Research on Urban Low-Carbon Transportation Development Strategy in Shanxi Province

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Abstract: With the rapid increase in the number of motor vehicles and the continuous increase in total pollutant emissions, the resulting urban pollution problems have become increasingly severe and have attracted attention from all parties. The development of low-carbon transportation has become the strategic direction of Chinese urban transportation development. Based on the current status of urban traffic and the relevant data of Statistical Yearbook in Shanxi Province, this article calculates the carbon emissions of the transportation industry by the forecast method of IPCC traffic carbon emissions. In addition, it analyzes the impact factors of provincial urban traffic carbon emissions through SPSS principal component analysis and multiple linear regression. Finally, the empirical results are analyzed to provide strategies for the development of urban low-carbon transportation in Shanxi Province.

1. Introduction

With the acceleration of Chinese urbanization process and the improvement of people's living standards, the overall consumption structure is gradually upgrading, the scale of cities is continuously expanding, and the degree of urban transportation motorization is increasing. Under the dual pressure of urbanization and motorization, the demand for urban transportation is increasing day by day . The low-carbon development of urban transport is urgent.

In 2017, General Secretary Xi Jinping proposed “to be the vanguard of the national energy revolution” when inspecting Shanxi, indicating the development direction for the transformation and development of Shanxi Province. In recent years, Shanxi Province has attached great importance to the low-carbon product, led the energy revolution with green and low-carbon growth, steadily promoted the transformation of economic development mode, and achieved high-quality development. Therefore, it is of great significance to study the effect of low-carbon transportation in Shanxi Province.

2. Literature review

Mao Lin (2010) believed that low-carbon transportation refers to the use of carbon emission reduction to evaluate the development of transportation construction, services and management. Su Fengming (2010) pointed out that low-carbon transportation is a new development concept embodied in the transportation field under the low-carbon development model of humanity. The methods and implementation results adopted to realize this concept is the goal of harmonious development between man and nature in the field of transportation.

Xie Feifei (2013) chose the "top-down" method to measure the carbon emissions of the Chinese transportation industry. Xie Suwen (2016) considered the principal component analysis is an essential and useful multivariate statistical methods, and both theory and application of principal component analysis carried out the research.

Shivika Mittal et al. (2016) compared the urban traffic conditions in China and India, using a bottom-up target end-use model, and analyzed the business as usual (BAU) scenario and low carbon

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scenario (LCS) linked to the global 2-degree stability target. Wenxiang Li et al. (2019) proposed a comparative evaluation method that considers the impact of urban population size, population density and economic development in response to the lack of comparability and comprehensive evaluation of low-carbon urban transportation.

3. Shanxi province urban traffic carbon emission calculation and analysis of influencing factors

3.1 Estimation of carbon emissions from urban transportation in Shanxi province

According to the content and availability of data in the "IPCC2006 Greenhouse Gas Inventory Guidelines", the transportation carbon emissions of Shanxi Province are calculated based on the "top-down method" of transportation fuel consumption. The specific calculation formula is:

$$Em = \sum Ei * Fi * Ki \tag{1}$$

Among them, Em is the calculated carbon emissions, Ei represents the consumption of the energy; Ki represents the carbon emission coefficient of the power; Fi represents the unit conversion coefficient of the energy, i=1,2,3, 4, respectively represent the four energy sources of coal, electricity, gasoline, and diesel. Since the "Shanxi Provincial Statistical Yearbook" does not have separate statistics on energy consumption in transportation, this article will roughly use energy consumption in transportation, storage and postal industries as energy consumption in the transportation sector.

The formula one is calculated to give the field of transportation carbon emissions and merged into the line graph as in FIG. 1 shown in: In recent years, Shanxi carbon emissions transportation industry a steady upward trend.

