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The Research of Carbon Emission Intensity and Measurement in Shandong Province

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Abstract

To implement the goal of carbon peak and carbon neutralization, all provinces and cities in China should achieve the goal of carbon peak as scheduled, which maintain economic growth and ensure the realization of the goal of modernization in 2035. The realization path is the low-carbon green transformation, but the situation of provinces, cities and regions in China is different. Can we achieve carbon peak at the same time? Therefore, it is of great significance to study the difference of regional carbon emission intensity for realizing the carbon peak of provinces and cities in 2030. According to the provisions of the National Development and Reform Commission, the four cities of Jinan, Qingdao, Yantai and Weifang are approved low-carbon pilot cities. In order to study the contribution to the difference of carbon emission intensity of every factor between low-carbon cities and non-low carbon cities, the paper chose the panel data of 17 prefecture-level cities in Shandong Province from 2007 to 2016 by the Oaxaca-Blinder decomposition method to investigate the difference of carbon emission intensity between them. We have concluded that they are important influence factors on carbon emission intensity in per capita GDP, industrial structure, urbanization level and energy consumption intensity. The improvement of urbanization rate and energy consumption intensity makes the carbon emission intensity increase; the decrease of the proportion of secondary industry in low-carbon cities is beneficial to the reduction of carbon emission intensity, but it is opposite to the carbon emission in non-low carbon cities. By the O-B decomposition method, we can conclude that the energy consumption intensity has the greatest impact on the difference of carbon emission intensity between low-carbon cities and non-low carbon cities, and the urbanization rate has greater impact on the difference between them. The level of economic development and industrial structure will also have impact on the difference. The textual innovation lies in using the carbon productivity of low-carbon cities as the dependent variable, that is, the carbon emission intensity per unit GDP. At the same time, we select factors from the economic, energy and social indicators in the low-carbon city rating index system to reveal the contribution of different factors to the carbon emission intensity difference between low-carbon cities and non-low carbon cities. It is useful to develop non-low-carbon cities, decrease the gap between them, and speed up the transformation from low carbon cities to non-low carbon cities.

Keywords

Low Carbon City, Non-Low Carbon City, Carbon Emission, Differences

1. Introduction

In order to actively respond to climate change, as early as August 2010, the National Development and Reform Commission officially launched the national low-carbon economy. In 2003, the British government first mentioned the term "low-carbon economy" in the Energy White Paper. With the development of industry, the pilot work of provinces, regions and low-carbon cities decided to first carry out low-carbon pilot work in eight cities, including Tianjin, Chongqing and Xiamen, The pilot areas should accelerate the formation of industrial structure and economic growth forms characterized by low carbon emissions. In order to promote the construction of ecological civilization, the development of low-carbon economy and the response to global climate change, the number of low-carbon pilot cities will increase to 81 by 2016. Among them, four cities in Shandong Province were listed as low-carbon pilot cities, including Jinan, Qingdao, Yantai, and Weifang. Nordhaus (2011) pointed out that policies and measures to reduce greenhouse gas emissions must work through the economic system, and climate change will also affect the production process and final output in the economic system (He, 2014). The development of low-carbon cities requires taking economic development as the basis, reducing energy consumption, carbon emissions and carbon emission intensity as the core, and finally achieving the decoupling of economic growth and energy consumption and inclusive growth of green and sustainable economic development. Hu Xiulian (2019) pointed out that the scenario of deep emission reduction at the urban level is a comparative scenario. Different cities have different levels of development, and their deep emission reduction scenarios may differ in location and perspective (Li et al., 2012). It is necessary to analyze the internal, external and potential constraints affecting the medium and long-term greenhouse gas emissions of cities, such as the optimization of urban industrial structure, energy transformation, and the total amount and intensity of cities related to the country. Considering that there are many low carbon pilot cities and non-low carbon pilot cities in China, in order to better study the difference of carbon emission intensity sources between low carbon pilot cities and non-low carbon pilot cities, Shandong Province is selected as an example. Studying the contribution of different influence factors between low carbon pilot cities and non-low carbon pilot cities to the difference in carbon emission intensity is conducive to exploring the idea of deep urban emission reduction in the medium and long term. The realization of the 1.5˚C-2.0˚C temperature control goal requires policy support. Only by in-depth study of the influencing factors and interrelationships of these problems can we analyze the correlation between them and deep urban emission reduction, Further provide certain and reliable support for the analysis of deep emission reduction.

