Low-carbon Development of Urban Logistics Based on Principal Component Analysis

—A Case Study of Lanzhou City

Huifang Bai[1], Kedong Tan[2], Kaishun Huang[1] & Qian Guo[1]

[1] College of Management, Northwest Minzu University, Lanzhou, China

[2] Gansu Society of Logistics, Lanzhou, China

Correspondence: Huifang Bai, Lecturer, College of Management, Northwest Minzu University, Lanzhou, Gansu, China.

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Abstract

The Low-carbon economy is a sustainable economic model advocated by many countries all over the world. Urban logistics, as an important source of urban environmental pollution, is in an urgent demand for the development. This paper takes Lanzhou City as the research object to find out the key factors of urban logistics carbon emissions through the construction of carbon emission index system, the principal component analysis of the impact indicators from 2005 to 2014. And by evaluating the carbon emission level of logistics in Lanzhou City, it provides the corresponding solutions for the low carbon logistics development in Lanzhou City.

Keywords: Lanzhou City, logistics, principal component analysis, carbon emission

1. Introduction

In recent years, environmental pollution has increasingly become the focus of attention in the world, for the sustainable development of society, the concept of the low-carbon economy was born. At the same time, the Chinese Government made a solemn commitment at the United Nations Climate Conference in Copenhagen to reduce carbon dioxide emissions per unit of GDP by 40 to 45 percent by 2020 compared to 2005, and at the Paris Climate Summit in 2015, the Chinese Government reiterated this commitment. However, with the accelerated process of urbanization, the rapid development of modern logistics industry, the logistics industry is at the forefront of energy consumption and carbon emissions as one of the ten pillar industries in China. Urban transportation, storage, distribution processing, packaging, distribution and other activities of the carbon emissions caused a definite negative impact on the urban environment and climate. Therefore, it is a vital research content of the healthy development of the city to analyse the driving factors of urban logistics carbon emission, to effectually control the emission of logistics, and to promote the development of low carbonisation of urban logistics.

Lanzhou City is the transportation hub of the west of China, and the status of logistics and transportation is remarkable, urban logistics is an important industry in the economic development of Lanzhou. However, in recent years Lanzhou City has introduced a variety of traffic control policies to control the urban environment and traffic problems, which has caused a greater threat to the logistics industry in Lanzhou. Therefore, it is imminent to reduce the carbon emission of urban logistics in Lanzhou. Based on this situation, this paper analyses the influencing factors of logistics carbon emissions in Lanzhou city by using SPSS software to analyse the key factors of carbon emission, and then provides the corresponding strategies for low carbon logistics development in Lanzhou City.

2. Analysis on the Influencing Factors of Urban Logistics Carbon Emission

There are many factors that affect the carbon emission of logistics in Lanzhou city. In the selection of factors index, this paper mainly follows two principles: firstly, the index is simple, and the calculation method should not be too complicated; secondly, the goal oriented, that is, the selection of indicators should have a significant correlation with the level of carbon emissions in Lanzhou City logistics. This paper roughly selected the following four indicators combined with the actual situation of Lanzhou city logistics and the availability of data.

2.1 Index System of Economic Development Level

The higher the level of economic development of a city, the higher the demand for urban logistics, the obvious result is the logistics industry carbon emissions increased. At the same time, the more developed of the urban economy, urban logistics will cause more and more attention of the society, the logistics industry will increase the intensity of investment, so the logistics industry, energy conservation and emission reduction are also increasingly important. Besides, the gross output value of urban transport industry, as well as the budget of transportation, play an decisive role in the current and future development of urban logistics. Therefore, the indicators of economic development level are: Lanzhou GDP (X1), Lanzhou GDP growth rate (X2), transportation storage postal industry gross output (X3), budgetary expenditure on transportation (X4).

2.2 Index System of Urban Infrastructure

The construction of urban infrastructure has a great influence on the development of urban logistics. Only with convenient transportation, urban logistics can be further developed. The existing urban infrastructure has consumedly restricted the development of modern logistics, resulting in the unnecessary carbon emission of urban logistics. In this paper, the road length (X5) and the per capita road area (X6) are used to construct the index system of urban infrastructure.

