Research on the Effect of Energy Consumption Structure on Carbon Emission Based on LMDI Model

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Abstract: The long-term and extensive economic development mode has a great impact on the environment of Sichuan Province, and the sustainable development of the economy is limited.A prominent problem in the economic development of Sichuan Province is that coal consumption is still high, and energy conservation and emission reduction work faces severe challenges. Adjusting the energy structure plays an important role in reducing carbon emissions and developing a low-carbon economy.This paper mainly studies the carbon emission coefficient, the per capita carbon emissions of Sichuan Province and the influencing factors of carbon emissions, analyzes the current situation of carbon emissions in Sichuan Province, and calculates the per capita carbon emissions based on the resident population data of Sichuan Province, and then the per capita carbon emissions in Sichuan Province. The quantity is the research object, and the LMDI model is established to comprehensively analyze the effect of energy consumption structure on carbon emissions in Sichuan Province.

1. Introduction

At present, China's carbon emissions are still far from the expected value, and carbon emission reduction has a long way to go.In the latest research, Lao Chengyu and Yan Yangsite [1] used vecm model and impulse response model analysis to find that strengthening energy structure optimization is an important reality for optimizing energy resource allocation and promoting long-term and stable economic development in Sichuan. significance.Meng Fansheng and Zou Yun [2] used the pso algorithm with improved inertia weight to determine the evaluation index system of energy structure optimization degree, and used the spa-topsis method to construct an empirical analysis of the regional energy structure optimization degree, and found that the proportion of clean energy and raw coal consumption The proportion and soot emissions have a significant impact on the optimization of energy structure.

Tong Guangyi and Wang Mengzhen [3] believe that the adjustment of energy structure should focus on the development of clean energy, reduce the proportion of coal consumption, increase the proportion of renewable energy and nuclear power consumption, increase energy-saving emission reduction upgrades, and innovate new energy transportation networks to form a national Adapted energy structure.Lu Mingxiang, Xie Heming, Xu Wuming, Zhu Guangcai and Cao Dan [4] used data envelopment analysis to establish an energy structure efficiency model, studied the energy structure efficiency of Sichuan Province, proposed to reduce the proportion of coal, gas natural gas and thermal consumption, and improve coke and oil products. The proportion of power consumption can effectively improve the efficiency of energy structure in Sichuan Province. Jin Leqin [5] analyzes the impact of energy structure transformation on economic development by comparing the goals and achievements of energy structure transformation in the United States and Germany, and proposes that optimizing energy structure should be based on different resource endowments in different regions, and choose the appropriate energy structure optimization direction. Consider renewable energy and optimize the terminal energy consumption structure.

2. Analysis of Current Energy Emissions

In order to calculate the energy carbon emissions of Sichuan Province, it is necessary to use the carbon emission coefficient of various energy sources in Sichuan Province. This study quoted the carbon emission coefficient table published by ipcc and found that the carbon emission coefficient of Sichuan Province is not the same as the energy type and technical level. Coke has the highest carbon emission coefficient; in comparison, the overall carbon emission coefficient of coal is generally higher than that of oil, while Sichuan Province relies on coal-based energy products, which indirectly reflects its total energy consumption in the country. The reason is higher than the average ratio of other provinces.

By combining the carbon emission factors of different types of energy with the data on the consumption of various types of energy in Sichuan Province published by the China Energy Statistics Bureau, it is possible to calculate the carbon emissions corresponding to each type of primary energy for each year. We mainly calculate the carbon emissions of traditional energy sources such as coal, oil and natural gas. Its calculation formula is:

$$EC_i = \sum_i E_{ij} * C_{ij}, i = 1,2,3$$

Where i denotes the energy category and 1-3 denotes coal, oil and natural gas respectively; E_{ij}indicates the energy consumption of the i-th class j subclass; C_{ij} indicates the carbon emission factor of the corresponding energy source.

Through the above calculation formula, the total carbon emissions of each traditional energy source in Sichuan Province from 2000 to 2016 are listed in tabular form, with columns 1-3 representing coal, oil and natural gas.