2. Ease of Use

Foreign scholars have made in-depth research on the influencing factors and contribution rate of carbon emissions, the most representative of which are the IPAT equation for measuring environmental pressure proposed by Ehrlich et al. and the Kaya equation for driving factors of carbon emissions proposed by Kaya Y (Li et al., 2015). Ehrlich et al. (1970) believed that the impact factors of environmental pressure include population size, technological progress and economic development level; Kaya (1990) believes that the influencing factors of carbon emissions include per capita GDP, energy intensity, carbon intensity, and population size, which can be used to derive the carbon dioxide emissions of a certain region (Li et al., 2015). Dietz et al. Improved the IPAT model on the basis of Kaya model and established a random IPAT model-STIRPAT model. Based on the STIRPAT model, Kaya identity and the logarithmic average weight Division decomposition method, Chinese scholars analyze the factors affecting carbon emissions from the macro and micro levels and propose solutions to reduce carbon emissions. Wang Zhongying et al. (2006) analyzed the relationship between China's GDP growth and carbon emissions by using data comparison and chart methods. The results show that there is a correlation between GDP and carbon emissions (Li et al, 2016). Lin Boqiang et al., (2009, 2010) by decomposing the Kaya identity, concluded that the most obvious factors affecting China's carbon emissions are economic growth, income and energy intensity (Lin & Ouyang, 2014); the Kaya identity modified with urbanization factors is used to study the influence factors on China's carbon emissions at this stage. The results show that if China wants to reduce carbon emissions on the basis of ensuring economic development, it needs to start with urbanization reform and improving the energy structure. Song Jiekun (2012) also used the same method to analyze the situation in Shandong Province (Liu et al., 2011). The results showed that the per capita GDP and population's pulling effect on carbon emissions decreased in turn, and the energy consumption intensity had a restraining effect on carbon emissions. Qi Shaozhou (2015) and others used inter-provincial panel data and lag instrumental variables to study the impact of industrial structure, urbanization level, foreign trade and technological progress on carbon emissions and carbon intensity in economic growth from different economic growth modes. Zhao Tao et al. (Liu et al., 2017) established a low-carbon city conceptual model from four aspects: energy structure and consumption, economic development capacity, environmental carrying capacity and social development capacity, and used structural equation model to explore the impact of per capita GDP, the proportion of tertiary industry in GDP, urbanization rate, urban forest coverage, industrial energy consumption and other indicators on the development of low-carbon cities (Zhang et al., 2018). Zhuang Guiyang (2018) pointed out the characteristics of low carbon cities from a static perspective, namely, high carbon productivity, low carbon consumption level, and cleaner energy structure. Chen Bangli and Xu Meiping (2018) explored the impact of different factors on China's carbon emissions from the dimensions of population, wealth, technology, openness, financial development and innovation capacity based on the areal data model (Zhang et al., 2019).

