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Target Responsibility System and CO_2 Emissions Convergence: Mechanism and Empirical Test

Sun Yongping[1]

Abstract

The Chinese government had already taken a string of policies and actions for CO_2 abatement, the most important of which is the introduction of energy conservation and carbon abatement into the target responsibility system. First, this paper elaborates the influencing mechanism of target responsibility system for the convergence of CO_2 emissions and considers that the bottom-up political system, investment impulse and the nature of CO_2 abatement have major impacts on the convergence of China's CO_2 emissions. Second, using interprovincial panel data and following the grouping methods of eastern, central and western regions, this paper compares China's CO_2 emissions convergence between the 10th Five-year Plan period (2001-2005) and the 11th Five-year Plan period (2006-2010). Analysis indicates that the effect of energy conservation and CO2 abatement target tends to be subjected to GDP growth targets. Therefore, this paper considers that in the context of growing international pressures, China needs to take the absolute value of CO_2 emissions decreasing into the target responsibility system.

Keywords: target responsibility system; energy conservation and emissions abatement; convergence of CO_2 emissions

1. Introduction

Since 1999, China had experienced a new round of heavy industrialization and the output value, investment, profit and proportion of heavy industry have overtaken light industry (Jian Xinhua, 2005). Renewed heavy industrialization and rapid economic growth had led to China's environmental degradation and CO_2 emissions increase. In 2009, China replaced the United States as the world's largest CO_2 emitter.

According to the statistics of the World Bank, China's per capita CO_2 emissions was 2.7 tons which represented 66% of the world per capita CO_2 emissions in 2000

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and reached 4.8 tons which exceeded 4.7 tons of the world per capita CO_2 emissions. China's per capita CO_2 emissions reached 7.35 tons which represented 145.9% of the world per capita CO_2 emissions in 2013. In comparison, China's per capita GDP represented only 17.56% of the world per capita GDP in 2000 and although this figure kept on the increase, it only reached 65.9% in 2013. In 2013, the proportion of China's per capita CO_2 emissions was 2.2 times that of China's per capita GDP. Accordingly, in 2013, China's CO_2 emissions accounted for 27.6% of the world's CO_2 emissions while its GDP accounted for 12.5% of the world's GDP. China have confronted tremendous international pressures in CO_2 emissions and climate change has become a key topic in China's political, economic and diplomatic negotiations.

