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Carbon Emission Accounting and LMDI Factor Analysis of Fossil Energy in Henan Province

Yaoling Shi, Jinshan Ma

Henan University of Science and Technology, School of Business Administration, Jiaozuo, Henan 454003, China

Abstract: The cultivation of fossil energy consumption in Henan Province between 2005 and 2022 is key to formulate carbon reduction strategies. This study uses the Logarithmic Mean Divisia Index (LMDI) method to decompose the factors of carbon emissions. The total carbon emissions from fossil energy in Henan Province amounted to 3.075 billion tons of CO2, showing an initial increase followed by a decrease, with fluctuations ranging from 125.59 million tons to 209.98 million tons. The LMDI analysis results show that the total effect of fossil energy carbon emissions fluctuated over time. From 2006 to 2011, the total effect was 84.39 million tons. From 2012 to 2019, it was -56.70 million tons. rom 2020 to 2022, it was 14.93 million tons. The greatest positive impact is the economic factor, accounting for 52.36% of the total effect. The greatest negative impact is the technological factor, accounting for 46.32%.Based on this, the study proposes the following carbon reduction strategies: adjusting the energy structure, fostering green technological innovation, and enhancing energy consumption management.

Keywords: Henan Province, Fossil energy carbon emissions, Fossil energy consumption, LMDI method, Carbon reduction strategies.

1. Introduction

As a big province of energy consumption in our country, Henan province has a high degree of industrialization, and its energy structure is dominated by coal, so it faces great pressure of carbon emissions. Therefore, it is very important to carry out the accounting of fossil fuel carbon emissions in Henan province and analyze its influencing factors for formulating practical carbon emission reduction countermeasures. Through in-depth analysis of the main sources of carbon emissions in Henan province and its key influencing factors, it can provide reference for related research.

In the calculation of carbon emissions from fossil fuels, scholars have used a variety of different calculation methods. Li Ching et al [1] used the emission factor method proposed by the United Nations Committee on climate change to calculate the carbon emissions from energy consumption in the Beijing-Tianjin-Hebei region. Tang Cheng Cai et al [2] calculated the carbon emission of energy consumption in Hubei province by using the method of carbon emission measurement. Hu Wen bao et al [3] proposed a calculation strategy combining primary energy factor and carbon emission factor, which considers the carbon emission of indirect energy. However, among many carbon emission calculation methods, the emission factor method has become the most widely used method because of its simple calculation, mature formula and authority [4].

On the choice of decomposition methods of carbon emission factors, scholars mostly use Generalized Divisia Index Method and Logarithmic Mean Divisia Index Method. Guo Wenqiang et al [5] used the GDMI method to decompose the driving factors of carbon emissions in our country. Lau Siu-lai et al [6] used the LMDI method to analyze the carbon emission factors of our country's manufacturing industry. Yang di [7] used LMDI method to study the driving factors of energy consumption in Xinjiang. In general, GDMI is suitable for complex multi-factor analysis, and LMDI is more suitable for carbon emission analysis due to its simple calculation and clear interpretation. Therefore, based on the data of fossil energy consumption in Henan province from 2005 to 2022, this study adopts the emission factor method proposed by the United Nations Panel on Climate Change (IPCC) to account for the carbon emissions of fossil energy consumption, and the carbon emission factor method is used to calculate the carbon emissions of fossil energy consumption, and through the LMDI model to analyze the driving factors of carbon emissions, provide targeted recommendations for carbon emission reduction in Henan province.

2. Fossil Energy Data of Henan Province

The data source of this paper is the Statistical Yearbook of Henan Province (2005-2022). The fossil energy consumption data of Henan province is obtained by querying the yearbook, the Table 1 for details.

As can be seen from Figure 1, the consumption of raw coal is the highest, accounting for 85.45% of total fossil energy consumption, at 4.761 billion tons of coal equivalent. As can be seen from Figure 2, the second largest consumer is coke, with a consumption of 286 million tons of standard coal, accounting for 5.14%, showing a trend of first rising and then falling. In third place is crude oil, with consumption of about 144 million tons of standard coal, accounting for 2.58%. Its consumption curve fluctuates a lot, but the overall trend is slightly upward.

