Research on Energy Industry Based on the Input-Output Model

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Abstract. This paper uses input-output model to calculate direct consumption coefficient, total distribution coefficient, direct consumption coefficient and total consumption coefficient of five energy industries. We analyze the related industries of the energy industry. The results show that the Electricity industry has the largest consumption coefficient and distribution coefficient, and the Electricity industry is an important part of the economy. The consumption coefficient and distribution coefficient of the coal industry are relatively large.

1. Introduction
Energy is an important part of our national economy. Since the reform and opening up, China's economy and society have continued to develop. In 2014, China's GDP was 64 trillion yuan, an increase of 8.19% over the same period of last year. In 2014, China's total energy consumption is 4000 million tons of coal, which was the total energy consumption in 2004. 1.8 times.1. As industrialization and urbanization continue to accelerate, the consumption rate of coal, oil, and natural gas is also accelerating, which has led to conflicts between economic growth and energy issues and environmental issues. How to achieve sustainable socio-economic development on the basis of reducing energy consumption has become an important issue. The energy industry not only directly promotes the growth of the economy, but also promotes the development of other industries through the relationship between industries, and indirectly promotes the development of the social economy. Therefore, optimizing the structure of the energy industry and promoting the structural reform of the energy industry have important practical significance.

Scholars have conducted a certain analysis of the energy industry structure of the energy industry. Wang Minmin(2017) pointed out that the industries closely related to the energy industry in Shaanxi Province are mainly concentrated in the primary industry and the secondary industry. Some industries and energy industries not only have a pulling relationship, but also a driving relationship. Jiang X (2016) and others analyzed that the forward and backward correlation effects and the ripple effect of the energy sector are higher than those of the non-energy sector.

This paper uses the input-output model, and the data is the national input-output data in 2012 to analyze the related industries of China's energy industry. The purpose is to achieve energy conservation through industrial restructuring, thereby improving energy efficiency.

1 Data resource: China Statistical Yearbook 2015
2. Research methods
This paper adopts the input-output method, selects China's 2012 input-output data, and according to Wang Minmin's assumption, defines the energy industry as coal mining and washing, oil and gas extraction, petroleum processing, coking and nuclear fuel processing, power, heat production and supply, gas production and supply industries.

2.1. The input-output model
The input-output model, also known as input-output analysis, was proposed by American economist Vasily Leontief in the 1930s. This article will examine the relationship between energy industry and non-energy industry.

2.2. The calculation of Energy industry correlation coefficient
The forward correlation coefficient of the energy sector refers to the relationship between the sectors with energy as the input factor, reflecting the relationship between the energy industry and the downstream industry, measured by the direct distribution index and the complete distribution index. The products of other production departments are used as input factors to reflect the relationship between the energy sector and the upstream industry, and are measured by the direct consumption coefficient and the complete consumption coefficient.

2.2.1. The direct distribution coefficient.
The direct distribution coefficient refers to the proportion of energy used as an input factor to the non-energy industry as a percentage of total energy output. The index of direct partition can be written as

\[ c_{ij} = \frac{x_{ij}}{q_i}, \quad (i=1, 2, 3...n, \quad j=1, 2, 3...n) \]

\[ x_{ij} \] represents the Energy industrial total amount directly allocated to the Non-energy industry department as an intermediate product in production activities, \( q_i \) is the total output of energy industrial. Here we hypothesis the direct distribution coefficient \( C \),

\[ C = \left[c_{ij}\right]_{n \times n}, \quad (0 \leq c_{ij} < 1, \text{and } \sum_{j=1}^{n} c_{ij} < 1, \quad i=1, 2, 3...n) \]

The direct distribution coefficient reflects the most direct forward correlation both the energy industry and non-energy industry. If the direct distribution coefficient is large, the direct promotion of the energy industry to the non-energy industry will be more obvious.

