

Calculation and Influencing Factors of Carbon Emissions in Countries along the Belt and Road Based on the LMDI Method

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Abstract. In order to study the carbon emissions of countries along the Belt and Road and its influencing factors, this paper calculates the energy carbon emissions of six major regions from 2013 to 2020 from the national level based on the LMDI index decomposition method and divides the driving factors into population, economy, industrial structure, energy intensity and carbon emission intensity, analyzing the contribution rate of each factor and regional differences. The results show that the carbon emissions of countries along the Belt and Road have shown an overall upward trend at present. The main influencing factors are economy and industrial structure, as well as reducing energy consumption intensity has also contributed more to the suppression of carbon emissions. Population and carbon emission intensity vary slightly by region. Therefore, governments should guide reasonable population growth, formulate reasonable carbon emission reduction policies according to local conditions, optimize the energy structure and accelerate the establishment of carbon markets.

Keywords: Carbon emissions; LMDI; The Belt and Road Initiative.

1. Introduction

In September 2013, Chinese President Xi Jinping proposed the initiatives of the "New Silk Road Economic Belt" and the "21st Century Maritime Silk Road" (referred to as the Belt and Road) in order to promote economic growth and regional cooperation of various countries in the world. Along the Belt and Road, developing countries account for a large proportion, who have huge trade demands to develop their economies. With the rapid development of the traditional economy, the numerous consumptions of fossil energy have led to a significant increase in greenhouse gas emissions, resulting in climate change that will obviously restrict the green development of all countries.

According to the statistics, from 1992 to 2016, the total carbon emissions of countries along the Belt and Road increased by 53.9% in these 25 years^[1]. In order to strive to turn the traditional economic model of countries along the Belt and Road into a green development economic model, Xi Jinping launched the Belt and Road Green Development International Alliance in his speech at the opening ceremony of the Belt and Road Forum for International Cooperation in May 2017. Cooperation and communications in green transformation, green finance, environmental laws, etc. have happened to help a greener Belt and Road. In September 2020, Xi Jinping proposed the "Dual Carbon Goals" at the 75th United Nations General Assembly, which further demonstrated China's firm determination to build a green and low-carbon world and its great responsibility to construct a community with a shared future for mankind.

Although the current increasing carbon emissions is a common problem facing the world, due to the regional development and uneven industrial structure of various countries, the core reasons for the high carbon emissions are also different. In order to specifically analyze the causes of carbon emissions, this paper uses the LMDI decomposition method to decompose and measure the carbon emissions of representative countries along the Belt and Road, analyzing the factors affecting carbon emissions from different perspectives and providing more detailed carbon emission data for different countries. And then help different regions implement carbon reduction to provide practical and targeted reference opinions, build an ecologically harmonious community and seek a green-sustainable development path.

2. Literature Review

At present, most of the research on carbon emissions focuses on the accounting of carbon emissions, exploring the relationship between carbon emissions and economic development, studying the driving factors of carbon emissions, and analyzing low-carbon emission reduction policies.

Japanese scholar Yoichi Kaya first proposed the Kaya Identity at the IPCC in 1989. This formula uses quantitative calculation methods to study the influencing factors of carbon dioxide emissions from a macro perspective and has been continuously improved by subsequent researchers. Nowadays, the decomposition methods of carbon emission driving factors mainly include Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA). The SDA is mainly based on the input-output table, while the IDA is based on energy data for comparison in time series. With the development of the discipline, the IDA method has gradually improved to produce the LMDI decomposition method, which can effectively solve the problem of zero and negative data and does not include unexplained residual items in the decomposition results. Therefore, it is widely used in the study of carbon emissions^[2].

