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Analysis the Impact of Urbanization on Carbon Emissions Using the Stirpat Model in Tianjin, China

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Abstract: The study uses STIRPAT model incorporating ridge regression to analysis the impact of various factors on carbon dioxide emission,especially the factor of urbanization.The results show that population and industial structure have the most important impact on carbon emissions and urbanization increases carbon enissons directly in Tianjin city.According the analysis,the study offers some suggestion to control and reduce the carbon emission in Tianjian.and provides policy reference for the development of low carbon economy in Tianjin.

Key words: Carbon emissions, urbanization, STIRPAT model, tianjin city

INTRODUCTION

Since the reform and opening up policy, China's urbanization has been developed quickly. According to the data of National Bureau of Statistics, China's urban population has jumped from 17.92% (1978) to 51.27% by the end of 2011. Rapid urbanization has posed some tremendous challenges. First ,food must be transported to urbanized populations and relatively smaller agricultural populations must modermize,entailing considerable increases agricultural energy use.Second ,more and more rural people will move to cities and shift to using modern energy sources.Moreover,large infrastructure such as housing,transportation,must consequently be created,which require a large number of iron, steel, cement and other high energy intensive products,consequently more energy will be consumed and more CO_2 will be emissioned.

As the third largest city and the earliest north coastal open city in China, studying the impact of urbanization on carbon emissions in Tianjin is necessary.The results will have a realistic value to other industrial cities.

The relationship between Urbanization and energy use and enissions has attracted much attention in recent years. Initially, due to the lack of statistical data, most of the research has focused on the relationship between urbanization and energy consumption. Such as Jones (1991) pointed out that in the process of economic development, industrialization and urbanization are accompanied. The largest single energy use changes derived from the personal transportation. Urban passenger transport increased fuel consumption. Xu and Li (2010) analyzed the short-term and long-term relationship between urbanization and energy consumption in Shandong Province, the results showed that urbanization raised energy consumption in Shandong Province. Peng (2010) drawn between the long-term level of urbanization and the demand for energy balance equation based on the gray system Verhulst model. From the above study, it can be found that urbanization has a positive impact on energy consumption.

With the problem of global warming, scholars began to turn its attention to the relationship between urbanization and carbon emissions. Parikh and Shukla (1995) studied the problem of energy use in the process of urbanization in developing countries, the analysis indicated that urbanization had led to Greenhouse Gas (GHG) emissions, but the impact was very small, the urban population increased 10%, carbon emissions increased by only 0.3%. Poumanyvong and Kaneko (2010) showed that the impact of urbanization on energy use varied across the stages of development. Urbanization decreased carbon emissions in the middle-income groups,while it increased carbon emissions in the high-income and low-income groups.With the STIRPAT model, Dai and Liu (2011) analyzed the relationship between urbanization, energy use and CO_2 emissions. The results showed that the effect of urbanization on CO_2 emissions was positive and significant.in the period of 1995 to 2009 in China. Lin and Liu (2010) had the same results using the Kaya

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identity. Liu and Liu (2011) and Guo and Liu (2012) used different model (STIRPAT model, panel varying coefficient models) analysing the relationship between urbanization and carbon emissions based on panel data of 29 provinces and cities in China. Results showed that the impact of urbanization on carbon emissions was different between the different provinces.

The main shortcoming of these investigations is that most of the existing research focus on the national or state-to-state data analysis,and seldom on the provincial level.Due this neglect, the further research on provincial perspective is necessary.

The study will analyse the impact of urbanization on carbon emissions,using an STIRPAT model incorporating ridge regression in the period of 1995 to 2011 in Tianjin, China ,to help policy makers design appropiate energy saving and emission reduction measures for Tianjin.

MATERIALS AND METHODS

STIRPAT model: In the 1970s, (Ehrlich and Holden, 1971; 1972) put forward the IPAT model (I = PAT)to specify the main driving forces that influence the environment pressure.in the model ,I is the environment impact,P denotes population size,A presents the affluence,T is technology level. The pivotal limitation of IPAT is that, it cannot permit hypothesis testing since the known the values of some terms determine the value of the missing term.moreover, the model assumes that impact factors on the environment is monotonic change in the same proportion.for instance,a 1% increase in population would lead to 1% change in CO_2 emissions.in addition ,it is not obvious that which factor is the most important driving force affecting the environment.