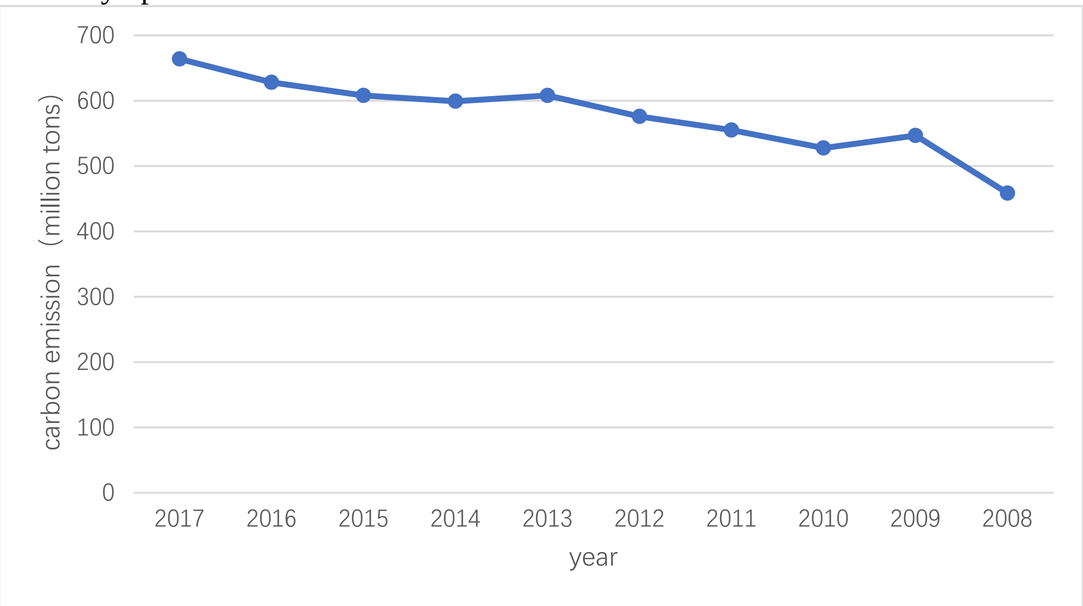

Figure 1: Carbon emissions of the transportation industry in Shanxi Province in the past ten years

3.2 Influencing factors of urban transportation carbon emissions

Many factors affect urban transportation carbon emissions, usually including the number of the urban population, the level of GDP, and the number of urban motor vehicles. Based on previous studies, combined with the current situation of Shanxi Province and the availability of data, this paper concludes that the main factors affecting the carbon emissions of low-carbon traffic in Shanxi Province are: the permanent population (X_1) and per capita GDP at the end of the year (X_2), per capita disposable income of residents (X_3), transportation-related tax revenue (X_4), transportation expenditure (X_5), urban transportation mileage (X_6), urban transportation freight volume (X_7), urban transportation cargo turnover Quantity (X_8), Private Cars (X_9), Total Civil Vehicles (X_{10}), Number of Public Transport Vehicles (X_{11}), Total Length of Public Transport Operation Lines (X_{12}), Total Passenger Transport of Public Transport (X_{13}), Urban Road Area per Capita (X_{14}), urban road length per capita (X_{15}).

3.3 Quantitative analysis of carbon emissions from urban transportation in Shanxi province

According to the relevant data provided by the "Shanxi Provincial Statistical Yearbook" and the "National Bureau of Statistics", the data on the factors affecting urban traffic carbon emissions in Shanxi Province are obtained. Based on the principal component analysis and multiple linear regression methods, quantitative research on urban low-carbon transportation carbon emissions.

3.3.1 Principal component analysis

In the actual research process, researchers often hope to obtain more information. Therefore, researchers choose multiple observation angles and use multiple variables to measure the various characteristics of things. Many variables provide researchers with much knowledge and also lead to the overlapping of information. Therefore, this paper mainly uses principal component analysis to analyze the factors that affect urban transportation carbon emissions.

The core idea of principal component analysis is to achieve the purpose of dimensionality reduction. Therefore, we can use principal component analysis for statistical analysis only when there is a strong correlation between the original variables. Thus, we should test the correlation of explanatory variables before using principal component analysis. Through the data of the correlation test of the explanatory variables by SPSS software, the absolute value of the correlation coefficient between the explanatory variables is mostly greater than 0.5, and is significant at the significance level of 0.05 or even 0.01. There is a strong relationship between the variables. For correlation, we can perform principal component analysis to achieve the purpose of dimensionality reduction.

Table 1 shows the results of the degree of commonality of each variable. The left side of the table represents the variance that all factors can explain each variable, and the right side represents the degree of commonality of the variables, that is, the degree of extraction of each original variable. The higher the degree of commonality, the easier to explain and more reasonable. We can conclude from this table that the commonality of the variables is very high, all more significant than 88%, indicating that most of the information in the variables can be extracted by the principal component, indicating that the effect of principal component analysis is significant.

Table 1: Common factor variance

	initial	extract
X1	1.000	0.950
X2	1.000	0.963
X3	1.000	0.986
X4	1.000	0.944
X5	1.000	0.910
X6	1.000	0.985
X7	1.000	0.966
X8	1.000	0.931
X9	1.000	0.984
X10	1.000	0.985
X11	1.000	0.923
X12	1.000	0.939
X13	1.000	0.880
X14	1.000	0.988
X15	1.000	0.974
Extraction method: principal component analysis method.		

In the principal component analysis, a relatively important step is to determine the number of principal components. From Table 2, we extract two principal components when the eigenvalue is greater than 1. When the cumulative contribution rate reaches 95%, we also extract two principal components. Also, the gravel map is available, and the slopes presented by the first two line segments are relatively steep, so it is feasible to extract two principal components in this paper.