Table 1. fossil energy consumption in Henan province from 2005 to 2022.Unit: ten thousand tons of standard coal

Year	Raw Coal	Coke	Crude Oil	Gasoline	Kerosene	Diesel	Fuel Oil	Natural Gas
2005	20213.70	992.80	667.95	233.60	13.91	328.50	76.65	237.25
2006	23754.20	1193.55	697.15	248.20	16.02	346.75	69.35	305.14
2007	26582.95	1438.10	715.40	211.70	17.05	459.90	62.05	331.42
2008	26794.65	1489.20	704.45	193.45	18.25	543.85	47.45	365.00
2009	29820.50	1463.65	795.70	200.75	25.55	532.90	25.55	438.00
2010	30229.30	1759.30	846.80	302.95	32.85	569.40	18.25	474.50
2011	33853.75	2080.50	886.95	365.00	51.10	671.60	43.80	547.50
2012	30806.00	2222.85	1011.05	427.05	54.75	737.30	14.60	730.00
2013	28112.30	1817.70	963.60	558.45	47.45	777.45	32.85	766.50
2014	26933.35	2701.00	846.80	529.25	51.10	799.35	51.10	766.50
2015	28455.40	1412.55	605.90	682.55	69.35	861.40	40.15	872.35
2016	27681.60	1343.20	686.20	700.80	73.00	927.10	40.15	879.65
2017	27656.05	1233.70	649.70	740.95	73.00	974.55	29.20	985.50
2018	24130.15	1423.50	828.55	762.85	80.30	992.80	32.85	1058.50
2019	22232.15	1430.80	799.35	770.15	91.25	1007.40	10.95	1058.50
2020	22243.10	1481.90	890.60	762.85	94.90	1025.65	3.65	1058.50
2021	22421.95	1580.45	923.45	777.45	91.25	1120.55	7.30	1168.00
2022	24217.75	1584.10	876.00	799.35	94.90	1171.65	51.10	1241.00
Total	476138.85	28648.85	14395.60	9267.35	995.98	13848.10	657.00	13283.81

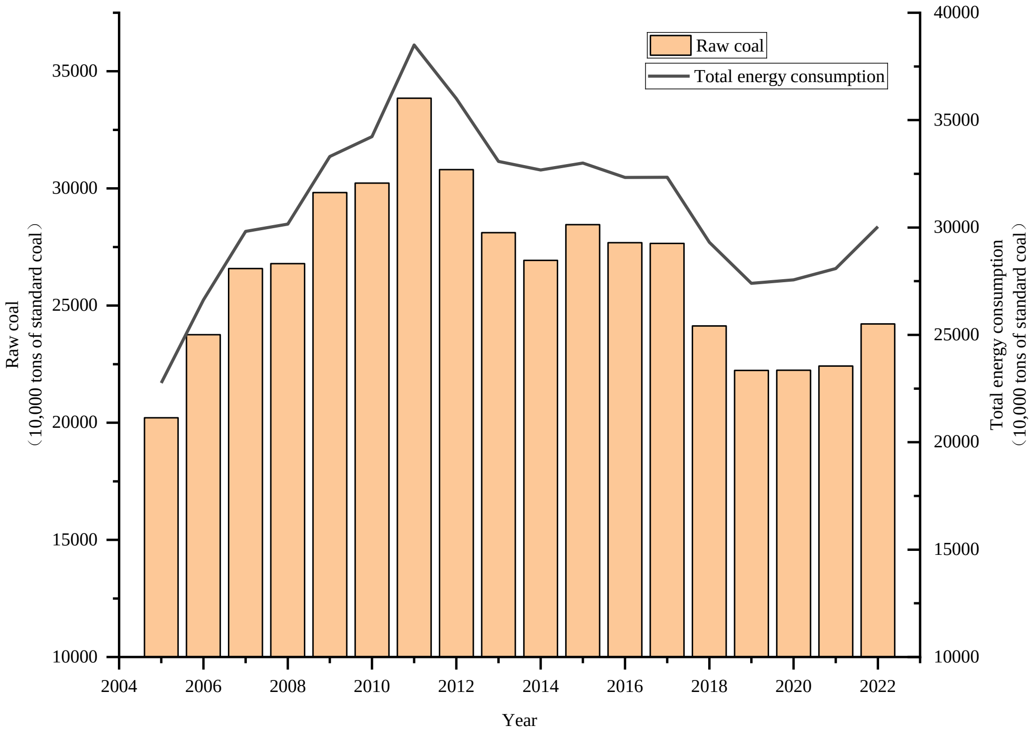

Figure 1. Total fossil energy consumption and raw coal consumption in Henan province from 2005 to 2022

Figure 3 shows that diesel, natural gas and gasoline accounted for 2.49%, 2.38% and 1.66% of total consumption of 138,132.8 and 92.67 million tons of coal equivalent, respectively. The consumption of the three kinds of energy showed a clear upward trend.

