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Correlation Analysis of Energy Consumption and Industrial Structure in Transportation Industry

-Taking Hebei Province as an Example

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***Abstract*—Taking into account the impact of the proportion of industrial structure on the energy consumption of transportation industry, the gray correlation degree theory is applied to analyze the relationship among the energy consumption of the transportation industry in Hebei Province, the first, second and third industries, and the gray prediction GM (1,1). The model predicts the energy intensity of the transportation industry and other industries in Hebei Province in the next five years, and puts forward corresponding suggestions for the development of low-carbon transportation in Hebei Province.**

Keywords—Industrial structure; Energy consumption; Correlation Analysis; Grey prediction

I. INTRODUCTION

China promises that by 2030, CO2 emissions from GDP will fall by 60%-65% compared with 2005, Energy consumption directly affects carbon emissions [1]. Hebei Province, as an important province for the coordinated development strategy of Beijing-Tianjin-Hebei, is facing the requirements of low-carbon development while continuously promoting coordinated economic development . The "13th Five-Year Plan for Energy Conservation in Hebei Province" released in 2017 pointed out that in order to achieve the goal of controlling the total energy consumption of the province in 2020 to 327.85 million tons of standard coal, the energy consumption per 10,000 yuan of GDP will fall by 17%. The transportation industry is an industry with high energy consumption and high carbon emissions. In 2016, the total energy consumption of the transportation industry in Hebei Province reached 12.86 million tons of standard coal, accounting for 4.3% of the total energy consumption in Hebei Province. Therefore, how to reduce the energy consumption and carbon emissions of the transportation industry is a major problem facing the realization of low-carbon development in the transportation industry in Hebei Province.

II. GREY CORRELATION ANALYSIS

Taking the industrial structure of Hebei Province as a large system and the transportation industry as a subsystem [2], the total energy consumption of the transportation industry in Hebei Province is selected as the reference series of correlation analysis, and the total production of the first, second and third industries in Hebei Province is occupied. The proportion of the value is used as a comparison sequence to calculate the degree of correlation between the two, and to explore the adaptive relationship between the energy consumption of the transportation industry in Hebei Province and the industrial structure.

As shown in Table I, the data of Hebei Province's GDP, the added value of primary, secondary and tertiary industries and energy consumption were selected from 2008 to 2017. The data in Table I is the basis for correlation analysis and energy intensity prediction.

TABLE I 2008-2017 ADDED VALUE AND ENERGY CONSUMPTION DATA OF VARIOUS INDUSTRIES IN HEBEI PROVINCE (100 MILLION TONS, STANDARD TONS OF COAL)

Time	Industrial output value					Energy consumption				
	Overall	*primary*	*Secondary*	*Tertiary*	*Transportation*	*Overall*	*primary*	*Secondary*	*Tertiary*	*Transportation*
2008	16188.6	2034.6	8777.4	5376.6	1281.2	24321.87	612.35	18433.74	1751.43	827.11
2009	17026.6	2218.9	8874.9	5932.8	1513.9	25418.79	644.81	19089.09	1836.24	831.68
2010	20197.1	2562.8	10705.7	6928.6	1880.3	26201.41	686.82	20350.17	2041.81	975
2011	24228.2	2905.7	13098.1	8224.4	2046.2	28075.03	703.93	23659.99	2225.57	1076.6
2012	26575	3186.7	14001	9387.3	2241.1	28762.47	707.46	24483.64	2384.43	1118.65
2013	28301.4	3500.4	14762.1	10038.9	2377.6	29664.38	574	23654	2538.96	1162

Table I, cont										
2014	29421.2	3447.5	15020.2	10953.5	2490.1	29320.21	625	23038	2659	1109
2015	29806.1	3439.5	14386.9	11979.8	2292.9	29395.36	642	22481	2881	1111
2016	31827.9	3492.8	15058.5	13276.6	2403	29794	648	22326	3192	1286
2017	35964	3507.9	17416.5	15039.6	2494.9	31354.2	642.3	23624.5	3161.8	1359.1

A. Calculation of grey correlation

Step 1: The total energy consumption of transportation industry in Hebei Province was selected as the reference sequence, and the ratio of the primary, secondary and tertiary industries in Hebei Province to the regional GDP was used as a comparison sequence.