In the existing literature on carbon emissions, most scholars state that the main affecting factors include economic growth, energy consumption intensity, carbon emission intensity, industrial structure and technological level. Wang Fengting et al. studied carbon emissions in the Beijing-Tianjin-Hebei region through the LMDI model and found that carbon emission intensity and energy consumption intensity are the main factors to inhibit carbon emissions and this inhibitory effect is increasing year by year; economic intensity factors have an enhancing effect on carbon emissions; industrial structure and energy structure have less impact on carbon emissions in the Beijing-Tianjin-Hebei region^[3]. Wang Jie et al. used the IPTA equation and the LMDI model to analyze the driving factors affecting the carbon emissions of the BRICS countries and found that economic intensity and demographic factor are the main factors to enhance carbon emissions, while energy intensity has an inhibitory effect on carbon emissions; the BRICS countries have differences in the effect of driving factors on carbon emissions^[4]. Victor Moutinho et al. started from the perspective of carbon emissions from renewable energy and used the LMDI decomposition method to analyze the influencing factors of carbon emissions in the top 23 countries ranked by using renewable energy in the world from 1985 to 2011. A major factor which countries' carbon emissions is the financial generation effect of electricity, while renewable energy production contributes to the reduction of carbon emissions^[5]. PF Gonzalez et al. also used the LMDI decomposition method to track the carbon emissions of the energy sector in EU countries. The results show that although the specific conditions of EU countries are different, the overall change in the energy mix factor is the main reason for affecting carbon emissions^[6].

Although the problem of carbon emissions is becoming more and more serious, scholars focus more on post-developed or developing countries. Since the Belt and Road Initiative was proposed, great changes have taken place in the economic development and industrial structure of the countries along the road. The backward transportation infrastructure initially restricted the economic and trade development of various countries, resulting in a series of problems such as long transportation time, low efficiency and high cost. Later, the road connection represented by the China-Europe Railway Express gradually changed the fate of the countries along the road^[7]. It not only provides infrastructure progress, but also provides opportunities for complementary industrial structures. The different production factor endowments and different economic development cycles of countries provide the basis for a more rational allocation of resources^[8]. Although the countries along the Belt and Road have developed rapidly, it is undeniable that these developments have also caused huge carbon emission problems. Xi Jinping emphasized that improving the green development of the Belt and Road Initiative in the context of Dual Carbon Goals, achieving high-quality development at the lowest cost and promoting the successful transformation to a low-carbon economic model are major goals in line with the new economic development concept.

In view of this, our paper uses the LMDI decomposition method to estimate the driving factors of carbon emissions in countries along the Belt and Road from 2013 to 2020, in order to identify the

main driving factors affecting carbon emissions, so as to provide references for countries along the Belt and Road to achieve low-carbon economy and green development.

3. Research methods

(1) Research data

This paper selects the countries along the Belt and Road in 2013 and 2020 as the research objects because 2013 is the starting year of the Belt and Road, which has comparative significance. The energy consumption data included in the calculation of carbon emissions comes from the World Energy Statistical Yearbook^[9] and carbon emission factors based on IPCC^[10], the United States Department of Energy^[11] and other institutions for reference. The population, GDP and other data are from the World Bank^[12].

(2) Calculation of carbon emissions and LMDI decomposition

Developing a green and low-carbon economy and reducing greenhouse gas emissions have become the primary goals of all countries. At present, there are three main ways to measure carbon emissions: the actual measurement method, the input-output method and the emission factor method. This paper uses the emission factor method to measure the carbon emissions generated by various energy types in different regions along the Belt and Road in 2013 and 2020.

Energy mainly refers to fossil energy. Fossil energy is divided into three types in this paper: coal, oil and natural gas. The carbon emission coefficient of each energy is shown below and this paper takes the average value of multiple agencies such as the U.S. Energy Agency for subsequent calculations.

Table 1. Carbon Emission Coefficient of Each Energy from Different Mechanism

Mechanism	Coal	Oil	Natural Gas
U.S. Department of Energy	0.702	0.478	0.389
Japan Energy Research Institute	0.756	0.586	0.449
China National Development and Reform Commission Energy Research Institute	0.747	0.582	0.443
Average Value	0.735	0.549	0.427

(Unit: ton CO_2 / ton)

The formula in the carbon emission factor method is as follows:

$$TCE = \sum_i E_{ij} \times B_j$$

Among them, E_{ij} represents the consumption of j energy in area i , B_j represents the carbon emission coefficient of j energy, and TCE represents the total carbon emission.