In order to overcome these shortcomings, this study takes STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) proposed by Rosa and (Dietz and Rosa, 1994; 1997) to examine the Impact of Urbanization on CO_2 emissions in Tianjin, given by thefollowing equation:

$$I_{it} = aP_{it}^{b} A_{it}^{c} T_{it}^{d} e \tag{1}$$

where I, P, A and T have the same meaning as in the IPAT model, a is a constant term, b, c and d are the elastic coefficients of P, A and T respectively to be estimated, e denotes random error, the subscript i and t represent selected samples and year. In order to lower the heteroskedasticity in the model, Eq. 1 may be converted to logarithmic form:

$$\ln I_{it} = a + b \ln P_{it} + c \ln A_{it} + d \ln T_{it} + e \tag{2}$$

Table 1: Coefficient of carbon emissions of different energy

Energy class	Coefficient of carbon emission	Energy class	Coefficient of carbon emission	Energy class	Coefficient of carbon mission
Raw coal	0.7559	Kerosene	0.5714	Diesel oil	0.5921
Fuel oil	0.6185	Crude oil	0.5857	Washed coal	0.7559
Coke	0.8550	Gasoline	0.5538	Natural gas	0.4483

The STIRPAT model allows other variables to be add.to investigate the impact of Urbanization on CO_2 emissions; the formula takes several variables into account as following model:

$$\begin{aligned} \ln I_{it} = {} & a + b \ln A_{it} + c \ln P_{it} + d \ln IND_{it} \\ & + e \ln EI_{it} + f \ln URB_{it} + u \end{aligned} \tag{3}$$

Where I represents CO_2 emissions, P is population size, A presents the affluence, IND denotes industrial structure (expressed as the share of in dustry sector in GDP), EI is energy intensity (proxied with the energy use divided by GDP, which has been used to identify the emissions changes by Shi (2003), URB denotes the urbanization factors.

Estimating the energy-related CO_2 emissions: This study adopts CO_2 emissions as the environmental impact, while the data is not given in Statistical Yearbook of Tianjin directly, in order to obtain the data; the reference of the 2006 IPCC (Intergovernmental Panel on Climate Change) National Greenhouse Gas Inventories can be used to calculate the energy-related CO_2 emissions excluding processing conversion, transport and distribution of energy loss:

$$C = \sum_{i} E_i * f_i \tag{4}$$

where, C represents total CO_2 emissions; Ei is the i-th kind of primary energy consumption, f_i is carbon emission coefficients of the i-th kind of primary energy,which can be regarded as a constant, as shown in Table 1.

In the list published by IPCC, the coefficient of heat and power is not given, but the calculation method is given. The carbon emission of heat and power in this study is calculated by the method.

Data source: In this study, the cross-sectional data from 1990 to 2010 of Tianjin city is used for the empirical study. The related data is mainly from "Tianjin City Statistical Yearbook" and "China Statistical Yearbook" from 1991 to 2011 and part of the data is from "China Energy Statistical Yearbook" or calculated from the data existing.

In order to eliminate the effects of inflation, any data in the form of value in this study, is changed with the same price in 1978. All variables are illustrated in Table 2.

Table 2: Definition of the variables used in the study

Variables	Definition	Unit
Total population(P)	Population at the end of year	Ten thousands
GDP per capita (A)	GDP divided by population at the end of year	Yuan per capita
Industrial tructure(IND)	Proportion of the second industry to GDP	Percent
Energy intensity (EI)	Total energy use divided by GDP	Tce per yuan
Urbanization (URB)	Proportion of urban population to total population	Percent

EMPIRICAL RESULTS

Ridge regression method: According to the data from the statistical yearbook and calculation, the regression results with least squares regression analysis using spss18 software, are shown in Table 3.

Table 3: Results of least squares regression

	Unstandardized coefficients		Standardized coefficients			Collinearity statistics	
Model	B	Std. error	Beta	t	Sig.	Tolerance	VIF
(Constant)	-9.962	3.394		-2.935	0.015		
lnA	0.649	0.289	1.283	2.248	0.048	0.004	279.398
lnP	0.428	0.807	0.130	0.531	0.607	0.020	51.269
lnIND	0.847	0.295	0.167	2.868	0.017	0.345	2.898
lnET	0.615	0.366	0.525	1.681	0.124	0.012	83.657
lnURB	-0.047	0.186	-0.020	-0.251	0.807	0.191	5.237

a: Dependent variable: CO_2

From the regression results, the coefficient of the variables lnP, lnET and lnURB is not significant at the 95% confidence interval, with the multiple linear regression equation. the VIF of every variable selected is more than 10, meaning serious multicollinearity in the regression equation.

The ridge regression method is applied to solve the multicollinearity in the regression equation.

