

# Study on Carbon Dioxide Emissions of Jilin Province in China

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**Keywords:** carbon emission, energy intensity, energy structure.

**Abstract:** By calculating the amount of carbon emission in Jilin province, this paper summarizes the characteristics and influencing factors of carbon emission in Jilin province. The substantial decrease of energy intensity in Jilin province has an inhibitory effect on carbon emission; however, coal-based energy structure and economic growth have increased carbon emissions.

## 1. Introduction

Jilin province is one of important heavy industry district in China, and its economic growth depends on the input of energy and resources heavily. With the economic growth, the pollution emission especially carbon dioxide emission rise up as well. As a traditional old industrial district, Jilin province faces the arduous task of energy conservation and emission reduction. Along with economic expansion and energy consumption growth, environmental pressure is increasingly pressing. Therefore, it is necessary to conduct an in-depth and detailed study on the carbon emissions in Jilin province.

## 2. Literature review

Much progress has been made in the quantitative analysis of energy consumption and pollution emissions by different factors, such as econometric regression, structural decomposition (SDA) and exponential decomposition (IDA).

Two methods are most commonly used in IDA exponential decomposition: laspeyre and Divisia indices. The Laspeyre index directly differentiates each factor assuming that other factors remain unchanged, and the residual term produced by this method is large. And the Divisia exponential takes the factors of decomposition as continuous differentiable functions of time, and finds out the influence of the changes of various factors by differentiating them with respect to time. Since it uses logarithmic growth rate to describe the change of factors, the remaining terms are small.

Ang (2004) compared various exponential decomposition methods, and considered that LMDI has the property of complete decomposition without residual error. Therefore, this method is considered as a better decomposition method at present, and has been widely used. This method also has some defects, when the data has zero and negative values, the logarithm can not be processed. When zero occurs, the zero value is replaced by a smaller value.

At present, there are two main types of researches on carbon emission using LMDI, one is cross-time factor decomposition, which uses annual time series data for analysis. The other category is transnational or trans-regional factor decomposition. Compared with cross-time analysis, there are relatively few literatures on transnational analysis.

Research on China's carbon emissions by using LMDI is also increasing. Xu(2005) quantitatively analyzed the period from 1990 to 2004, and believed that the contribution of economic growth to carbon emissions increased exponentially, and the contribution of energy intensity and energy structure presented an inverted "U" shape. Hu(2008) studied the carbon emission factors based on the data of energy consumption in six sectors in China from 1990 to 2005, and showed that energy intensity and economic scale were the two main factors affecting carbon emissions. Song(2009) divided the stage of China's carbon emissions based on the results of factor decomposition. He

defined four growth modes and studied the stage characteristics and causes of China's carbon emissions in detail.

This paper firstly calculated the per capita carbon emissions of Jilin province, and then decomposes the factors affecting carbon emissions by using LMDI method.

### 3. Methodology

#### 3.1 Kaya identity.

The Kaya Identity was advanced by Japanese Dr. Yoichi Kaya in the Intergovernmental Panel on Climate Change (IPCC) in 1996. The carbon dioxide emission is written as formula (1).

$$C = \sum c_i = \sum \frac{E_i}{E} \frac{C_i}{E_i} \frac{E}{Y} \frac{Y}{P} P \quad (1)$$

E is consumption of primary energy;  $E_i$  is the consumption of the kind of energy  $i$ ; Y stands for GDP; P stands for population;  $F_i = CO_2/E_i$  is the coefficient of carbon emission;  $S_i = E_i/E$  stands for energy structure;  $I = E/Y$  is energy intensity;  $R = Y/P$  stands for GDP per capita. 1=petroleum, 2=natural gas, 3=coal. The formula of carbon dioxide emission also can be written as identity (2). Carbon dioxide per capita is written as formula (3).

$$C = \sum c_i = \sum S_i F_i I R P \quad (2)$$

$$A = C/P = \sum S_i F_i I R \quad (3)$$

#### 3.2 Decomposition method.

This paper uses Logarithmic mean Divisia index to analyze the influence factor of carbon dioxide emission. Some scholars such as Ang, Zhang and Choi put forward LMDI time-series analyses and cross-countries analyses respectively around 1997 and 2001. The change of average carbon emission between two periods is written as  $\Delta A$ , and  $\Delta A$  can be decomposed into 5 parts, which are  $\Delta A_S$ ,  $\Delta A_F$ ,  $\Delta A_I$ ,  $\Delta A_R$  and  $\Delta A_{rsd}$ .  $\Delta A_F$  is the effect of emission coefficient on carbon dioxide emissions,  $\Delta A_S$  is the effect of energy structure on carbon dioxide emissions,  $\Delta A_I$  is the effect of energy intensity on carbon dioxide emissions,  $\Delta A_R$  is the effect of per capita GDP on carbon dioxide emissions. Ang(1997) proved  $\Delta A_{rsd}$  is equal to 0.