The Kaya Identity analyzes the four driving factors of carbon emissions from a macro perspective: population, per capita GNP, energy consumption per unit of production value and emission factors per unit of energy consumption, using quantitative calculation methods to study the influencing factors of carbon dioxide emissions. Its expression is as follows:

$$TCE = POP \times \frac{GDP}{POP} \times \frac{E}{GDP} \times \frac{CO_2}{E}$$

With the optimization and development of carbon emission methods, the decomposition model has become increasingly mature. The most representative of them is the Log Mean Divisa Index (LMDI) decomposition method proposed by Ang. B. W et al., which is the Logarithmic Average Divisa Index decomposition method. Its basic definition is as follows^[13]:

$$L(a, b) = (a - b) / (\ln a - \ln b)$$

The weights for factorization are expressed as follows:

$$\Delta V_a = L(V^t, V^0) \ln\left(\frac{a^t}{a^0}\right)$$

$$\Delta V_b = L(V^t, V^0) \ln\left(\frac{b^t}{b^0}\right)$$

Among them, V represents the sum of n departments in a certain area, which is $V = \sum_{i=1}^n V_t$, a, b represent the influencing factors; V^t, a^t, b^t represent during t period the values of V, a, b ; $\Delta V_a, \Delta V_b$ represent the weights of the influencing factors a, b to the change of V .

Based on the Kaya Identity and the LMDI decomposition method, this paper introduces the industrial structure $\frac{GDP_i}{GDP}$ in the region into the Kaya Identity and obtains the extended Kaya equation:

$$TCE = \sum CO_{2i} = POP \times \frac{GDP}{POP} \times \frac{GDP_i}{GDP} \times \frac{E_i}{GDP_i} \times \frac{CO_{2i}}{E_i}$$

Among them, i represents a certain region, TCE represents the total carbon emission, CO_{2i} represents the carbon emission in the i region, POP represents the total population, E_i represents the energy consumption in the i region, GDP_i represents the gross product of the i region, $\frac{GDP}{POP}$ represents the per capita GDP, $\frac{GDP_i}{GDP}$ represents the proportion of GDP in region i to the total GDP, $\frac{E_i}{GDP_i}$ represents energy consumption per unit of production value in region i , and $\frac{CO_{2i}}{E_i}$ represents region i CO_2 factor of unit energy consumption emission.

The above formula is further expressed:

$$TCE = \sum CO_{2i} = p \times g \times s_i \times e \times c_i$$

Among them, p is the total population, representing the population factor; g is the per capita GDP, representing the economic factor; s_i is the proportion of the GDP of a certain region to the total GDP, representing the industrial structure factor; e is the energy consumption per unit of production value, representing the energy consumption intensity factor; c_i is the CO_2 factor of unit energy consumption in a certain area, representing the carbon emission intensity factor.

The following five factors need to be further quantified. Suppose TCE^0 represents the total annual carbon emissions in the base period, TCE^t represents the total annual carbon emissions in the t period and ΔTCE represents the change in carbon emissions during $[0, t]$. Therefore, the extended Kaya equation of the simplified representation above can be expressed as the LMDI addition model in $[0, t]$. Here is the equation:

$$\Delta TCE = TCE^t - TCE^0 = \Delta TCE_p + \Delta TCE_g + \Delta TCE_{s_i} + \Delta TCE_e + \Delta TCE_{c_i}$$

Among them, $\Delta TCE_p, \Delta TCE_g, \Delta TCE_{s_i}, \Delta TCE_e$ and ΔTCE_{c_i} respectively represent the quantified influence degree of population, economy, industrial structure, energy intensity and carbon emission intensity during $[0, t]$.

