Measuring the impacts of urbanization on energy consumption and economic growth in China: A computable general equilibrium analysis

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Key words: energy consumption; urbanization; CGE

Abstract: With the increasing energy demand, the urbanization level of China has been greatly improved in last decades. This paper utilized a static CGE model to simulate the impact of urbanization against energy consumption based on data from IO-table 2007. The result implies that urbanization imposed salient positive stimulus on macro economy development; Urbanization will cause the increase of household's energy consumption.

Introduction

Since the new century, various sources of development have been converged rapidly following the unexpected industrialization and urbanization, which resulted in fast city booming via 'Scale Economy' and additionally accelerated the economic growth. According to the China Statistical Yearbook 2013, the urban residents increase about 270 million, along with 18% rise of urbanization rate that decomposed with 2.1% average growth rate for late five years. As 'Macro-Economy Blue Book' projected, issued by Chinese Academy of Social Science, that China's urbanization rate will up to 60% in 2020, in other words, China still undergone fast urbanization in the future. Urbanization changed the structure of urban and rural district and industrial structure, which relatively brings to numerous fundamental facility construction and municipal construction work imposing great stimulus on energy consumption. Until 2013, measured by 10 000 tons of SCE, China's energy consumption is 37,500 (ten thousand tons of SCE), with 24% rise compared with 2008. There are series of novel problems and challenges confronted by energy development consistent with intensified energy constraints, ecological depravation, and heavy stress for structural adjustment, energy efficiency and energy security.

Literature review

Energy consumption has been repeatedly discussed in energy economy lately. Scholars mainly do empirical research focusing on the correlation between energy consumption and economic growth by utilizing econometric method, Han et al. analyzed co-integration and causality between Chinese GDP and energy consumption, which concludes that there is bi-directional causality between Chinese GDP and energy consumption, but no co-integration between them [1]. Later, many

scholars applied different quantitative method, as Granger Causality Test, Co-integration Analysis, Impulse Response Function, and Error Correction Model, to detect the correlation between energy consumption and economic growth [2-4]. Besides, some scholars use Grey Relational Analysis, Panel Data to analyze it [5-6]. Based on it, some scholars combined energy consumption, economic growth and carbon emission together to analyze the correlation among them considering the environmental constraint [7-8]. Someone else put lights on the relationship among energy efficiency, energy consumption and economic growth [6, 9].

As Chinese urbanization move forward so fast, scholars have put more concentration on the relationship between urbanization, energy consumption and economic growth. Wang and Wei conducted a fixed effects panel model to estimate a balance equation reflecting the impacts of urbanization on energy consumption in China, and the results show that at the national level, China's urbanization and industrialization positively affect energy consumption [10]. In sum, we can see that there are intimate relationship within energy consumption, economic growth and carbon emission, also energy efficiency, which is relative to multiple macroeconomic factors and department. Scholars adopted energy-economic-environmental CGE model to simulate the impact of fluctuation of energy price on macro-economy and energy consumption [11-12]. However, there still haven't been studies about impact of urbanization on energy consumption and economic growth founded in China. So, we conduct a static CGE model to analyze the impact of urbanization on energy consumption in China.

Methodology and Hypothesis

Computable General Equilibrium (CGE) model, based on neoclassical economic growth theory, is a macroeconomic model, which can put various microeconomic entity's behavior into a framework driven by price, also with characteristic of multiple department and bodies. Under that framework, the exogenous shock or policy change will cause the price change that might influence the optimal decision making. Thus, CGE model can greatly simulate the impact of outer shock on energy consumption, household welfare and economic growth. The Fig1 shows the general structure framework of ENCGE Model.