Since China identified the first batch of low-carbon pilot cities in 2010, relevant research on the low-carbon pilot work has also become a hot spot in the academic community. According to the relevant literature, the low-carbon pilot provinces and cities have been investigated and evaluated mainly from the aspects of carbon emission level and intensity. Such research often starts from the low-carbon pilot cities themselves, and carries out policy evaluation based on the changes in their carbon emissions performance before and after the pilot, which belongs to the category of "single difference analysis". However, there is a lack of research on the impact factors of carbon emissions in pilot and non pilot areas, which makes it impossible to scientifically evaluate the effects of low-carbon pilot policies. Only by further exploring the specific measures behind it and achieving the reduction of carbon emission intensity in the low-carbon pilot areas can we better play the leading role of demonstration and provide experience for other regions. Therefore, this paper selects 17 prefecture-level cities in Shandong Province as the research object, selects indicators from the aspects of economic development capacity, energy consumption level and social carrying capacity, and analyzes the differences of carbon emission intensity from the perspective of low carbon pilot cities and non-low carbon pilot cities. The research idea is to use panel data to conduct empirical analysis on low carbon pilot cities and non-low carbon pilot cities respectively, reveal the differences in the impact of economic development, energy consumption, urbanization level, and industrial structure on carbon emission intensity, and then use Oaxaca-Blinder decomposition technology to analyze the contribution rate of different factors to the difference between low carbon pilot cities and non-low carbon pilot cities from two aspects of characteristic effect and coefficient effect, Finally, according to the development of different cities of the same kind, suggestions are put forward for the development of China's low-carbon pilot cities and the reduction of carbon emission intensity.

3. Method and Data

3.1. Method

Oaxaca (1973) and Blinder (1973) proposed Oaxaca-Blinder decomposition technology can decompose the impact of sample feature differences and coefficient differences on the average level of the explained variable, and calculate the contribution rate of each factor to the total difference; Ouyang Jinqiong et al. (2015) used Oaxaca-Blinder decomposition technology to study the provincial differences in economic growth of 31 provinces and cities in China from 1993 to 2012, and studied the differences of different factors on the economic growth rate of regions with rapid and slow economic growth from human capital, material capital, industrial structure and technological progress.

The regression model of carbon emission intensity between low carbon pilot cities and non-low carbon pilot cities can be expressed as follows:

$$TE_{it} = \beta_0 + \beta_1 LnY_{it} + \beta_2 Si_{it} + \beta_3 UR_{it} + \beta_4 E_{it} + \varepsilon_i \quad (1)$$

Using the above model for OLS regression, the regression coefficient of low-carbon pilot cities is obtained as $\hat{\beta}^E = (\beta_0^E, \beta_1^E, \beta_2^E, \beta_3^E, \beta_4^E)^T$, Regression coefficient of non-low-carbon pilot cities $\hat{\beta}^0 = (\beta_0^0, \beta_1^0, \beta_2^0, \beta_3^0, \beta_4^0)^T$. OLS regression meets = 0, meeting the requirements of Oaxaca-Blinder decomposition method.

3.2. Data

1) The data used in this paper include the panel data of four low-carbon pilot cities in Jinan, Qingdao, Yantai and Weifang and 13 other non-low-carbon pilot cities from 2007 to 2016. The selected 10 years cover the "11th Five-Year Plan" and "12th Five-Year Plan". The data comes from the Shandong Statistical Yearbook, the China Energy Statistical Yearbook and the statistical yearbooks of the corresponding years of cities at all levels. The selection of Shandong Province as an example is based on the following three aspects: a) relevant data of Shandong Province are available; b) There are more low-carbon cities in Shandong compared to other provinces, which is convenient for comparison within the province; c) Cities in the same province have effectively reduced differences due to environmental, economic, policy and other factors, making them more comparable; The policy, economic and environmental factors of urban development in the same province are consistent, which is more conducive to the comparison between low carbon pilot cities and non-low carbon pilot cities.

2) Current status of carbon emissions in Shandong Province

The carbon emissions of cities in Shandong Province from 2007 to 2016 are shown in **Figure 1**. It can be seen that the carbon emission intensity of low carbon pilot cities is significantly lower than that of non-low carbon pilot cities, and the carbon emission intensity of Laiwu, Rizhao, Zibo, Liaocheng and other non-low carbon pilot cities is much higher than that of low carbon pilot cities. The carbon emission intensity of all cities in Shandong Province has decreased year by year, which meets the requirements of "low carbon emissions" and "high carbon productivity" to achieve sustainable and inclusive economic growth and continuous improvement of residents' low-carbon living standards. In terms of carbon emissions, the carbon emissions of each city in the low carbon pilot cities are more than those of the non-low carbon pilot cities, which is related to the high level of economic development of the low carbon pilot cities. Jinan, Qingdao,