According to Kaya Identity and LMDI decomposition method, the differences in carbon emissions are completely decomposed and five driving factors can be obtained: population, economy, industrial structure, energy intensity and carbon emission intensity. The additive formulas are as follows:

$$\Delta TCE_p = \frac{TCE^t - TCE^0}{\ln TCE^t - \ln TCE^0} \ln\left(\frac{p^t}{p^0}\right)$$

$$\Delta TCE_g = \sum \frac{TCE^t - TCE^0}{\ln TCE^t - \ln TCE^0} \ln\left(\frac{g^t}{g^0}\right)$$

$$\Delta TCE_{s_i} = \sum_i \frac{TCE_i^t - TCE_i^0}{\ln TCE_i^t - \ln TCE_i^0} \ln \left(\frac{s_i^t}{s_i^0} \right)$$

$$\Delta TCE_e = \sum \frac{TCE^t - TCE^0}{\ln TCE^t - \ln TCE^0} \ln \left(\frac{e^t}{e^0} \right)$$

$$\Delta TCE_{c_i} = \sum_i \frac{TCE_i^t - TCE_i^0}{\ln TCE_i^t - \ln TCE_i^0} \ln \left(\frac{c_i^t}{c_i^0} \right)$$

According to the above results, we can continue to calculate the contribution rate of each factor:

$$\varepsilon_p = \frac{\Delta TCE_p}{\Delta TCE} \times 100\%$$

$$\varepsilon_g = \frac{\Delta TCE_g}{\Delta TCE} \times 100\%$$

$$\varepsilon_{s_i} = \frac{\Delta TCE_{s_i}}{\Delta TCE} \times 100\%$$

$$\varepsilon_e = \frac{\Delta TCE_e}{\Delta TCE} \times 100\%$$

$$\varepsilon_{c_i} = \frac{\Delta TCE_{c_i}}{\Delta TCE} \times 100\%$$

4. Results and Discussion

(1) Analyze decomposition results of carbon emission influencing factors

The countries along the Belt and Road cover a wide range and the entire region accounts for about 40% of the world's land area and 64% of the world's population. There is a large gap between these countries in terms of geographic location, economic development level and resource endowment. Therefore, based on the principle of data availability, the paper selects representative countries in the Belt and Road and divides them according to their geographic locations for 6 different regions, combining with relevant data to study further.

Table 2. 6 Regions in the Belt and Road

Region	Nation	Number of Countries
Asia & Pacific	China (CHN), Malaysia (MAS), South Korea (KOR), Singapore (SGP)	4
West Asia	Turkey (TUR), Israel (ISR), Saudi Arabia (SAU), Azerbaijan (AZE)	4
South Asia	India (IND), Pakistan (PAK), Bangladesh (BGD)	3
Central Asia	Kazakhstan (KAZ), Turkmenistan (TKM), Uzbekistan (UZB)	3
Eastern Europe	Russia (RUS), Ukraine (UKR), Poland (POL), Austria (AUT)	4
Africa and Latin America	Egypt (EGY), South Africa (ZAF), Morocco (MAR), Peru (PER)	4

The carbon emissions are calculated according to the emission factor method and the results of the total carbon emissions in each region are as follows:

Table 3. The Results of the Total Carbon Emissions

Region	2013	2020
Asia & Pacific	114187991.1	163398576.2
West Asia	49148663.34	57696517.63
South Asia	37973917.63	46703413.45
Central Asia	24819519.08	29056666.5
Eastern Europe	158792067.8	149643740.4
Africa and Latin America	20462928.02	23070265.32

(Unit: ton CO₂)

According to the LMDI model, the decomposition results of the factors affecting carbon emissions in countries along the Belt and Road are obtained as shown in the following table:

Table 4. The Decomposition Results

2013-2020	Population	Economy	Industrial Structure	Energy Intensity	Carbon Emission Intensity	Sum
Asia & Pacific	27717138.8 5	291203695. 4	131770451. 9	- 134277135. 8	- 1973208.83 4	314440941.516
West Asia	25807526.1 2	- 49406045.1 8	- 74543797.2 7	36049870.7 9	- 206004.906 8	-62298450.4468
South Asia	19185877.0 3	64203026.0 3	31014502.0 9	- 35091165.6 9	- 4683.61587 8	79307555.8441 22
Central Asia	3467945.58 9	- 10582265.7 4	- 13995870.5 1	11708006.5 3	- 16615.0512 4	-9418799.18224
Eastern Europe	- 387051.577 6	- 55551039.1 4	- 106318979. 8	60447544.1 6	346853.429 8	- 101462672.927 8
Africa and Latin America	10112466.6 5	- 23459205.1	- 32207371.7 3	4531748.53	- 170122.080 5	-41192483.7305