Figure 4 shows that the consumption of fuel oil and kerosene is the lowest among all fossil fuels, accounting for 0.12% and 0.18% of total energy consumption at 6.57 million and 9.9598 million tons of coal equivalent, respectively. The consumption of fuel oil showed a fluctuating downward trend and began to rise in 2021, while the consumption of kerosene showed a fluctuating upward trend.

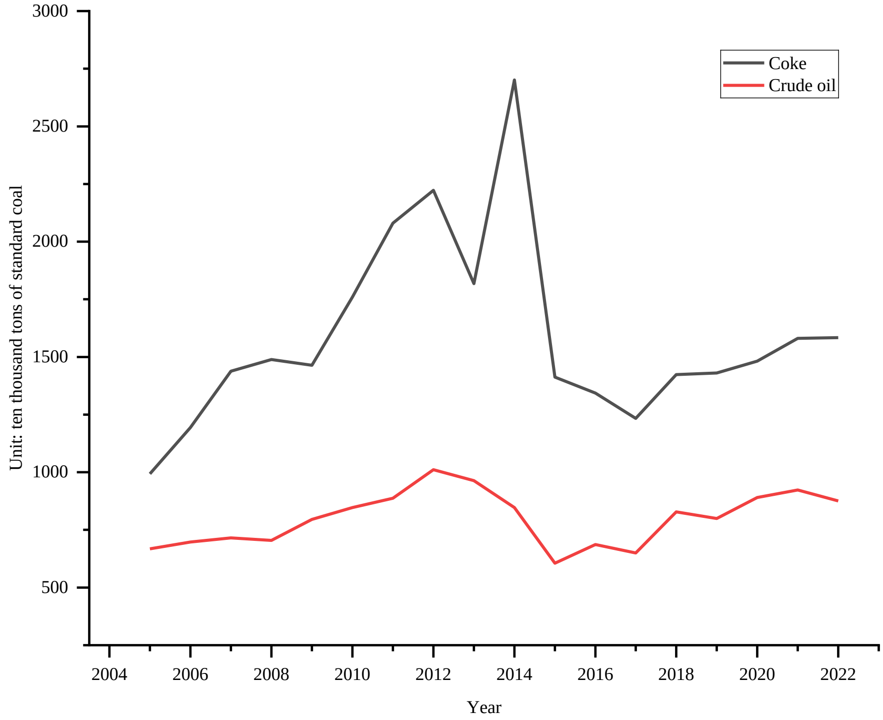

Figure 2. Coke and crude oil consumption in Henan province from 2005 to 2022

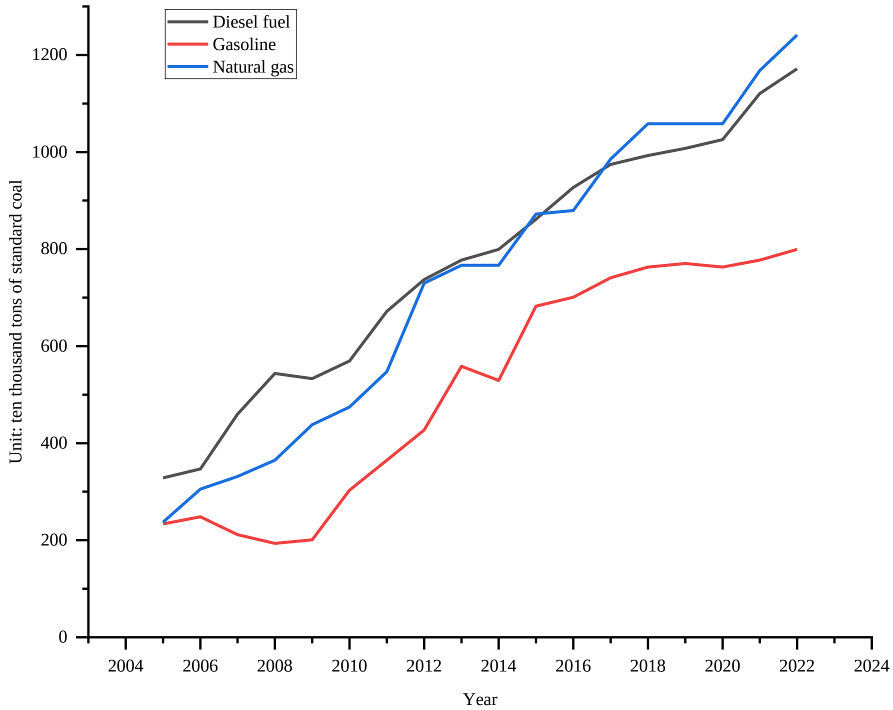

Figure 3. Consumption of diesel, gasoline and natural gas in Henan province from 2005 to 2022

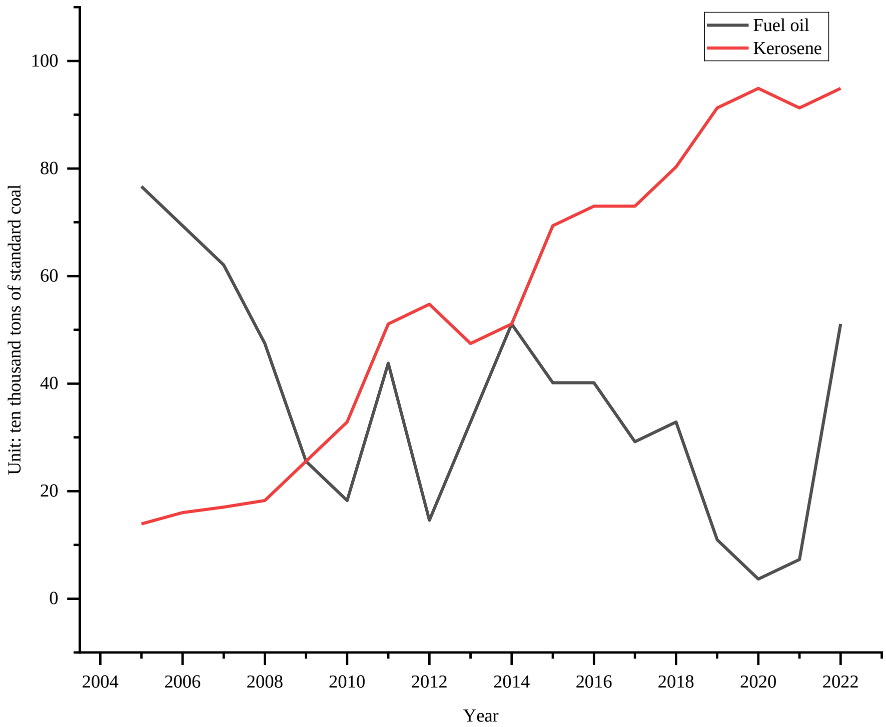

Figure 4. Consumption of fuel oil and kerosene in Henan province from 2005 to 2022

3. Calculation of Carbon Emissions from Fossil Fuels in Henan Province

3.1. Research Methods

Among many carbon emissions calculation methods, the IPCC carbon emissions calculation method can account for countries, enterprises, projects in the industrial sector greenhouse gas emissions [8]. In order to calculate the carbon emission data of fossil energy in Henan province, the carbon emission calculation method in the IPCC guidelines for National Greenhouse Gas inventories (2006) was adopted.

$$Greenhouse\ gas\ emissions = activity\ data \times emission\ factors \tag{1}$$

Where activity data is a measure of production or consumption activities that contribute to greenhouse gas emissions. The emission factor is the coefficient corresponding to the activity data.

3.2. Carbon Emission Calculation Formula

Calculate CO2 emissions from fossil fuels according to the *IPCC National Greenhouse Gas* Guidelines.

$$Y = \sum E_i \times C_i \times B_i \tag{2}$$

Y represents carbon emissions, E_i represents the energy consumption of i energy, C_i represents the standard coal conversion factor of i energy, B_i represents the carbon emission conversion factor of i energy. According to the China Energy Statistical Yearbook can be known all kinds of energy conversion standard coal coefficient, detailed data see Table 2.