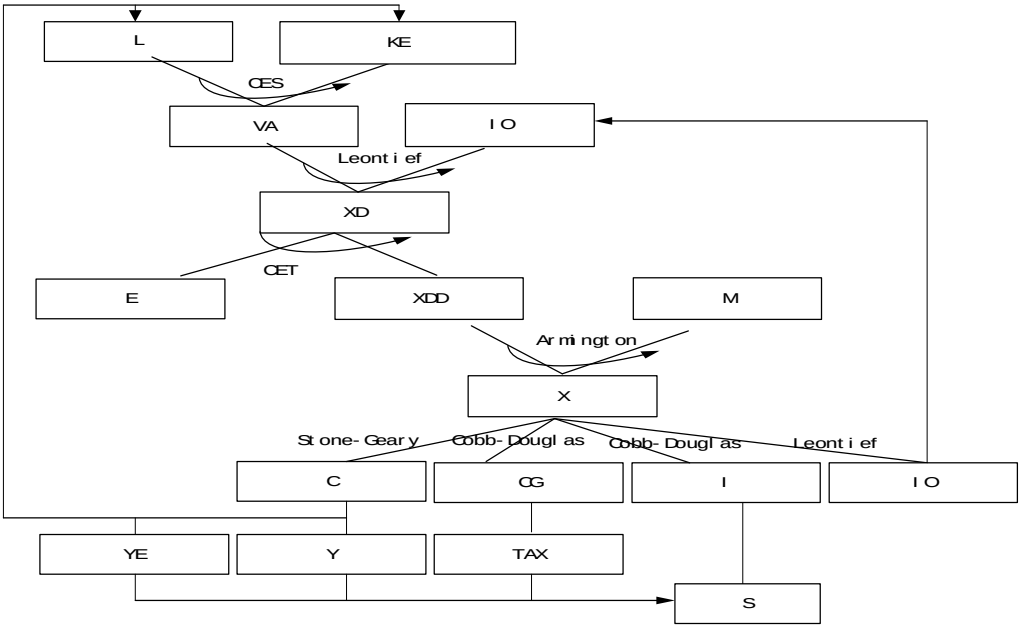

Fig 1 General Structure Framework of CGE Model

This model specifies 26 sectors of production, and each sector produce only one product. The

products partially consumed by households, which also contributes to intermediate inputs and export. The model includes public sector equal to a single government agent that produce s public goods and services. Tax revenues are either transferred back to households or used for public consumption. The model also specifies a foreign sector, including Rest of World ROW. The model based on subsequent hypothesis, 1) perfect competition. Firms are assumed to maximize profits subject to technology restrictions, and consumers are assumed to maximize utilities subject to budget restrictions. 2) No economies of scale in production, technological change is exogenous, firm's production functions are specified as nested Constant Elasticity of Substitution (CES) functions, and the output is determined by Leontief function. 3) Consumer's utility determined by Stone-Geary functions subjected to disposable income restrictions. 4) This model follows Armington assumption. 5) In this single-country and open economy CGE model, using a small country assumption, the prices of imports and exports are exogenously fixed. 6) The Numeraire set of labor endowments is exogenously fixed, and the close rule is neo-classical type.

Data

Social Accounting Matrix (SAM)

The principal data set essentially has the form of the 2007 Social Accounting Matrix (SAM) for China contributed by Ge and Tokunaga (2011). Besides, other data relating to tax, saving, transform expenditures, energy and employment comes from China Statistical Yearbook 2008, China Fiscal Yearbook 2008, China Custom Yearbook 2008, China Energy Statistical Yearbook 2008, etc. All data refer to 2007 as benchmark year.

Parameters

There are two types of parameters in this model, one is technological parameters, as tariff rate, proportion rate of CES or CET functions. The other one is elasticity parameters, which are obtained from the literature. Table 1 summarizes the primary parameters of this model.

Table 1 Primary parameters

Energy Sectors	Tariff rate*	Armington elasticity σ_M**	CET elasticity σ_E***	Substitution elasticity of Value-added σF****	Income elasticity of goods (rural household)****	Income elasticity of goods (urban household)****
Coal	0.011	3.1	-4.6	2.182	0.254	0.857
Oil	0.016	7.4	-4.6	2.182	0.254	0.857
Gasoline	0.009	2.1	-3.8	0.435	0.937	0.813
Electricity	0	2.8	-3.8	2.541	0.937	0.813
Gas	0	2.8	-3.8	2.541	0.937	0.813

Sources：*Ge and Tokunaga [13]；**Willenbockel [14]；***Zhai and Hertel [15]；****Zhao and Wang [16]。

Simulation Results

Simulation sets aims to evaluate the impact of urbanization against economic development, energy consumption and household welfare. Here the scenario we choose is that the non-agricultural labor supply increase 3.79%, and the agricultural labor supply decrease 2.35%, which represent the average change rate among 2007-2011 of urban employees and rural employees (see Table 2).