a

According to the results, carbon emissions of countries along the Belt and Road showed an overall growth trend from 2013 to 2020, with a total increase of 179376091.07278 tons. Carbon emissions in Asia & Pacific and South Asia showed an increasing trend, while those in West Asia, Central Asia, Eastern Europe and Africa and Latin America showed a decreasing trend. From a regional perspective, population, economy and industrial structure factors accelerate the release of carbon emissions for Asia & Pacific. The factors of economy, industrial structure and carbon emission intensity have an inhibiting effect on the carbon emissions for West Asia. For South Asia, population, economy and industrial structure have great influence on increasing carbon emissions. For Central Asia, the factors of economy, industrial structure and carbon emission intensity can effectively reduce carbon emissions. Controlling population scale, economy and industrial structure plays a certain role in reducing the total carbon emission in Eastern Europe. Controlling economy, industrial structure and carbon emission intensity can restrain the total carbon emission in Africa and Latin America.

(2) Contribution rate of cumulative effect of various influencing factors of carbon emission

According to the decomposition results of the driving factors of carbon emission and the relevant calculation formula, the contribution rate of effect can be obtained as follows:

Table 5. The Contribution Rate of Effect

2013-2020	Population	Economy	Industrial Structure	Energy Intensity	Carbon Emission Intensity
Asia & Pacific	8.815%	92.610%	41.906%	-42.703%	-0.628%
West Asia	-41.426%	79.305%	119.656%	-57.866%	0.331%
South Asia	24.192%	80.954%	39.107%	-44.247%	-0.006%
Central Asia	-36.819%	112.353%	148.595%	-124.305%	0.176%
Eastern Europe	0.381%	54.750%	104.786%	-59.576%	-0.342%
Africa and Latin America	-24.549%	56.950%	78.187%	-11.001%	0.413%
Average Value	-11.568%	79.487%	88.706%	-56.616%	-0.009%

It can be seen that during the study period, the industrial structure has the most significant effect, with an average value of 88.706% and the effect of this factor has reached more than 100% in West Asia, Central Asia and Eastern Europe. Economy is also one of the main factors for the growth of carbon emissions. The effect reached 112.535% in Central Asia and the average value of each region reached 79.487%. The reduction of energy consumption intensity can effectively restrain the release of carbon emissions and the average contribution rate is -56.616%. Some scholars believe that population increase mainly affects carbon emissions by increasing energy demand, destroying forests and changing land use patterns, etc.^[14]. However, it will show different effects according to the specific conditions of each region.

5. Conclusion and suggestion

Based on the LMDI model, this paper analyzes the energy carbon emissions of countries along the Belt and Road from 2013 to 2020. From the decomposition results of carbon emission factors, the total carbon emissions of countries along the Belt and Road are showing an upward trend, which should be owed to Asia & Pacific and South Asia, possibly due to the influence of China, India, Malaysia and other countries which are more rapidly developing in these two regions. Some scholars can prove this point of view: Wang Yan' an et al.'s research on the carbon emissions of urban life in China found that the improvement of economic level is the main reason for the growth of carbon emissions^[15]. G. Ortega-Ruiz et al.'s study on the increase of carbon emissions in India found that its rapid economic growth is the main reason for the 276% increase in carbon emissions during the study period^[16]. Chin Hao Chong et al. on Malaysia's carbon emissions has the same results^[17]. The Belt and Road Initiative is the reason for the rapid economic development of these countries. The direct investment of the more economically developed countries along the Road has a huge impact on the development of smart manufacturing, digital economy and other industries in our country China, helping us to achieve chain expansion. At the same time, there are many low-level economy and medium-level economy developing countries along the Road and direct investment to China can help them obtain positive technological spillovers and scarce innovation resources^[18].