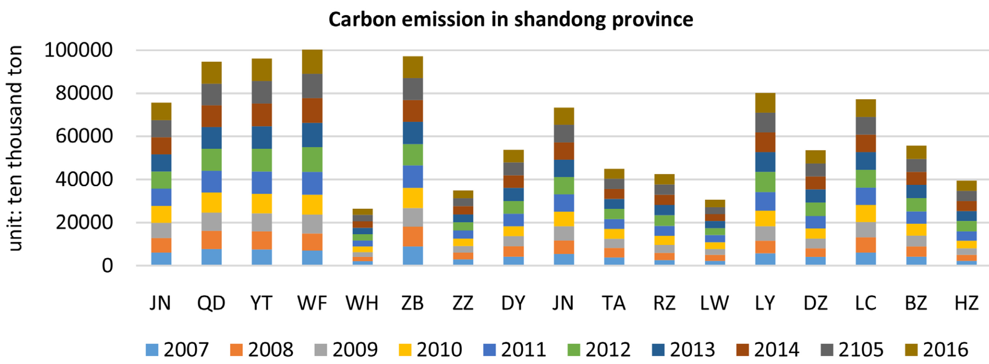

Figure 1. Carbon emission in Shandong province.

Yantai and Weifang have achieved "high carbon productivity" with economic growth.

4. Empirical Research

According to the idea of Oaxaca-Blinder decomposition technology, the selected samples need to be divided into two groups: low carbon pilot cities and non low carbon pilot cities. The differences of the selected sample data can be seen from **Table 1**. 1) There are significant differences between the per capita GDP, energy consumption per unit GDP, urbanization level and other indicators of low carbon pilot cities and non-low carbon pilot cities. The per capita GDP and urbanization rate of low carbon pilot cities are significantly higher than those of non-low carbon pilot cities, and the difference between indicators of similar cities is small. The number of low carbon pilot cities in line with Zhang Shihui's (2021) low carbon potential province is the largest, The emission coverage rate is also high 2) For the explained variable, the carbon emission intensity of low carbon pilot cities is significantly lower than that of non-low carbon pilot cities, and the carbon emission intensity of the latter is 1.63 times that of the former, with a significant difference. From 2007 to 2016, the carbon emission intensity of 10,000 yuan of GDP in low carbon pilot cities was reduced from 2.34 (t standard coal/10,000 yuan) to 1.32 (t standard coal/10,000 yuan), and the carbon emission intensity of non-low carbon pilot cities was also significantly reduced. In 2016, the energy consumption of 10,000 yuan standard coal in non-low carbon pilot cities was 2.32 t, which was 1.8 times lower than that in 2007, in line with the promotion of the development of low carbon pilot cities mentioned by Zhou Suogo, Zhuang Guiyang, etc. (2018) Requirements for improving carbon productivity of urban system. The characteristics of carbon emission intensity and influencing factors conform to the application form of O-B decomposition method.

4.1. Unit Root Test and Cointegration Test of Panel Data

In order to avoid false regression, unit root test and cointegration test are needed for panel data. Levin, Lin, Chu test, Breitung test, Fisher-ADF test and Fisher-PP

Table 1. Descriptive statistical analysis of variables in Shandong province.

Variable (symbol)	Mean	Standard deviation of low-carbon pilot cities	Mean	Standard deviation of non low-carbon pilot cities
Per GDP (*Y*)	6.74	2.24	4.83	3.10
Pet GDP intensity (*E*)	0.8	0.18	1.33	0.69
Proportion of tertiary industry (*SI*)	42.75%	8.23	44.96%	12.88
city rate (*UR*)	60.16%	6.24	49.62%	8.77
Intensity (CO_2)	1.85	0.64	3.02	1.12

Note: Data source: Shandong statistical yearbook and China energy statistical yearbook.

test are selected in this paper. Levin, Lin, Chu test and Breitung test belong to homogeneity test; Fisher-ADF test and Fisher-PP test belong to heterogeneity test. From the unit root test results in **Table 2**, it can be seen that the results of other tests are significant except for the high concomitant probability of individual test results. Overall, we can see that the level of low carbon pilot cities and non-low carbon pilot cities is stable. Co-integration test can be used to verify whether there is a long-term stable relationship between the variables. This paper selects Kao test, Pedroni test and Fisher test to verify the cointegration of panel data.

