Research on Logistics Carbon Emission Mathematical Estimation and Compensation by Computer Statistics and Data Analysis

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Abstract. Global warming is one of the most serious environmental problems facing human society. Greenhouse gases represented by CO2 are considered to be an important cause of climate change. The development of human society is the main reason for the generation of CO2. Economic development and population growth make the use area of fossil fuels continue to expand, which is an important factor leading to the increase of CO2 emissions. The logistics industry is developing rapidly. Its development not only brings value-added economic benefits, but also increases CO2 emissions, and the carbon emission of the logistics industry has gradually become one of the hotspots of attention. Based on the previous theories on carbon emission, this paper determines the research on carbon emission estimation and carbon compensation in the operation of logistics industry, and estimates the carbon emission of logistics industry around the official statistical yearbook data and survey data. Finally, this paper further improves the carbon compensation mechanism of logistics industry from the perspective of compensation subject, compensation standard, compensation mode, process management and carbon price formulation, and puts forward the corresponding measures of carbon compensation mechanism from the perspectives of planning, management, technology, market and publicity.

Keywords: Logistics industry; Carbon emission; Carbon compensation.

1. Introduction

Global climate change is the most serious environmental problem facing human society so far, among which global warming is the most prominent. Greenhouse gas emissions represented by CO2 are considered to be the main factor causing global warming. The development of logistics industry is closely related to global climate change. The environmental pollution problems caused by logistics enterprises in the process of loading, unloading, handling, storage and transportation can not be ignored. From the existing literature, it can be found that the research on the logistics industry and carbon emissions mainly focuses on two aspects. On the one hand, Zhang Jinliang and others focus on the analysis and calculation of energy consumption and carbon emissions in the operation process of the logistics industry. On the other hand, Zhang Liguo and others used decoupling theory to study the
relationship between economic growth and carbon emission growth of logistics industry. Logistics can realize people's rapid demand for goods. Large trucks not only bring convenience to people's life, but also emit a lot of waste gas polluting the environment. Statistics show that by the end of 2012, the carbon emissions of logistics enterprises have increased nearly twice compared with the previous 10 years. The pollution problem of logistics enterprises is one of the important sources of pollution, which is bound to affect the long-term development of their enterprises. However, the pollution brought by logistics enterprises has not attracted extensive attention. As one of the high pollution sources, logistics enterprises need to seek the mutual coordination between the economic benefits of logistics enterprises and environmental pollution in order to realize the long-term development of logistics enterprises.

As an important industry of fossil fuel emission, logistics enterprises are facing profound changes under the pressure of carbon emission and carbon-neutral. In recent years, logistics enterprises have formed a series of consensus in freight transportation, urban distribution, express parcels, energy conservation and emission reduction, especially in express packaging and new energy vehicles.

2. Research on carbon emission estimation method of logistics industry
The carbon emission of logistics industry can be divided into direct emission and indirect emission. Direct emission refers to the carbon emission directly generated in the logistics process to realize goods transportation, storage and other links. Indirect emission is the carbon emission indirectly generated by the logistics industry in the operation process. The former refers to the CO2 emitted by the direct energy consumption within the logistics industry system, while the latter refers to the CO2 produced by the intermediate products of the logistics system and related enterprises and links.

2.1. Research on carbon emission estimation method of logistics industry
The carbon emission is dominated by the Intergovernmental Panel on Climate Change (IPCC). At present, many countries are paying attention to carbon emissions and related research, especially in the past decade, the methods for estimating industry carbon emissions have gradually matured, but the common estimation methods also have some problems.

(1) Actual measurement method
The basic principle of the actual measurement method is to measure the flow rate, flow and concentration of exhaust gas through some detection means and continuous measurement tools, and obtain the carbon emission through calculation and other statistical methods. The formula is:

$$E = Q \times C \times K$$

Where, $E$——emission of a certain gas; $Q$——air flow; $C$——concentration of a gas in the medium; $K$——unit conversion factor.

The source of the basic data of this method should rely on the environmental monitoring station to collect and analyze samples scientifically and reasonably, and the samples must be highly representative and universal.