$$\begin{aligned} \Delta A &= A_t - A_{t-1} \\ &= \sum F_i^t S_i^t I_i^t R_i^t - \sum F_i^{t-1} S_i^{t-1} I_i^{t-1} R_i^{t-1} \\ &= \Delta A_F + \Delta A_S + \Delta A_I + \Delta A_R + \Delta A_{rsd} \end{aligned} \quad (4)$$

$$\Delta A = A_t - A_0 = \sum S_i^t F_i^t I_i^t R_i^t - \sum S_i^0 F_i^0 I_i^0 R_i^0 = \Delta A_S + \Delta A_F + \Delta A_I + \Delta A_R + \Delta A_{rsd}$$

$$\Delta A_S = \sum W_i^t \ln \frac{S_i^t}{S_i^0}, \Delta A_F = \sum W_i^t \ln \frac{F_i^t}{F_i^0}, \Delta A_I = \sum W_i^t \ln \frac{I_i^t}{I_i^0}, \Delta A_R = \sum W_i^t \ln \frac{R_i^t}{R_i^0}$$

#### 3.3 Data.

Because the carbon emission coefficient of energy is relatively stable,  $\Delta A_F = 0, D_F = 1$ . The carbon emission coefficient is shown in Table 1. The energy consumption and economic data come from Statistical yearbook of Jilin province from 1980-2013.

Table 1 Carbon emission coefficient

energy	coal	oil	gas
Coefficient	0.7329	0.5574	0.4226
energy	coal	oil	gas

#### 4. Analysis of carbon emission factors in Jilin province

##### 4.1 General trend of per capita carbon emission in Jilin province.

Figure 1 shows the general trend of per capita carbon emissions in Jilin province, which can be roughly divided into three stages. From 1989 to 2002, the per capita carbon emission decreased; from 2003 to 2012, the per capita carbon emission increased and accelerated.

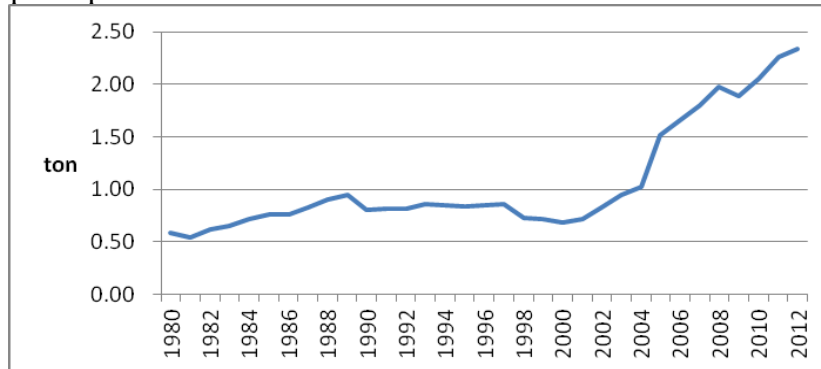


Fig.1 Per capita carbon emissions in Jilin province (1981-2012)

##### 4.2 General trend of per capita carbon emission in Jilin province.

Figure 1 shows the general trend of per capita carbon emissions in Jilin province, which can be roughly divided into three stages. From 1989 to 2002, the per capita carbon emission decreased; from 2003 to 2012, the per capita carbon emission increased and accelerated.

##### 4.3 Analysis of the influence factors on carbon emission in Jilin province.

According to the factor decomposition method, the factors affecting carbon emissions in Jilin province are classified into three categories, energy intensity factor, energy structure factor and economic growth factor. According to formula (1) - (3), the specific influence values are calculated in this paper, as shown in Table 2 and figure 2.