Table 2: Explanation of total variance

ingredient	Initial eigenvalue			Extract the sum of squared loads		
	total	Percentage of variance	Cumulative%	total	Percentage of variance	Cumulative%
1	13.169	87.791	87.791	13.169	87.791	87.791
2	1.138	7.586	95.377	1.138	7.586	95.377
3	0.336	2.237	97.615			
4	0.183	1.222	98.836			
5	0.091	0.604	99.440			
6	0.054	0.359	99.799			
7	0.014	0.094	99.892			
8	0.013	0.086	99.978			
9	0.003	0.022	100.000			
10	1.541E-16	1.027E-15	100.000			
11	6.552E-17	4.368E-16	100.000			
12	-1.697E-16	-1.132E-15	100.000			
13	-3.930E-16	-2.620E-15	100.000			
14	-6.739E-16	-4.493E-15	100.000			
15	-1.369E-15	-9.129E-15	100.000			
Extraction method: principal component analysis method.						

V1 and V2 are the values presented in the component matrix, and F1 and F2 are the eigenvector matrices calculated by SPSS.The formula is: F1=V1/SQRT(13.169) and F2=V2/SQRT(1.138), where SQRT is the characteristic value of the corresponding principal component.

At the same time, standardize the original data, where ZX_1-ZX_{15} correspond to the standardized values of the original indicators X_1-X_{15}. From the eigenvector matrix (that is, the values of F1 and F2), we can get the calculation formula of the principal component as:

$$Z1=0.26ZX_1+0.27ZX_2+0.27ZX_3+0.27ZX_4+0.23ZX_5+0.27ZX_6+0.26ZX_7+0.27ZX_8+0.27ZX_9+0.27ZX_{10}+0.26ZX_{11}+0.23ZX_{12}+0.22ZX_{13}+0.27ZX_{14}+0.25ZX_{15}$$

$$Z2=0.16ZX_1+0.03ZX_2-0.19ZX_3+0.04ZX_4+0.46ZX_5+0.06ZX_6-0.24ZX_7-0.03ZX_8-0.23ZX_9-0.21ZX_{10}-0.02ZX_{11}+0.44ZX_{12}+0.47ZX_{13}-0.21ZX_{14}-0.34ZX_{15}$$

The data of principal components Z1 and Z2 are obtained by inputting formulas in SPSS and calculating.

3.3.2 Multiple linear regression

Before performing multiple linear regression analysis, considering the consistency and nondimensionalization of the data, first standardize the carbon emission Em and record it as Zim. In order to reflect the impact of urban transportation carbon emissions, this paper selects standardized carbon emission ZEm as the explanatory variable, the principal components Z1 and Z2 obtained above are used as explanatory variables,and it conducts multiple linear regression analysis by SPSS software. The value of R^2 is 0.895, indicating that the model fits the data very well.

According to the results of the analysis of variance: the significance P-value of the model is 0.000, so we can judge that the overall model is very significant, and the linear relationship between the explained variable and the explanatory variable is significant, which proves that the establishment of a linear regression model is reasonable.

We can obtain the equation of multiple linear regression as:

$$ZEm=0.000001+0.26Z1+0.009Z2$$

The regression between the dependent variable and the principal component is transformed into the regression between the dependent variable and the independent variable through the linear relationship between the central element and the respective variable, namely:

$$ZEm=0.000001+0.07ZX_1+0.07ZX_2+0.07ZX_3+0.07ZX_4+0.06ZX_5+0.07ZX_6+0.07ZX_7+0.07ZX_8+0.07ZX_9+0.07ZX_{10}+0.07ZX_{11}+0.06ZX_{12}+0.06ZX_{13}+0.07ZX_{14}+0.06ZX_{15} \quad (2)$$

Equation 2 is the regression equation of the standardized independent variable to the standardized dependent variable, which reflects the degree of influence of the selected 15 original indicators on Chinese carbon emissions. Among them, the standardized transportation expenditure (X_5), the total length of public transportation operation lines (X_{12}), the total number of public transportation passengers (X_{13}), and the size of urban roads per capita (X_{15}) have less impact on carbon emissions.

Equation 2 can be reduced to:

$$Em=111.38+0.040699X_1+0.000623X_2+0.000842X_3+0.000021X_4+0.000007X_5+0.000591X_6+0.000158X_7+0.000001X_8+0.000003X_9+0.000003X_{10}+0.00369X_{11}+0.001132X_{12}+0.000191X_{13}+1.885738X_{14}+16.62036X_{15} \quad (3)$$

Through principal component analysis and multiple linear regression analysis on the data of Shanxi Province, we can see that there are many factors affecting carbon emissions in the transportation sector. Equation 3 reflects explicitly the impact of 15 elements on Shanxi Province's carbon emissions, such as the permanent population and per capita GDP of the province at the end of the year, per capita disposable income of residents, transportation-related tax revenue, and transportation expenditures.