2.3 Indicator System of the Development Level of Transport Warehousing and Postal Service

Transport warehousing Post industry is an important indicator in the statistical yearbook, which can not only reflect the level of local economic development but also reflect the level of its logistics. Especially with the rapid rise of e-commerce in China, the number of postal services and the number of express parcels rising sharply, which brings a thorny problem of energy consumption and environmental pollution to China under the background of promoting low-carbon economic development model, so the transportation of the study and consideration is particularly important. This paper mainly selects five indicators to analyse it: Railway Freight Volume (X7), Road freight volume (X8), Air Cargo Volume (X9), Transport storage postal industry practitioners (X10), Postal ordinary package (X11).

2.4 Energy Structure Index System

The environmental pollution caused by logistics industry in the city, mainly on the energy consumption of a great quantity of carbon emissions. It is crucial to discuss the energy structure of cities and the use of new energy sources, and to influence the carbon emissions of urban logistics. In this paper, we mainly analyse three indexes, which are gasoline consumption (X12), diesel consumption (X13) and electricity consumption (X14), which affect carbon emission.

The above 14 indicators constitute the index system of urban logistics carbon emission factors (see Table 1). However, the system is not easy to find the key indicators of urban logistics carbon emission levels in Lanzhou city because of the many indicators. To this end, factor analysis is needed to identify several comprehensive indicators from multiple evaluation indicators.

Table 1. Urban logistics carbon emission indicator system

Level	Specific indicators	Represents the value
The level of economic development	Lanzhou City GDP	X1
	The Growth Rate of GDP in	X2
	Transportation storage postal industry GDP	X3
	Budgetary Expenditure on Financial Transportation	X4
Level of urban infrastructure	Road length	X5
	Per capita road area	X6

The development level of postal service in transportation and storage	Railway freight volume	X7
	Road freight volume	X8
	Air cargo traffic	X9
	Transport warehousing postal industry practitioners	X10
	Postal ordinary package	X11
Urban Energy Structure Level	Consumption of gasoline	X12
	Diesel fuel consumption	X13
	Electricity consumption	X14

3. Principal Component Analysis

The principal component analysis is the most significant method of factor analysis. This paper evaluates the low carbon level of logistics industry in Lanzhou by finding out the components from the multiple impact indicators through Principal Component Analysis. We analysed the 14 indicators of data which are derived from the "statistical yearbook of Lanzhou City", "China City" "Lanzhou Statistical Yearbook", "the national economic and social development statistical bulletin" from 2005 to 2014 by using SPSS19.0 software.

3.1 Correlation Coefficient Matrix

There may be some correlation between the comprehensive evaluation index of logistics in Lanzhou city from the qualitative point of view, and the correlation matrix of principal component analysis is mainly used to measure the correlation between each index. Therefore, to test whether the correlation between 14 indicators, the need to calculate the correlation coefficient matrix (see Table 2).

Table 2. Correlation Matrix[a]

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
Correlation	X1	1.000	.175	.992	.986	.518	.860	-.136	.996	.974	-.253	-.958	-.738	.955	.937
	X2	.175	1.000	.198	.240	-.343	-.022	.138	.138	.165	-.267	-.370	-.341	.057	.146
	X3	.992	.198	1.000	.990	.480	.833	-.176	.992	.987	-.270	-.956	-.716	.953	.922
	X4	.986	.240	.990	1.000	.526	.859	-.232	.987	.990	-.272	-.975	-.704	.935	.879
	X5	.518	-.343	.480	.526	1.000	.804	-.588	.551	.536	.038	-.449	-.207	.525	.315
	X6	.860	-.022	.833	.859	.804	1.000	-.458	.886	.860	-.032	-.770	-.529	.770	.702
	X7	-.136	.138	-.176	-.232	-.588	-.458	1.000	-.214	-.292	-.320	.098	-.350	-.123	.159
	X8	.996	.138	.992	.987	.551	.886	-.214	1.000	.984	-.214	-.941	-.688	.948	.913
	X9	.974	.165	.987	.990	.536	.860	-.292	.984	1.000	-.222	-.940	-.631	.930	.860
	X10	-.253	-.267	-.270	-.272	.038	-.032	-.320	-.214	-.222	1.000	.390	.620	-.168	-.224
	X11	-.958	-.370	-.956	-.975	-.449	-.770	.098	-.941	-.940	.390	1.000	.774	-.910	-.866
	X12	-.738	-.341	-.716	-.704	-.207	-.529	-.350	-.688	-.631	.620	.774	1.000	-.653	-.795
	X13	.955	.057	.953	.935	.525	.770	-.123	.948	.930	-.168	-.910	-.653	1.000	.922
	X14	.937	.146	.922	.879	.315	.702	.159	.913	.860	-.224	-.866	-.795	.922	1.000

a. This matrix is not positive definite.