Table. 1 Evolution trend of total carbon emissions in Sichuan Province

2000	4057.5694	218.6137	18.9162	2009	10141.48332	848.688	40.9437
2001	3932.0125	260.4613	20.3348	2010	9865.63256	916.0267	56.5068
2002	4591.4518	277.18071	22.5563	2011	9888.29535	1026.6639	50.3229
2003	6018.245	320.538	24.0781	2012	10310.28155	1091.8615	49.3298
2004	6885.2118	385.166	25.9997	2013	10332.7271	1216.2458	47.8144
2005	6654.7515	430.4147	28.8628	2014	9942.827701	1552.817	53.2536
2006	7308.0133	522.0476	34.202	2015	8606.05956	1716.6085	55.1269
2007	8121.5008	630.4534	36.1591	2016	8103.535291	1700.0478	58.5413
2008	9065.6797	728.3608	35.1241	2017			

Calculate the carbon emission coefficient based on the total consumption of coal, oil and natural gas in the seventeen years from 2000 to 2016.That is, through the obtained traditional energy carbon emission data, the carbon emission coefficients of coal, oil and natural gas are classified and calculated.Calculated as follows:

$$C_i = EC_i / E_i$$

The calculated carbon emission coefficient of coal fluctuates between 0.7637 and 0.7723, and there is an overall upward trend. Since 2003, it has basically increased year by year.This situation reflects minor changes in the structure of coal consumption.More coal types with lower emission factors are put into use, which reduces the overall carbon emission coefficient of coal-based energy. However, after the large-scale stimulus policy appeared in 2009, the proportion of low-quality coal used to rise again, so the carbon emissions of coal The coefficient has increased year by year.In addition, due to the country's stricter fuel use standards, the carbon emission coefficient of oil fluctuates around 0.5770, and the overall upward trend is not obvious; but in 2014-2016, whether it is coal or oil, the carbon emission factors of these two primary energy sources It has shown a high value in these three years and peaked in 2015.Relatively speaking, the carbon emission coefficient of natural gas is relatively stable. After retaining four significant figures, the value is stable at 0.4483.

Changes in the carbon emission coefficient can not only reflect the progress of energy processing technology, but also the impact of different primary energy consumption structures.According to the different carbon emission factors of traditional energy sources in each year, different carbon emission effects corresponding to different energy structures can be more effectively analyzed, thus providing a more powerful guidance basis for the introduction of relevant government policies.

3. LMDI Model Establishment

In order to analyze the factors affecting Sichuan's carbon emissions and to scientifically predict future development trends, we chose the lmdi model for research, hoping that the system will measure the degree of energy structure adjustment.This model has a prominent advantage in exploring the factors related to carbon intensity.

The lmdi model is called the logarithmic mean Deis decomposition method, and the basic formula for carbon emissions [6] is:

$$C = \sum_i C_i = \sum_i \frac{E_i}{E} \times \frac{C_i}{E_i} \times \frac{E}{Y} \times \frac{Y}{P} \times P$$

Where c is the carbon footprint, $C_i$the carbon emissions for the i-th energy; E is the primary energy consumption; $E_i$is for the energy consumption; y is Sichuan Province's gross domestic product (GDP); p is the resident population of Sichuan Province.Since this paper only studies the impact of energy structure on carbon emissions, the above deformation can be obtained:

$$\frac{EC}{P} = \sum \frac{EC_i}{P} = \sum \frac{EC_i}{E_i} \cdot \frac{E_i}{P}$$

Where ec is the total amount of carbon emissions for Sichuan Province, Pis for the resident population of Sichuan Province, EC/Prepresents the total carbon emissions per capita in Sichuan, i=1, 2, 3,EC_icorresponding to the total carbon emissions of coal, oil and natural gas in Sichuan Province, Ej corresponds to the total consumption of coal, oil and natural gas in Sichuan Province.