Table 2 Sets of simulation on increase of energy demand under urbanization

Simulation Set	
non-agricultural labor supply	Increase 3.79%
agricultural labor supply	Decrease 2.35%

Source: China Statistical Yearbook 2012

The simulation results are the equilibrium computation results under fixed capital stock, the subsequent numbers among following tables are represent the change comparing to the benchmark year.

The results show that, urbanization imposed obvious positive pull effect on macroeconomic development (see Table 3). We can infer that the energy demand of macro sectors all increase about 2%, especially for agriculture sector. The increase of energy demand will correspondingly lead to energy price up, as coal price increasing 2.17% , oil price increasing 2.25% , gasoline price increasing 2.21% , electricity price increasing 2.25% , gas price also increasing 2.26%. Moreover, the rural household income add 4.29%, relatively for urban household gain 3.41% appreciation. Table 3 shows that the total tax grow 3.9% in respect that the augment of production and household income. In short run, the increase of consumption and production will notably give rise to nominal GDP account for 3.7% augment. The government investment also strikingly increase about 4.4%, which implies that government investment would still be dominated mode of China's economic development in the future.

Table 3 Impact of Urbanization in macro-economy development of China

Variation of energy demand among various sectors	%
Energy demand of agricultural sector	
Coal	2.83
Gasoline	2.63
Oil	3.21
Electricity	2.42
Gas	2.73
Energy demand of industrial sector	
Coal	1.50
Gasoline	1.70
Oil	1.77
Electricity	1.40
Gas	1.59
Energy demand of service sector	
Coal	2.04
Gasoline	1.90
Oil	1.73
Electricity	2.09
Gas	1.85
Variation of macroeconomic development	
Nominal GDP	3.72
Actual GDP	1.42
Coal price	2.17
Oil price	2.25
Gasoline price	2.21
Electricity price	2.25
Gas price	2.26
Rural household's income	4.29
Urban household's income	3.41
Rural household's consumption	1.86
Urban household's consumption	1.09
Total tax income	3.90
Rate of capital return	4.30
Income level of agricultural labor	7.67

The simulation results tell us that, urbanization contributes to increasing household's demand of energy consumption, along with the rise of energy input of production sector. Table 4 indicates the change of household's energy consumption resulting from urbanization. Apart from oil not belongs to intermediate input, which surely not account for household's energy consumption, other energy attain strikingly increase, especially for electricity, gasoline and gas, which are the principal part of energy consumption structure. The consumption of rural household rise about 2%, as urban household about 1% as a consequence of accelerating urbanization. The main reason of rising energy demand may account for that urbanization facilitates the immigration of household from rural to urban district. The reason why rural residents transmit to urban district induced is mainly induced by urbanization. On the one hand, the increasing supply of urban labor force has brought

more output, which decreased the goods price and hence stimulated household's consumption. On the other hand, the decreasing amount of rural residents has resulted in the rising demand of rural labor forces, which push the wage of rural household up, so that they can gain more incomes to support their consumption.

Table 4 Impact of Urbanization against energy demand of household in China %

Energy Types	Rural household	Urban household
Petroleum	0.0	0.0
Coal	0.5	1.1
Gasoline	1.9	1.0
Electricity	2.0	1.1
Gas	2.0	1.1

The augment of household's energy demand will lead to the increasing input of each factors (see Table 5). Except the trivial down trends of energy input in Coal and Water, other industrial sectors gains an obvious energy input expansion, especially for Manufactural industry and Construction industry. Urbanization will bring manufacture construction in an immense scale to Manufactural industry and Construction industry, which is appreciable for policy simulation background setting.

Table 5 Impact of Urbanization against factors input of Industry in China %

	Energy	Capital	Urban labor force
Coal	-0.2	-2.1	5.9
Petroleum	0.6	-1.2	7.5
Other mining	0.1	-1.7	6.3
Gasoline	1.8	0.0	2.7
Electricity	1.1	-0.7	7.8
Gas	1.1	-0.7	7.5
Water	-0.6	-2.3	6.8

Conclusions

We adopt the static CGE model to simulate the effect of urbanization on China's energy consumption and economic development. The result shows that, urbanization imposed obvious positive pull effect on macroeconomic development. Besides, urbanization contributes to increasing household's demand of energy consumption, along with the rise of energy input of production sector. Finally, we have found that the augment of household's energy demand will lead to the increasing input of each factors. In the future process of urbanization, governments ought to improve the energy efficiency to reduce the energy consumption and increase energy intensity.

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