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# Energy Consumption Efficiency Research of Logistics Industry in Beijing Based on Input-Output Model

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***Abstract:*** **The paper uses input-output method to analyze the energy consumption efficiency of Logistics industry. At first, an input-output model was made by introducing energy consumption. Then, the energy consumption efficiency of Logistics industry in Beijing was analyzed using this model. The results show that direct consumption efficiency and complete consumption efficiency are on the low side in all the sectors; direct consumption efficiency and complete consumption efficiency enhanced from 2005-2010. Based on analysis, some pieces of suggestion were put forward, for example, improving indirect consumption efficiency and direct consumption efficiency of Logistics at the same time.**

***Keywords:*** Logistics industry; Energy Consumption Efficiency; Input-Output Model; Direct Consumption Coefficient; Complete Consumption Coefficient

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## 1. Introduction

Since man entered the industrialization society, rising oil and energy demand makes extensive use of the existing crude oil reserves getting exhausted. Energy issues become prominent global issues. In recent years because of China sustained and rapid economic growth, energy consumption will continue to increase. The Beijing statistical yearbook bulletin shows that 2010 total energy consumption was 6954.1 Million tons of standard coal, an increase of 5.8% [1]. According to statistics, two-thirds of world oil consumption comes from transportation. Energy consumption in this area has been the general concern of scholars home and abroad. According to rough statistics, the energy cost of logistics enterprises has occupied 40% of the total cost, or even 80% [2]. High energy consumption has become a bottleneck restricting the development of the logistics industry. Modern logistics developed on the basis of the traditional transportation and warehousing industry, and is considered to be the third source of profits of the enterprise to reduce material consumption and increase labor productivity. Modern logistics plays an important role in national economic and social development.

## 2. Logistics Industry Input-output Model of Energy Consumption

Energy consumption in the logistics industry in the traditional input-output table is based on the input-output table [3], the introduction of energy consumption. Energy consumption is the primary energy consumption, including coal, crude oil, natural gas, hydropower, nuclear and other power energy (wind, geothermal, etc.) generating capacity. Low calorific value fuel production, biomass, solar energy and the secondary energy converted from the primary energy production. In order to more clearly see the difference of the efficiency of energy consumption between the logistics industry and other industries, the paper re-classified industries in Beijing input-output table. The 42 major sectors in national economy were divided into 5 sectors, the agriculture, the industry, the construction, the logistics industry and the tertiary industry. Energy consumption is the primary energy consumption, including coal, crude oil, natural gas, hydropower, nuclear and other power energy (wind, geothermal, etc.) generating capacity. Low calorific value fuel production, biomass, solar energy and the secondary energy converted from the primary energy production. In order to more clearly see the difference of the efficiency of energy consumption between the logistics industry and other industries, the paper re-classified industries in China input-output table. The 42 major sectors in national economy were divided into 5 sectors, the agriculture, the industry, the construction, the logistics industry and the tertiary industry. Among them, the agriculture refers to the agriculture, forestry, animal husbandry and fishery; the logistics industry refers to the transportation and warehousing industry and the postal industry; the third industry refers to other industries except for the logistics industry.

By Table 1, we can calculate the logistics industry's direct energy consumption coefficient to reflect the amount of energy consumed directly per unit of product. In 2010, the output value, direct energy consumption amount and the direct consumption coefficient values of the various industrial sectors, as shown in Table 2.

**Table 1 Logistics industry energy consumption input-output**

| Output / Input | | Intermediate use | | | | | Final Use | Output |
|---|---|---|---|---|---|---|---|---|
| | | Agriculture | Industry | Construction | Logistics | The Tertiary | | |
| Intermediate inputs | agriculture | $X=(x_{ij})_{n\times n}$ | | | | | $Y=\begin{bmatrix}Y_1\\Y_2\\\vdots\\Y_n\end{bmatrix}$ | $X=\begin{bmatrix}X_1\\X_2\\\vdots\\X_n\end{bmatrix}$ |
| | Industry | | | | | | | |
| | Construction | | | | | | | |
| | Logistics | | | | | | | |
| | The Tertiary | | | | | | | |
| Energy Consumption | | $E=(E_1 \quad E_2 \quad \cdots \quad E_n)$ | | | | | $F$ | $G$ |
| Added Value | | $V=(V_1 \quad V_2 \quad \cdots \quad V_n)$ | | | | | | |
| Input | | $X=(X_1 \quad X_2 \quad \cdots \quad X_n)$ | | | | | | |

