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Carbon emission performance in logistics in the Yellow River Basin

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ABSTRACT

With increasingly serious environmental pressure, carbon emission and the development of logistics industry are constrained by each other. The chief objective of this study is to reveal the relationship between input–output activities in logistics and carbon emissions, to evaluate the carbon emission performance in logistics in the Yellow River Basin based on DEA–Tobit model, and to analyze the factors affecting the environmental performance. The results indicate the following: (1) Ningxia, Inner Mongolia, Henan, Qinghai, Shandong achieved good carbon emission performance in logistics, while the logistics environmental performance of Shanxi, Gansu, Shaanxi and Sichuan is bad, which needs to be adjusted in time to avoid further aggravating unreasonable carbon emissions. (2) The intensity of environmental regulation and energy consumption have a positive and negative correlation, respectively, with the carbon emission performance in logistics, and the industrial aggregation and the government intervention have no significant impact on the carbon emission performance in logistics in the Yellow River Basin. Based on the research results, this paper discusses some principles applicable to improve the logistics environmental performance, which can provide reference for logistics enterprises in the micro-scale and logistics departments in the macro-scale to reduce energy consumption and to eliminate unreasonable pollution factors in the Yellow River Basin.

Keywords: Climate change; Logistics; The Yellow River Basin; DEA–Tobit; Carbon emission

1. Introduction

Although there are quite a few uncertainties in the impact of human activities on the earth's climate system, the possibility of causal relationship between them has been confirmed by more and more scientific evidence [1]. Consistent greenhouse gas (GHG) emissions have exposed human beings to multiple risks such as economic development retardation, health damage, the shortage of water resources, frequent extreme weather, sea level rise, and so on [2]. Underdeveloped and vulnerable areas are subject to the damage resulted from more serious climate change [3]. Scientific evidence reveals that China is facing higher risk of climate change than other countries [4].

Existing research reveals that logistics contributes a lot to GHG emissions [5]. 95% of the GHG increase comes from energy consumption [6], and more than 20% of energy consumption can be attributed to logistics and transportation [7]. Emissions from the transport sector also account for the fastest growing source of GHG emissions [8]. According

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to the current energy structure of China, only in 2014, the total consumption of gasoline, diesel oil and fuel oil in China's logistics industry accounted for 47.72%, 94.89% and 64.33%, respectively [9], and the logistics industry had become one of the dominant carbon emission contributors in China [10]. China has surpassed the United States in CO_2 emissions since 2006 and become the top in the world [11]. Owing to the public opinions from the international climate negotiation and China's commitment to the target of carbon emission reduction by 2030, Chinese government feel compelled to take into actions on the industries with unreasonable carbon emissions. In order to achieve nationally determined contribution targets in China, the logistics industry should undertake a critical responsibility for energy saving and carbon emission reductions.

The Yellow River Basin covers nine provinces, including Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan and Shandong, with a total area of more than 3 million km^2 and a total population of 390 million. The Yellow River Basin, where the ecological environment is fragile, is currently confronted with severe ecological problems. The inputs and outputs in logistics in this area are unreasonable. On the one hand, seven provinces in the upper and middle reaches of the Yellow River Basin are areas with insufficient economic development, and the pace of transformation and upgrading of traditional industries lags behind. On the other hand, there are problems such as high energy consumption, high carbon emission and low efficiency in the region, and there is still existing relatively serious tendency of extensive development at the expense of the environment.

The Chinese government has ranked the ecological protection and high quality development of the Yellow River Basin as the major national strategy. However, the regional development stages, industrial composition and geographical conditions in the nine provinces are distinctive, and their energy consumption and carbon emissions differ, too. To a great extent, the logistics development level affects and restricts the high-quality development and ecological benefits of the whole region. Therefore, it is particularly urgent to improve the environmental quality and to reduce carbon emissions in this region while ensuring the sound development in logistics, and it is of the vital important to fulfil the effective transformation from logistics to environmental performance in this region. This study attempts to answer the following questions: (1) Which provinces in the Yellow River Basin have unreasonable inputs and outputs in logistics, which need to be adjusted in time to avoid further increasing unreasonable CO_2 emissions? (2) What are the key factors affecting carbon emissions in logistics and what factors exacerbate unexpected carbon emissions? (3) How can we reduce the dependence of regional logistics on carbon emissions by using policy regulations?