Co-integration test can be carried out for the same order single integration of variables to verify whether there is a long-term stable relationship between variables. This paper selects Kao test, Pedroni test and Fisher test to verify the cointegration of panel data. **Table 3** shows that the Panel-PP, Panel-ADF, Group-PP, and Group-ADF statistics of low carbon pilot cities and non low carbon pilot cities reject the original hypothesis, and there is a long-term cointegration relationship between various factors. Other statistics accept the original hypothesis. Overall, there is a long-term cointegration relationship between the panel data of low carbon pilot cities and non low carbon pilot cities, which can be used for panel data estimation.

4.2. Analysis of Factors

According to the statistical results, the coefficient of energy consumption intensity of low carbon pilot cities is far greater than that of non-low carbon pilot cities. The energy consumption per unit of GDP of low carbon pilot cities is reduced by one unit, and the carbon emission intensity is reduced by 2.586 units, while the non-low carbon pilot cities are only reduced by 0.716 units. The energy intensity coefficient of all cities is close to that of non-low-carbon pilot cities, which is related to the proportion of non-low-carbon pilot cities in Shandong Province. The reduction of carbon emissions per unit of GDP has been listed by the Chinese government as the 2020 emission reduction action commitment and

Table 2. Regression results of individual fixed effect model.

Viable	All	Low carbon	Non low carbon
Constant	5.616*** (13.47)	160*** (1.88)	5.765 (12.21)
Per GDP	−0.071*** (−3.50)	−0.05*** (−2.04)	−0.155*** (−3.96)
Intensity	0.754*** (−8.67)	2.59*** (8.04)	0.717*** (5.24)
Industry structure	0.002*** (6.21)	0.05*** (4.47)	−0.015*** (−1.77)
City level	−0.067 (0.35)	−0.06*** (−4.61)	0.046*** (−3.86)

Note: The data in brackets in the table are t statistic values, indicating that 1% has passed the significance test.

Table 3. Unit root test results of panel data of low carbon pilot cities and non-low carbon pilot cities.

viable	LLC test	Breitung test	Fisher-ADF test	Fisher-PP test	conclusion
CO_2	(0.000)/(0.000)	(0.913)/(0.002)	(0.000)/(0.001)	(0.000)/(0.000)	stable
Y	(0.000)/(0.000)	(0.494)/(0.773)	(0.002)/(0.376)	(0.507)/(0.000)	stable
E	(0.046)/(0.000)	(0.251)/(0.141)	(0.058)/(0.013)	(0.000)/(0.000)	stable
SI	(0.004)(0.000)	(0.741)/(0.950)	(0.072)/(0.050)	(0.009)/(0.000)	stable
Ur	(0.000)/(0.000)	(1.000)/(1.000)	(0.000)/(0.067)	(0.072)/(0.548)	stable

Note: (low carbon pilot cities)/(non low carbon pilot cities). The data in the chart is the accompanying probability of the horizontal unit root test.

the "12th Five-Year Plan". China is in the middle stage of industrialization, and the secondary industry still dominates the GDP. The improvement of energy consumption intensity is of great significance to the reduction of carbon emissions in China and the realization of green and sustainable economic development. The urbanization level of low carbon pilot cities and non-low carbon pilot cities has a similar impact on carbon emission intensity. With the improvement of urbanization level, carbon emission intensity increases. The improvement of urbanization level leads to the population gathering from rural to urban areas, the increasing density of urban population, and the change of lifestyle leads to the increasing energy consumption; With the improvement of urbanization level, the land utilization rate has increased, and the green coverage rate and forest coverage area of urban areas have been reduced, resulting in the reduction of "carbon sink" and the increase of carbon dioxide emissions;