Table 2. Conversion Factors of Various Types of Energy

Conversion Factor	Raw Coal	Coke	Crude Oil	Gasoline	Kerosene	Diesel	Fuel Oil	Natural Gas
Coefficient of standard coal	0.7413	0.9714	1.4286	1.4714	1.4714	1.4571	1.4286	1.3300
Carbon emission factor	0.7476	0.1128	0.5854	0.5532	0.3416	0.5913	0.6176	0.4479

3.3. Carbon Emissions from Fossil Fuels

Through the calculation method of IPCC carbon emissions, the data of fossil energy carbon emissions in Henan province from 2005 to 2022 are obtained, see Table 3.

From 2005 to 2022, the total fossil energy consumption in Henan province was 557,235.54 million tons, of which the total carbon emissions from coal energy was 267,013.36 million tons, accounting for 86.83% of the total energy carbon emissions. The two least consumed types of energy were kerosene (5,006,100 tonnes) and fuel oil (5,797,600 tonnes), accounting for 0.187% and 0.217% respectively. The change trend of carbon emissions of all kinds of fossil energy is roughly consistent with the change of their consumption. The carbon emissions of raw coal, Coke and crude oil increased first and then decreased, while those of gasoline, diesel and natural gas continued to increase. The carbon emissions of fuel oil fluctuated greatly, but increased significantly in 2022, while the carbon emissions of kerosene showed a fluctuating upward trend.

Table 3. carbon emissions from fossil fuels in Henan province from 2005 to 2022.Unit: in tons

Year	Raw Coal	Coke	Crude Oil	Gasoline	Kerosene	Diesel	Fuel Oil	Natural Gas	Carbon Emissions
2005	11202.35	108.78	558.61	190.15	6.99	283.03	67.63	141.33	12558.87
2006	13164.48	130.78	583.03	202.03	8.05	298.75	61.19	181.77	14630.09
2007	14732.16	157.58	598.29	172.32	8.57	396.24	54.75	197.43	16317.34
2008	14849.48	163.18	589.13	157.46	9.17	468.57	41.87	217.43	16496.30
2009	16526.40	160.38	665.45	163.41	12.84	459.14	22.54	260.92	18271.07
2010	16752.95	192.77	708.18	246.59	16.51	490.59	16.10	282.66	18706.36
2011	18761.61	227.97	741.76	297.10	25.68	578.64	38.64	326.15	20997.56
2012	17072.56	243.57	845.54	347.61	27.52	635.25	12.88	434.87	19619.79
2013	15579.72	199.17	805.86	454.57	23.85	669.84	28.98	456.61	18218.60
2014	14926.35	295.96	708.18	430.80	25.68	688.71	45.09	456.61	17577.38
2015	15769.87	154.78	506.72	555.58	34.86	742.17	35.42	519.67	18319.06
2016	15341.03	147.18	573.87	570.44	36.69	798.77	35.42	524.01	18027.42
2017	15326.87	135.18	543.35	603.12	36.69	839.66	25.76	587.07	18097.69
2018	13372.83	155.98	692.92	620.94	40.36	855.38	28.98	630.56	16397.95
2019	12320.97	156.78	668.50	626.89	45.87	867.96	9.66	630.56	15327.17
2020	12327.03	162.38	744.81	620.94	47.70	883.68	3.22	630.56	15420.33
2021	12426.15	173.18	772.28	632.83	45.87	965.45	6.44	695.79	15717.98
2022	13421.38	173.58	732.60	650.65	47.70	1009.47	45.09	739.27	16819.74

4. LMDI Factor Decomposition Process

4.1. LMDI Decomposition

The LMDI method is based on the logarithmic mean method, which decomposes the contribution of each factor to the total change by logarithmic subtraction. Compared with the traditional arithmetic average method, the logarithmic mean method can capture the relative influence of factors more accurately. In addition, the decomposition results provided by the LMDI method are not only quantitative, but also have clear economic meaning. The contribution of each factor represents the influence of different economic phenomena or social activities on the change of total carbon emissions. We let *Y* be the total amount of carbon emissions and convert it.