On the whole, the industrial structure is also one of the main reasons for the growth of carbon emissions. As far as China is concerned, some scholars have found that there is a nonlinear relationship between the industrial structure and carbon emission intensity of various provinces in China and with the improvement of urbanization level, the positive effect of industrial structure on carbon emission intensity will gradually weaken^[19]. The reason may be that carbon emissions mainly come from the secondary industry, but with the modernization of cities and the advancement of technology, the secondary industry is increasingly mechanized and the industrial core is gradually shifting to the tertiary industry, so the proportion of the secondary industry will gradually decrease. Therefore, in order to reduce carbon emissions, countries should shift the economic core from the

secondary industry to the tertiary industry based on their own actual conditions, while promoting the development of new urbanization and focusing on coordinated development between regions. "Western Development" implemented in China is an excellent example whose strategy is to realize the adjustment of the industrial structure from the geographical environment.

At the same time, the population in the Asia & Pacific and South Asia also showed a positive promoting effect. On the one hand, it may be due to the large population base and on the other hand, it may be the influence of the large population density. The literature of the following scholars can prove this point of view. Based on the IPTA expansion model, Song Xiaohui et al. found that the total population of China and India is the main reason for the change of their carbon emissions^[20]. In the paper of Chin Hao Chong et al, the carbon emissions are closely related to the population. Although the carbon emissions caused by population growth are increasing year by year, the relative emissions are decreasing year by year^[17]. However, the impact of population density is the result of adjusting measures to local conditions. Some studies have shown that the carbon emission intensity of the northern coastal areas of China is significantly affected by industrial and population agglomeration variables, but there is no significant impact on the eastern, central and western regions^[21]. Therefore, while urgently promoting national economic development and adjusting industrial structure, the government should formulate population policies that adapt to low-carbon development according to local conditions. In China, the average household size has the greatest impact on carbon emissions. Hence, the government should pay more attention to the size of households. Meanwhile, promoting the technological progress of renewable energy and controlling the consumption of living energy are also effective ways. In Malaysia, the government should pay more attention to the impact of the number of immigrants on population growth and optimize the energy structure of residents' living. In India, the government should lay stress on the impact of the rate of birth and set up a one child policy to avoid excessive population growth, which leads to energy shortages.

On the premise that the countries along the Belt and Road are showing an uprising trend, carbon emissions in West Asia, Central Asia, Eastern Europe and Africa and Latin America have decreased. The breadth of coverage also proves that the world is paying more and more attention to green and low-carbon development. Combined with the analysis of the contribution rate of each factor, reducing energy consumption has played a more important role in curbing carbon emissions. Due to the large oil reserves in Africa, a large amount of energy will be consumed in the process of its exploitation. In order to avoid excessive energy consumption, African countries have expanded the use of renewable energy through green technology innovation and screened environmentally friendly foreign direct investment at the same time, avoiding local pollution to alleviate environmental problems caused by energy consumption^[22]. Therefore, governments should formulate a series of effective energy-saving policies, exchange experiences with each other and implement corresponding carbon emission reduction measures according to local conditions. Simultaneously, strengthening investment in technological innovation, relying on economic leverage and technological innovation to improve energy utilization efficiency and reduce the use of fossil energy are also influential^[3].

In addition, the global market should use economic tools such as carbon trading and carbon tax to accelerate the establishment of carbon markets to effectively reduce carbon emissions. And increasing environmental ecological compensation, encouraging companies from all over the world to cooperate in energy conservation, emission reduction and low-carbon technologies, changing experience actively and contributing to the joint creation of a green earth are imperative under the situation^[23].

References

- [1] [One Belt One Road Observation] Carbon Emission Pressures and Challenges in Countries Along the "One Belt One Road" Tencent News [EB/OL]. /2022-04-14. <https://new.qq.com/omn/20210514/20210514A07RUG00.html>.
- [2] Ang B W, Zhang F Q. Handling zero values in the logarithmic mean Divisa index decomposition approach [J]. Energy Policy, 2007: 238–246.