It is of the great significance to study the influencing factors of carbon emission performance in logistics for the ecological protection and high-quality development in the Yellow River Basin.

According to existing studies, the carbon emission performance has been widely analyzed in different sectors. In terms of the relationship between the carbon emission and the logistics performance, Orji et al. [12] believed that environmental protection and sustainability were becoming more and more important, and that changing the ecological concept helped to ensure the sustainable development and environmental protection in the logistics freight. Fan et al. [13] studied the difference and changes of the regional logistics carbon emission performance by using two indicators of the regional logistics energy utilization and the carbon emission spatial distribution, and put forward suggestions for energy conservation and CO_2 emission reduction according to the regional situation. von der Gracht and Darkow [14] designed five scenarios based on Delphi, including energy and CO_2 emissions, consumer behavior, future transportation modes, future supply chain design and innovation. McKinnon and Piecyk [15] claimed that the potential and cost-effectiveness of CO_2 emission reduction varied with functions and activities, and the CO_2 emission reduction target should follow the principle of logistics decarbonization. Kwon et al. [16] analyzed the technical efficiency and voluntary environmental awareness of 12 European countries and introduced log mean decomposition index to decompose CO_2 emissions, providing scientific guidance and suggestions for reducing CO_2 emissions. Li et al. [17] calculated China's GHG and the pollutant emission lists in 2012–2030 by scenario analysis, and argued that the energy-saving and emission reduction, and logistics informatization could effectively alleviate the carbon emissions in China's road traffic industry. Holden et al. [18] claimed that reducing CO_2 emission in logistics freight was the key to achieve the future GHG emission reduction, and that data envelopment analysis (DEA) method could measure the performance of freight operations more effectively.

DEA is an approach commonly used, which evaluates the relative efficiency of a group of decision-making units with multiple inputs and outputs. Tone [19] proposed a non-radial and non-angle DEA analysis method based on slack variable measure, namely slack based measure (SBM) model. The economic input–output analysis laws should be followed using DEA to evaluate logistics performance, in which capital, labor force and so on are taken as input factors, and the output value of logistics industry is taken as the output factor. By introducing DEA to measure the logistics performance of Organization for Economic Co-operation and Development countries, Rashidi and Cullinane [20] found that the United States, the Netherlands, Norway and Australia performed best, while Greece, South Korea, Italy and Portugal did worst. Markovits-Somogyi and Bokor [21] used DEA method to evaluate the logistics performance of 29 European countries. With the increasingly prominent environmental problems, more and more scholars have realized that the cost of carbon emissions generated by transportation activities should be taken into consideration in addition to the traditional logistics cost. In order to measure the logistics efficiency, the undesirable outputs should be included in the control content, and the undesirable outputs must be reduced as much as possible to achieve the best economic performance. Mariano et al. [22] analyzed the carbon emission performance in logistics in 104 countries around the world. Cao and Deng [23] studied the carbon emission performance in logistics in China's Yangtze River Economic Belt. The low-carbon constraints can reflect the performance in regional logistics more objectively and comprehensively, which is of more practical significance.

Through literature review, it is found that the existing research objects focus on the global level, the national level, urban agglomerations and cities, and there is little research on the carbon emission performance in logistics in the Yellow River Basin. Therefore, this study aims to fill in the literature gap by exploring the carbon emission performance in logistics in this region. The sequential Super-SBM model is introduced to measure the carbon emission performance in logistics in the Yellow River Basin, and the regional differences are analyzed by using the map visualization. According to the theoretical and practical analyses, this paper reveals the deep-seated influencing factors behind the logistics development in the Yellow River Basin, so as to find out the difficulties and challenges they encounter in the low-carbon process. On this basis, we discuss how to achieve the coordinated development of regional logistics industry by using policies to reduce the dependence on CO_2 emissions, and try to provide data support and theoretical support for the development of regional logistics industry, which has theoretical and practical implications for the government to implement energy conservation, CO_2 emission reduction and environmental regulation in logistics, and to improve carbon emission performance in logistics in the Yellow River Basin.

