Research on the Path of Cooperative Development between Urban Carbon Emission and "Population-Energy-Economy" in Beijing

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***Abstract*—Using System Dynamics, it analyzed the influences of carbon emissions in the aspects of "population-energy-economy" qualitatively. Then calculated Beijing's carbon emissions quantity based on the energy consumption. Though improved model of relationship of "population-energy-economic" to carbon emissions, it analyzed the regression relationship and different affection of "population-energy-economy" on carbon emissions by the related data in 1980-2014. The impulse response function analysis shows that giving an impact to independent index showed that the effect of changes in the total energy consumption is greater than the other elements in short term. Finally, some suggestions are put forward for the citizen low-carbon cooperative development.**

Keywords—Cooperative development; carbon emission; population-energy-economy; Beijing

I. INTRODUCTION

Coordinated development of Climate change, population growth, energy saving and economic is the main theme of the world development. the new type of urbanization makes the urban population scale expansion, rapid development in economic, energy consumption and environmental pollution. As energy consumption and carbon emissions of large households, urban becomes the key to the construction of low carbon city. Therefore, it is the inevitable choice and the focus on the sustainable urban development mode in the perspective of "population-energy- economy".

As the capital in China, Beijing's resident population increased by12.8 million from 1978 to 2014 and the urbanization rate is 86.4%. GDP rose by 2.12 trillion Yuan from 1978 to 2014. As a driving force for the development of population and economy, the energy consumption in Beijing has increased rapidly. The fossil energy consumption accounts for about 90%, in which the high emission of coal consumption accounts for about 70% [1]. According to IEA statistics, carbon emissions caused by fossil energy consumption has exceeded the United States in 2007. So, it has a certain practical and theoretical significance to explore the collaborative development mode and the issue of carbon emission in the perspective of population, energy consumption and economic development.

Projects:① Shandong Provincial Education Department project (J16YF12);
② Jinan philosophy and social science project (JNSK16D18);
③ Shandong Provincial Statistical research project (KT15137) ;
④ Shandong Jiaotong University project (JY201413).

II. LITERATURE REVIEW

There are many achievements about the population, energy, economy and carbon emissions from Domestic and foreign scholars. York, Rose and Dietz(2003)[2] analysis the relationship among carbon emissions, population, energy and urban, pointed out that population has a single way effect on carbon emissions by the STIRPAT model. Richmond AK and Kaufmann RK(2006)[3] analyzed the relationship between income and energy use or carbon emissions. They indicated that whether there is a turning point in the relationship between economic activity and energy use and carbon emissions dependent on fuel mix, the specification for income, and the level of economic development. Mellon H. (2012) [4] analysis comparatively the influence factors of carbon emissions in the perspectives of energy, population and the environment between Canada and other national and consider that the influence of the factors of carbon emissions include population growth, fossil fuel consumption in Canada. Liddle B. (2013)[5] summarized the way demographic factors to influence carbon emissions and energy consumption, which include population, age structure, household size, urbanization, and population density. And considered that urbanization appears positively associated with energy consumption and carbon emissions. Higher population density is associated with lower levels of energy consumption and emissions. Wang Feng(2010)[6] considered the main positive factors of emissions are per capita CDP, number of vehicle, total population, economic structure and average household income and the respective average contributions are 15.82%, 4.93%, 1.28%, 1.14% and 1.11%. While the negative factors are energy intensity of production sector, transportation routes length per vehicle, household energy intensity, and the contributions are -8.12%, -3.29%, and -1.42%.

III. QUALITATIVE AND QUANTITATIVE ANALYSIS

A. The Analysis by System Dynamics

Recently, rapid economic development, new urbanization and the increase of per capita income level made city lift gathered and demand increased. Consumer demand growth need housing, traffic and infrastructure, and this increase energy consumption. The irrational energy structure and lack of supply side of infrastructure increased emissions and environmental problems.