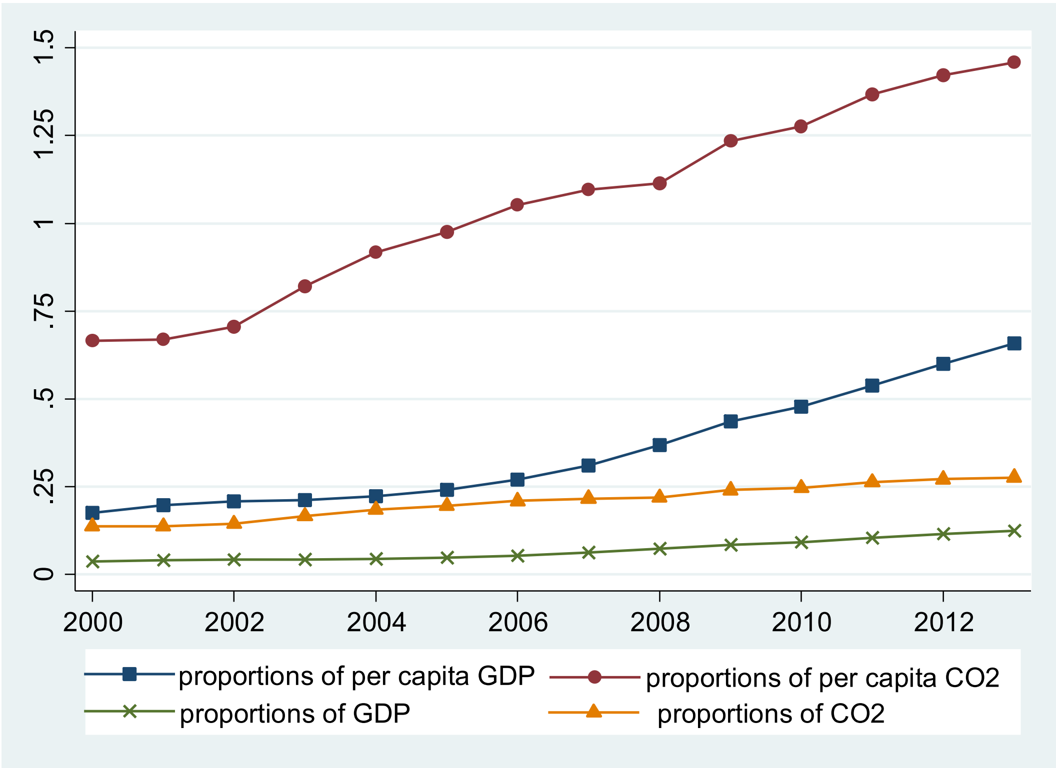

Figure 1: Proportions of China's GDP and Carbon Emissions

Data source: the World Bank, the World Development Indicators Database, http://databank.worldbank.org/.

The Chinese government attaches great importance to climate change and adopted a series of policies and actions, the most important of which is the inclusion of energy conservation and emissions abatement into the evaluation indicators of the target responsibility system. In 2005, the central government decided to initiate energy conservation and emissions abatement on a nationwide scale and introduced the reducing energy intensity by 20% as one of eight binding indicators for the performance evaluation of government officials during the 11th Five-year Plan period (2006-2010). Under fiscal decentralization system, target responsibility system is considered as the most powerful policy arrangement because the evaluation indicators imposed by the central government have a major influence on the decision-making of local officials.

According to the Global Carbon Budget 2014,39.4% of the CO2 emissions comes from coal combustion, 30.0% from oil, 16.7% from natural gas, and in total 86.1% CO_2 emissions from fossil energy combustion（Le Quere *et al*., 2014). Thus energy conservation and CO_2 abatement have a strong collaborative effect. How should we evaluate the contributions of energy conservation to CO_2 abatement? Answering these questions is of great significance for the timely adjustment of performance evaluation system for local government officials, low carbon and sustainable development and international climate negotiations.

2. Literature Review

Climate change brought about by CO_2 emissions has universal and extensive impacts on the world. However, due to their global and indirect impact, CO_2 have not been regarded as a pollutant by various countries over the years. In the recent decade, scholars have paid growing attention to the environmental problems caused by the changing concentration of greenhouse gases such as CO_2 and mainly employed empirical analysis and mathematical modeling methodologies in their respective studies.

Research results of many scholars have confirmed the existence of EKC curve for CO_2 emissions, particularly for OECD countries (Richmond and Kaufmann, 2006; Strazicich and List 2003; Brock and Taylor 2010). However, other studies indicate that under the situation of large samples, convergence does not exist (Nguyen Van, 2005; Aldy 2006). Studies by some scholars have confirmed the existence of the EKC curve of China's CO_2 emissions, believing that an obvious inverted U-shaped relationship exists between CO_2 emissions and economic growth (Xu and Song, 2010; Li and Li, 2010; Zheng and Zhu, 2012; Du, 2010). Some scholars believe that there is an N-shaped relationship between economic growth and carbon emissions (Hu et al., 2008; He and Zhang, 2012). However, other scholars believe that the EKC curve of China's CO_2 emissions has not been demonstrated (Lin and Jiang, 2009; Hu, Liu and Tang, 2013).

There are significant differences in the research conclusions of convergence studies. According to the study by Li and Feng (2014), there is a significant divergence in the national carbon total factor productivity (TFP) but "club convergence" is demonstrated with regards to the technology efficiency between eastern and western regions. Wang, Zhang and Cai (2014) consider that China's carbon emissions intensity is significantly divergent on the whole but the club convergence also exists. Zhou (2014) believes that absolute β convergence of carbon intensity does not exist on a nationwide basis and for central and western regions but conditional β convergence exists and club convergence exists for eastern and north-eastern regions. Xu (2010) considers that absolute β convergence does not exist for China's per capita carbon emissions but conditional β convergence exists and club convergence exists for eastern, central and western regions. Lin and Huang (2011) consider that China's regional carbon emissions demonstrate the characteristic of “convergence of clubs”. Wang, Zhou and Zhou (2010) believe that convergence exists in the CO_2 emissions performance.

