

# The Economic Analysis of the Carbon Emissions: Evidence From China

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**Abstract.** Carbon emissions exacerbate global climate change. As is known, transitioning away from coal is a cost-effective path to a low-carbon economy. In recent years, China faces the challenge of reducing the carbon intensity of its economy while also fostering economic growth. Undoubtedly, China's CO<sub>2</sub> emissions are directly related to the stages of economic development. According to the statistics of the International Energy Agency and China's Statistical Yearbook, China's CO<sub>2</sub> emissions in 1984 were about 1.76 billion tons. However, from 1984 to 1996, CO<sub>2</sub> emissions showed an upward trend. It is worth noting that in 1997, China's CO<sub>2</sub> emissions began to decline due to the Asian financial turmoil. In 1999, CO<sub>2</sub> emissions were 2.92 billion tons. Since then, with the recovery of China's economy and the growth of energy demand, it reached a record high of 9.19 billion tons in 2013. But after 2014, CO<sub>2</sub> emissions began to decline again. Although many articles have discussed the issue of economic growth and pollutants. Few papers focused on the impact of environmental protection tax, and pollution fee levy on the cost of environmental degradation. This paper seeks to fill this gap by developing a theoretical model discussing the relationship between carbon emission and economic growth. In this paper, we take China as a case to discuss the effect. However, due to China has formally levied environmental protection tax since 2018, only one year's data is available, in order to observe the interaction between carbon emission and economic growth, we utilize vehicle purchase tax, which is relevant to environmental pollution, as an alternative for environmental tax data.

**JFL classification:** H23, H26, P43, Q53

## 1. Introduction

Panayotou(1997) catches data from 30 countries from 1982 to 1994, finding that low-income policies had a positive effect on improving the environment, with the increase of income level, the effect became more obvious, that is to say, the faster the economic growth, the higher the population density, the higher the environmental cost of economic growth(some examples are Zoundi 2017)[1,2]. However, there is also a broad literature that supports the EKC hypothesis. Bruyu(1997) selectes data from developed countries in the 1980s to discuss, which show that changes in economic structure had no significant effect on SO<sub>2</sub> emissions, but in the high-income stage, environmental policies formed by international agreements could well explain the negative correlation between environment and income[3]. Grossman(1995) regards urban air pollution and oxygen content in river water as environmental indicators. Through regression analysis, it is concluded that economic growth causes deterioration of environmental indicators in the low-income stage, and improves with economic growth in a certain stage, and the inflection point occurs at the income level of \$8,000 (some examples are Sherry 2008, Gurluk 2009)[4,5]. In addition, Menyah and Wolde-Rufael(2010) examine the causal relationship between economic growth, pollutant emissions and energy consumption for South Africa, suggesting that South Africa has to sacrifice economic growth or reduce its energy consumption in order to reduce pollutant emissions[6]. Harbaugh et al.(2002) show that the relationship between economic growth and environmental pollution is not only influenced by economic factors, but also by sample selection and research

methods[7]. Consider that China is the most populous country in the world, and its economy has been growing rapidly in recent decades. In this paper, we take China as an example and establish theoretical and empirical models estimating whether the current carbon emissions have reached the critical inflection point.

## 2. Methodology

We use statistical methods to check the existence of the Kuznets Curve and where the Kuznets Curve is located in China's air pollution emissions and GDP data over the past 27 years. If the Kuznets Curve does not exist, it means that with economic growth, environmental pollution emissions will increase and the environment will continue to be destroyed. As we know, most of China's energy needs are directly derived from coal and most of coal consumed on the China is mined in China itself. According to the International Energy Agency data of main energy supply in China from 1990 to 2016, coal supply in total energy has been the highest. Taking 1990, 1995, 2000, 2005, 2010, 2015 and 2016 as examples, energy supply from coal are measured in Ktoe, and its proportion in total energy (bracketed data) are 530, 516 (61%), 648, 032 (62%), 664, 720 (59%) and 1,203,693 (68%), 1,790,421 (71%), 1,996,620 (67%) and 1,916,209 (65%) respectively. Clearly, how to reduce the proportion of coal supply to all energy supply is the keypoint to reduce carbon emissions.