(2) Mass balance method
Mass balance method is a method of quantitative analysis of materials used in the production process, that is, in the production process, the quality of materials put into the system or equipment must be equal to the quality of materials produced by the system. This method is suitable for physical production enterprises to maintain material balance in the production process. At present, the material balance algorithm is used in most carbon source carbon emission estimation and basic data collection. The formula is:

$$E_{all} = \sum(EF_{abc} \times Activity_{abc})$$
Where, $E_{all}$ —— emission, $EF$ —— Emission coefficient, $Activity$ —— Energy consumption, $a$ —— energy type, $b$ —— activity sector and $c$ —— technology type.

(3) Emission coefficient method

Emission coefficient method usually refers to the statistical average value of gas emissions per unit product under normal technical, economic and management conditions. It is the first carbon emission estimation method proposed by IPCC and is also a widely used method. The formula is:

$$E = AD \times EF$$  \hspace{1cm} (3)

Where, $E$——greenhouse gas emission; $AD$——activity data; $EF$——emission factor.

The difficulty of this method lies in the source of activity data, and if the emission factor adopts the default value given in the IPCC report, there will be a certain deviation in the results.

(4) Decision tree method

The decision tree method is usually used to calculate the carbon emissions of a certain region in a decentralized way, and it is generally used to estimate the carbon emissions from the micro level. However, there is no more accurate and effective way for this method to estimate the macro carbon emission of the industry. In addition, IPCC also uses decision tree method to determine the analysis of key sources of carbon emissions.

(5) Life cycle method

Life cycle method is to analyze and deal with the energy consumed in the whole life cycle of industry operation in detail. From the perspective of life cycle, CO2 is generated in all the activity processes in the whole cycle, form these activity processes into a whole, and comprehensively analyze each link of the whole.

2.2. Comparison of carbon emission estimation methods

The advantages and disadvantages of carbon emission estimation methods are shown in Table 1.
Table 1. Comparison of carbon emission estimation methods

| Method                          | Advantage                                      | Inferiority                                      | Characteristic | Input                                  | Output                                | Applicability               |
|--------------------------------|------------------------------------------------|--------------------------------------------------|----------------|----------------------------------------|----------------------------------------|-----------------------------|
| Actual measurement method      | Few intermediate links and the results are accurate | Difficult data acquisition and high cost         | The measurement requires high accuracy            | Air flow, gas concentration, conversion coefficient |
| Mass balance method            | Clearly distinguish the differences between various facilities and natural resources | There are more intermediate emission processes to be considered, which are prone to systematic errors and difficult to collect data | Complete basic data | Total material input | CO2 emission s | Forests                  |
| Emission coefficient method    | Mature calculation methods, data and emission factor database | The treatment capacity of the discharge system itself is worse than that of the mass balance method | The calculation is simple and practical        | Combustion consumption and emission coefficient | CO2 emission s | Industrial production |
| Decision tree method           | Effectively avoid repeated calculation and missing calculation Comprehensiveness qualitative and quantitative analysis | Cannot be used alone | Take activity chain as classification unit | Phased carbon emission | CO2 emission s | Fossil fuel combustion |

2.3. Construction of carbon emission estimation method of logistics industry
(1) Carbon emission estimation in logistics transportation

In the logistics industry, the most important source of carbon emission is in the transportation process. Due to the many choices of transportation means, it often needs a variety of transportation
forms to be used comprehensively. Vehicles emit CO2 mainly through fuel consumption. According to the calculation method provided by IPCC, the mileage of various modes of transportation, fuel consumption per unit mileage of each mode of transportation and carbon emission coefficient of various fuels are generally used for calculation. In the process of logistics transportation, it is mainly divided into transportation to the destination and transportation within the destination city. These two parts estimate the carbon emission of transportation. The formula is:

\[ TE_{\text{trans}} = TE_e + TE_m \]
\[ TE_e = \sum (H_a + D_a + \rho_a) \times 2 \]
\[ TE_m = \sum (H_b + D_b + \rho_b) \times 2 \]

Where, \( TE_e \) —— carbon emission during transportation to destination, \( TE_m \) —— Carbon emissions from transportation within the destination city, \( H_a, H_b \) —— is the traffic volume of vehicles a and b, \( D_a, D_b \) —— is the actual transportation distance of vehicles a and B, \( \rho_a, \rho_b \) —— is the carbon emission intensity per unit haul distance of vehicles a and B.