In terms of political incentives, GDP growth has been the first and foremost indicator under China’s existing performance evaluation system. Local governments are highly incentivized to support polluting enterprises that generate significant output value and tax revenues rather than imposing environmental regulation upon them. Nevertheless, the target responsibility system of energy conservation and emissions abatement comprises an important basis for the evaluation of provincial-level government leadership, which is subject to the one-ballot veto system. Li, Ma and Qi (2011) believe that the target responsibility system serves as a real and effective environmental constraint on local governments. However, Jia (2014) maintains that local government officials, whose promotion hinges upon rapid economic growth, are highly motivated to attract polluting and energy-intensive industries. Yang et al. (2007) tested the relationship between fiscal decentralization and environmental quality and discovered that an increase in the level of fiscal decentralization has a significant negative impact on environmental quality and that the reform of fiscal decentralization is likely to have reduced local government efforts of environmental regulation. Kevin (2014) holds that although the target responsibility system of energy conservation and emissions abatement have provided local governments with political incentives to pursue low-carbon development, unreasonable configuration of objectives and imperfect statistical system have undermined the policy effectiveness of CO_2 abatement. Central government policies often failed to be fully implemented and in some cases, were even distorted by local governments. Zhang et al. (2011) investigated the relationship between fiscal decentralization and environmental pollution from the perspective of CO_2 emissions. They discovered that the increase in the level of decentralization is unfavorable to the reduction of carbon emissions and that decentralization is likely to compromise government efforts of environmental regulation. Nevertheless, significant differences exist in the impacts of fiscal decentralization on carbon emissions for different provinces with different energy consumption structures, locations and environmental policies.

Target responsibility system as one of the most political system with Chinese characteristics has an important impact on the local officials. With CO2 as the main body of the greenhouse gases has not been identified as pollutants, action to reduce emissions has extensive externalities. So, target responsibility system has a significant effect in promoting local economic growth target responsibility system, whether a significant impact has on CO2 emission reduction is very worthy research topics. that is the starting point and the innovation points of this article.

3. Influence Mechanism

According to the scope of influence, environmental quality can be divided into local public goods and global public goods. In the views of environmental federalism, environmental quality as local public goods should be provided by local governments given that local governments are the most knowledgeable about local constraints and preferences of residents and thus able to internalize environmental quality and costs within the regional scope and provide local residents with environmental quality at the lowest cost (Oates, 2002). Environmental quality as global public goods should be provided by the central government. In this case, environmental quality lacks competitiveness and exclusivity because beneficiaries including all residents of a country and even the world and that cost and benefit internalization cannot be realized for a certain region, local governments tend to take the “free ride”. As typical global public goods, CO_2 abatement must be provided by the central government since local governments are not motivated to do so. However, no one is exempt from such environmental problems as climate change, increasing frequencies of extreme weather, rising sea levels, reducing grain output and extinction of species.

Qian and Roland (1998) believe that administrative decentralization and fiscal decentralization are important drivers of local economic growth. Zhou (2007) offered another explanation that in the promotion championship of local officials, GDP growth rates is the key factor. Fiscal decentralization and the promotion championship are bottom-up political incentives that have compromised local government efforts of environmental regulation and exacerbated environmental pollution (Wang, Zhang *et al.*, 2007; Yang *et al.*, 2007; Tao *et al.*, 2009). Therefore, although energy conservation is covered by the one-ballot veto system, over-fulfillment of this objective cannot add scores to political performance. Rather, it may sacrifice local GDP growth. As a result, local officials still focus on GDP growth as their primary objective and the political incentive of “one-ballot veto” is difficult to be converted into the internal incentive of CO_2 abatement for local governments.

Investment impulse is an important factor for the China’s CO_2 emissions growth while high saving rate provides the foundation for investment impulse. Focusing on CO_2 emissions, Francesconi and Pieroni (2012) created an extended Solow model with interest rate as the only policy variable in order to analyze on the differences between steady states under green rules and golden rules and conclude that without policy intervention, the optimal savings rate under golden rules exceeds the optimal savings rate under green rules. Therefore, they argued that in order to achieve sustainable development, savings rate must be adjusted. Based on the statistics of Latin American and the Caribbean countries, the empirical study indicates that countries with high debt levels have high per capita CO_2 emissions and vice versa and concluded that reducing liability level can lead to CO_2 abatement(Aubourg, Good and Krutilla,2008).