From Table 2, we can see that there are strong correlations among some indicators, so they can not be directly used to comprehensively evaluate the impact factors of urban logistics carbon emissions in Lanzhou. Otherwise, it will cause information overlap and impact evaluation of the objectivity; it must be principal component analysis.

3.2 Total Variance Analysis

From Table 3, it can be seen that the first and second constituents are 9.353 and 2.321, respectively, which account for 66.810% and 16.579% of the total variance of the original variables respectively. The cumulative contribution rate of these two characteristic roots reached 83.389%, indicating that these two components more comprehensive reflection of the vast majority of information of the original data. According to the principle that the principal component characteristic root is more than one and the cumulative contribution rate is more than 75%, the extraction of the two principal component factors is more suitable.

Table 3. Total variance explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.353	66.810	66.810	9.353	66.810	66.810	9.313	66.523	66.523
2	2.321	16.579	83.389	2.321	16.579	83.389	2.361	16.866	83.389
3	.949	6.781	90.170						
4	.808	5.769	95.939						
5	.337	2.410	98.349						
6	.135	.962	99.310						
7	.064	.458	99.769						
8	.024	.169	99.938						
9	.009	.062	100.000						
10	.000	.000	100.000						
11	.000	.000	100.000						
12	.000	.000	100.000						
13	.000	.000	100.000						
14	.000	.000	100.000						

Extraction Method: Principal Component Analysis.

3.3 Principal Component Analysis

From Table 4 we can see that a load of each index in the two principal component factors. The first principal component factor is mainly determined by the eight indexes of indicators X1, X3, X4, X8, X9, X11, X13 and X14, that is, the correlation coefficient between these eight indicators and the first principal component is relatively higher. The second principal component factor is mainly determined by X7. Therefore, we can see those indicators which have higher correlation with the first principal component are the Lanzhou City GDP, transportation storage postal industry GDP, budgetary expenditure on fiscal transport, road freight, air cargo, ordinary postal package, Diesel Consumption of electricity. The higher correlation with the second principal component is rail freight.

Table 4. Component Matrix[a]

	Component	
	1	2
X1	.995	-.013
X8	.991	.063
X4	.991	.014
X3	.990	-.018
X9	.976	.090
X11	-.967	.153
X13	.949	.043
X14	.913	-.205
X6	.874	.383
X12	-.753	.527
X7	-.174	-.821
X5	.561	.655
X10	-.291	.623
X2	.185	-.571

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

3.4 Comprehensive Evaluation Model

In order to evaluate the carbon emissions of the logistics industry in Lanzhou from 2005 to 2014, a comprehensive evaluation model of the principal component should be constructed in this paper. First, we calculated the principal component values for each year according to SPSS (see Table 5). Then the factor score function is obtained according to the regression method: F = 66.810% * Z1 + 16.579% * Z2, the two principal component values of each year are substituted into the formula to get the carbon emissions from logistics industry in Lanzhou in 2005 to 2014. The comprehensive evaluation value of the quantity and the sorting result (as shown in Table 6).

Table 5. Component score

years	Z1	Z2
2005	-1.07871	1.63942
2006	-0.80846	0.89334
2007	-1.07666	-0.87966
2008	-0.63857	-0.45626
2009	-0.42212	-0.02676
2010	-0.2322	-0.47739
2011	0.41856	-1.52603
2012	0.88949	-0.75805
2013	1.28726	0.53685
2014	1.66141	1.05454

Table 6. Comprehensive evaluation values

years	F(score)	compositor
2005	-0.44889	3
2006	-0.39203	4
2007	-0.86516	1
2008	-0.50227	2
2009	-0.28645	5
2010	-0.23428	6
2011	0.026639	7
2012	0.468591	8
2013	0.949023	9
2014	1.28482	10

3.5 Conclusion Analysis

Based on the comprehensive index system of urban logistics carbon emission, this paper carries out principal component analysis, and calculates the comprehensive evaluation values of urban logistics carbon emission in Lanzhou. By sorting the comprehensive evaluation values from 2005 to 2014, we can see that the carbon emissions of the logistics industry in Lanzhou increased from 2009 to 2014, which indicates that the low-carbon development of urban logistics in Lanzhou is imminent.