Sichuan's current economy is still in the middle of development. Economic development has an exponential growth in per capita carbon emissions, while energy structure has a “u” for per capita carbon emissions. [7] Since it is impossible to sacrifice economic development to reduce carbon emissions, it is necessary to explore energy. Structure reductions in per capita carbon emissions are possible.Therefore, this paper focuses on the lmdi model with per capita carbon emissions as the research object, and analyzes the factors affecting it.

$$\text{Make:} n = \frac{EC}{P},\ n_i = \frac{EC_i}{P}, C_i = \frac{EC_i}{E}, S_i = \frac{E_i}{P}$$

The above formula can be converted into:

$$n = \sum n_i = \sum C_i \cdot S_i$$

In the above formula, n represents the per capita carbon emissions of Sichuan Province.C_iFor coal, oil and gas emission factors,S_iPer capita consumption of coal, oil and natural gas.On this basis, the energy structure can be reflected by the total consumption of each energy source.Neglect discussions about the proportion of their various energy consumption structures and the results of energy consumption.

It can be seen from Table 2 that since 2000, the consumption ratio of coal, oil and natural gas has changed far less than the change of carbon emissions. Therefore, this paper establishes the LMDI model of carbon emissions.Since the carbon emission coefficient is closely related to energy utilization efficiency and industrial technology, and the technological revolution cannot be achieved in the short term, it can be considered that the carbon emission coefficient cannot affect in the short term, so the decisive factor for carbon emission is the energy structure.Referring to the LMDI model research paper published by Ang. BW et al. in 2003 [8], due to the existence of additive decomposition and multiplication decomposition$\triangle n_x/\ln\triangle D_x = \triangle n_y / \ln\triangle D_y$[9], and the additive decomposition effect is better in this paper, so the additive decomposition value is the main one, and the multiplication decomposition is mainly used as the supplementary analysis of the additive decomposition value. The change of the intensity between the t-th period and the t-1 period can be expressed separately. For:

$$\triangle n = n^t - n^{t-1} = \triangle n_{C_i} - \triangle n_{S_i}$$

$$D = n^t/n^{t-1} = D_{C_i} \cdot D_{C_i}$$

Among them$\triangle n_{C_i}$. $\triangle n_{S_i}$representing the contribution of carbon emission coefficient and per capita consumption to per capita carbon emissions,D_{C_i}.$D_{C_i}$are the contribution rate of carbon emission coefficient and per capita consumption to carbon emission intensity respectively is based on the research of Ang.BW et al.

$$\triangle n_{C_i} = \sum(n_i^t - n_i^{t-1}) / (\ln n_i^t - \ln n_i^{t-1}) \cdot \ln(C_i^t / C_i^{t-1})$$

$$\triangle n_{S_i} = \sum(n_i^t - n_i^{t-1}) / (\ln n_i^t - \ln n_i^{t-1}) \cdot \ln(S_i^t / S_i^{t-1})$$

$$\triangle D_{C_i} = \exp\{\sum(n_i^t - n_i^{t-1})/(\ln n_i^t - \ln n_i^{t-1}) \cdot \triangle n_{C_i}\}$$

$$\triangle D_{S_i} = \exp\{\sum(n_i^t - n_i^{t-1})/(\ln n_i^t - \ln n_i^{t-1}) \cdot \triangle n_{S_i}\}$$

4. Conclusion

This paper comprehensively analyzes the effects and trends of the energy consumption structure of Sichuan Province on carbon emissions through four aspects: per capita carbon emission and energy consumption per capita, factors affecting carbon emission coefficient, decomposition effect of carbon emission coefficient, and decomposition of energy structure effect. Studies have shown that the relationship between carbon emissions and energy structure in Sichuan is very close, among which coal has the most important impact on carbon emissions, while oil and natural gas are smaller.Although it is difficult to reduce carbon emissions based on the current economic development background, it can start to reduce carbon emissions per capita, that is, reduce carbon emission factors of various energy sources and change existing energy structures.

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