Seven provinces have currently initiated pilot carbon emission trading system programs and the national carbon market is under preparation. Emission trading system allows enterprises to trade carbon emission allowances in the national carbon market. However, this does not change the nature of CO_2 abatement as global public goods and political incentives of the local officials for carbon abatement. Therefore, the central government must set a cap for each province based on current target responsibility system as the basis for evaluating the performance of local officials. Cai *et al.* (2008) also believe that environmental quality requires the institutional design of the central government.

4. Model and Data

4.1 Model

Empirical model of this paper is based on the Green Solow model of Brock and Taylor (2010). In the Brock and Taylor (2010) model, CO_2 is regarded as a byproduct of production activity. The dynamic form of carbon emission function can be expressed as follows:

$$\dot{e}^c \big/ e^c = -g_A + \dot{y}^c \big/ y^c$$

The growth rate of per capita CO_2 emissions equals to the difference between per capita income growth rate and the advancement rate of emissions abatement technology. Based on the above equation, the logarithmic mean value of discrete time section N can be arrived at:

$$(1/N)\log(\dot{e}^c \big/ e^c_{t-N}) = -g_A + (1/N)\log(\dot{y}^c \big/ y^c_{t-N})$$

After logarithmic linearization, we may arrive at the following absolute convergence regression equation:

$$(1/N)\log(\dot{e}^c_{it} \big/ e^c_{it-N}) = \beta_0 + \beta_1 \log(e^c_{it-N}) + \mu_{it}$$

Given that the individual fixed effects such as energy endowment and geographical location of various provinces do not change with time and have certain impacts on CO_2 emissions, we have included known individual effects that do not change with time into the model. Meanwhile, considering that the central government continuously introduces new policies to regulate the environmental quality, we have introduced the yearly dummy variable into the model. In order to comprehensively analyze the determinants of growth rate of per capita CO_2 emissions, we have introduced other control variables into the model. In addition, limited by the regression method of fixed effect model, we are unable to get the coefficient of known individual effect variables. Therefore, based on the research objectives of this paper, we configure the conditional convergence regression equation as follows:

$$(1/N)\log(\dot{e}^c / e^c_{it-N}) = \beta_0 + \beta_1 \log(e^c_{it-N}) + \beta_2 X_{it} + \alpha_i + \lambda_t + \mu_{it}$$

Where, X is the vector set of the control variables, i denotes cross-section data and t denotes the time sequence data, α_i denotes individual fixed effect, λ_t denotes the fixed effect of time and μ_{it} denotes the stochastic disturbance term.

4.2 Data

There is not a direct statistics system for CO_2 emission. As a result, we can only indirectly calculate the CO_2 emissions of each province based on the energy statistics system and emission coefficients of various energy released by the IPCC or the Department of Climate Change of the National Development and Reform Commission (NDRC). Current discussions on the measurement of carbon emissions fall into the following three categories: measurement at energy extraction side, measurement at energy production side and measurement at energy consumption side. There are great controversies in the academia regarding which method should prevail. Nevertheless, measurement at energy consumption side is a common approach widely adopted by various countries. Therefore, this paper has also followed the measurement at the consumption side for both primary energy and secondary energy. Final data of this paper derives from *China Statistical Yearbook* between 2000 and 2014.

The most critical element in the calculation of CO_2 emissions is the emission coefficients of various energy because which is subject to such as the fuel type, combustion technology, operational conditions, control technology, oxidation factor and maintenance quality and equipment age. These data all require site measurement at the corporate level. Therefore, this paper has adopted the reference methodology and parameters in the second volume (energy) of the IPCC Guidelines for National Greenhouse Gas Inventories. Table 1 is a summary of various energy emission coefficients employed in this paper.

Table 1: CO_2 Emission Coefficients of Energies

Energy Types	Raw coal	Crude oil	Natural gas	Coke	Gasoline	Diesel	Kerosene	Fuel oil
IPCC Emission factor ($kgCO_2/TJ$)	94600	73300	56100	107000	69300	74100	71900	77400
Net calorific value in China (kJ/kg)	20908	41816	38931	28435	43070	42652	43070	41816
CO_2 emission coefficient ($kgCO_2/kg$)	1.98	3.07	2.18	3.04	2.98	3.16	3.10	3.24

In order to investigate the effect of regional on the convergence of CO_2 emissions, this paper divides China into regions as eastern, central and western. Different from traditional method is of classification of Liaoning into eastern region and the inclusion of Heilongjiang and Jilin into central region. Eastern region includes the following 11 provinces: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. Central region includes the following eight provinces: Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. And western region includes the following 12 provinces: Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

4.3 Variables

Per capita CO_2 emissions (perCO_2): calculated by dividing the CO_2 emissions by the quantity of permanent residents of each province.

