Analysis of Factors Estimation and Influence of Regional CO_2 Emissions—A Case of Shandong Province Example

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Abstract. Contemporary society with the economic development, the demand for fossil fuels was increasing, leading to the increase of CO_2 emissions, resulting in more serious environmental problems. So it was of great significance to analyze carbon emissions and the factors that affected its emissions, which could promote the sustainable development of low-carbon economy. According to the IPCC2006 method, the CO_2 emissions of Shandong province in 1995-2012 were estimated by method, and the important factors affecting CO_2 emissions were analyzed by using Kaya identity and Laspeyres decomposition method. The results showed that the most important factor affecting CO_2 emissions was the population, energy structure, economic development level and energy structure carbon intensity; developing clean energy was an important way to reduce energy consumption and CO_2 emissions, and it was an important choice to achieve low carbon economy.This study provided an important reference value for protecting environment and promoting sustainable development of economy.

Introduction

In recent years, with the development of global economy, more and more use of fossil fuels, which caused by the greenhouse effect and other environmental problems became increasingly serious. Kyoto Protocol to control the six greenhouse gases, CO_2 greenhouse greatest impact on. Since the beginning of industrialization, the concentration of global CO_2 had increased from 280 ppm to 379 ppm in 2005, within the past century, the average surface temperature caused by the greenhouse effect has increased by about 0.6℃[1]. How to effectively control and reduce CO_2 emissions by region, the problem of CO_2 emissions and what factors were key issues at home and abroad, had been studied[2-6].

Shandong province was one of the most developed provinces in China, the economic data in the country ranked first. However, economic development in Shandong province had also made the increasing energy consumption and carbon emissions. China energy report data show that in 2005 the total carbon emissions in Shandong province reached 160 million t, ranking first in the country. From 2000 to 2007, the average growth rate of per capita CO_2 emissions ranked fourth in the country[7]. Currently, in response to the Party Central Committee and the state put forward the call of energy-saving and emission reduction, Shandong province is only based on the current situation of energy consumption in Shandong Province, using scientific methods to estimate the carbon emissions in Shandong Province, and analysis of the causes, to put forward the feasible scheme of energy saving and emission reduction.

Therefore, CO_2 emissions based on IPCC2006 estimation method of 1995-2012 in Shandong Province, using the Kaya identity and Laspeyres decomposition method to analyze important factors affecting CO_2 emissions. The results provided important reference value for protecting environment and promoting the sustainable development of economy.

Research Methods

Carbon emissions estimation methods. The method according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provided, the specific carbon emissions calculation formula is:

$$CO_2 \text{ emissions} = \text{Carbon Emission Factor} \bullet \text{Fuel consumption} \quad (1)$$

In the formula: Referring to the total amount of CO_2 emissions from burning fossil fuels for some release of CO_2, the carbon emission factor is the release of CO_2 from fuel combustion default factors, including the value of carbon oxidation factor 1, that is, after the fuel consumption of the fuel consumption can release energy.

Kaya identity. Kaya identity model is the human activity generated by CO_2 and policy, economy, population and other factors combine by simple mathematical formula. The formula is:

$$F = P \bullet (G/P) \bullet (E/G) \bullet (F/E) = Pgef \tag{2}$$

In the formula: F , P , G , E , g , e , f respectively represent CO_2 emission, population quantity, GRP, primary energy consumption, per capita GDP, energy structure, energy structure and carbon emission intensity.

Laspeyres decomposition. The Laspeyre model is the CO_2 emissions from combustion of primary energy is decomposed into different influence factors. The CO_2 emissions as a function of 4 variables, that is

$$F = \phi(P, g, e, f) \tag{3}$$

By differentiating factors calculated for each degree of influence on carbon emissions, and then calculate the sum.

$$\Delta F = (\Delta F)_P + (\Delta F)_g + (\Delta F)_e + (\Delta F)_f \tag{4}$$

The formula (4) can also be further decomposition:

$$(\Delta F)_P = (\frac{\partial F}{\partial P})_{gef} \cdot \Delta P = g^0 e^0 f^0 (p^t - p^0) \tag{5}$$

Formula (5) is the number of factors affecting the population exploded on CO_2 emissions. Analogy to this method of calculation to break down other factors, determine the impact of energy structure, the level of economic development, energy and other factors on the structure of the carbon intensity of CO_2 emissions.