$$Y = (Y/E)\times(E/G)\times(G/P)\times P \quad (3)$$

Among them, E for energy consumption, G for the province's GDP; P for the total population. Set the $S = Y/E$ to structural effect, indicating carbon intensity. $T = E/G$ for technical effect, the ratio of energy consumption to GDP. GDP is per capita, economic effect. P for the total population, indicating the population effect. Carbon emission y is the function of structure effect, technology effect, economic effect and population effect.

$$Y = f(S,T,A,P) = S\times T\times A\times P \quad (4)$$

The product model is logarithmically transformed into an additive model

$$Y^t - Y^{t-1} = \Delta Y = \Delta S + \Delta T + \Delta A + \Delta P \quad (5)$$

Combined with the amount of carbon emissions between ($t-1$) to t, then splits the logarithmic difference.

$$\Delta Y = \frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}}\times(\ln\frac{S^t}{S^{t-1}}\times\ln\frac{T^t}{T^{t-1}}\times\ln\frac{A^t}{A^{t-1}}\times\ln\frac{P^t}{P^{t-1}}) \quad (6)$$

$$\Delta Y = \frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}}\times(\ln\frac{S^tT^tA^tP^t}{S^{t-1}T^{t-1}A^{t-1}P^{t-1}}) \quad (7)$$

Y^t is the total carbon emissions of the period t, Y^{t-1} is the total carbon emissions of the period ($t-1$); S^t is the carbon emission intensity of the period t, S^{t-1} is the carbon emission intensity of the period ($t-1$); T^t is the ratio of energy consumption to GDP of the period t, T^{t-1} is the period of ($t-1$) energy consumption and GDP value; A^t is the period of t per capita GDP, A^{t-1} is the period of ($t-1$) per capita GDP, P^t is the period of the t total population, P^{t-1} is the period of the ($t-1$) total population.

LMDI decomposition formula for known fossil fuel carbon emissions [9]:

$$\Delta Y_X = \sum(\frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}})\times\ln(\frac{X^t}{X^{t-1}}) \quad (8)$$

X represents the influencing factor, such as S,T,A,P; $\ln Y^t - \ln Y^{t-1}$ represents the logarithmic difference between the carbon emissions of the current period and the previous period; $\ln(\frac{X^t}{X^{t-1}})$ represents the logarithmic difference between the data of the current period and the data of the previous period; This shows the specific contribution of each factor to carbon emissions:

$$\Delta Y_S = \sum(\frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}})\times\ln(\frac{S^t}{S^{t-1}}) \quad (9)$$

$$\Delta Y_T = \sum(\frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}})\times\ln(\frac{T^t}{T^{t-1}}) \quad (10)$$

$$\Delta Y_A = \sum(\frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}})\times\ln(\frac{A^t}{A^{t-1}}) \quad (11)$$

$$\Delta Y_P = \sum(\frac{Y^t - Y^{t-1}}{\ln Y^t - \ln Y^{t-1}}) \times \ln(\frac{P^t}{P^{t-1}}) \quad (12)$$

The change in carbon emissions is the sum of the contributions:

$$\Delta Y = \Delta Y_S + \Delta Y_T + \Delta Y_A + \Delta Y_P \quad (13)$$

ΔY_S, ΔY_T, ΔY_A, ΔY_P represent the effects of structure, technology, economy and population on the total carbon emissions of industrial enterprises in Henan province.

4.2. Calculating the Numbers

S, T, A, P are carbon intensity, energy intensity, GDP per head and population, which can be calculated as shown in table 4.

Table 4. LMDI numbers

Year	Carbon Intensity	Energy Intensity	Per capita GDP	Population
	(CO_2/Coal)	(ton/$10,000)	($10,000)	(billion)
2005	0.5517	2.2223	10486.7629	0.9768
2006	0.5494	2.2233	12197.4236	0.9820
2007	0.5472	2.0114	15021.2686	0.9869
2008	0.5470	1.7003	17882.5670	0.9918
2009	0.5486	1.7362	19244.5069	0.9967
2010	0.5464	1.5111	20976.8704	1.0800
2011	0.5454	1.4628	24096.9420	1.0922
2012	0.5449	1.2431	26492.7918	1.0932
2013	0.5508	1.0456	28655.2224	1.1039
2014	0.5379	0.9452	31142.8211	1.1102
2015	0.5551	0.8899	33060.6223	1.1217
2016	0.5576	0.8033	35399.5954	1.1370
2017	0.5596	0.7215	39399.5957	1.1377
2018	0.5595	0.5869	43635.0052	1.1444
2019	0.5594	0.5101	46768.0219	1.1486
2020	0.55949	0.50795	47075.68107	1.15260
2021	0.55955	0.48372	50352.40614	1.15330
2022	0.5600	0.4896	62140.4477	0.9872

4.3. LMDI Factor Decomposition

Taking the data in table 4 into the LMDI model, the results of LMDI factor analysis of fossil energy carbon emissions in Henan province are obtained. Factor analysis results and total effect data for each year from 2005 to 2022 are detailed in table 5.