$X=(x_{ij})_{n\times n}$ is the intermediate goods consumption matrix, which $x_{ij}$ means that number of products of the jth sector consume the ith sector ; $Y=(Y_1 \quad Y_2 \quad \cdots \quad Y_n)'$ is the vector of industries end-use; $X=(X_1 \quad X_2 \quad \cdots \quad X_n)'$ is the total output vector of each industry sector; $E=(E_1 \quad E_2 \quad \cdots \quad E_n)$ is the industry's energy consumption matrix, which $E_j$ is the number of the jth industrial energy consumption; $F$ is the final use energy consumption; $G$ is the sum of energy consumption; $V=(V_1 \quad V_2 \quad \cdots \quad V_n)$ is the industry added value vector; $X=(X_1 \quad X_2 \quad \cdots \quad X_n)$ is the total input of each industry.

## 3. Analysis on the Direct Energy Consumption Efficience of the Logistics Industry

The logistics industry consumed 19% energy, but had the contribution of 6% GDP to national economy. Direct energy consumption coefficient of logistics was 0.4170, the largest in all industries, followed by the agriculture, industry, the tertiary industry and construction. Therefore, the direct energy consumption efficiency of logistics in all sectors in the national economy was the lowest. On the one hand, the industrial features of the logistics industry determine its high energy consumption. According to statistics, about 58% diesel consumptions were consumed by Logistics [4]. On the other hand, more extensive development of China's logistics industry has lower social and professional level, and higher logistics costs paid. China's total logistics expenditure shares GDP nearly 20%, while that of the United States and Japan is less than 10%. Extensive and inefficient logistics operation mode is resulted in increased energy consumption and energy waste.

In order to analyze the direct energy consumption efficiency of the logistics industry changes, energy consumption calculation table can be seen in Table 3.

Table 3 can be concluded that: direct energy consumption coefficient of logistics industry in Beijing between 2005 and 2010 was declining, falling from 0.5048 tons of standard coal / million Yuan in 2005 to 0.4170 tons standard coal / million Yuan in 2010 It showed that direct energy consumption efficiency of the logistics had continued to increase.

**Table 2 Direct energy consumption coefficients of industrial sectors table in 2010**

| | Units | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry |
|---|---|---|---|---|---|---|
| Out put | Billion Yuan | 2649.52 | 328.02 | 3169.75 | 14389.82 | 25084.55 |
| Total energy consumption | Million tons of standard coal | 1104.80 | 100.30 | 167.00 | 2559.70 | 1792.60 |
| direct consumption coefficient | Tce/million Yuan | 0.4170 | 0.3058 | 0.0527 | 0.1779 | 0.0715 |

**Table 3 Direct energy consumption efficiency of the logistics industry table from 2005 to 2010**

| | Units | 2005 | 2007 | 2010 |
|---|---|---|---|---|
| Out put | Billion Yuan | 1116.03 | 1477.16 | 2649.52 |
| Total energy consumption | Million tons of standard coal | 563.40 | 840.80 | 1104.80 |
| direct consumption coefficient | Tce/million Yuan | 0.5048 | 0.5692 | 0.4170 |