In contrast with the traditional method, this article is aimed at examining the relationship between carbon emissions, vehicle purchase tax, and pollution fee levy by using empirical approach, where carbon emissions are measured in MtCO<sub>2</sub>, vehicle purchase tax and pollution fee levy are measured in RMB ten thousand yuan and RMB one hundred million yuan, respectively. The datas about CO<sub>2</sub> emissions, population, GDP, TPES and coal supply came from the International Energy Agency, the vehicle purchase tax and pollution fee levy data collected from National Bureau of Statistics of China. However, vehicle purchase tax is consumption tax, as we know, even though vehicle purchase tax is levied, the demand for oil products will not decrease significantly, and thus the purpose of alleviating air pollution will not be achieved. Whereas pollution fee levy is a penalty levied on polluters who directly emit air pollution, such an approach accords with the polluter-pays principle. We adopt Kuznets curve analyzing the relationship between environmental degradation costs and economic growth in China. In Table 1,  $\ln\text{Loss}$  variable indicates the logarithm of environmental degradation cost caused by air pollution, mainly related to carbon dioxide emissions.  $\ln\text{CO}_2$  is the logarithm of carbon dioxide emissions measured in Mt,  $\ln\text{GDP}$  represents the logarithm of gross national product measured in billion 2010 USD, and  $(\ln\text{GDP})^2$ , using a quadratic form means that we can determine the location and curvature of Kuznets Curve,  $\ln\text{Coalsupply}$  denotes the logarithm of energy supply from coal measured in Mtoe,  $\ln(\text{TPES}/\text{GDP})$  represents all major energy supplies as a percentage of GDP,  $\text{TPES}/\text{POPULATION}$  depicts all major energy supplies as a percentage of POPULATION,  $\ln\text{EMISSIONFEELEVY}$  is the logarithm of penalty for pollution discharge, and  $\ln\text{VEHICLEPURCHASETAX}$  depicts the logarithm of the purchase tax of vehicles. In model 2 of Table 1, we add  $\ln\text{COALSUPPLY}$  variable on the basis of model 1, while other models add different variables separately.

## 3. Empirical Results

To illustrate the environmental degradation costs and economic variables, the analyses can be stated formally as follows.

Case 1: In model 1 of Table 1 showing there is an inverted U-shaped relationship between the cost of environmental degradation and GDP in China, and the AR (1) and AR (2) coefficients obtained through the model after revising the second-order autocorrelation pass the 1% significance test. Further, we find that not considering the impact of other variables on carbon dioxide emissions, China's GDP growth in 2016 has already exceeded the inflection point. According to model 1 of table1, the inflection point of the quadratic curve is 3.824, whereas, China's GDP in 2016 is 9,505 measured in US\$ one billion, based on 2010, the logarithmic value of 9,505 is

9.159573. This suggests that not considering the effects of other policies, the current economic development of China has exceeded the inflection point of the Kuznets Curve.

Case 2: In model 2 of Table 1, we see the regression coefficient of  $\ln\text{COALSUPPLY}$ , denoting energy from coal, is 0.774558, reaching a significant level of 1%. Due to the positive sign of the coefficient, denoting that the increase of coal supply further enhances the cost of environmental degradation to a certain extent.

Case 3: In model 5 by adding  $\text{TPES/POPULATION}$  variable into model 1, showing the corresponding regression coefficient is 0.230068. The coefficient passes the 10% significance test, depicting that the increase of the total energy supply per person, to a certain extent, may result in the increase of  $\text{CO}_2$ , accelerating the cost of environmental degradation.

Case 4: In model 3 by adding  $\ln\text{POPULATION}$  variable into model 1, the corresponding regression coefficient is  $-17.28379$ , which passes the 1% significance test, the  $\ln\text{POPULATION}$  variable of model 8 has a corresponding regression coefficient of 4.578423. The coefficient only passes the 10% significance test, depicting that if the impact of population on the cost of environmental degradation is chosen solely, they are negatively correlated, but if population and other independent variables are included in the model concurrently, the impact of population on the cost of environmental degradation is positively correlated. Through model 3 and model 8, showing that the increase of population is not the main keypoint for the increase of the cost of environmental degradation in China. It may be that if a country continues to develop low-carbon energy resources such as wind, solar energy and hydropower, then even if the population increases significantly, a country's carbon emissions will probability alleviate.

Case 5: In model 6 by adding  $\ln\text{EMISSION FEE LEVY}$  variable on the basis of model 1, the corresponding regression coefficient is 0.530869, which does not pass the 10% significance test. However, if  $\ln\text{EMISSION FEE LEVY}$  and other independent variables are included in model 8 concurrently, the impact of emission fee levy on the cost of environmental degradation represents a corresponding regression coefficient of 0.077042, passing the 5% significance test. It denotes Chinese penalties for environmental pollution in recent years can not reduce the environment degradation costs, which may be one of the reasons why China had replaced penalties with environmental protection taxes since 2018.

Case 6: Model 7 of Table 1 is based on Model 1 plus  $\ln\text{VEHICLE PURCHASE TAX}$ , the corresponding regression coefficient is 0.144742, passing the 10% significance test. However, in model 8, the corresponding regression coefficient of  $\ln\text{VEHICLE PURCHASE TAX}$  is  $-0.008775$ . Due to the taxation of vehicle purchase in China is mainly imposed on the users of taxable vehicles in the consumption link, that is, those with higher consumption ability bear more taxes than those with lower consumption ability. In Model 7 and model 8, however, we show that the taxation of vehicle purchase has no significant effect on reducing the cost of environmental degradation.