Table 5. analysis results of carbon emission factors of fossil energy. Unit: 10000 tons

Year	Structure Effect	Technology Effect	Economic Effect	Population Effect	Total Effect
2006	-57.0236	5.9116	2050.2948	72.0385	2071.2213
2007	-60.7728	-1548.0105	3219.0871	76.9426	1687.2464
2008	-5.8151	-2757.1276	2860.6519	81.2582	178.9674
2009	51.0820	363.2453	1274.8419	85.5984	1774.7677
2010	-74.3211	-2567.8979	1593.5569	1483.9561	435.2939
2011	-38.0909	-643.1705	2749.7042	222.7487	2291.1916
2012	-16.7038	-3303.9159	1924.2748	18.5786	-1377.7663
2013	202.4621	-3271.6212	1483.7784	184.1923	-1401.1884
2014	-424.6621	-1808.2200	1489.8132	101.8433	-641.2256
2015	566.1510	-1081.8229	1072.4176	184.9339	741.6796
2016	79.9763	-1860.0651	1242.2500	246.2025	-291.6363
2017	64.1583	-1938.6880	1933.6875	11.1169	70.2746
2018	-2.6377	-3557.9472	1759.6480	101.1938	-1699.7432
2019	-2.8659	-2225.4950	1099.4917	58.0877	-1070.7814
2020	3.3107	-64.4040	100.8033	53.4459	93.1559
2021	1.5258	-760.9393	1047.6142	9.4523	297.6530
2022	12.7536	197.1537	3420.8576	-2529.0034	1101.7615
Full-time effect	298.5269	-26823.0144	30322.7732	462.5861	4260.8719

From 2006 to 2022, the total effect of fossil energy carbon emissions in Henan province showed a fluctuating trend of first decreasing and then increasing. Specifically, the total effect of carbon emissions continued to decline between 2006 and 2008, rising in 2009 and then declining further in 2011. Carbon emissions fell the most in 2011, by 36.6895 million tonnes, and the total effect level remained basically unchanged until 2013. From 2015 to 2022, the total effect of carbon emissions fluctuated greatly and showed an overall upward trend. Overall, the total amount of fossil energy carbon emissions in Henan province has changed by 4.261 billion tons.

4.3.1. Structural Effects

The structural effect has the lowest positive driving degree to the total effect, and its contribution to carbon emissions in the whole period is 2.9853 million tons. The structural effect was negative in most years between 2006 and 2014. The negative driving value was-4.2385 million tons, indicating that the fossil energy consumption structure effectively curbed carbon emissions during this period. From 2015 to 2022, although the overall trend shows a continuous downward trend, the value of most structural effects is always positive, and the positive driving value of this interval is 7.2237 million tons. This shows that the relevant departments have optimized and upgraded the energy consumption structure after the introduction of the policy of “Energy saving and emission reduction and low-carbon development work arrangement in Henan province in 2015”, but there is still a certain potential for carbon emission reduction. Overall, the total effect from 2006 to 2022 is positive, indicating that despite changes in energy consumption structure, there is still a potential to reduce carbon emissions from fossil fuels.

4.3.2. Technical Effects

It can be seen from table 5 that the impact of technological progress on carbon emissions in Henan province fluctuates from 2006 to 2022. Specifically, in 2008,2010,2013 and 2018, the negative impact of technological progress on carbon emissions rebounded the following year, respectively. The negative driving effect in 2010 was the most significant, reaching 29.3114 million tons. Reductions in energy intensity often result from technological progress, reflecting improvements in energy efficiency [10]. Compared with the impact of other factors on the total amount of fossil carbon emissions, the technical effect has a total effect of-268230100 tons. This shows that from 2005 to 2022, the technological progress in the field of fossil energy carbon emissions in Henan province has played a positive role in reducing carbon emissions.