Table 2 The results of factor decomposition (1981-2012)

	1981	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
$\Delta A$	-0.04	0.17	0.23	0.29	0.13	0.97	1.13	1.26	1.45	1.34	1.51	1.72	1.80
$\Delta A_S$	-0.01	-0.01	-0.12	-0.15	-0.17	0.02	0.03	0.00	0.01	0.02	0.03	0.03	0.03
$\Delta A_I$	-0.06	-0.12	-0.21	-0.47	-0.78	-1.20	-1.30	-1.41	-1.55	-1.72	-1.87	-2.02	-2.15
$\Delta A_R$	0.03	0.31	0.56	0.90	1.08	2.15	2.40	2.67	2.99	3.04	3.34	3.70	3.91

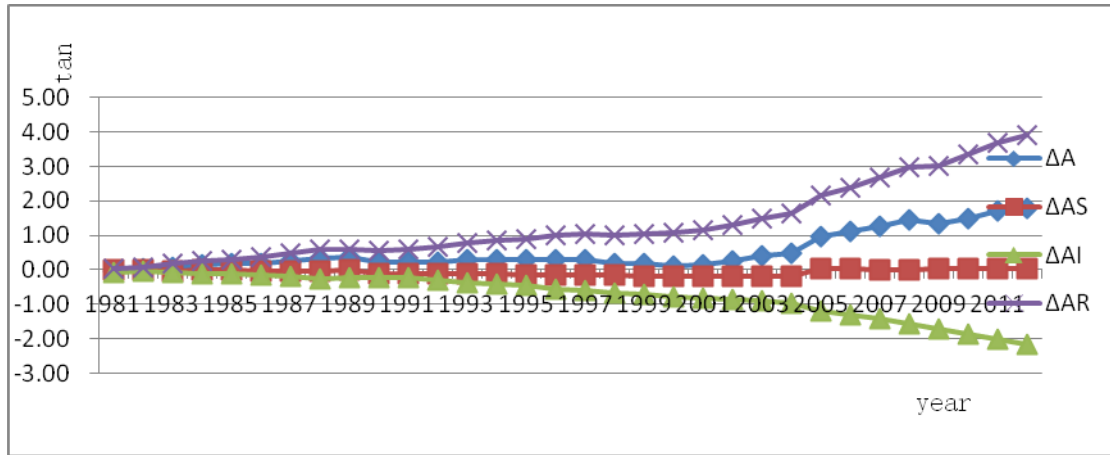


Fig. 2 The results of influencing factors of the carbon emission of Jilin province

As shown in Figure. 2, from 1981 to 2009, the decline of energy intensity was the major factor restraining per capita carbon emission in Jilin province. Energy intensity has been a major contributor to carbon emissions and a major contributor to their decline.

The energy structure had little inhibitory effect on per capita carbon emissions. The energy structure reduced carbon emissions slightly and in some years increases them. The coal-based energy structure in Jilin province has not changed significantly in the past 30 years, with coal consumption accounting for more than 50% and 70% in many years. Since 2003, coal consumption has been on a significant upward trend, which has accelerated the amount of carbon emissions in Jilin province.

The main factor causing the growth of carbon emission in Jilin province is the expansion of economic scale. Especially after 2005, the rapid economic development of Jilin province also accelerated the trend of carbon emission.

In a word, the inhibiting effect of energy intensity and energy structure on carbon emissions did not offset the increasing effect of economic growth on carbon emissions, so Jilin province still showed the trend of continuous growth of carbon emissions.

## 5. Conclusion

According to the above models and calculation results, per capita carbon emissions in Jilin province presented a relatively stable state from 1980 to 2003, and accelerated from 2004 to 2012. The decline in energy intensity restrains per capita carbon emissions. The energy structure has little inhibitory effect on per capita carbon emissions, slightly reduces carbon emissions, and in some years promoted the increase of carbon emissions. What contributes to per capita carbon emissions in Jilin province is economic growth. The effect of energy intensity and energy structure on carbon emissions does not offset the increasing effect of economic growth on carbon emissions, so Jilin province still shows the trend of continuous growth of carbon emissions.

In view of the above conclusions, this paper proposes the following countermeasures. First of all, the energy should be improved. In recent years, developed countries such as France and Germany have reduced their carbon emissions mainly due to the adjustment of energy structure. The energy structure gradually shifts to nuclear, wind, hydropower and other clean energy sources. Jilin province should gradually reduce the proportion of coal, appropriately increase the use of oil and natural gas, and try to open up wind energy, hydropower and other clean energy. Secondly, the use of carbon reduction technologies should be increased. Carbon capture technologies, particularly in the coal sector, should be developed and used to enhance the use of clean coal to reduce environmental damage. At last, the role of energy intensity should be enhanced.

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