2. Materials and methods

2.1. Data source and preprocessing

2.1.1. Input indicators

According to the economic principle, we adopt capital and labor force as the input factors. The fixed assets investment in logistics is applied as the capital input indicator, the total wages of logistics employees in each province are introduced as the capital labor input indicators, and the terminal energy consumption of 16 types of energy in each province is converted into the standard coal aggregation and acts as the energy input indicator.

This paper focuses on the data originating from nine provinces in the Yellow River Basin, which span from 2008 to 2017. The data of energy consumption come from China Energy Statistical Yearbook (2009–2018), and the data of the fixed asset investment, total wage of employees, Gross Domestic Product (GDP), and freight turnover in all regions are derived from China Statistical Yearbook (2009–2018) and the Provincial Statistical Yearbook (2009–2018).

2.1.2. Output indicators

Generally speaking, there are two types of output indicators, one of which is the desirable output, and the other is the undesirable output.

As in many countries, there is no separate classification for the logistics industry in the industry category systems in China. The statistical data published by the National Development and Reform Commission reveal that the added value of transportation, storage and postal industry accounts for more than 85% of the added value of the logistics industry. Therefore, the data of transportation, storage and postal industry in the Statistical Yearbook are employed for analysis, which stand for the data of the logistics industry.

In the production process, the fixed production factors tend to bring forth some undesirable outputs alongside with desirable outputs, such as carbon emissions. The carbon emission is calculated by multiplying the end energy consumption of 16 kinds of energy in each province by the standard coal conversion coefficient, and then multiplying the carbon emission coefficient of each province [19]. The calculation formula is represented as follows:

$$C = \sum_{i=1}^{16} E_i \times \mathrm{SC}_i \times \mathrm{CF}_i \tag{1}$$

where E_i denotes the end energy consumption of the ith energy source, SC_i represents the standard coal conversion coefficient of the ith energy source, and CF_i signifies the carbon emission coefficient of the ith energy source. The reference coefficient of energy conversion standard coal comes from China Energy Statistics Yearbook, and the data of carbon emission factors are derived from China Statistics Yearbook and Guidelines for National Greenhouse Gas Emissions Inventories 2006. The discount standard coal coefficient and the carbon emission coefficient of fuels are shown in Table 1.

2.2. Super-SBM model

Assuming that there are n decision making units (DMUs), and each DMU contains m input factors, r_1 desirable output factors and r_2 undesirable output factors, the vectors are expressed as $x \in R^m$, $y^d \in R^{r1}$, $y^u \in R^{r2}$, respectively, in which x, y^d and y^u represent the matrices of the input, the desirable output and the undesirable output, respectively. SBM model can be formulated as follows [23]:

$$\begin{aligned}
&\min \rho = \frac{1-(1/m)\sum_{i=1}^{m}\left(w_i^- / x_{ik}\right)}{1+1/(r_1+r_2)\left(\sum_{s=1}^{r_1} w_s^d / y_{sk}^d + \sum_{q=1}^{r_2} w_q^u / y_{qk}^u\right)} \\
&s.t. x_{ik} = \sum_{j=1}^{n} x_{ij}\lambda_j + w_i^-, i = 1,\cdots,m \\
&y_{sk}^d = \sum_{j=1}^{n} y_{sj}^d \lambda_j - w_s^d, s = 1,\cdots,r_1 \\
&y_{qk}^u = \sum_{j=1}^{n} y_{qj}^u \lambda_j + w_q^u, q = 1,\cdots,r_2 \\
&\lambda_j > 0, j = 1,\cdots,n, w_i^- \geq 0, i = 1,\cdots,m \\
&w_s^d \geq 0, s = 1,\cdots,r_1, w_q^u \geq 0, q = 1,\cdots,r_2
\end{aligned} \tag{2}$$