Ridge trace diagram can be got by application of ridge regression method for the original data, as shown in Fig. 1.

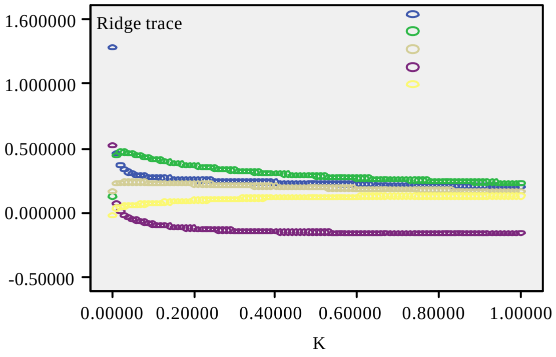

Fig. 1 Ridge trace diagram

According to the ridge trace diagram, when k=0.28 every ridge trace curve tends to be slow and steady. Then taking K=0.28, the standardization, the original non-standard parameters, F, t test and the coefficient of determination are to calculate by SPSS software. The results are shown in Table 4.

Table 4: Results of Ridge Regression with k = 0.28

	B	SE (B)	Beta	t	Sig.	F	Sig.F	R^2
lnA	0.125	0.103	0.133	12.089	0.000	60.207	0.000	0.968
lnP	0.908	0.146	0.336	7.6030	0.000			
lnIND	0.798	0.234	0.216	4.6840	0.001			
lnET	-0.158	0.047	-0.145	-3.386	0.007			
lnURB	0.455	0.114	0.207	2.2440	0.048			
(Constant)	-9.779	1.301	0.000	-7.515	0.000			

From Table 3, regression results are satisfactory. The F test and t test are passed at the 95% confidence interval, and R2 = 0.968, close to 1, meaning better equation fit. The original non-standard ridge regression Eq. is:

$$\ln I = -9.779 + 0.125 \ln A + 0.908 \ln P + 0.798 \ln IND - 0.158 \ln ET + 0.455 \ln URB \tag{5}$$

Standard ridge regression equation is:

$$\ln I = 0.133 \ln A + 0.336 \ln P + 0.216 \ln IND - 0.145 \ln ET + 0.207 \ln URB \tag{6}$$

Analysis of regression results: From the standard regression equation, population, industrial structure and urbanization are the main factors for carbon emissions in the city of Tianjin, followed by energy intensity and per capita GDP. For every 1% increase in Population (P), total carbon emissions will increase by 0.908%. Numerous business opportunities exist in the city of Tianjin, which is the main one in the Beijing-Tianjin-Hebei economic circle, attracting many people to come. A variety of human activities are the cause to energy consumption and carbon emissions increase. Industrial structure (IND) in this study is represented by the proportion of the second industry. According to the regression results, every 1% increase in the second industry will lead to 0.798% increase in the total carbon emissions. As an important industrial city, the traditional second industry needs more energy consumption in Tianjin, leading to more emissions increased. The elastic coefficient of urbanization is 0.455, meaning that every 1% increase in urbanization will result in 0.455% increase in the total carbon emissions. Consistent with the data of reality, urbanization level of Tianjin increased from 56.77% in 1995 to 79.02% in 2010, along with increased carbon emissions.

The result shows that urbanization indeed has an important impact on carbon emissions for the city of Tianjin. Urbanization as a variable in the equation can capture the effect of the rapid urbanization to the city of Tianjin.

CONCLUSION

Based on the STIRPAT model framework, through the data of Tianjin from 1995 to 2010, effects of various factors are empirical analyzed, especially the influence of urbanization on carbon emissions. The analysis results show that urbanization increases carbon dioxide emissions, and population and industry structure are also the important driving factors for carbon emissions. This conclusion has an important significance for urbanization process and control of carbon emissions in Tianjin:

- The empirical results of the analysis show that population transferred in the process of urbanization increases carbon emissions. So the government should properly control the process of urbanization, and improve energy structure and industrial structure to achieve carbon reduction. At the same time, it also should take urbanization as an opportunity to control carbon emissions growth rate for leading the city into a low-carbon economic development
- Reasonable and effective energy policy should be put forward to improve the city’s energy structure and the city's energy efficiency, to realize more reasonable and clean energy structure
- To promote energy-saving way of life. To some extent, the process of urbanization is also the selection process of the life style. The life style will directly affect the energy consumption, thereby affecting carbon emissions. Residents should be guided by the positive policy to choose low carbon life style, which will reduce the city’s energy consumption and carbon emissions

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