- [3] Wang Fengting, Fang Kai, Yu Chang. Decoupling Elasticity and Driving Factors of Industrial Energy Carbon Emissions and Economic Growth in Beijing-Tianjin-Hebei Region——Empirical Based on Tapio Decoupling and LMDI Model[J]. *Industrial Technology Economy*, 2019, 38(08): 32–40.
- [4] Wang Jie, Li Zhiguo, Gu Jijian. Decoupling Elasticity and Driving Factors of Carbon Emissions and Economic Growth in BRICS Countries: An Analysis Based on Tapio Decoupling and LMDI Model[J]. *World Geographic Research*, 2021, 30(03): 501–508.
- [5] Victor M, Mara M, Roula I-L, 等. Factors affecting CO2 emissions in Top countries on Renewable Energies: A LMDI decomposition application [D]. Campus de Santiago: University of Aveiro.
- [6] PF G, M L, M.J. P. Tracking European Union CO2emissions through LMDI (logarithmic-mean Divisia index) decomposition. The activity revaluation approach[J]. *Energy*, 2014, Volume 73: 741–750.
- [7] Yu Jinping, Zhang Yanyan. The Influence of "One Belt, One Road" National Railway Connectivity on China's Exports[J]. *World Economic and Political Forum*, 2021(1).
- [8] Zhang Hui, Yan Qiangming, Tang Yuxuan. Research on the Industrial Structure Height and Cooperation Path of “One Belt, One Road” related countries[J]. *Learning and Exploration*, 2019(282).
- [9] BP_Stats_2021.pdf [J].
- [10] IPCC — Intergovernmental Panel on Climate Change [J].
- [11] Homepage - U.S. Energy Information Administration (EIA) [EB/OL]. /2022-04-17. <https://www.eia.gov/index.php>.
- [12] World Bank Open Data | Data [EB/OL]. /2022-04-17. <https://data.worldbank.org.cn/>.
- [13] Ang B W, Pandiyan G. Decomposition of energy-induced CO2 emissions in manufacturing [J]. *Energy Economics*, 1997: 363–374.
- [14] Birdsall N. Another see population and global warning[J]. *Population, health, and nutrition policy research*,
- [15] Wang Yanan, Xie Yanqi, Xie Liqin, et al. Factor decomposition analysis of China's urban living carbon emissions based on LMDI model and Q-type clustering[J]. *Environmental Science Research*, 2019, 32(04): 539–546.
- [16] G.O-R,A.M-N,J.E.G-R. Is India on the right pathway to reduce CO2 emissions? Decomposing an enlarged Kaya identity using the LMDI method for the period 1990-2016[J]. *Science of The Total Environment*, 2020, 737(1).
- [17] Chin H C, Wei X T, Zhao J T. The driving factors of energy-related CO2 emission growth in Malaysia: The LMDI decomposition method based on energy allocation analysis[J]. *Renewable and Sustainable Energy Reviews*, 2019, 115.
- [18] Zhang Jifeng, Liu Qichao. Space-time evolution and influencing factors of China's direct investment in countries along the "One Belt One Road"[J]. *Public Governance Research*, 2022, 34(1): 89–98.
- [19] Zhao Liping, Li Yuan. The impact of industrial structure on carbon emission intensity [J]. *City Problems*, 2018(6).
- [20] Song Xiaohui, Zhang Yufen, Wang Yimei, et al. Analysis of the impact of population factors on carbon emissions based on IPTA extended model[J]. *Environmental Science Research*, 2012, 25(1): 109–115.
- [21] Zhang Cuiju, Zhang Zongyi. The Impact of Industrial and Population Spatial Agglomeration on China's Regional Carbon Emission Intensity[J]. *Technological Economy*, 2016, 35(1): 71–77.

- [22] Lamini D. Factors affecting CO₂ emissions and environmental efficiency: evidence from different regions in Africa[D]. Jiangsu University, 2020.
- [23] Ma Ying, Shao Changxiu. Analysis of Influencing Factors and Decoupling Effect of Energy Consumption Carbon Emissions in Beishang and Tianjin Based on LMDI[J]. Journal of Gansu Science, 2022, 34(01): 124–132.