2.2.2. The total distribution coefficient.
The total distribution coefficient refers to the quantity that the energy industry provides to the non-energy industry through a direct or indirect relationship for each additional value added. The complete distribution coefficient is the sum of direct allocation and various indirect distributions. Here we hypothesis the direct distribution coefficient \( D \)

\[ D = (I - C)^{-1} - I = \left[d_{ij}\right]_{n 	imes n} \]

I is the unit matrix. The total distribution coefficient represents the forward full degree of relevance, reflecting the full promotion of the energy industry to the non-energy industry. If the total distribution coefficient is great, the energy industry's full promotion of the non-energy industry will be more obvious. Conversely, if the total distribution coefficient is small, the energy industry's full promotion of the non-energy industry will be weak.

2.2.3. Direct consumption coefficient.
The direct consumption coefficient refers to the amount of intermediate inputs of the energy industry consumed by the total output of the non-energy industry during the production and operation process. The index of direct consumption index can be written as

\[ a_{ij} = \frac{x_{ij}}{q_j}, \quad (i=1,2,3...n, \quad j=1, 2, 3...n) \]
\( x_j \) represents the energy industrial total amount directly input to the non-energy industry as an intermediate product in production activities, \( q_i \) is the total output of non-energy industrial. Here we hypothesis the direct consumption coefficient \( A \),

\[
A = \left[a_{ij}\right]_{n \times n} \quad (0 \leq a_{ij} < 1, \quad \text{and} \quad \sum_{i=1}^{n} a_{ij} < 1, \quad i,j = 1,2,3\ldots n) \quad (5)
\]

2.2.4. Total consumption coefficient. Total consumption coefficient refers to the total consumption of the non-energy industry's final products for the energy industries; it is the sum of both the direct consumption and the indirect consumption of the industry, reflecting the linear relationship between the final product and energy consumption.

Here we hypothesis the direct consumption coefficient \( B \),

\[
B = (I - A)^{-1} - I = \left[b_{ij}\right]_{n \times n} \quad (6)
\]

\( I \) represents the unit matrix, and \( b_{ij} \) represents the amount of the energy industry to product the non-energy industry in production activities.

3. The coefficient between energy industries

This paper calculates the direct distribution coefficient, total distribution coefficient, direct consumption coefficient, the total consumption coefficient, using the input-output data of 2012. The result is showed below.

3.1. The direct distribution coefficient

After calculating the four coefficients of the energy industry and non-energy industry, we choose some industries to analysis the direct distribution coefficient. We can see that among the energy industry the biggest direct distribution is electricity industry, the direct distribution coefficient is 0.326. The direct distribution coefficient of the coal industry is 0.039, oil and gas industry is 0.045, oil and nuclear fuel industry is 0.016, the gas production and supply industry is 0.022.

| Industry                     | Direct distribution coefficient |
|------------------------------|---------------------------------|
| Coal industry                | 0.039                           |
| Oil and gas industry         | 0.045                           |
| Oil and nuclear fuel         | 0.016                           |
| Electricity industry         | 0.326                           |
| Gas production and supply    | 0.022                           |
| Water supply industry        | 0.158                           |
| Metal mine industry          | 0.098                           |
| Timber processing industry   | 0.002                           |
| Chemical products industry   | 0.042                           |

In the non-energy industry, the direct distribution index of the Chemical products industry is 0.042. The direct distribution coefficient of water supply industry is 0.158, it is after the Electricity industry. The Metal mine industry is 0.098, and the Timber processing industry is 0.02. We can see that the energy industry also uses manufacturing as the input material, in addition to energy as a raw material.

3.2. The total distribution coefficient

Then we calculate the total distribution coefficient, the result is displayed in Table 2.
Table 2. The total distribution coefficient

| Industry                  | Total distribution coefficient |
|---------------------------|--------------------------------|
| Coal industry             | 0.113                          |
| Oil and gas industry      | 0.116                          |
| Oil and nuclear fuel      | 0.115                          |
| Electricity industry      | 0.547                          |
| Gas production and supply | 0.115                          |
| Water supply industry     | 0.289                          |
| Metal mine industry       | 0.225                          |
| Timber processing industry| 0.109                          |
| Chemical products industry| 0.166                          |

We can see that among the energy industry the biggest total distribution is electricity industry, the direct distribution coefficient is 0.547. The direct distribution coefficients of the left four industries are similar. The direct distribution coefficient of the coal industry is 0.113, oil and gas industry is 0.116, oil and nuclear fuel industry is 0.115, and the gas production and supply industry is 0.115.