**Table 4 2010 Input-Output table in Beijing (Units: Billion Yuan, Tce/million Yuan)**

| © | | Intermediate use | | | | | Output |
|---|---|---|---|---|---|---|---|
| | | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry | |
| Intermediate inputs | Agriculture | 56.46 | 127.24 | 7.38 | 0.21 | 103.54 | 328.02 |
| | Industry | 68.08 | 8451.00 | 1719.27 | 555.56 | 4792.50 | 14389.82 |
| | Construction | 0.01 | 13.51 | 69.28 | 12.04 | 575.10 | 3169.75 |
| | Logistics Industry | 13.08 | 731.66 | 139.84 | 1028.29 | 1449.15 | 2649.52 |
| | The Tertiary Industry | 66.03 | 2302.44 | 609.60 | 341.41 | 8275.42 | 25084.55 |
| Energy Consumption | | 100.30 | 2559.70 | 167.00 | 1104.80 | 1792.60 | |

## 4. Chemicalsotal Energy Consumption Efficiency in the Logistics Industry

Logistics industry not only directly consumes energy, but also indirectly consumes energy through its indirect investment in other industries. By industry association study, there are 38 directly related with logistics industry in 41 sectors in the national economy, and the associated surface is 93%[5]. If the logistics industry requires large amounts of transportation equipment, and transportation equipment manufacturing will consume a large amount of energy. Therefore, to fully estimate energy consumption of the logistics industry, it is necessary to analyze the logistics industry total energy consumption coefficient. In this paper, the 2010 Beijing input-output tables were consolidated; combined with the 2013 Beijing Statistical Yearbook data, seen in the Table 4.

Using the data in Table IV and Table II, total energy consumption coefficients of each industry can be calculated, seen in Table 5.

**Table 5 2010 Total energy consumption coefficient of each sectors in Beijing (Units: Tce/million Yuan)**

| | $b_{ij}$ | | | | |
|---|---|---|---|---|---|
| | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry |
| Agriculture | 0.2227 | 0.0362 | 0.0278 | 0.0171 | 0.0203 |
| Industry | 1.0682 | 2.0092 | 1.9326 | 1.2646 | 1.0397 |
| Construction | 0.0179 | 0.0232 | 0.0451 | 0.0251 | 0.0446 |
| Logistics Industry | 0.2332 | 0.3296 | 0.3162 | 0.8047 | 0.2618 |
| The Tertiary Industry | 0.6724 | 0.7994 | 0.8306 | 0.6613 | 0.8098 |
| $b_{ej}$ | 0.7101 | 0.7421 | 0.5985 | 1.0313 | 0.4320 |

The total energy consumption coefficient of the logistics industry was 1.0313 tons of standard coal/million Yuan, the highest in the industrial departments. Based on direct energy consumption

coefficient of the logistics industry, the indirect energy consumption coefficient of the logistics industry was 0.6143 tons of standard coal factor / million Yuan. Energy consumption efficiency of the logistics industry was the lowest.

In order to analyze the efficiency of the logistics industry changes in total energy consumption, Beijing's 2007 input-output tables were consolidated, with the 2013 Beijing Statistical Yearbook data, seen in Table 6.

To study the total energy consumption efficiency of the logistics industry changes, the direct energy consumption coefficient of each industry and the total energy consumption coefficient of the logistics industry were calculated, seen in Table 6 and Table 7.

**Table 6 2007 Input-Output Table in Beijing (Units: Tce/million Yuan)**

| Output / Input | | Intermediate use | | | | | Output |
|---|---|---|---|---|---|---|---|
| | | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry | |
| Intermediate inputs | Agriculture | 93.61 | 162.12 | 7.53 | 0.27 | 98.70 | 273.13 |
| | Industry | 45.22 | 5855.06 | 1178.57 | 378.55 | 3090.85 | 9217.70 |
| | Construction | 0.01 | 4.39 | 23.72 | 5.41 | 184.44 | 1932.12 |
| | Logistics Industry | 4.97 | 257.78 | 40.32 | 367.23 | 370.99 | 1477.16 |
| | The Tertiary Industry | 27.96 | 911.77 | 208.44 | 144.63 | 3708.01 | 13849.8 |
| Energy Consumption | | 96.40 | 2685.00 | 108.80 | 840.80 | 1548.7 | |