Case 7: In model 8 of Table 1, incorporating variables that affect carbon emissions into analysis. Empirical results express that the logarithm of GDP of model 8, Table 1, in 2016 is 9.15, which has not yet reached but is approaching the turning point of the Kuznets Curve 10.02. In other words, consider the non-linear growth of GDP, the cost of environmental degradation in China is increasing. In sum, in Table 1, we show that the model 1, model 5, model 6, and model 7 are convergence function. However, the model 2, model 3, model 4 and model 8 are divergent function, which have not reached the inflection point of the Kuznets curve, indicating that with the growth of China's GDP, environmental pollution will not be automatically improved for the time being.

Table 1. Regression analysis of environmental degradation cost.

Independent variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
ln GDP	-0.633768 (-1.163962)	0.193446 (1.460805)	5.576340* (4.957335)	1.897956* (12.92399)	-0.199397 (-0.359905)	-3.797532* (-4.032505)	8.180981* (8.249898)	-5.255635* (-5.548564)
(ln GDP) <sup>2</sup>	0.082856** (2.432931)	-0.001710 (-0.192161)	-0.224783* (3.920254)	-0.044522* (-5.321973)	0.048377 (1.337284)	0.245242* (4.615193)	-0.451602* (-7.929695)	0.262291* (5.192822)
ln COAL-SUPPLY		0.774558* (20.58857)						1.407807* (9.484629)
lnPOPULATION			-17.28379* (-5.816013)					4.578423*** (2.184505)
ln(TPES/GDP)				1.249412* (24.80402)				-0.550272** (-2.835023)
TPES/POPULATION					0.230068** (2.044252)			0.012321 (1.193907)
lnEMISSION FEE LEVY						0.530869 (5.508365)		0.077042** (3.443810)
lnVEHICLE PURCHASE TAX							0.144742** (1.934957)	-0.008775 (-0.367507)
AR(1)	1.309846* (6.513925)	-0.191329* (-0.554599)	0.997779* (5.097859)		1.306810* (6.252795)	1.262288* (4.232701)	1.064240* (3.697230)	-1.656154** (-5.165148)
AR(2)	-0.493201* (-2.255023)			-0.594127** (-2.626970)	-0.496795* (-1.940219)	-0.582980** (-1.766222)	-0.752304* (-4.548959)	-0.900716** (-4.187646)
D-Wstat	0.283584	1.795465	0.582877	2.298624	0.470959	0.890492	0.883543	3.351773
Adjusted-R <sup>2</sup>	0.973502	0.998741	0.988809	0.999004	0.976325	0.988069	0.990605	0.999848
$\gamma^*$ (inflection point of KC)	3.824514	56.56315	12.403829	20.985802	2.0608657	7.742417	9.057733	10.018710

Notes: 1. Variables in logarithmic form; \*, \*\*, \*\*\* stand for at 1%, 5% and 10% significance level; The number in brackets is the t-statistic of the estimated parameter. 2. the logarithm of GDP in 2016 is 9.159573. 3. The data about CO<sub>2</sub> emissions, population, GDP, TPES and coal supply came from the International Energy Agency, the vehicle purchase tax and pollution fee levy data collected from National Bureau of Statistics of China.

Table 2 shows that the peak level of model 2 and model 4 are far from the actual situation, indicating that there do not exist Kuznets curve in the case of model 2 and model 4.

Table 2. The number of years required to reach the EK inflection point.

Independent variable	Model 1		Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Existence of Kuznets Curve or not	Yes		No	Yes	No	Yes	Yes	Yes	Yes
At present, CO <sub>2</sub> emissions are on the left or right side of Kuznets Curve inflection point.	Right			Left		Right	Right	Right	Left
N* (the time required to reach the Kuznets Curve inflection point : unit year)				34.6					9.2

#### 4. Conclusions

In comparison with traditional literature, the major findings of this study indicated the following results. Firstly, we find that not considering the effects of government policies, the current economic development of China has exceeded the peak of the inflection point of the Kuznets curve. It means that the further growth of economic scale will not lead to the worsening of environmental quality. Secondly, if we insert relevant variables affecting carbon emissions into analysis. It shows that the current economic development of China has not yet reached but is approaching the inflection point of the Kuznets Curve. In other words, consider the non-linear growth of GDP, the cost of environmental degradation in China is increasing, in this case, it will take 9.2 years to reach the turning Point of Kuznets Curve.

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