Average growth rate of per capita CO_2 emissions (agr_perCO_2): In a strict sense, convergence of economic growth takes into account the convergence of growth rates rather than per capita GDP. Therefore, in study of CO_2 emissions convergence, growth rates rather than absolute quantities should be adopted. Referencing the approach of convergence studies of economic growth, this paper has adopted the following equation:

$$agr\_perCO2 = (1/N)\log(\dot{e}^{c} / \dot{e}^{c}_{t-N})$$

Savings rate (saving): These is the absence of savings rate in China's statistical system, although this figure can be obtained by per capita disposable income minus consumption and then divided by per capita disposable income, the disposable incomes of urban and rural residents are accounted separately and therefore, the weighted average statistics are not accurate. Hence, this paper adopts capital formation rate as the proxy variable for savings rate.

Capital shallowing (n+g+δ): n is natural growth rate of population. g is the advancement rate of technology, denoted by the growth rate of domestic patent application authorizations. δ is depreciation rate, denoted by the share of fixed asset depreciation in GDP.

Dummy variable (year): Successive introduction of various environmental regulation policies by the Chinese government at different levels will inevitably affect CO_2 emissions. Therefore, we employ the yearly dummy variable to capture such a continuous policy effect.

Energy intensity (energy/GDP): It is denoted by the standard coal equivalent consumed for the production of each unit of GDP to reflect energy utilization efficiency.

Energy intensity decreasing target (target): It is used to stand for the pressure of energy conservation which is denoted by the energy intensity decreasing target set central government for local government in target responsibility system.

Fuel price index (price): rising fuel price will increase the production cost and thus incentivize manufacturers to increase energy efficiency and ultimately reduce CO_2 emissions. This indicator reflects the impact of fuel price variations on CO_2 emissions.

4.4 Estimation Method

Panel data possess the advantages of expanded information quantity, increased freedom of test statistics and reflection of the gradual changes of economic structure and economic system, which have drawn extensive attention from researchers. In the configuration and application of panel data, it is necessary to assess and test whether error decomposition satisfies fixed effect or stochastic effect. However, the academia never stopped arguing about which method should be adopted. Before conducting regression, this paper also configures stochastic effect regression model for B-P test (chi-square value is 116.45) and result rejects the null hypothesis Var(u) = 0, which indicates the existence of disturbance and justifies the employment of stochastic effect model.

5. Regression Results

5.1 β Convergence

In Table 2, we have presented the regression results of absolute convergence and relative convergence. In the first column, the beginning per capita CO_2 emissions are the only explanatory variable, which has a significantly negative coefficient and passes 1% significance level test. This indicates that provinces with high beginning per capita CO_2 emissions have relatively low average growth rates and β absolute convergence exists in the per capita CO_2 emissions. From equation (2) to equation (5), we have respectively introduced such control variables as savings rate, capital shallowing, energy intensity, target indicators, fuel price index and dummy variable of time without altering the coefficient and significance of logperCO_2_2000. Thus, β conditional convergence exists in China's per capita CO_2 emissions.

Table 2: Regression Results of Absolute Convergence and Relative Convergence

Equations	（1）	（2）	（3）	（4）
Explained variables	agr_perCO2	agr_perCO2	agr_perCO2	agr_perCO2
logperCO2_2000	−0.013***	−0.021***	−0.021***	−0.024***
	(−6.28)	(−7.06)	(−12.06)	(−11.71)
logsaving		0.069***	0.065***	0.045***
		(5.39)	(8.84)	(4.53)
log(n+g+δ)		−0.013	−0.015**	−0.020***
		(−1.22)	(−2.39)	(−3.41)
energy/GDP				0.005**