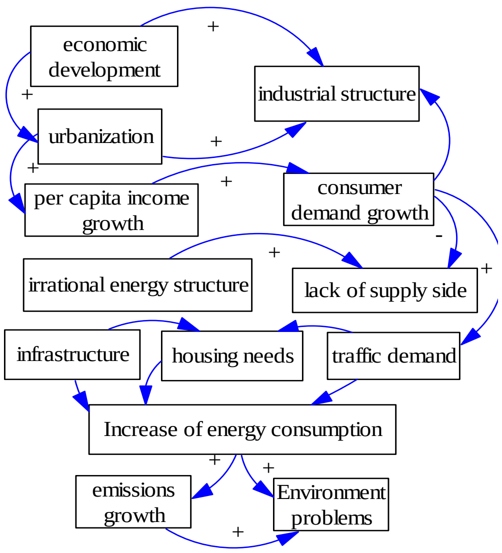


Fig. 1. Causal in Influence factors of carbon emissions

B. Improved STIRPAT model analysis

The classic model of environmental impact (IPAT) is that the environmental impact(I) and population (P), economic (A) and technology (T). Dietz and Rose constructed STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) model by IPAT.

- $I_t = aP_t^{\alpha} A_t^{\beta} T_t^{\gamma} \mu_t$ (1)
- Improved model(1) to the "population-energy-economy" model(2), to study the effect factors of carbon emission in Beijing, then give logarithm to both sides (3), that is:

$$C_t = aP_{1t}^{\alpha_1} P_{2t}^{\alpha_2} E_{1t}^{\beta_1} E_{2t}^{\beta_2} G_{1t}^{\gamma_1} G_{2t}^{\gamma_2} \mu_t \quad (2)$$

- $\ln C_t = \ln a + \alpha_1 \ln P_{1t} + \alpha_2 \ln P_{2t} + \beta_1 \ln E_{1t} + \beta_2 \ln E_{2t} + \gamma_1 \ln G_{1t} + \gamma_2 \ln G_{2t} + \ln \mu_t$ (3)
- In model(2)and (3), C is for carbon emissions. a is a constant. P_1, P_2 are for population, the urbanization rate. E_1, E_2 are for energy consumption, energy consumption structure. G_1, G_2 are for the amount of economic growth, economic structure.
- α_1, α_2, β_1, β_2, γ_1 and γ_2 are for elasticity coefficient of P_1, P_2, E_1, E_2, G_1 and G_2. μ, t are for random error term and time.

C. Calculating the emissions of Beijing

At present, More than 95% of the global carbon emissions came from the fossil fuels burning. So, the emissions can be estimated based on the energy consumption and emission factors. Refer to the "2006 IPCC Guidelines for National Greenhouse Gas Inventories", "Provincial Greenhouse Gas Emission Inventory Guidebook" et al. According to energy consumption and carbon emission factors (EF) [7] to calculate.

TABLE I. CARBON EMISSIONS AND "PEOPLE-ENERGY-ECONOMIC"

Year	C	P1	E1	G1	P2	E2	G2
1980	4757	904	1908	139	58	72	27
1981	4744	919	1903	139	58	73	29
1982	4788	935	1920	155	58	74	29
1983	4949	950	1985	183	59	74	32
1984	5346	965	2144	217	59	75	33
1985	5514	981	2211	257	60	76	33
1986	5984	1028	2400	285	60	76	35
1987	6173	1047	2476	327	61	76	37
1988	6514	1061	2613	410	61	76	37
1989	6615	1075	2653	456	62	76	36
1990	6756	1086	2710	501	73	76	39
1991	7161	1094	2872	599	74	76	44
1992	7449	1102	2988	709	74	76	45
1993	8140	1112	3265	886	75	75	47
1994	8442	1125	3386	1145	75	75	49
1995	8810	1251	3533	1508	76	75	53
1996	9311	1259	3735	1789	76	74	56
1997	9273	1240	3719	2077	76	71	59
1998	9495	1246	3808	2377	77	71	62
1999	9740	1257	3907	2679	77	71	63
2000	10332	1364	4144	3162	78	69	65
2001	10545	1385	4229	3708	78	68	67
2002	11061	1423	4436	4315	79	69	69
2003	11590	1456	4648	5007	79	70	69
2004	12815	1493	5140	6033	80	70	68
2005	13768	1538	5522	6970	84	72	70
2006	14721	1601	5904	8118	84	72	72
2007	15671	1676	6285	9847	84	73	74
2008	15776	1771	6327	11115	85	72	76
2009	16382	1860	6570	12153	85	72	76
2010	17339	1962	6954	14114	86	69	76
2011	17442	2019	6995	16252	86	70	77
2012	17896	2069	7178	17879	86	69	77
2013	16765	2115	6724	19801	86	67	78
2014	17033	2152	6831	21331	86	66	78

notes: the unit of C1,P1,E1,G1 are 10 thousand tons,10 thousand persons,10 thousand tons,100 thousand Yuan.
The unit of P2,E2,G2 are %.