**Table 7 Direct energy consumption coefficients of industrial sectors table in 2007**

| | Units | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry |
|---|---|---|---|---|---|---|
| Out put | Billion Yuan | 273.13 | 9217.70 | 1932.12 | 1477.16 | 13849.85 |
| Total energy consumption | Million tons of standard coal | 96.40 | 2685.00 | 108.80 | 840.80 | 1548.7 |
| direct consumption coefficient | Tce/million Yuan | 0.3529 | 0.2913 | 0.0563 | 0.5692 | 0.1118 |

**Table 8 2007 Total energy consumption coefficient of each sectors in Beijing (Units: Tce/million Yuan)**

| | $b_{ij}$ | | | | |
|---|---|---|---|---|---|
| | Agriculture | Industry | Construction | Logistics Industry | The Tertiary Industry |
| Agriculture | 0.5522 | 0.0900 | 0.0674 | 0.0373 | 0.0451 |
| Industry | 0.9988 | 2.1740 | 2.1059 | 1.2312 | 1.0604 |
| Construction | 0.0058 | 0.0083 | 0.0201 | 0.0106 | 0.0215 |
| Logistics Industry | 0.0879 | 0.1370 | 0.1248 | 0.3907 | 0.0957 |
| The Tertiary Industry | 0.3645 | 0.4609 | 0.4609 | 0.3590 | 0.5311 |
| $b_{ej}$ | 0.9299 | 1.0863 | 0.8172 | 1.2041 | 0.5517 |

From Table 8, the logistics industry's total energy consumption in 2007 was 1.2041 tons of standard coal factor / million. The indirect energy consumption coefficient was 0.6349 tons of standard coal / million based on direct energy consumption coefficients of the logistics industry in 2007. Compared with 2007, the

logistics industry's total energy consumption coefficient decreased significantly in 2010. Total consumption coefficient was 1.2041 tons of standard coal / million Yuan in 2007, down to 1.0313 tons of standard coal / million Yuan in 2010. This suggests that the total energy consumption efficiency of logistics had been improved.

## 5. Problems and Recommendations

To develop low-carbon economy in China today, the logistics industry as a high-energy consumption industry is found that the problems of energy consumption and appropriate solutions development are particularly important. For the above analysis the following three-point proposal was put forward.

### *5.1. Improving the Direct Consumption Efficiency and Indirect Energy Consumption Efficiency of Logistics at the Same Time*

Compared with 2007, the logistics industry, the direct energy consumption coefficient is only 0.1522 drop in 2010. However at the same period, the indirect energy consumption coefficient is 0.1728 drop. This indicates that the logistics industry should not only concern the direct energy consumption, while also improving the indirect energy consumption as a policy priority to save energy.

### *5.2. Improving Existing Means of Transport the Transport Conditions*

Wang Wenyong (2004) [7] pointed out that the direct energy consumption in the logistics industry is mainly consumed to drive vehicles, mainly oil consumption. Factors that affect the use efficiency include vehicle characteristics (such as two models, the load weight, vehicle age and engine displacement), road geometry characteristics and conditions (such as slope, curvature, and road maintenance conditions), traffic conditions (such as the free flow of traffic or congestion). Highway vehicle fuel consumption and vehicle speed was U-shaped curve. That is, in the case of low and high speed fuel consumption are high. Therefore, on the one hand, for large vehicles, the improvement of the engine fuel economy, reduction of vehicle weight to reduce the driving resistance can be done. On the other hand, improvements of the traffic conditions include the strengthening of highway monitoring to minimize traffic jams and improvement of the pavement structure and materials to reduce energy consumption in road maintenance.

### *5.3. Strengthen the Construction of Logistics and Transportation Management Information*

According to statistics, China's load rate of road freight of railway is 46%, and load rate of road freight is as high as 50%. Therefore, the information construction, transport organizations and transport management of the logistics industry should be strengthened, including tonnage composition of freight vehicles and improvement of the mileage rate utilization and implementation.

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