				(2.52)
target				0.001**
				(2.5)
logprice				-0.005
				(-0.12)
2000.year			0	
			(.)	
2001.year			0.004	
			(0.83)	
2002.year			0.009*	
			(1.91)	
2003.year			0.022***	
			(4.47)	
2004.year			0.032***	
			(6.63)	
2005.year			0.043***	0
			(8.8)	(.)
2006.year			0.051***	0.005
			(10.57)	(1.16)
2007.year			0.060***	0.008
			(12.29)	(1.58)
2008.year			0.063***	0.009**
			(13.04)	(2.29)
2009.year			0.068***	0.009
			(13.93)	(1.07)
2010.year			0.075***	0.012***
			(15.34)	(2.87)
2011.year			0.083***	0.015***
			(17.0)	(3.67)
Constants	0.050***	-0.153**	-0.173***	-0.05
	(17.01)	(-2.44)	(-4.82)	(-0.26)
Samples	356	356	356	209
Wald chi^2	39.47	66.07	950.53	239.70

Note: Numbers in brackets are z values; *denotes p<0.1, **denotes p<0.05 and *** denotes p<0.01; ln denotes that natural logarithm is adopted for the variable. Software employed in this paper is Stata SE 13.1.

In Table 2, we may see that with the gradual inclusion of control variables, the coefficient of savings rate remains significantly positive and relatively stable and passes 1% significance level test. Under the political system of fiscal decentralization and political performance championship, local governments have a strong investment impulse and investment level of provinces with high capital formation rate, is relatively high, which is consistent with the conclusions of Brock and Taylor (2010). For regression equations (3) to (5), the coefficient of capital shallowing is significantly negative, which indicates that CO_2 emissions of provinces with a high capital shallowing are relatively limited.

5.2Target Responsibility System

In equations (4), energy intensity with significantly positive coefficient, which demonstrates that for provinces with high energy intensity, the growth rate of per capita CO_2 emissions is high as well. The reason is that for provinces with high energy intensity, the production of each unit of GDP requires more resources, i.e. energy efficiency is relatively low. Table 2 shows that target of energy intensity decreasing is significantly positive, which means the greater target, the higher per capita CO2 emissions growth rate. This is because the target setting is to consider the result of many factors. In regression equation (4), we have introduced fuel price index, which has no significance. Theoretically speaking, with the rise of resource prices, enterprises tend to conserve energy consumption under cost considerations. However, central government guidance price for energy is the reason of increasing energy prices has no significant effect on carbon emissions.

In regression equations (3) to (4), we have included the dummy variable of year and given that statistics for energy intensity indicator are available only after 2005, the dummy variable of year in equation (4) is 2005-2011. In equation (3), the year of 2000 is taken as the benchmark with the value of zero. From 2003 to 2011, the coefficient of dummy variables of year is significantly positive, which indicates that compared with 2000, the growth rate between 2003 and 2011 is on the increase. In order to more accurately reflect the changes of coefficient, we have calculated the first-order difference of the dummy variable coefficient, i.e. $\Delta coef_t = coef_t - coef_{t-1}$, with relevant results shown in Figure 2. Although the coefficient between 2003 and 2008 is positive compared with 2000, the first-order difference of coefficient kept on the decrease, which indicates a decreasing time trend. In the context of maintaining growth as the top political priority after the financial crisis, many energy intensive projects have re-emerged and the first-order difference of the coefficient swerved to increasing time trend.