In addition, two principal component factors extracted by principal component analysis have strong correlation with some indexes. The first principal component factor has a forceful correlation with Lanzhou City GDP, transportation warehousing postal industry GDP, financial transport budget expenditure, road freight, air cargo, ordinary postal package, diesel consumption, power consumption of these 8 indicators . It can be seen that the low-carbon development of the logistics industry is greatly affected by the level of urban economic development, the level of transportation (road and air transport) and energy consumption (diesel and electric power). With the improvement of urban economic development level and traffic volume (Especially road transport and air transport), the energy consumption of diesel fuel also increased, so the city's carbon emissions from the logistics industry has increased year by year. The second principal component factor has a strong relationship with railway freight volume. It can be seen from the factor loading value that the higher the Railway freight volume and the higher the logistics efficiency, the easier the low carbonisation level of urban logistics can be realised. Therefore, the paper provides the reference standard for promoting the development of logistics low carbonisation in Lanzhou by analysing the strong correlation index represented by the principal component.

4. Study on the Development of Low-carbon Logistics in Lanzhou City

4.1 Provide Green Loans and Financing Support for Low Carbon Logistics on the Economic Development Level

From the principal component analysis, that the level of economic development in the energy-saving emission reduction in the logistics industry plays an important role. On the one hand, the logistics industry to seize the city's rapid economic development opportunities, efforts to upgrade all aspects of the logistics service level, in the "Internet +" concept, optimise the city logistics, to achieve economies of scale, thus reducing logistics costs and carbon emissions. On the other hand, the Lanzhou municipal government should strengthen its low-carbon economic concept, not only value economic benefits, but also value the sustainable development of economy and environment, provide appropriate policy support and loans to logistics enterprises with low carbon development concept, provide a strong policy guidance and economic support for the logistics industry to achieve low-carbon development

4.2 Actively Guide Transport Mode Conversion

In the "The Belt and Road" Initiative background, foreign trade will be the main direction of Lanzhou in the future development. Therefore, it is momentous for the logistics industry to introduce advanced transport methods and tools for the development of low carbon logistics industry in Lanzhou city. However, from the data analysis, it is found that the logistics industry in Lanzhou mainly relies on road transport, and large transport capacity, low energy consumption, low transport costs of railway transport is declining year by year. Therefore, we should vigorously promote and propaganda the railway transport, and actively introduce advanced modes of transport, such as the more popular Combined Transport by Highway and Rail. At the same time, increase the construction of transportation infrastructure, especially the density of highway network and route planning, making the transport distance can be reduced to reduce the city's transport time.

4.3 Optimise the Energy Structure and Use of New Energy Sources Economic

From the above principal component analysis, we can see that the energy structure has a key effect on the carbon emissions of urban logistics. Therefore, starting from the energy to reduce carbon emissions is the most direct and effective strategy. At present, the logistics industry in Lanzhou is mainly based on gasoline and diesel as the main source of energy, the rate of new energy utilisation is low, so we can make efforts to optimise the energy structure and open up. On the one hand, use new energy vehicles (such as natural gas, electricity) for urban distribution, on the other hand, introduce Transport equipment with high energy utilisation rate for city transport to reduce the amount of diesel fuel and carbon emissions.

5. Concluding Remarks

In this paper, through the establishment of Lanzhou city logistics carbon emissions comprehensive evaluation index system, the Lanzhou City's low carbon level was evaluated by the principal component analysis, and some significant policy recommendations were provided for the low carbon logistics development. The analysis shows that the low-carbon development of urban logistics in Lanzhou City is not ideal. On the one hand, the problem of the environment has been neglected because of the transition from urban development to the development of economic level. On the other hand, transportation mode and energy structure have also affected the low carbon development of the logistics industry. Therefore, this paper puts forward some suggestions on how to develop a low-carbon city from three aspects. This has important significance for the sustainable development of Lanzhou city logistics. Meanwhile, this method can be applied to other cities, and the conclusion has important reference meaning to the low carbon logistics development of other cities. However, an important indicator can not be ignored is the public and corporate low-carbon awareness, only the public and the enterprise's low carbon awareness level has been improved, a city's low carbon development can be more long-term, which can not be reflected in the data analysis.

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