Step 2: The original data of each sequence is processed, and the data is processed by the mean method. The mean method is as follows:

$$x_i'(k)=\frac{x_i(k)}{\frac{1}{n}\sum_{k=1}^{n}x_i(k)},i=0,1,\cdots,m;k=0,1,\cdots,n \tag{1}$$

Step 3: calculate the correlation coefficient. The calculation formula of the correlation coefficient is as follows

$$\xi(x_0(k),x_i(k))=\frac{\min\limits_i\min\limits_k\left|x_0'(k)-x_i'(k)\right|+\rho\max\limits_i\max\limits_k\left|x_0'(k)-x_i'(k)\right|}{\left|x_0'(k)-x_i'(k)\right|+\rho\max\limits_i\max\limits_k\left|x_0'(k)-x_i'(k)\right|} \tag{2}$$

Where: $\min\limits_i\min\limits_k\left|x_0'(k)-x_i'(k)\right|$ is the minimum difference of two levels; $\max\limits_i\max\limits_k\left|x_0'(k)-x_i'(k)\right|$ is two-level range maximum; $\xi(k)$ is the correlation coefficient between the reference sequence and the comparison sequence; usually $\rho=0.5$.

Step 4: Calculate the gray correlation degree. Calculate the mean value of the correlation coefficient between the comparison sequence and the corresponding element of the reference sequence, that is:

$$r=\frac{1}{n}\sum_{k=1}^{n}\xi_i(k) \tag{3}$$

According to the formula of gray correlation degree, the gray correlation degree between the proportion of the primary, secondary and tertiary industries in Hebei Province and the energy consumption of the transportation industry in 2008-2017 is r1=0.665, r2=0.667, respectively. r3=0.750, the degree of relevance is r3>r2>r1, which is the proportion of the tertiary industry>the proportion of the second industry>the proportion of the first industry.

B. Grey correlation analysis

It can be obtained from the results, the gray correlation degree between energy consumption of transportation industry and the proportion of tertiary industry is the largest, the value is 0.750; the second is the proportion of secondary industry. The gray correlation degree is 0.667; the last is the proportion of the first industry, and the gray correlation degree is 0.665. The proportion of the tertiary industry has the highest correlation with the energy consumption of the transportation industry. It shows that during 2008-2017, the energy consumption of the transportation industry in Hebei Province has the greatest effect on the economic output of the tertiary industry, and also reflects the traffic from the side. The transportation industry itself is part of the tertiary industry. The difference in the gray correlation degree between the proportion of the secondary industry and the proportion of the primary industry is not significant, indicating that Hebei Province has been committed to industrial restructuring in recent years and has achieved initial results.

From the perspective of overall development, the correlation between the energy consumption of transportation industry in Hebei Province and the proportion of the three industrial structures is strong, and the correlation degree is above 0.65, indicating the energy input of the transportation industry in Hebei Province and the three industries. There is a strong correlation between economic output, which shows that the transportation industry has played a fundamental role in the development of national economy in Hebei Province. Therefore, in order to realize the low-carbon development of the transportation industry in Hebei Province, it is necessary to play a joint role from the three factors of the primary industry, the secondary industry and the tertiary industry.

III. ENERGY INTENSITY PREDICTION

A. Calculation of energy intensity

Energy intensity can be used to measure the energy comprehensive utilization efficiency of different industries and the dependence of different industries on energy [3]. The higher the energy intensity, the higher the energy consumed by the industrial output per unit of GDP, the general energy consumption and the economy. The ratio of the output is used to calculate the energy intensity, and the energy intensity is set as follows:

$$\varepsilon=\frac{E}{G} \tag{4}$$

Among them, E represents the energy consumption of various industries, G stands for economic output. According to Table I data and formula (4), the energy intensity of the first, second and third industries and transportation industry in Hebei Province are shown in Table II.