4.3.3. Economic Effects

The economic effect has the largest positive driving force on the total effect, with a cumulative total of 30.2277 million tons of CO_2. From 2005 to 2022, the economic effect is always positive and the overall trend is upward. In 2008, affected by the global financial crisis, the economic effect of a substantial decline in the 15.8581 million tons. Since then, the economic effect has gradually rebounded and declined again after reaching 27.497 million tons in 2011 until it stabilized in 2015. From 2017 to 2020, the impact of economic effects on fossil energy carbon emissions showed a downward trend. Since then, the economic effect has continued to grow and reached 34,208,600 tons in 2022. Because the economic effect has the highest positive driving degree on fossil energy carbon emissions, it shows that economic growth is the main factor to promote the increase of fossil energy carbon emissions in Henan province

4.3.4. Population Effect

The positive impact of population on fossil fuel carbon emissions is relatively small, at 4,625,860 tons. From 2006 to 2021, the impact factors of population effect on fossil energy carbon emissions were all positive, and the impact degree was 29.9159 million tons of CO_2. In 2022, the impact of population effect on carbon emissions has a negative driving force, which is-25.2 million tons of CO_2. From 2006 to 2022, the population effect has increased carbon emissions by 4.6259 million tons, indicating that population growth has a positive driving effect on fossil energy carbon emissions.

5. Carbon Emission Reduction Measures

5.1. Optimizing the Energy Consumption Structure

Optimizing energy consumption structure is an important way to improve energy efficiency [11]. Optimizing the energy consumption structure, that is, reducing the dependence on traditional high-carbon energy, can reduce the growth of carbon emissions caused by structural changes. To achieve this goal requires the joint efforts of the government and enterprises. The government can gradually reduce the proportion of fossil energy consumption by increasing clean energy investment, strengthening carbon emission regulation and promoting green finance Enterprises can reduce energy waste and improve energy efficiency by introducing energy-saving technologies, improving equipment efficiency and developing energy-saving products. The two work together to promote the optimization of the energy structure.

5.2. Promoting Innovation in Green Technologies

Green technology innovation is an important way to promote technology upgrading, which can fundamentally reduce carbon emissions [12]. The key to promoting green technology innovation is to increase support for research and development of core technologies, especially in cutting-edge areas such as carbon capture and storage (CCUS) and battery storage in addition, the government can encourage enterprises to increase r & D investment in green technology through fiscal subsidies, green credit and other policy means. With the continuous improvement of technology, the application effect of green technology is enhanced, thus further reducing carbon emissions.

5.3. Strengthening Energy Management

Strengthening energy consumption management can reduce the correlation between energy consumption and carbon emissions in economic activities, and help to reduce the impact of economic factors on carbon emissions. Strengthening energy consumption management can achieve this goal by building an intelligent energy consumption management platform, implementing energy consumption restrictions, promoting renewable energy and other measures. The construction of intelligent energy consumption management platform can improve energy efficiency by reducing energy loss [13]. The implementation of energy consumption restriction policy can gradually phase out high carbon emission energy by regulating carbon emission quota and adjusting market mechanism. The promotion of renewable energy can guide enterprises and residents to transform the use of fossil energy to clean energy by constructing supporting facilities and issuing green subsidies.

6. Conclusion

This study aims to calculate the carbon emissions of fossil fuels in Henan province, analyze the impact of relevant factors on them, and provide suggestions for carbon emission reduction in Henan province. Through the decomposition of LMDI factors, the carbon emissions caused by fossil energy consumption are divided into four factors: Structure, technology, economy and population. The contribution of each factor to the total effect of carbon emissions was 2.9853 million tons, -268.2301 million tons, 303.2277 million tons and 4.6259 million tons, respectively. The results show that: economic growth and technological progress significantly affect carbon emissions; energy structure change, economic development and population growth positively drive carbon emissions of fossil energy in Henan province; The improvement of technology has a negative impact on carbon emissions. In response to this problem, this paper proposes countermeasures to optimize the energy structure, promote green technology innovation and strengthen energy consumption management, aiming to reduce the impact of structural factors on carbon emissions and enhance the negative driving effect of technology, and reduce the correlation between energy consumption and carbon emissions from economic activities.

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