While the urbanization rate is increasing, industries such as industry and tertiary industry services are developing rapidly. The construction of urban buildings and public infrastructure will use a large number of raw materials, cement, etc., resulting in an increase in energy consumption and carbon dioxide emissions. This paper uses the proportion of the gross domestic product of the secondary industry to GDP to express the development level of industrial structure. The impact of industrial structure on the carbon emission intensity of low carbon pilot cities and non-low carbon pilot cities is quite different. The increase in the proportion of secondary industry will increase the carbon emission intensity of low carbon pilot cities and reduce the carbon emission intensity of non-low carbon pilot cities. Among the three major industries, the second industry has the greatest impact on the intensity of carbon emissions, and each industry has different needs for different energy. After 2012, the weight of the secondary industry in the low carbon pilot cities in Shandong Province has gradually decreased, with the average share falling from 55% in 2007 to 44% in 2016, a significant decline. The adjustment of industrial structure has an important impact on China's economic development and the change of energy consumption structure. While the secondary industry is declining, the carbon emission intensity of low carbon pilot cities is continuously decreasing, which is consistent with China's low carbon economic development. The proportion of the secondary industry in most of the non-low-carbon pilot cities has been decreasing, but the proportion is still more than 50%, which does not conform to the industrial structure model of the low-carbon pilot cities. The carbon emission intensity of non-low-carbon pilot cities increases with the decline of the secondary industrial structure.

5. Conclusion and Enlightenment

Using the empirical analysis of panel data from 17 prefecture-level cities in Shandong Province from 2007 to 2016 and the results obtained by Oaxaca-Blinder decomposition technology, we can draw the following conclusions and provide suggestions for the development of low-carbon pilot cities:

1) The difference in carbon emission intensity between low carbon pilot cities and non low carbon pilot cities is influenced by the level of economic development, energy consumption intensity, industrial structure, and urbanization rate. Since energy consumption per unit of GDP is the most important factor affecting the difference in carbon emission intensity between low carbon pilot cities and non low carbon pilot cities, in order to develop low carbon pilot cities and narrow the difference in carbon emission intensity between the two types of cities, it is necessary to reduce the energy consumption intensity of non low carbon pilot cities and improve energy utilization efficiency. In industry, the government should increase funding and investment in energy conservation and emission reduction technologies, especially for industries with high energy consumption and high energy consumption intensity. It should accelerate technological innovation, vigorously develop low energy consumption production tech-

nologies, improve carbon production capacity, and ultimately achieve the development of new industrialization. The report of the 19th National Congress of China clearly points out that by cultivating new drivers in the green and low-carbon fields, developing a green and low-carbon economic system, energy system, and lifestyle, we can deepen low-carbon development and promote high-quality economic development. The development of low-carbon pilot cities requires improving the carbon productivity and cultural development level of cities, which is conducive to high-quality development of Chinese cities and the realization of the construction of a beautiful China.

2) From the O-B decomposition, it can be seen that urbanization rate is also a major factor affecting the difference in carbon emissions between low carbon pilot cities and non low carbon pilot cities. In order to promote the transformation of non low carbon pilot cities, it is necessary to promote the improvement of urbanization rate. The level of urbanization is in the middle stage, with population concentration and the expansion of the size and number of cities, the intensity of carbon emissions increases; Low carbon pilot cities are in the mature stage of urbanization. Due to the utilization of new energy and the improvement of technological level, as the urbanization rate increases, the pressure on carbon emissions will decrease, and the intensity of carbon emissions will decrease. While improving the level of urbanization, non low-carbon pilot cities should promote the use of new energy and accelerate technological progress and innovation.