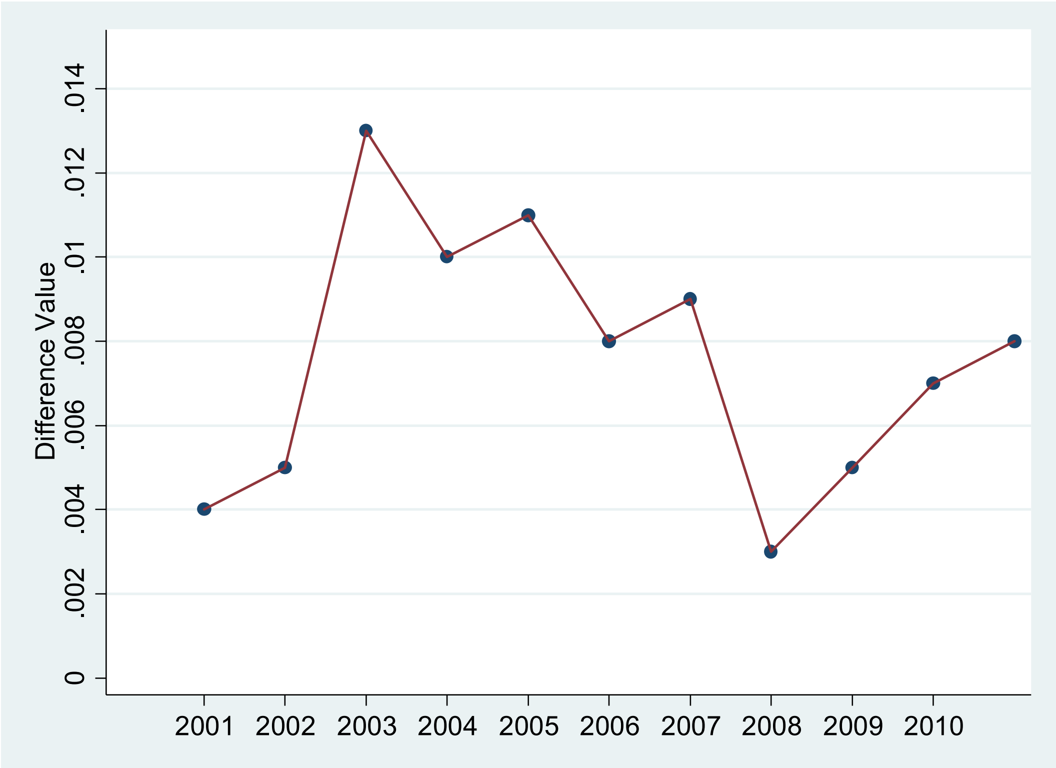

Figure 2: Difference Value of the Coefficient of Time Variables

Although the coefficient is positive, first-order difference of coefficient shows decreasing time trends from 2003 to 2008. During the "Tenth Five-year Plan" period, from 2002 to 2003, the per capita CO2 emissions increasing trend is very obvious. During the “Eleventh Five-year Plan”, due to the implementation of the target responsibility system for energy conservation, there is obvious decline from 2005 to 2006. After the financial crisis, the growth was taken as the first priority political goal, a lot of energy project resurge, first-order difference of coefficient turn around to rise from 2009 to 2011. Evidently, CO2 emissions are not only the energy problem but also a development issue. In conclusion, the energy intensity could reduce the growth rate of per capita CO2 emissions, which has remarkable effect on the convergence of the CO2 emissions. However, the target of energy intensity decreasing does not promote the convergence of per capita CO2 emissions, which is a departure from the principle of design.

6. Robustness Test

Analytical conclusions of the econometric model could be sensitive to the variations of model and data, which makes is necessary to conduct robustness test. Robustness test means the discussion of whether regression results will change with sample capacity, model configuration and variable selection. Therefore, the basic approach of robustness test in this paper is to test whether significant changes when adjust sample capacity. As we have already observed from Table 4, altering the time scope of samples or including additional control variables will not change the symbol and significance of the logperCO_2_2000 and logsaving.

Neumayer (2004) discovered that geographical location has a major impact on the convergence of CO_2 emissions. Results of some studies have also confirmed the effects of different geographical locations on the convergence of CO_2 emissions (Li *et al*., 2014; Wang, *et al*., 2014; Zhou, 2014; Xu, 2010). Therefore, following the latest classification method of the NBS, this paper has divided China into eastern, central and western regions. In Table 3 and Table 4, we have demonstrated the regression results of absolute convergence and conditional convergence. As far as regional grouping is concerned, the significance of beginning per capita CO_2 emissions logperCO_2_2000 is the highest for the eastern region, followed by the central and western region with a diminishing trend from the eastern to western regions. Nevertheless, the coefficient is insignificant for the western region, which indicates that the eastern and central regions demonstrate absolute convergence, which is not the case for the western region.

Table 3: Regression Results of Absolute Convergence Based on Regional Grouping Methods

Explained variable Region	agr_perCO2 Eastern	agr_perCO2 Eastern	agr_perCO2 Western
logperCO2_2000	−0.025*** (−8.62)	−0.006* (−1.80)	0.004 (0.83)
Constants	0.066*** (14.10)	0.038*** (8.35)	0.035*** (6.32)
Samples	130	96	130
Wald chi^2	74.33	3.23	0.69

Note: Numbers in brackets are z values; *denotes $p<0.1$, **denotes $p<0.05$ and *** denotes $p<0.01$; ln denotes that natural logarithm is adopted for the variable. Software employed in this paper is Stata SE 13.1.

