposed in this paper can be extended to the analysis of industrial linkage in other regions, and the application of the improved measurement method has a promising prospect.

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