DMU_k as SBM effective only when $\rho = 1$, $w^- = 0$, $w^d = 0$ and $w^u = 0$. Here, we define DMU_k as SBM effective, and the Super-SBM model including undesirable output is shown in Eq. (3):

$$\min \varphi = \frac{1/m \sum_{i=1}^{m} \left(\bar{x} / x_{ik} \right)}{1/(r_1 + r_2) \left(\sum_{s=1}^{r_1} \bar{y}^d / y_{sk}^d + \sum_{q=1}^{r_2} \bar{y}^u / y_{qk}^u \right)}$$

$$\begin{aligned}
& s.t.\bar{x} \geq \sum_{j=1,\neq k}^{n} x_{ij}\lambda_j, i = 1,\cdots,m \\
& \bar{y}^d \leq \sum_{j=1,\neq k}^{n} y_{sj}^d \lambda_j, s = 1,\cdots,r_1 \\
& \bar{y}^u \geq \sum_{j=1,\neq k}^{n} y_{qj}^u \lambda_j, q = 1,\cdots,r_2 \\
& \lambda_j > 0; j = 1,\cdots,n, \bar{x} \geq x_k; i = 1,\cdots,m \\
& \lambda_j > 0; j = 1,\cdots,n, \bar{x} \geq x_k; i = 1,\cdots,m \\
& \bar{y}^d \leq \sum_{s=1}^{r_1} y_{sk}^d, s = 1,\cdots,r_1; \bar{y}^u \leq \sum_{q=1}^{r_2} y_{qk}^u, q = 1,\cdots,r_2
\end{aligned} \tag{3}$$

The Super-SBM model is introduced to calculate the efficiency of logistics industry which is expressed as technical efficiency (TE), and the regional logistics performance k in year t can be expressed as Eq. (4):

$$\mathrm{TE}_{kt} \begin{cases} \rho_{kt}, \rho_{kt} < 1 \\ \varphi_{kt}, \varphi_{kt} = 1 \end{cases} \\ (k = 1,\cdots,9; t = 2008,\cdots,2017) \tag{4}$$

2.3. Tobit model

Based on the previous research results, this study takes four factors as explanatory variables to illustrate the environmental performance in logistics in the Yellow River Basin, which are the intensity of environmental regulation, the energy intensity, the industrial agglomeration and the government intervention, as shown in Table 2.

The efficiency values of the explained variables are greater than 0 in the study, and the collected data are truncated, so the ordinary least squares cannot completely present the data, resulting in the estimation deviation. Therefore, by employing panel Tobit model, this paper studies the impact of carbon emission constraints on the growth efficiency of logistics industry in nine provinces in the Yellow River Basin. According to the selected influencing factors, we analyze the Tobit model as follows [24]:

$$\ln \mathrm{Efficiency} = \beta_0 + \beta_1 \mathrm{Env} + \beta_2 \mathrm{Ins} + \beta_3 \mathrm{Gov} + \beta_4 \mathrm{Ene} + \varepsilon \tag{5}$$

where the dependent variable Efficiency comes from logistics CO_2 emission performance as calculated in Eq. (5); $\beta_0,\ldots,\beta_4$ represent the regression coefficient of each index, respectively, and ε denotes the residual term.

3. Results and discussion

3.1. Carbon emission performance in logistics

By using Super-SBM model, the carbon emission performance in logistics in the Yellow River Basin is calculated, the results of which are shown in Fig. 1.

In terms of carbon emission performance in logistics in the nine provinces, we find that the provinces with the good carbon emission performance are Ningxia, Inner Mongolia, Henan, Qinghai, and Shandong, while the provinces with the bad performance are generally located in the upper and middle reaches, namely Shanxi, Gansu, Shaanxi and Sichuan, which need to be adjusted in time to avoid further aggravating unreasonable carbon emissions. Fig. 1 demonstrates that Ningxia and Inner Mongolia have achieved the best carbon emission performance in logistics. Ningxia and Inner Mongolia are located in the middle reaches of the Yellow River Basin, where the ecological environment is excellent, and the population is sparse. The smaller economies and minimal amount of logistics-related carbon emissions might have brought about the best performances for these two provinces. The following might account for the better carbon emission performance in logistics in Henan and Qinghai. Henan has a good traffic geographical location; and the energy-saving and environmental protection

