An Empirical Analysis of the Impact on Carbon Emissions of China's Urbanization

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Abstract. This paper researches the influence factors of carbon emissions from the perspective of the China's urbanization. Firstly, based on the STIRPAT model, the paper builds a relational model of carbon emissions and urbanization. And then it uses the China's annual time series of urbanization, per capita GDP, energy intensity and carbon emissions from 1990 to 2011, to study the long-term equilibrium relationship between China's carbon emissions and urbanization level by Cointegration test and Granger-causality test. Finally, according to the analysis results, this paper gives some conclusions and policy advices.

Introduction

Along with China's rapid economic growth and urbanization is the rapid increase of carbon emissions. Especially as China's urbanization speeding up, more and more rural populations migrate to cities. Rural land convers to urban land and the carbon balance of payments is out of balance. China's urbanization will bring more carbon emissions of industries and service industry and bring more energy consumption. Meanwhile urban expansion would destroy some areas of farmland, indirectly reduce the nature's absorption of carbon dioxide and bring some environmental problem [1].

Due to the increasing growth of carbon emissions, how to balance promoting urban development and protecting the environment is a very important concern for governments departments. This paper researches the influence factors of carbon emissions from the perspective of the China's urbanization. Firstly, based on the STIRPAT model, the paper builds a relational model of carbon emissions and urbanization. And then it uses the China's annual time series of urbanization, per capita GDP, energy intensity and carbon emissions from 1990 to 2011, to study the long-term equilibrium relationship between China's carbon emissions and urbanization level by Cointegration test and Granger-causality test. Finally, according to the analysis results, this paper gives some conclusions and policy advices.

Theory Model

This paper's theory model is based on the STIRPAT model[2,3], the form of the model is as follows:

$$I = P^\alpha A^\beta T^\theta \tag{1}$$

In Equation 1, I is pollution levels, namely carbon level C; P refers to the population, the total population variables is expressed by the urbanization level "urb"; A refers to the level of economic development, which is expressed by per capita GDP "y"; T refers to the technical level, which is represented by energy intensity "ei"[2,3].

To test the relationship between urbanization and China's carbon emissions, this paper takes the logarithm on both sides of Equation 1, and then get the Equation 2 as follows:

$$lnC_t = \gamma + \alpha lny_t + \beta lnurb_t + \theta lnei_t + \varepsilon_t \tag{2}$$

In Equation 2, I_t indicates the level of carbon emissions of the phase t, P_t refers to the proportion of urban population, A_t means per capita GDP, T_t is expressed in energy intensity, t refers to the year, ε_t means the random error[2,3].

Model Variables

The model variables in this research including: Urbanization rate, Carbon emissions, Per capita GDP, Energy intensity.

(1) Urbanization rate. The paper use the proportion of urban population to measure the level of urbanization.

(2) Carbon emissions, which is expressed by "C". Its calculated formula is as follows[4]:

$$C = \sum_t m_t * \delta_i \tag{3}$$

$$m_t = F_i * E \tag{4}$$

In Equation 3 and 4, m_i stands for i kind of energy consumption, E stands for the total energy consumption, F_i stands for the ith kind of energy consumption accounts for the proportion of total consumption, δ_i stands for coefficient of carbon emissions of ith kind of energy[4].

(3)Per capita GDP, which is expressed by "y".

(4)Energy intensity, the ratio of the total energy consumption and GDP, which is expressed by "ei".

The research's data are from China statistical yearbook, China regional statistical yearbook, China energy statistical yearbook from 1990 to 2011.

Empirical Analysis

The paper mainly uses Cointegration test and Granger-causality test to do the empirical analysis.

The stationarity test of series
For lnC, lny, lnurb and lnei, the research does the Stationarity test of series and their difference series firstly. The results of test are shown in Table 1.

Table 1 Stationarity test of series

	ADF value	P value	1% critial value	5% critial value	10% critical value	Stationary or not
lnC	0.566520	0.9845	-3.831511	-3.029970	-2.655194	nonstationary
lny	0.649999	0.9867	-3.886751	-3.052169	-2.666593	nonstationary
lnurb	-0.702377	0.8243	-3.808546	-3.020686	-2.650413	nonstationary
lnei	-2.022693	0.2755	-3.808546	-3.020686	-2.650413	nonstationary
ΔlnC	-1.797062	0.3710	-3.808546	-3.020686	-2.650413	nonstationary
Δlny	-0.595392	0.4467	-2.685718	-1.959071	-1.607456	nonstationary
Δlnurb	-2.071645	0.2569	-3.808546	-3.020686	-2.650413	nonstationary
Δlnei	-1.773238	0.3819	-3.808546	-3.020686	-2.650413	nonstationary