As can be seen from Table 3, the eastern, central and western regions have all displayed relative convergence. The coefficient of savings rate demonstrates a significant positive correlation in the eastern and western region. The coefficient of savings rate is positive but insignificant for the central region. Capital shallowing demonstrates a significant negative correlation in all groupings. The coefficient of energy intensity coefficient displays a positive significance in the eastern and central region but insignificance in the western region. The coefficients of energy intensity decreasing target are positive and significant in the western region. Thus, in the eastern and central region, energy intensity is more binding, while in the western region energy intensity decreasing target is relatively more binding. Price index of energy products has no significance as well. Coefficient of the dummy variables of year basically has positive significance since 2006. Regression results based on groupings demonstrate once again that the model’s robustness is relatively high and does not change greatly with the alteration of sample quantity.

Table 4: Relative Convergence Regression Results by Regional Groups

Explained variable Region	agr_perCO2 Eastern	agr_perCO2 Eastern	agr_perCO2 Western
logperCO2_ 2000	−0.041*** (−15.84)	−0.031*** (−14.22)	−0.047*** (−9.15)
logsaving	0.030** (2.47)	0.005 (0.49)	0.163*** (14.74)
log(n+g+δ)	−0.044*** (−4.08)	−0.025*** (−4.73)	−0.076*** (−13.35)
energy/GDP	0.046*** (7.9)	0.026*** (9.9)	0.0004 (0.18)
target	0.001 (1.57)	0.001 (0.33)	0.009*** (10.45)
logprice	−0.035 (−0.82)	−0.043 (−1.47)	−0.015 (−0.44)
2006.year	0.005 (1.25)	0.007** (2.3)	0.005* (1.71)
2007.year	0.01 (1.75)	0.014*** (3.2)	0.008* (1.82)
2008.year	0.014*** (3.13)	0.010*** (3.73)	0.012*** (3.57)
2009.year	0.009 (0.94)	0.021*** (3.13)	0.01 (1.57)
2010.year	0.019*** (4.13)	0.018*** (6.0)	0.013*** (3.97)
2011.year	0.026*** (5.19)	0.028*** (8.22)	0.017*** (4.86)
Constants	−0.089 (−0.40)	−0.113 (−0.73)	−0.393** (−2.32)
Samples	77	56	70
Wald chi2	472.27	292.48	368.98

Note: Numbers in brackets are z values; * denotes p<0.1, ** denotes p<0.05 and *** denotes p<0.01; ln denotes that natural logarithm is adopted for the variable. Software employed in this paper is Stata SE 13.1.

7. Concluding Remarks

This paper first elaborates the mechanism of relationship between target responsibility system and the convergence of CO_2 emissions. China's political system is characterized by administrative decentralization, fiscal decentralization and the promotion championship. Because of the high capital formation rate and global public goods, the target responsibility system including energy intensity in evaluation indicator has a limited contribution to the convergence of China's per capita CO_2 emissions, which remains subjected to economic growth targets. Later, using interprovincial panel data, this paper compared the convergence of CO_2 emissions during the "10th Five-year Plan" (2001-2005) and the "11th Five-year Plan" (2006-2010) and arrived at the following conclusions:

China's per capita CO_2 emissions demonstrate absolute β convergence and conditional β convergence. The eastern and central regions demonstrate absolute conditional convergence while the western region displays conditional convergence but does not satisfy absolute convergence. Although the coefficient is significantly positive, energy intensity as an indicator in the target responsibility system largely subjects to the GDP growth target. The provinces which capital formation rate is relatively high, the growth rate of per capita CO_2 emissions is high. Investment impulse is a major factor affecting the CO_2 emissions convergence.

The Chinese government attaches great importance to the work on climate change and successively introduced such policies as pilot programs of low-carbon provinces, low-carbon cities and carbon trading. In 2006, the Chinese government introduced energy intensity into the target responsibility system. Nevertheless, on account of CO_2 abatement as typical global public goods, the costs and benefits of abatement cannot be internalized in specific administrative regions and local governments do not have strong political and economic impetus to engage in CO_2 abatement effort. In order to achieve low-carbon development, the Chinese government must improve the current evaluation indicator of target responsibility system by changing the relative indicator of carbon intensity into the absolute ones and set cap on the CO_2 emissions growth for local governments.

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