Table 1
Discount standard coal coefficient and CO_2 emission coefficient of fuels

Fuels	Discount standard coal coefficient/ standard coal	Carbon emission coefficient/(t carbon)	Fuels	Discount standard coal coefficient/ standard coal	Carbon emission coefficient/(t carbon)
Raw coal	0.7143	0.7559	Diesel	1.4571	0.5921
Cleaned coal	0.9000	0.7559	Fuel oil	1.4286	0.6185
Coke	0.9714	0.8550	Liquefied petroleum gas	1.7143	0.5042
Coke oven gas	6.1430	0.3548	Refinery dry gas	1.5714	0.4602
Other coal gas	3.5701	0.3548	Natural gas	12.143	0.4483
Crude oil	1.4286	0.5857	Power	1.229	0.2900
Gasoline	1.4714	0.5538	Other oil product	1.2000	0.5857
Kerosene	1.4714	0.5714	Other coking products	1.3000	0.6449

Note: (1) The coefficient comes from the IPCC National Greenhouse Gas Inventory Guidelines.
(2) The unit of conversion coefficient of natural gas, coke oven gas and other gas into standard coal is kg standard coal (10 m^3), and the unit of conversion coefficient of electric power into standard coal is kg standard coal (10 kW h).

Table 2
Index system of influencing factors of logistics CO_2 emission performance

First level index	Secondary index	Calculation method	Code
Explained variables	Logistics CO_2 emission performance	Results from DEA	Efficiency
Explanatory variables	Intensity of environmental regulation	Expenditure in environmental governance/GDP	Env
	Industrial agglomeration	Logistics location quotient	Ins
	Government intervention	Expenditure in transportation/total financial expenditure	Gov
	Energy consumption intensity	Logistics energy consumption/logistics output value	Ene

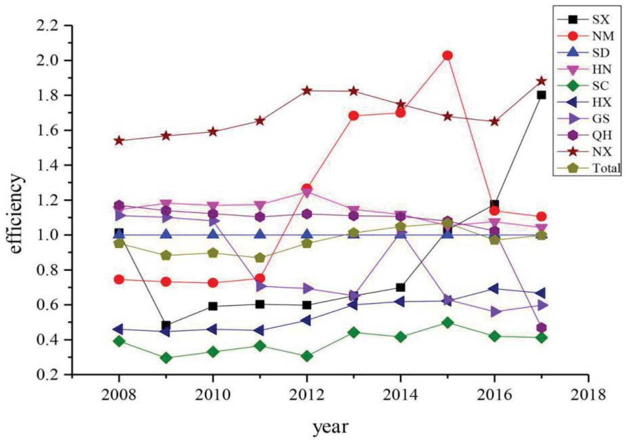

Fig. 1. Carbon emission performance in logistics in the Yellow River Basin during 2008–2017.

is listed as one of the leading strategic targets. Qinghai has a strong sense of resource conservation and environmental protection in logistics. Shaanxi and Sichuan perform worst among the nine provinces. The terrain and landform of the two provinces are mainly hills and mountains. The cost of road construction and operation is relatively high, which might have increased the investment of resources. In addition, there are more fixed capital investments in the logistics industry during the period, and the large-scale factor investment might not have been converted into production capacity, which wastes a large amount of resources. Moreover, energy consumption and pollution-intensive development might have resulted in the worst environmental performance in logistics in the two provinces, which also indicates that there are considerable potential for Shaanxi and Sichuan to improve their carbon emission performance in logistics. Gansu has the low-scale specialization in logistics, lacking logistics value-added services such as circulation processing, information service, inventory management, cost control and the awareness of environmental protection. Shanxi is rich in coal resources, logistics is an important sector of coal consumption, and the proportion of resource-based logistics is rather high.

In the meantime, it is worth noting that Shandong, which ranks in the middle, is located at the estuary of the lower Yellow River Basin, where the geographical location is superior and information technology is advanced, but its intensive energy consumption and high labor cost might have contributed to the major resistance to the improvement of its environmental performance.