The estimate of Shandong province CO_2 emissions

Table 1 Shandong Province primary energy consumption during 1995-2012

Year	Raw coal /10^4t	Coke /10^4t	Natural gas /10^4t	Gasoline /10^4t	Kerosene /10^4t	Diesel /10^4t	Fuel Oil /10^4t	LPG /10^4t
1995	10915.18	466.91	1347.91	309.89	192.83	23.51	309.78	34.86
1996	11116.77	407.01	1425.65	322.37	194.14	30.22	314.37	36.90
1997	10993.80	404.06	1528.55	292.22	221.63	37.16	349.09	55.37
1998	11026.03	306.34	1448.98	258.97	198.52	52.27	298.57	52.78
1999	10891.13	334.38	1477.59	281.31	169.80	48.65	288.20	53.36
2000	10348.22	424.82	1771.20	344.27	188.52	48.25	343.87	61.32
2001	12537.57	460.96	1777.95	271.38	188.92	49.49	332.62	55.19
2002	15035.15	415.41	1628.23	270.54	176.84	41.98	248.71	72.01
2003	15165.31	640.50	2214.02	223.20	209.51	14.24	515.49	85.56
2004	18270.04	1235.49	3196.38	279.15	233.67	21.75	582.28	102.53
2005	25247.93	1992.57	3300.37	294.45	495.52	21.97	1132.30	221.63
2006	28998.56	2419.88	3878.27	304.12	540.60	23.87	1220.96	236.26
2007	31702.77	2593.43	4075.66	367.23	572.79	32.02	1286.94	213.48
2008	34384.49	2611.90	4626.96	155.42	548.60	30.73	1177.74	196.97
2009	34795.17	2922.57	5142.90	378.94	790.91	35.41	1346.01	193.93
2010	37327.89	3067.58	5593.40	1286.77	802.40	38.61	1448.12	236.70
2011	38920.53	3314.77	5826.37	1466.60	806.41	39.36	1664.29	250.24
2012	40232.80	3506.05	6271.50	1695.20	811.58	77.08	1814.34	289.37

According to the statistical yearbook of Shandong province, 1995-2012 years in various primary energy average daily consumption of available, consumed by the average daily amount of energy take days, could get the primary energy consumption (Table 1).

Table 2 was an emission factor of various types of energy, low calorific value and the energy conversion coefficient, the energy conversion coefficient said mass per unit volume or per unit mass of energy converted into standard coal equivalent calorific value.

Table 2 Various types of energy emission factor, low calorific value and energy conversion coefficient

Parameters	Raw coal	Coke	Natural gas	Gasoline	Kerosene	diesel	Fuel Oil	LPG
Emission Factor/kg · TJ	94600	107000	56100	69300	71500	74100	77400	63100
LHV/ $kj \cdot kg^{-1}, kj \cdot m^{-3}$	20908	28435	38931	43070	43070	42652	41816	50172
Energy conversion coefficients /t	0.7143	0.9714	12.143	1.4714	1.4714	1.4571	1.4286	1.7143

According to the formula (1) could be estimated CO_2 emissions of different forms of energy. CO_2 emissions of the fuel consumed each year to produce the sum was calculated, you could get the total emissions per year(Table 3). The primary energy consumption in Shandong province in Table1 according to the coefficient of energy conversion in Table 2 for standard coal, can be calculated in each of the primary energy consumption, are shown in Table 3.

Table 3 Shandong Province total primary energy consumption, GDP and population during 1995-2012

Year	Total energy consumption /10^4t	Total CO_2 emissions /10^4t	GDP /10^9 Yuan	Population /10^4 People	Per capita CO_2 emissions /10^4t	CO_2 emissions intensity
1995	11448.04	28416.01	4953.35	8705	3.2643	5.7367
1996	11684.77	28872.28	5883.8	8738	3.3042	4.9071
1997	11830.87	28997.56	6537.07	8785	3.3008	4.4359
1998	11507.99	28308.73	7021.35	8838	3.2031	4.0318
1999	11449.96	28128.31	7493.84	8883	3.1665	3.7535
2000	11781.13	28369.97	8337.47	8997	3.1533	3.4027
2001	13261.12	32537.72	9195.04	9041	3.5989	3.5386
2002	14663.53	36769.09	10275.5	9082	4.0486	3.5783
2003	16163.58	39614.91	12078.15	9125	4.3414	3.2799
2004	20615.63	50050.23	15021.84	9180	5.4521	3.3318
2005	27896.99	69308.04	18366.87	9248	7.4944	3.7735
2006	32053.95	79667.77	21900.19	9309	8.5581	3.6378
2007	34642.76	86396.73	25776.91	9367	9.2235	3.3517
2008	36836.32	91688.37	30933.28	9417	9.7365	2.9641
2009	39091.24	96449.63	33896.65	9470	10.2421	2.8454
2010	43225.45	106231.85	39169.92	9579	11.2809	2.7121
2011	45538.14	111917.21	45361.85	9637	11.8846	2.4672
2012	47972.60	117444.69	50013.24	9685	12.4716	2.3483

Seen from Table 3: In the 1995-2012 year, CO_2 emissions from fossil fuel combustion, Shandong Province, was increasing, but the rate of increase declined. A large degree of development of this relationship and the economy of Shandong Province, the rapid development of economy and the demand of energy had greatly increased, resulting in CO_2 emissions increased year by year.