The Paris Agreement first proposed efforts to achieve the 1.5˚C temperature control goal, and further explored the feasibility of achieving the 1.5˚C goal. Developing a low-carbon pilot city means developing a low-carbon city. This article studies the differences between factors that affect the carbon emission intensity of low-carbon pilot cities and non low-carbon pilot cities, which is no different from exploring the driving factors for the medium and long-term development of cities, including economic development level, industrial structure, sustainable development, and multi-objective coordinated development.

6. Under Research

As the data selected in this article are sourced from 17 prefecture-level cities in Shandong Province, the number and influencing factors of the selected low-carbon pilot cities are relatively small, and the rating indicators of most low-carbon pilot cities cannot be covered. The rating indicator system for low-carbon pilot cities is temporarily not unified, there is no unified standard, and there is no way to accurately select the influencing factors in the indicator system. In addition, Laiwu was classified into Jinan in 2019, which also had a certain impact on the analysis results. This article only studies the differences in carbon emission intensity between low carbon pilot cities and non low carbon pilot cities from three aspects: economic development capacity, energy consumption level, and social development capacity, without covering the impact factors on environmental carrying capacity; Secondly, the Oaxaca-blinder decomposition method is applied using low carbon pilot cities as a benchmark, and there may be significant errors in studying the differential contribution of various impact factors to low carbon pilot cities and non low carbon pilot cities.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

He, J. K. (2014). An analysis of China's CO_2 Emission Peaking Target and Pathways. *Advances in Climate Change Research, 5,* 155-161. https://doi.org/10.1016/j.accre.2015.04.002

Li, H. N., Mu, H. L., Zhang, M., et al, (2012). Analysis of Regional Difference on Impact Factors of China's Energy-Related CO_2 Emissions. *Energy, 39,* 319-326. https://doi.org/10.1016/j.energy.2012.01.008

Li, B.-B., Liang, Q.-M., & Wang, J.-C. (2015). A Comparative Study on Prediction Methods for China's Medium- and Long-Term Coal Demand. *Energy, 93,* 1671-1683. https://doi.org/10.1016/j.energy.2015.10.039

Li, B., Liu, X. J., & Li, Z. H. (2015). Using the STIRPAT Model to Explore the Factors Driving Regional CO_2 Emissions: A Case of Tianjin, China. *Natural Hazards, 76,* 1667-1685. https://doi.org/10.1007/s11069-014-1574-9

Li, L., Lei, Y. L., He, C. Y., et al, (2016). Prediction on the Peak of the CO_2 Emissions in China Using the STIRPAT Model. *Advances in Meteorology, 2016,* Article ID 5213623. https://doi.org/10.1155/2016/5213623

Lin, Q., & Ouyang, X, L. (2014). Analysis of Energy-Related CO_2 (Carbon Dioxide) Emissions and Reduction Potential in the Chinese Non-Metallic Mineral Products Industry. *Energy, 68,* 688-697. https://doi.org/10.1016/j.energy.2014.01.069

Liu, J., Feng, T.-T., & Yang, X. (2011). The Energy Requirements and Carbon Dioxide Emissions of Tourism Industry of Western China: A Case of Chengdu City. *Renewable and Sustainable Energy Reviews, 15,* 2887-2894.

Liu, Q., Gu, A. L., Teng, F., et al. (2017). Peaking China's CO_2 Emissions: Trends to 2030 and Mitigation Potential. *Energies, 10,* 209. https://doi.org/10.3390/en10020209

Zhang, Y., Liu, C., Li, K., Zhou, Y. (2018). Strategy on China's Regional Coal Consumption Control: A Case Study of Shandong Province. *Energy Policy, 112,* 316-327. https://doi.org/10.1016/j.enpol.2017.10.035

Zhang, Y., Liu, C., Chen, L., Wang, X., Song, X., Li, K. (2019). Energy-Related CO_2 Emission Peaking Target and Pathways for China's City: A Case Study of Baoding City. *Journal of Cleaner Production, 226,* 471-481. https://doi.org/10.1016/j.jclepro.2019.04.051