In order to demonstrate the spatial evolution of environmental performance in logistics in the Yellow River Basin from 2008 to 2017 more intuitively, this paper selects 2008, 2011, 2014 and 2017 as representative years, and employs the map visualization to present the spatial distribution characteristics of the environmental performance in the Yellow River Basin, as is shown in Fig. 2.

3.2. Analysis of the factors influencing the efficiency of carbon emission

It is proposed to use the panel model for regression analysis. Hausman test for fixed and random effect model reveals that the hypothesis of fixed effect and residual correlation in fixed effect model is rejected at the significant level of 1%. Therefore, by employing the panel Tobit random effect model, we obtain the measure results of carbon emission performance in the Yellow River Basin (Table 3).

3.2.1. Intensity of environmental regulation

The local environmental regulation has a positive impact on the carbon emission performance in logistics in the region, and passes the 5% significance level test. The overall environmental regulation of each province has a significant effect on the improvement of logistics performance under regional environmental constraints. With the growing improvement of the whole society's understanding of environmental problems, there has been a broad consensus that extensive economic growth in the past resulted in the destruction of ecological environment. Due to the complex relationship between economic development and environmental pollution, the government is often confronted with the choice of "balance" or "restriction" between economic development and environmental protection in decision-making, and tries to find a policy tool that can have a positive impact on economic development and environmental protection at the same time, so environmental protection fiscal expenditure becomes an important choice. The scale of environmental protection investment reflects the importance of regional environmental protection to a certain extent, which is an effective means to improve the environmental performance. However, the average expenditure on environmental protection of nine provinces in the Yellow River Basin in the past 10 y has been less than 3.5% of the total budget of the government, and the proportion has been the lowest among all levels of financial budget projects, reflecting that the willingness and ability of environmental expenditure still need to be improved.

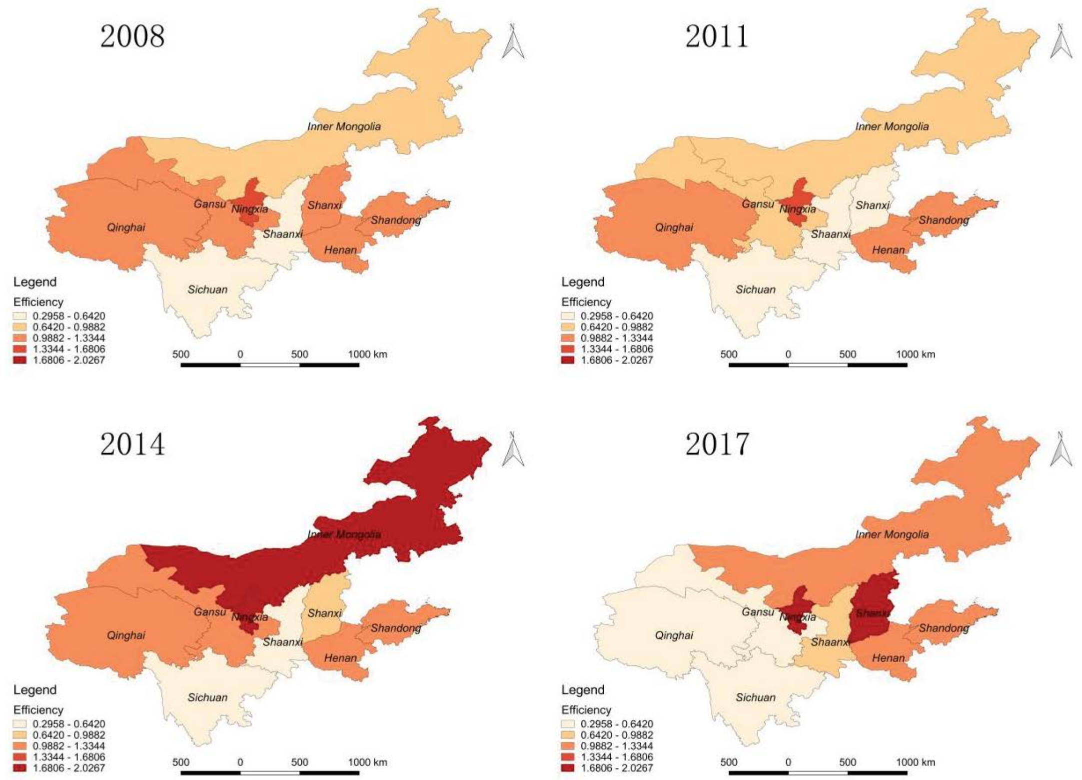

Fig. 2. The environmental performance of nine provinces in the Yellow River Basin in 4 y.