(2) Carbon emission estimation in logistics storage process

The carbon emission in the storage process is mainly the carbon emission of energy consumption generated in the process of goods storage. Generally speaking, it is mainly the indirect carbon emission generated by power consumption and the direct carbon emission such as fossil energy consumption. The estimation methods of carbon emissions during storage are mainly top-down and bottom-up methods. The formula is:

\[ TE_{\text{storage}} = \sum TE_i = \sum E_m \times C_m \times EF_{ce} \]

Where, \( TE_{\text{storage}} \) —— carbon emission during storage, \( TE_i \) —— Carbon emissions generated when goods are stored in the i-th warehouse, \( E_m \) —— Consumption of the m-th energy when stored in the i-th warehouse, \( C_m \) —— When stored in the i-th warehouse, the coefficient of the m-th energy converted into standard coal, \( EF_{ce} \) —— emission coefficient of standard coal, taken as 3.14.

(3) Carbon emission estimation during logistics loading, unloading and packaging

The carbon emission in the process of loading, unloading and packaging is related to the logistics goods. It is mainly used to calculate the energy consumption generated in the process of providing cargo loading, unloading and outer packaging services, mainly power consumption. The formula is:

\[ TE_{\text{other}} = \sum TE_j = \sum E_j \times C_j \times EF_{ce} \]

Where, \( TE_{\text{other}} \) —— carbon emissions during loading, unloading and packaging services, \( TE_j \) —— Carbon emission of goods in the j-th link, \( E_j \) —— The power consumption in the j-th link can be counted through field investigation, \( C_j \) —— In the j-th link, the coefficient of converting electric energy into standard coal.

(4) Carbon emission estimation in logistics enterprise management

Logistics enterprise management mainly includes the energy consumption generated in the process of operation, maintenance and other investment required for the normal operation of the enterprise. For example, the energy consumption of enterprise offices, including staff offices, rest places,
customer service centers, etc., is mainly power consumption; Energy consumption of enterprise employees commuting; Carbon emissions from waste disposal generated in the logistics process, etc. The calculation formula of carbon emission generated by these three parts is:

\[
TE_{\text{manage}} = TE_{\text{operate}} + TE_{\text{commute}} + TE_{\text{garbage}}
\]  
\[ TE_{\text{operate}} = \sum EQ_m \times CF_m \times EF_{ce} \]  
\[ TE_{\text{commute}} = PD_m \times ED \times JD \times K_m \]  
\[ TE_{\text{garbage}} = \sum (IW_n \times CCW_n \times EF_n \times 44 \div 12) \]

Where, \(TE_{\text{manage}}\) is the management cost of logistics enterprises, including \(TE_{\text{operate}}\) (operation cost), \(TE_{\text{commute}}\) (commuting) and \(TE_{\text{garbage}}\) (waste disposal). \(EQ_m\) ——Energy consumption of relevant departments of enterprise operation, \(CF_m\) ——Conversion coefficient of various energy sources into standard coal, \(PD_m\) ——Number of employees who choose the m-th means of transportation, \(ED\) ——Commute Distance of employees, \(JD\) ——The number of days employees need to work, \(K_m\) ——Unit carbon emission intensity of the m-th vehicle, \(kg\ CO_2 / p \cdot km\), \(IW_n\) ——Incineration amount of the nth kind of garbage, \(CCW_n\) ——The proportion of carbon content in the nth kind of garbage, \(EF_n\) ——The burning rate of the nth kind of waste incineration, \(44 \div 12\) ——C coefficient of conversion to \(CO_2\).