TABLE II ENERGY INTENSITY OF VARIOUS INDUSTRIES IN HEBEI PROVINCE (2008-2017)

Time	primary industry	Secondary industry	Tertiary Industry	Transportation industry	Overall industry
2008	0.301	2.100	0.326	0.646	1.502
2009	0.291	2.151	0.310	0.549	1.493
2010	0.268	1.901	0.295	0.519	1.297
2011	0.242	1.806	0.271	0.526	1.159
2012	0.222	1.749	0.254	0.499	1.082

Table II, cont					
2013	0.164	1.602	0.253	0.488	1.048
2014	0.181	1.534	0.243	0.445	0.997
2015	0.187	1.563	0.240	0.485	0.986
2016	0.186	1.483	0.240	0.535	0.936
2017	0.183	1.356	0.210	0.545	0.872

Note: Units of tons of standard coal / 10,000 yuan ($*10^{-4}$)

It can be seen from Table II that The energy intensity of various industries in Hebei Province has shown a downward trend in the past decade, showing a large downward trend in 2009-2015, indicating that since 2009, China has promised to reduce carbon dioxide emissions and develop industries at the World Climate Change Summit. Since low energy consumption, Hebei Province has actively responded to the national call for industrial upgrading and development of energy-saving and emission reduction technologies. The energy intensity of the secondary industry and the energy intensity trend of the whole industry are roughly the same, showing a trend of decreasing year by year. The secondary industry is an industry with high energy consumption. The decline in energy intensity indicates that Hebei Province has responded to national policies and has made initial progress in industrial restructuring. The energy intensity of the primary industry and the tertiary industry showed a steady downward trend, while the energy intensity of the transportation industry showed a fluctuating trend, and the overall trend is declining.

B. Energy Intensity prediction

Use the "trend line" option in the EXCL file to fit the trend line of energy intensity in various industries. After exponential, logarithmic, moving average, polynomial, power, and linear trends, the energy intensity of various industries in Hebei Province was discovered. Showing a downward trend in the index.According to the relevant research literature [4], Exponential function model is used to express the development trend of energy intensity in different time series of various industries in Hebei Province. That is:

$$\varepsilon = ke^{at} \tag{5}$$

Where ε is the energy intensity, k is a constant, a is the rate of decline, and t is time.

According to the trend of the energy intensity of various industries in Hebei Province with the change of time series, the gray prediction model is used for forecasting [5]. According to the energy intensity data of each industry in Table II, the energy intensity change of the transportation industry is taken as an example to establish GM (1,1) model.

The GM (1,1) model can be used to derive the functional relationship between the energy intensity of the transportation industry in Hebei Province over time. At the same time, the raw data and the predicted data are analyzed and the residuals are tested to obtain a data comparison table, as shown in Table III below. The function of energy intensity of transportation industry in Hebei Province as a function of time is as follows:

$$\varepsilon(t) = -145.839 * e^{-0.0036(t-1)} + 146.485$$

The average relative error is 4.8% and the model accuracy is 95.2%.

TABLE III COMPARISON TABLE OF ENERGY INTENSITY DATA OF TRANSPORTATION INDUSTRY IN HEBEI PROVINCE

year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Raw data	0.646	0.549	0.519	0.526	0.499	0.488	0.445	0.485	0.535	0.545
Forecast data	0.646	0.517	0.515	0.513	0.511	0.510	0.508	0.506	0.504	0.502
Absolute residual	0	0.032	0.004	0.013	0.012	0.022	0.063	0.021	0.031	0.043
Relative residual	0	0.059	0.008	0.024	0.025	0.044	0.141	0.043	0.058	0.078

The same reason, the function of energy intensity of the first industry in Hebei Province as a function of time is:

$$\varepsilon(t) = -4.14 * e^{-0.069(t-1)} + 4.441$$

The functional relationship between the energy intensity of the secondary industry in Hebei Province over time is:

$$\varepsilon(t) = -40.554 * e^{-0.052(t-1)} + 42.654$$

The function of energy intensity of the tertiary industry in Hebei Province as a function of time is:

$$\varepsilon(t) = -7.373 * e^{-0.042(t-1)} + 7.699$$

By calculating the accuracy of the model, it is found that the average relative error is controlled within 5%, and the accuracy of the model is above 95%, indicating that the accuracy of the model is relatively high.