The increase in carbon emissions in the transportation sector is the result of the combined effect of many factors.

4. Analysis of empirical results

It can be seen from Equation 3:

All 15 variables have positive effects on carbon emissions. To reduce carbon emissions, we must start in all aspects.

For each increase of 1 yuan in per capita GDP (X_2) and per capita disposable income (X_3), carbon emissions increase by 6.23 tons and 8.42 tons, respectively. The impact of per capita GDP on carbon emissions is lower than the impact of per capita disposable income on carbon emissions. With the improvement of the level of economic development and people's living standards, carbon emissions in the transportation sector is increasing.

The impact of urban traffic mileage (X_6) and the total length of public transport operation lines (X_{12}), urban transport freight volume (X_7), urban transport cargo turnover (X_8) and comprehensive public transport passenger transport (X_{13}) on carbon emissions. To a certain extent, it shows that the current development of the transportation industry and the acceleration of urbanization are closely related to the growth of carbon emissions to a certain extent.

Each increase in the number of private cars (X_9), the total number of civilian vehicles (X_{10}), and the number of public transport vehicles (X_{11}) will increase carbon emissions by 0.03 tons, 0.03 tons and 36.9 tons, respectively. The increase in private car ownership will increase carbon emissions.

5. Conclusion

(1) As the level of economic development and people's living standards improve, the process of urbanization continues to accelerate, and people's demand for private cars increases, resulting in an increase in carbon emissions in the transportation sector. Fiscal and tax policies do not have a perfect effect on suppressing carbon emissions. Considering levying carbon taxes and other taxes directly related to carbon emissions or charging related fees.

(2) To achieve the reduction of carbon emissions, it is necessary to change people's travel concepts, raise low-carbon awareness, and promote low-carbon transportation concepts.

(3) The current development of the transportation industry and the acceleration of the urbanization process are closely related to the growth of carbon emissions to a certain extent. Therefore, we must transform the development mode, improve innovation capabilities, innovate and develop new types of transportation and clean fuels, such as advocating the way to travel by rail transit to reduce carbon emissions.

(4) Encourage reasonable consumption and purchase small-displacement cars—for example, new energy vehicles. At the same time, promote low-carbon transportation, encourage travellers to travel green, optimize bicycle and walking travel systems, and advocate non-motorized travel and zero-carbon travel.

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References

[1] Wenxiang Li, Lei Bao, Luqi Wang, Ye Li, Xianmin Mai. Comparative evaluation of global low-carbon urban transport [J]. Technological Forecasting & Social Change, 2019,143.

[2] Arlinghaus, J. and K. van Dender. The environmental tax and subsidy reform in Mexico[R], OECD Taxation Working Papers, No. 31, OECD Publishing, 2017.

[3] Shivika Mittal, Hancheng Dai, PR Shukla. Low carbon urban transport scenarios for China and India: A comparative assessment [J]. Transportation Research Part D, 2016, 44.

[4] Hari Bansha Dulal, Rajendra Dulal, Pramod Kumar Yadav. Delivering green economy in Asia: The role of fiscal instruments [J]. Futures, 2015, 73.

[5] Huang Yi, Chang Xiangyang. Low-carbon economy and the development of transportation industry: an empirical study based on the data of national central cities [J]. Social Scientist, 2019(11): 67-73.

[6] Li Ping. The low-carbon transition from the perspective of the social-technological paradigm [J]. Research in Science of Science, 2018, 36(06): 1000-1007.

[7] Shan Jikun, Zhang Hewei. Path analysis of low-carbon city construction: Taking Beijing as an example [J]. Learning and Exploration, 2018(04): 126-130.

[8] Zhao Tao, Yu Chenxia, Pan Hui. Research on Chinese low-carbon city development model based on energy consumption cycle [J]. Arid Land Resources and Environment, 2017, 31(09): 20-25.

[9] Xie Suwen. Application research based on principal component analysis and factor analysis mathematical model [D]. Shandong University of Technology, 2016.

[10] Huang Zhongwen. SPSS statistical analysis and application [M]. Beijing: Electronic Industry Press, 2016.

[11] Xie Feifei. Research on Influencing Factors of Urban Transportation Carbon Emissions and Low-Carbon Transportation Development [D]. Beijing Jiaotong University, 2013.

[12] Mao Lin. Thoughts on the fundamental issues of the "Twelfth Five-Year" development plan for low-carbon transportation in Hangzhou [J]. Highway, 2010(08):183-184.

[13] Su Fengming. The concept and realization of low-carbon transportation[J]. Comprehensive Transportation, 2010(05): 13-17.