data sources: Statistical yearbook of China, Statistical yearbook of Beijing, 2015.

EF is 0.67 which is from the report of Energy Research Institute National Development and Reform Commission.

D. Empirical analysis

To avoid spurious regression unstable caused by time-series, it logarithm each variables ($\ln C$, $\ln P_1$, $\ln P_2$, $\ln E_1$, $\ln E_2$, $\ln G_1$, $\ln G_2$) used ADF test (Augmented Dickey-Fuller Test, ADF). The results showed that the statistic ADF of test t of the variables are greater than the significance level of the t statistic, and the corresponding probability P> 10%. Therefore the variables have unit roots and are non-stationary, and first-order difference sequence have smoothness. So, the variables are integrated of order one sequence, meet premise regression.

Based on Dietz's IPAT and improved STIRPAT, $\ln C$ is the dependent variable, and $\ln P_1, \ln P_2, \ln E_1, \ln E_2, \ln G_1, \ln G_2$ are the independent variables. The regression analysis results are the formula:

- $$\ln C = 1.2345 + 0.0069\ln P_1 + 0.9367\ln E_1 + 0.0226\ln G_1 + 0.0025\ln P_2 + 0.1047\ln E_2 - 0.0266\ln G_2$$
  $R^2 = 99.9\%, D.W. = 2.24, F = 44676$

P=99.9% showed that the regression fit well. Therefore, the improved STIRPAT model is significant statistically. The analysis concluded that the impact of energy and its structure is more significant than the other variables.

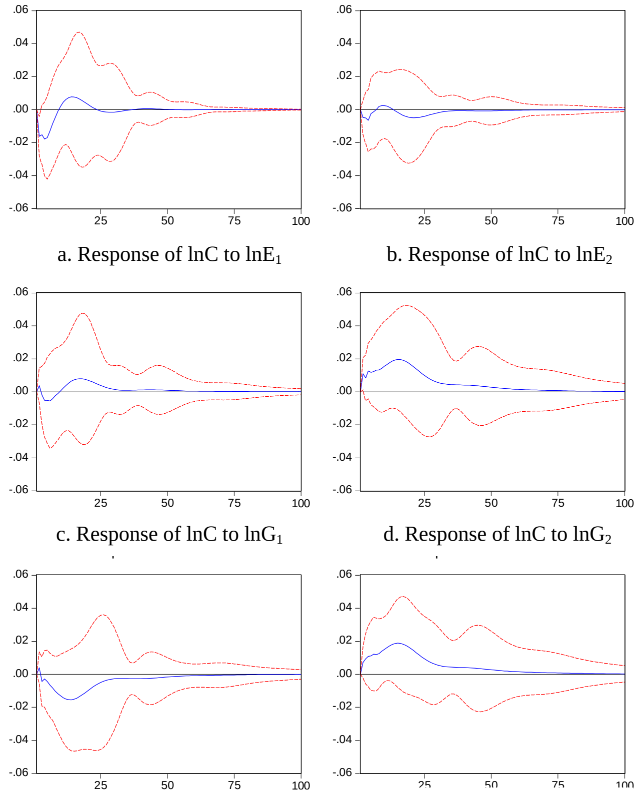
To analysis the dynamic influence of dependent variables when independent variables subjected to some kind of shock, it select impulse response function (IRF) method.

$$\begin{cases} x_t = a_1 x_{t-1} + a_2 x_{t-2} + b_1 y_{t-1} + b_2 y_{t-2} + \varepsilon_{1t} \\ y_t = c_1 x_{t-1} + c_2 x_{t-2} + d_1 y_{t-1} + d_2 y_{t-2} + \varepsilon_{1t} \end{cases}, t = 1, 2, \cdots, T$$