In the non-energy industry, the direct distribution coefficient of water supply industry is 0.289, it is after the Electricity industry. The Metal mine industry is 0.225, and the Timber processing industry is 0.109, the Chemical products industry is 0.166.

3.3. The direct consumption coefficient

Then we calculate the direct consumption coefficient, the result is displayed in Table 3.

Table 3. The direct consumption coefficient

| Industry                  | Direct consumption coefficient |
|---------------------------|--------------------------------|
| Coal industry             | 0.182                          |
| Oil and gas industry      | 0.009                          |
| Oil and nuclear fuel      | 0.039                          |
| Electricity industry      | 0.326                          |
| Gas production and supply | 0.001                          |
| Water supply industry     | 0.001                          |
| Metal mine industry       | 0.0001                         |
| Timber processing industry| 0.0002                         |
| Chemical products industry| 0.001                          |

We can see that among the energy industry the biggest direct consumption coefficient is electricity industry, the direct consumption coefficient is 0.326. The direct consumption coefficient of the coal industry is 0.182, oil and gas industry is 0.009, oil and nuclear fuel industry is 0.039, and the gas production and supply industry is 0.001.

In the non-energy industry, the direct consumption index of water supply industry is 0.001, the Metal mine industry is 0.0001, and the Timber processing industry is 0.0002, the chemical industry is 0.001, the direct consumption of the non-energy is little. It doesn’t mean that these industries are rely on energy industry.

3.4. The total consumption coefficient

Then we calculate the total consumption coefficient, the result is displayed in Table 4.
Table 4. The total consumption coefficient

| Industry                        | Total consumption coefficient |
|---------------------------------|------------------------------|
| Coal industry                   | 0.351                        |
| Oil and gas industry            | 0.076                        |
| Oil and nuclear fuel            | 0.103                        |
| Electricity industry            | 0.547                        |
| Gas production and supply       | 0.003                        |
| Water supply industry           | 0.003                        |
| Metal mine industry             | 0.024                        |
| Timber processing industry      | 0.013                        |
| Chemical products industry      | 0.094                        |

We can see that among the energy industry the biggest total distribution is electricity industry, the direct distribution coefficient is 0.547. The direct distribution coefficients of the left four industries are similar. The direct distribution coefficient of the coal industry is 0.113, oil and gas industry is 0.116, oil and nuclear fuel industry is 0.115, and the gas production and supply industry is 0.115.

In the non-energy industry, the direct distribution coefficient of water supply industry is 0.289, it is after the Electricity industry. The Metal mine industry is 0.225, and the Timber processing industry is 0.109.

Figure 1. The coefficient of the five industries

Overall from the perspective of the energy industry, the direct consumption index of the energy industry is relatively large. The direct distribution coefficient, the total distribution coefficient, the direct consumption coefficient and the total consumption coefficient of the power industry are the largest among the five major energy industries. It shows that there is a close relationship between the power industry and others. The backward correlation coefficient of the coal industry is relatively large, indicating that in the production process, the non-energy industry is the input factor, and the relationship between the coal industry and the backward related industries is relatively close.

4. Conclusion

This paper uses the input-output method to compute the direct consumption coefficient, total distribution coefficient, direct consumption coefficient and total consumption coefficient of five energy industries. We analyze the related industries of the energy industry. The analysis results show that the Electricity industry has the largest consumption coefficient and distribution coefficient, and the Electricity industry is an important part of the economy. The consumption coefficient and distribution coefficient of the coal industry are relatively large. As a major energy country, China's
coal industry has driven the development of the related industries and promoted the development of related industries in the preceding paragraph. At the same time, we found that the secondary industry is the industry with the largest energy consumption. For example, in the manufacturing industry, the distribution coefficient of the production industry is relatively large.

Based on the above analysis, we made several suggestions.

Firstly, we can upgrade the industrial structure, help to save energy and reduce emissions, eliminate industries with high energy consumption, and develop industries that consume low energy and contribute to economic development.

Then, in the future, we must improve the efficiency of energy use and reduce pollution.

Finally, we should develop new energy sources to achieve sustainable energy development.

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