$\Delta^2 \ln C$	-3.401248	0.0241	-3.831511	-3.029970	-2.655194	stationary
$\Delta^2 \ln y$	-3.222387	0.0388	-3.959148	-3.081002	-2.681330	stationary
$\Delta^2 \ln ur$	-4.562240	0.0022	-3.831511	-3.029970	-2.655194	stationary
$\Delta^2 \ln ei$	-4.437367	0.0028	-3.831511	-3.029970	-2.655194	stationary

Cointegration test

First, the research uses OLS method to do the parameter estimation, and gets the result as follows:

$$lnC_t = -0.9709 + 1.0298 lny_t + 0.1176 lnurb_t + 1.0293 lnei_t$$
$$t = (-5.8850) \quad (50.6052) \quad (2.59438) \quad (48.4437)$$
$$R^2 = 0.9995 \quad F = 12382.45 \quad D.W = 0.9101$$

Then based on the residual sequence, the research uses the ADF test to infer the stationarity of random error term, the test result is shown in Table 2.

Table 2 Cointegration test

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.007320	0.0047
Test critical values: 1% level	-2.685718	
5% level	-1.959071	
10% level	-1.607456	

The test result t=-3.0073 indicates that, the total carbon emissions has a long-term equilibrium relationship with per capita GDP, urbanization rate, energy intensity.

Eliminate the serial correlation

According to the result of OLS regression, explanatory variables are passed the T test, but the DW value is very small. It indicates that the models are related. Using Cochrane-Orcutt iterative method to modify the original model, the results could be obtained as follows.

$$lnC_t = -1.3082 + 1.0366 lny_t + 0.1615 lnurb_t + 1.0728 lnei_t + 0.5776 AR$$
$$t = (-4.294) \quad (34.9825) \quad (2.4535) \quad (25.9960) \quad (3.1457)$$
$$R^2 = 0.9997 \quad F = 13808.58 \quad D.W = 1.997$$

DW=1.997 shows that the autocorrelation of equation has been eliminated. The results indicate that GDP per capita, urbanization rate, energy intensity and carbon emissions are positively related. 1% growth in urbanization rate, will cause 0.1615% growth in carbon emissions, 1% growth in GDP per capita and 1.0366% growth in total carbon emissions respectively. 1% growth in energy intensity, will cause 1.0728% growth in total carbon emissions.

Granger-causality test

The paper uses the Granger-causality test to test the causal relationship between total carbon emissions and urbanization rate, the test result is shown in Table 3.

The results shows that, the hypothesis "lnU is not lnC's Granger reason" could not be rejected in the F test, which means urbanization is the cause of the sustainable growth of carbon emissions; the

hypothesis "lnC is not lnU's Granger reason" could be rejected in the F test, which means carbon emissions is not a motivating factor of urbanization.

Table 3   Granger-causality test

Null Hypothesis:	Obs	F-Statistic	Prob.
LNURB does not Granger Cause LNC	20	7.76766	0.0048
LNC does not Granger Cause LNURB		0.18145	0.8359

Conclusions

This paper studies the long-term equilibrium relationship between China's carbon emissions and urbanization level by Cointegration test and Granger-causality test with the data from 1990 to 2011. Through the above analysis, this research formed the following conclusions:

Empirical analysis indicates that GDP per capita, urbanization rate, energy intensity and carbon emissions are positively related. 1% growth in urbanization rate, will cause 0.1615％ growth in carbon emissions, 1％ growth in GDP per capita and 1.0366％ growth in total carbon emissions respectively. 1％ growth in energy intensity will cause 1.0728％ growth in total carbon emissions. It also shows that total carbon emission is effected not only by the current period elements but also by the earlier state ones. And the current period carbon emissions may be influenced by the use habit of energy such as the current stage wealth level, urbanization, energy efficiency, etc. In the long term, the great influence of the urbanization level in China on the carbon emissions level after the reform and opening-up proves that urbanization is one of the important elements that cause the increase of the carbon emissions in China. Granger test indicates that urbanization is the cause of the sustainable growth of carbon emissions which is not a motivating factor of urbanization.

Low carbon-emissions will not necessary hinder the economic development. The governments departments can, through shaping healthy and civilized consumer culture and so on, achieve the sustainable development ultimately, and lessen the effect of the urbanization on environment.

Acknowledgements

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