Factors affecting study of Shandong province's CO_2 emissions

Calculated results of the Kaya identity factor decomposition. The variable calculation adjacent year by Kaya identities, could get the influence factors of energy intensity, population structure, the per capita GDP and carbon intensity of energy structure changes of CO_2 emissions affected the quantity, the results in Table 4.

The decomposition results of Laspeyres. Using Laspeyres decomposition method, based on the indicators in Tab.4 of the total CO_2 emissions from the decomposition by year.In the decomposition process, respectively, a year ago for the decomposition of the base, using the formula (5) to calculate (Figure 1).

Table 4 Changes in the amount of Population factors, the strength of the energy mix, per capita GDP and carbon intensity of the energy structure impact of CO_2 emissions

Year	population factors variation/t	per capita GDP variation /t	energy structure variation/t	carbon intensity variation/t
1995-1996	1003.017	48513.15	-37234.6	-37234.6
1996-1997	1248.154	24384.91	-20578.1	-20578.1
1997-1998	1291.767	14483.06	-20208.7	-20208.7
1998-1999	960.3654	11672.78	-12783.4	-12783.4
1999-2000	2245.167	17228.51	-13154	-13154
2000-2001	814.1311	16229.29	3436.475	3436.475
2001-2002	867.309	21508.18	-2011.01	-2011.01
2002-2003	990.7435	35550.8	-13019.6	-13019.6
2003-2004	1303.78	51107.06	5516.269	5516.269
2004-2005	2095.735	60457.37	30201.52	30201.52
2005-2006	2794.869	78202.38	-15409.5	-15409.5
2006-2007	2923.077	79629.31	-38366.3	-38366.3
2007-2008	2485.212	90167.26	-53042.9	-53042.9
2008-2009		42022.94	-13844.4	-13844.4
2009-2010		70133.47	-19432.6	-19432.6
2010-2011		75404.93	-43074.5	-43074.5
2011-2012		46876.18	-20350.2	-20350.2

Factors Affecting Shandong Province CO_2 emissions analysis.(1) Decomposition of population. As can be seen from Table 3, the population was increasing year by year, Shandong Province, while Figure 1 showed the CO_2 emissions to rise year after year, proportional relationship existed between the two. Visible impact of population factors on CO_2 emissions was always positive, but the impact on CO_2 emissions relative to GDP, and the degree of energy structure was relatively small. (2) Decomposition of energy structure. As could be seen from Figure 1, the intensity of the energy mix in addition to CO_2 emissions in 2000, 2003 and 2004 than had been negative, indicating there was inversely proportional relationship between the two. In 2000, 2003 and 2004, the impact of changes in the structural strength of the energy CO_2 emissions was positive, indicating that there was a positive correlation between the two. (3) Decomposition of GDP per capita. From figure 1, you could see that per capita GDP was one of the biggest degree of impact on CO_2 emissions, the influence of variation of value was always positive, showed that factors influencing the direct proportion relationship between per capita GDP and CO_2 emissions. (4) Decomposition of the carbon intensity of energy structure. As could be seen from Figure 1, the carbon intensity of the energy structure in addition to 2000-2001, 2003-2005, there was a negative correlation between the rest of the year and CO_2 emissions. (5) Calculation of CO_2 emissions per unit of GDP. As could be seen from Tab.3, the CO_2 emissions overall in Shandong province GDP decreased, but increased in the 2000-2002 years and 2004-2005 years.

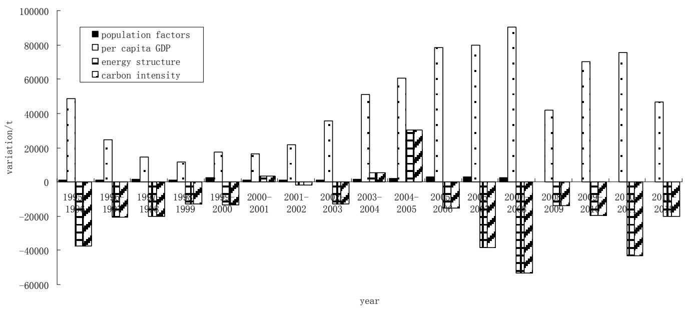

Fig.1 Decomposition result of Shandong Province CO_2 emission

Conclusion

Shandong Province, total CO_2 emissions from combustion of primary energy in 1995-2012 increased year by year, but the rate of increase had declined in 2003-2004, CO_2 emissions increased 104353200t, in 2008-2009, CO_2 emissions volume only increased 47612600t. But after 2009 re-emerged rapidly growing carbon emissions. Besides CO_2 emissions per unit of GDP as early as 2009 to reach a minimum and then starts to increase, but the growth rate was not great.

By studying the contents of this article could be seen: the energy structure, the per capita GDP of Shandong Province were the two main factors affect carbon emissions, including the impact on GDP per capita CO_2 emissions was positive, while the energy structure of the carbon emissions of the degree of influence by the negative into a positive.

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