Among them, a_i, b_i, c_i, d_i is the parameter. Assumed that the disturbance $\varepsilon_t = \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$ is white noise sequence, the system started from 0, $x_{-1} = x_{-2} = y_{-1} = y_{-2} = 0$. When $t = 0$, $x_0 = 1, y_0 = 0$ and when $t = 1$, $x_1 = a_1, y_1 = c_1$ and when $t = 2$, $x_2 = a_1^2 + a_2 + b_1 c_1$ $y_2 = c_1 a_1 + c_2 + d_1 c_1$.

When administered to population(lnP1),urbanization (lnP2),energy consumption (lnE1), energy consumption structure (lnE2), economic growth (lnG1) and economic structure (lnG2) a positive impact of unit size, the Carbon emission (lnC) impulse response function figure as fig.2.

The horizontal axis represents the impact lag period, and the vertical axis represents responsiveness. The solid line represents the response of lnC to the impact of the corresponding elements. Fig.2. shows that when give a impact to lnP(lnP1,lnP2), lnE(lnE1,lnE2), lnG(lnG1,lnG2), it will cause fluctuations in lnC, and the fluctuation will reduce over time gradually. Comparison of pulse response function of lnP, lnE, lnG based on no considering the influence of lnC itself, which showed that the effect of changes in lnE is greater than the other elements in short term.



a. Response of lnC to $\ln E_1$ b. Response of lnC to $\ln E_2$
c. Response of lnC to $\ln G_1$ d. Response of lnC to $\ln G_2$
e. Response of lnC to $\ln P_1$ f. Response of lnC to $\ln P_2$

Fig. 2. Response of lnC to lnP, lnE, lnG,

IV. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

Overall, population-energy-economy has a significant impact on carbon emissions, but it is different for various factors.

1) Energy. Affected factors of carbon emissions arranged in order: energy consumption> Energy Structure> economy> Total population> urbanization rate> economic structure.

2) Economic.Energy is directly related to carbon emissions, but energy consumption is impacted by economic growth, and the industrial structure is impacted the energy consumption structure in the long term.

3) Population.the impacted Coefficient of total population and urbanization on carbon emissions are 0.69%, 0.25%, indicats that the population growth promots the carbon emissions but not obviously.

B. Suggestions

With the rapid development of urban economy and urbanization, energy consumption, Energy consumption grew fast. It lead to a sharp increase in carbon emissions. Therefore, It has a certain practical significance based on the Perspective of population-Energy-Economic. According to the analysis, in order to further promote low-carbon growth, recommendations the following:

1) Reduce energy consumption, and adjusting energy structure.

Total energy consumption, especially coal accounts for the proportion of total energy consumption is a key factor in the growth of carbon emissions. Therefore, to control carbon emissions to achieve a low-carbon development, must control the total energy consumption, adjust the coal-dominated energy structure, increase the proportion of green energy in total energy consumption, to achieve green energy development.

2) coordinated and equilibrium the relationship between low-carbon and economy, adjust the industrial structure actively.

To reduce carbon emissions to achieve a low-carbon development, it should balance low-carbon and economic development. So it must ensure less impact on economic development under the conditions of the current economic downward pressure. Furthermore, it is a negative correlation between industrial structure and carbon emissions. The optimization and upgrading of industrial structure lead to economic growth while reducing carbon emissions. Therefore, upgrading the industrial structure is a priority to reduce carbon emissions.

3) Regulated the total population of mega-cities and the urbanization rate.

Economic growth is inseparable from the people gathered, while the population gathered promote economic growth and bring pressure to low-carbon urban development. Especially population of Beijing is over 10 million, it is a megacity. Large urban population is one of the main factors in the growth of carbon emissions. To control carbon emissions in Beijing, it must regulate urban population growth reasonably.

Acknowledgment

Thanks are due to my supervisor, Professor Duan, for a lot of valuable discussion, which make me explore the good direction not only in this thesis but also in my future study. I shall extend my thanks to some projects that cause me work hard, that is footnoted on the first page.

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