Table 3
Analysis results from Tobit fixed effect regression model

Variables	Coefficient	Standard deviation	*Z*-statistics	Significance level	Variance inflation factor
Env	11.88985**	5.772289	2.06	0.039	2.2
Ins	0.260928	0.166743	1.56	0.118	2.53
Gov	−0.32684	1.11424	−0.29	0.769	1.23
Ene	−0.30165***	0.089134	−3.38	0.001	1.31
C	0.845666***	0.297432	2.84	0.004	

The increase of environmental expenditure shows that the government has paid more attention to the environment. Increasing governance causes the logistics industry to improve carbon emission reduction technology and reduce carbon emissions. As an environmental policy maker, the government should comprehensively consider and fully investigate the differences in the social and economic foundation of each province and the actual situation of carbon emission, formulate carbon emission reduction plans for the logistics industry according to the local conditions, and adopt “common but different” policies.

3.2.2. Energy consumption intensity

The energy consumption intensity has a negative impact on the carbon emission performance in logistics in the region, and it has passed the significance level test of 1%. The results verify the resource curse hypothesis, that is, the areas with rich resource may lead to excessive consumption and inefficient use of resources due to the opportunistic behavior of resource use and the generation of rent-seeking activities. The energy consumption intensity is an important indicator of energy efficiency. As an industry with high energy consumption and heavy dependence on energy consumption, the logistics industry consumes a large amount of energy, which means more carbon emissions. With the environmental constraints increasingly intensified, the effective utilization of energy resources in the Yellow River Basin plays an important role in the development of China’s ecological civilization society. If the development of logistics industry is regarded as artery economy, energy conservation, emission reduction and environmental protection belong to the vein economy. It is a tough problem to be solved urgently for the local government to break the ice between the economic growth of logistics industry and carbon emissions so as to make the relationship match each other in the development of ecological environment in the Yellow River Basin.

The transportation sector in the Yellow River Basin mainly consumes energy with large carbon emission factors, such as gasoline, kerosene, diesel oil and so on. The unreasonable energy consumption structure and the high energy intensity lead to high energy consumption and low carbon emission performance in logistics, which proves that high energy consumption and high carbon emission are the bottlenecks restricting the high-quality development of logistics industry. The following measures should be taken to reverse the current adverse situation. On the one hand, we should improve energy utilization, reduce the use of energy with large carbon emission factors such as coal, gasoline and diesel, increase investment in clean energy such as natural gas and electricity, and reduce carbon emissions. On the other hand, the new logistics equipment and technology should be promoted. We should decrease the energy demand and thereby carbon emissions by utilizing lightweight shipping containers [25]. For example, if the weight of 40-foot container is reduced by 20%, it will save us $28 billion in fuel, and reduce the energy demand by 3.6 times in the service life of container in 15 y [26]. Therefore, the composite shipping container is a highly promising candidate for reducing carbon emissions, saving fuel, and thus reducing the operating costs of transportation.

3.2.3. Industrial agglomeration

The industrial agglomeration has a positive impact on the logistics carbon emission performance in the region, but it fails to pass the 10% significance level test. According to Marshall's externality theory, industrial agglomeration has the positive scale effect and the negative congestion effect. The positive scale effect can concentrate industrial resources, realize collaborative sharing of element resources and infrastructure, and promote industrial innovation. The negative congestion effect reveals that with the development of agglomeration, the allocation of element resources is unreasonable, resulting in high pollution, high energy consumption and other problems, which is not conducive to the improvement of industrial efficiency.