3. Carbon compensation mechanism and measures in logistics industry

The principle of carbon compensation is "Whoever emits will pay, who absorbs will get compensation", which is also applicable to the carbon compensation of logistics enterprises. According to this principle, compensation is made among different subjects. Specific measures include:

(1) Formulate a reasonable enterprise carbon compensation plan
According to the goal of carbon emission reduction of logistics enterprises, formulate corresponding carbon compensation plan projects, and formulate good implementation mechanism and supervision feedback mechanism. The plan of each emission reduction project is repeated in the process of "plan - organization - Implementation - Supervision - Revision - rescheduling" to finally determine the feasible scheme. The carbon emission plan involves the executive subject of the compensation project, the selection of compensation objects and compensation standards, the objectives of compensation, the supervisor of the implementation of the compensation plan, etc.

(2) Improve the infrastructure construction of green logistics enterprises
Logistics enterprise infrastructure is a service provided to meet logistics needs and ensure the safe and smooth delivery of goods, including facilities and equipment directly related to logistics activities such as warehousing, transportation, distribution, loading and unloading and packaging, as well as infrastructure indirectly related to logistics activities such as water supply, power supply and sanitation required for daily operation of enterprises.

(3) Establish corresponding carbon emission estimation, monitoring and detection system
On the one hand, strengthen the statistical work of greenhouse gas emissions, do a good job in carbon emission coefficient calculation and data detection, establish corresponding carbon emission calculation standards, establish a special working team and scientific research team, implement monthly or even weekly monitoring of key carbon emission enterprises, and strictly control carbon emissions. On the other hand, restrict the high-carbon logistics behavior in the process of enterprise
operation anytime and anywhere. At the same time, fiscal and tax policies should be established to encourage carbon reduction. The government should increase financial investment in the green and low-carbon development of the logistics industry, and strengthen the leading role of the green logistics industry in the development of a low-carbon and environmental protection society. For example, for the logistics industry, carbon tax and environmental tax shall be appropriately levied.

(4) Realize the intelligent and digital transformation of logistics from the perspective of technology

Specific technologies include: ① Using intelligent logistics to reduce the no-load rate of freight vehicles. The development of smart logistics not only greatly improves the logistics efficiency, but also effectively reduces the invalid and inefficient driving of vehicles. As of June 2020, according to the disclosure of the Ministry of public security, the number of trucks in China is 29.44 million. At present, the no-load rate of vehicles in the freight industry has reached 40%. Assuming that the no-load rate of these vehicles decreases from 40% to 20%, the annual invalid mileage will be reduced by 147.2 billion km, and the corresponding carbon dioxide emission will be reduced by 69.508 billion kg. ② The cutting-edge technology adopted is a powerful measure to promote carbon-neutral. Innovative applications of cutting-edge technologies such as AI and cloud computing enable transportation with technology, realize emission reduction and carbon reduction through logistics intelligence, and apply 5g technology to transform the small traffic of single vehicle into large traffic connected with all vehicles and roads, so as to reduce pollution and carbon. ③ Green packaging will reduce huge carbon emissions. Logistics packaging brings the burden to the environment. Reducing packaging is an important measure for the logistics industry, especially the express industry. The use of inflatable gasbags instead of foam materials will greatly reduce the use of cushioning materials, and the use of plant fiber tapes that can naturally degrade in a short time instead of traditional adhesive tape are all useful steps for packaging low carbonization.

4. Conclusion

On the basis of summarizing the existing carbon emission theories at home and abroad, this paper constructs the carbon emission system and carbon emission estimation method of logistics enterprises, and puts forward the carbon compensation mechanism and measures. This paper believes that the main carbon source in the development process of logistics enterprises is transportation and storage services, so as to confirm the carbon emission list. By analyzing the logistics industry structure and combining the characteristics of modern logistics enterprises, this paper further determines the carbon emission calculation formula in the development process of logistics enterprises. Secondly, by sorting out various carbon emission estimation methods, the estimation method of carbon emission in the development process of logistics enterprises is finally determined, which solves the basic problems of carbon emission in the development process of logistics enterprises, and lays a theoretical foundation for the actual carbon emission estimation.

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