Bring t=11,12,13,14,15 into the energy intensity prediction model of various industries in Hebei Province, and obtain the predicted values of energy intensity of various industries in Hebei Province in the next five years as shown in Table IV:

TABLE IV ENERGY INTENSITY FORECAST FOR VARIOUS INDUSTRIES IN HEBEI PROVINCE IN THE NEXT FIVE YEARS

Time	**primary industry**	**Secondary industry**	**Tertiary Industry**	**Transportation industry**	**Overall industry**
2018	0.148	1.287	0.208	0.501	0.788
2019	0.138	1.222	0.199	0.499	0.739
2020	0.129	1.160	0.191	0.497	0.694

Table IV, cont					
2021	0.121	1.101	0.183	0.495	0.652
2022	0.112	1.045	0.176	0.493	0.612
Rate of decline	0.0072	0.0484	0.0064	0.0016	0.0352

The results of energy intensity forecast for various industries in Hebei Province in the next five years show that maintaining the current state of development, the energy intensity of various industries in Hebei Province will decline year by year in the next five years. The decline in energy intensity indicates that the same energy consumption in various industries can produce more GDP, but the rate of decline in energy intensity is very small, with the rate of decline in energy intensity in the transportation industry being the smallest. Therefore, Hebei Province should vigorously develop other energy conservation and emission reduction policies and reduce energy consumption in the transportation industry on the premise of maintaining current economic policies.

IV. Conclusion and Suggestion

This paper analyzes the relationship between energy consumption and industrial structure of transportation industry in Hebei Province, and forecasts the energy intensity of various industries in Hebei Province in the next five years. According to the statistics of the International Energy Agency (IEA), China's transportation industry has relatively high energy consumption. It has ranked second in energy consumption in various industries for many years, accounting for 10%-20% of total energy consumption[6]. The growth of transportation energy consumption will also lead to The increase in CO2 emissions from transportation, so Hebei Province needs to vigorously implement energy conservation and emission reduction in the transportation industry in the future economic development and competition. The following recommendations are made for this article:

(1) Strengthen the adjustment of industrial structure and promote the development of the tertiary industry in Hebei Province. Through the calculation of the gray correlation degree in the previous article, the energy consumption of the transportation industry in Hebei Province has the greatest correlation with the proportion of the tertiary industry. Therefore, during the “13th Five-Year Plan” period, Hebei Province should vigorously optimize the industrial structure and promote the tertiary industry and high-tech. The development of the technology industry.

(2) Promote the use of public transportation and new energy vehicles, and reduce the travel rate of private cars. It is possible to gradually implement the carbon emission tax for private cars,

increase the parking standards for parking in Hebei Province, and increase fuel taxes to reduce the number of private cars. At the same time, implement limit measures to reduce the travel rate of private cars; Provide convenient transfer service and preferential fare policy to encourage passengers to travel by public transportation.

(3) Formulate and implement energy use standards for the transportation industry, match carbon emission standards and energy consumption limit standards with models with different energy consumption standards, and implement different vehicle and vessel tax, fuel consumption tax, vehicle purchase tax and other charging standards to promote The application of energy-saving cars.

References

[1] Chai Jian, Xing Limin, Lu Quanying, Hu Yi, Wang Shouyang. Extraction and Prediction of Core Influencing Factors of Traffic Energy Consumption in China[J]. Management Review, 2018,30(03):201-214.

[2] Zhou Qingyuan, Chen Hailong. Analysis of the Interaction between Energy Consumption and Industrial Structure in China[J].Statistics & Decision,2018,34(20):99-102.

[3] Guo Weixiang, Sun Hui. Grey Correlation Analysis of Carbon Sequestration and Industrial Structure Carbon Locking in Five Provinces of Northwest China[J]. Industrial Technology & Economy, 2018, 37(07): 119-127.

[4] Chen Xiangyang, Li Junjun. Research on the Relationship between Energy Consumption, Carbon Emission and Economic Growth——Theoretical Mechanism and Empirical Test[J].Journal of Nanjing University of Finance and Economics,2018(05):98-108.

[5] Feng Yan, Zhu Lingyun, Zhang Dahong. Spatial Econometric Research on the Influence of Industrial Structure Adjustment on Carbon Intensity in China[J].Soft Science, 2017, 31(07): 11-15.

[6] Zhu Yuanyuan. Analysis of the Measurement of Traffic Carbon Footprint and Its Driving Factors in Wuhan[J].China Population, Resources and Environment,2015,25(S1):470-474.