The agglomeration of logistics industry in the Yellow River Basin can enhance the information exchange of logistics enterprises, and make common use of logistics infrastructure and labor market, so as to save production costs and reduce energy consumption. At the same time, the establishment of agglomeration can effectively accelerate technological innovation, improve the utilization rate of logistics resources, and generate scale economic benefits. In order to realize the linkage mechanism of the logistics industry in the upper, middle and lower reaches, and increase the support for the development of the logistics industry in the upper and middle reaches, the relevant departments in the Yellow River Basin should integrate resources to establish a modern multimodal transport system in the way of "sharing + logistics", so as to give full play to the excellent economic effect of the logistics industrial agglomeration.

3.2.4. Government intervention

The government intervention has a negative impact on the carbon emission performance in logistics in the region, and it is not significant at all. This is in agreement with Zhong Zuchang's view that the government intervention has a negative effect on the agglomeration of logistics industry in the early stage [27]. In the economic market, the "visible hand" of the government plays a key role in the development of the logistics industry. With regard to the logistics industry in the Yellow River Basin, the proper government intervention can strengthen regional cooperation and effectively prevent the repeated construction of infrastructure such as transportation and communication in the region. Henan, Shaanxi, Sichuan and some other provinces in the Yellow River Basin are all located in the important strategic hub, undertaking the resources between the East and the West. At the same time, the government intervention can intensify the resource competition among the nine provinces. From the point of view of developed countries, when a country needs to contend with the major problems such as the fierce competition and low efficiency of logistics and transportation, and the excessive discharge of pollutants, it will take multimodal transport as a strategic project [28]. Therefore, in order to reduce unreasonable carbon emissions, the local governments should enhance the sense of cooperation so that the intermodal transport can be effectively connected, reduce the regulation on the development of the industry, and cancel the approval and restriction of the transport companies in many aspects, such as business route, joint carrier, transport rate, transport agency, so as to reduce the threshold of access, promote fair competition, create a convenient environment, and make the industry resources flow effectively.

4. Conclusion

Carbon emissions derived from energy consumption have induced serious environmental problems such as climate change and global warming. Countries and regions faced with these problems have been endeavoring to alleviate carbon emissions in several sectors. Efforts have contributed to reducing carbon emissions generated by energy consumption. However, as environmental issues become increasingly severe, it is crucial to make great efforts to improve the carbon emissions reduction performance for solving climate change. In order to facilitate such efforts, it is necessary to measure the current situation. In this study, DEA–Tobit model is proposed to evaluate the carbon emission performance in logistics in the Yellow River Basin, and the explanatory variables affecting the environmental performance factors are selected for analysis.

The emission performance in logistics in the Yellow River Basin is studied in this paper. We find that there are such problems as high investment, high energy consumption, high carbon emissions and low efficiency in the logistics industry in this region. The analysis and optimization of the phenomenon plays an important role in the sustainable development and carbon emission reduction goals. Based on DEA–Tobit model, this paper measures the performance of carbon emission in logistics in the Yellow River Basin. First, we introduce DEA to evaluate the unreasonable areas of carbon emission, and then we adopt the panel Tobit model to demonstrate the influencing factors of logistics environmental performance. The results are as follows: (1) Ningxia, Inner Mongolia, Henan, Qinghai and Shandong achieved good carbon emission performance in logistics, while the logistics environmental performance of Shanxi, Gansu, Shaanxi and Sichuan is bad, which needs to be adjusted in time to avoid further aggravating unreasonable carbon emissions. (2) From the perspective of influencing factors, the environmental regulation can improve the carbon emission performance in logistics, and the energy intensity has a negative impact on the carbon emission performance in logistics, while the industrial agglomeration and the government intervention have no significant impact on the carbon emission performance in logistics in this region.

Based on the research results, the paper discusses some principles applicable to the carbon emission reduction in logistic, which can provide reference for logistics enterprises in the micro-scale and logistics industry departments in the macro-scale to reduce energy consumption and to eliminate unreasonable factors of pollution in the Yellow River Basin.

However, there are some limitations in this paper. First of all, in terms of index selection, the added value of transportation, storage and postal industry should be taken as the added value of logistics industry, which needs further consideration. Second, the empirical research is based on the data spanning from 2008 to 2017, and the future research should consider longer research time. Finally, the implementation effect of regional environmental protection expenditure has not been evaluated, which will be discussed in the future study.

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