Economic growth, Population Changes and residential energy consumption in China

Leiwen Jiang and Brian O'Neill

This paper aims at studying the impacts of economic growth, population compositional changes on residential energy consumption and its environment consequences in China. Applying the China Rural and Urban Socio-economic Household Survey datasets in the 1990s and historical socio-economic, demographic data and macro date of energy use, we analyze the relative importance of changes in residential energy use to the general trends of overall energy consumption; study the relationship between population, income and energy consumption and its consequent emission of radiative pollution. By statistically analyzing Chinese rural and urban household energy consumption, we will stress the importance of urbanization in the energy transition from biomass to modern fuel. Combining with population and household projection results, we simulate the impacts of household compositional changes and urbanization on future residential energy consumption under different socioeconomic and demographic scenarios.

Extended abstract

1. Motivation

As the largest developing country and the second largest green house gas emitter, China's energy consumption has important implication for global climate change. In the past two decades, energy consumption in China was more than doubled. From an energy exporter, China has become a major energy importer since the middle of 1990s. To understand the changes, rapid economic growth is clearly the main driving force of the tremendous increase of emission, given that China experienced dramatic fertility decline since the 1970s.

Moreover, energy consumption in China more recently demonstrated a path of rises and falls: it increased before 1996, and declined in the period of 1996 to 2000, but rebounded after 2001 (Fridley, Sinton and Lewis, 2003; Streets et al., 2001; Sinton and Fridley, 2001; Sinton and Fridley, 2000). The overall decline in Chinese energy consumption and CO_2 emission in the period 1996-2000 was so large that it caused global CO_2 emission to shrink in both 1998 and 1999 (Streets et al, 2001). Although some may doubt about the accuracy of statistics, many people indicates the importance of sectoral changes in industrial structures and reductions in energy intensity, (e.g. Sinton and Levine, 1994; Streets et al., 2001; Sinton and Fridley, 2001; Zhang 2003). This may contribute to the explanation of the rise and fall of energy use before 2000, however, it could not tell the reason of the rebound afterwards.

China has been single out as one of the major targets at the subsequent negotiations after the Kyoto meeting in which developing countries were exempted from the responsibility of GHGs emission reduction. This exemption was based on the belief that limits on emission would affects economic growth of the developing world, which will eventually contribute to future reduction in environmental pollution and GHGs emission (Galeotti,

2002). This belief is captured in the hypothesis known as the Environmental Kuznets Curve (EKC) (Grossman and Krueger, 1991, 1995; Shafik and Bandyopadhyay, 1992; Panayotou, 1993, 1995, 2003; Selden and Song, 1994).

Here, one observed a contradictory situation if one adopt the EKC hypothesis to address the changes of emission in China recently. In fact, there exist a lot of criticisms against the EKC hypothesis. Firstly, some people argue that economic growth should not be regarded as the only determinants of downward trend of emission; technological progress, institutional intervention, and environmental awareness may play important role (Galeotti, 2002). Secondly, some authors criticize the use of multi-country, macro-level data sets which are sensitive to the number and types of countries included in the analysis as well as to model specification. Others use micro-data at household level to test the EKC hypothesis (e.g. Foster, Vivien, Jean-Philippe Tre, and Wodon, 2000; Plassmann and Khanna, 2003; Viswanathan and Kumar, 2003).

In the past decade, many studies have been conducted to test the EKC hypothesis. Most of the studies deal with the problem of air pollution, while some scholars extend their test of the EKC hypothesis to land degradation[1]. Many empirical evidences appear to be consistent with the EKC hypothesis in some instances but inclusive in others. For example, those air pollutants bearing direct impact on population (e.g. sulphur dioxide and carbon monoxide) show a clear inversely U-shaped curve; on the contrary, when environmental problems can be externalized (e.g. carbon dioxide and nitrogen oxides), the curve does not even fall at high income levels. Some studies find an inverted-U shape for deforestation with the peak at relatively low income levels (e.g. Panayotou, 1993, and 1995; cropper and Griffiths, 1994), whereas others conclude that per capita income appears to have little bearing on the rate of deforestation (Shafik, 1994; Barbier and Burgess, 2001).

A major reason of deforestation in many developing countries is the excessive biomass use for heating and cooking by the rural households. Firewood is more often used in the rural areas, and caused serious in-door pollution which is internal to household and should be averted at an earlier stage of development. It explains the findings of Panayotou et al, and is also consistent with the term of energy transition which indicates a shift within developing country households toward increasing use of modern fuels, and decreasing reliance on biomass, even in the absence of policies explicitly aimed at achieving this outcome. On the other hand, land degradation and GHGs emission caused by firewood use is also an externality which may not be stopped until the later stage of economic development is achieved. Our study in rural China shows that biomass use by rural households was rather stable in the 1990s, and only the highest income group of households significantly reduced biomass use (Jiang and O'Neill, 2003).

[1] According to the World Resource Institute, deforestation together with land use changes, accounts for about 17-23% of total anthropogenic carbon dioxide emissions.

Moreover, while the advocators of EKC consider urbanization as a main contributor to increase of environmental pollution[2], others argue that urban growth contributes to environmental sustainability in densely populated Asian countries (e.g. Marcotullio, 2001). Since urbanization involves more efficient use of infrastructure, more efficient use of transportation, and more efficient land use. More specifically, our primary statistical analysis shows that Chinese urban households consume less energy than their rural counterparts when biomass is taken into account. Since 63% of households still use biomss for heating and cooking, this accounts for more than 70% of total fuel use among the China rural population (Jiang and O'Neill, 2003).

Certainly, like many other variables, urbanization correlates with other factors, in particular with economic development and income growth. However, urbanization might be independent from income growth. For example, in the period 1960s to 1980s, Chinese government, being afraid of the problems of rapid urbanization happened in some other countries, blocked the rural residents migrating to the urban areas, kept the national urbanization level at very low level. Realizing the importance of urbanization to socio-economic development, Chinese government altered urbanization policy in the era of economic reform which greatly enhanced urbanization. Rapid urbanization may induce difficulties for the cities in terms of infrastructure shortage, congestion, pollution control. On the other hand, urbanization might be environmental-friendly. For example, utmost of Chinese urban residents do not use biomass, and use other fuels in the more efficient way. Therefore, urbanization of recent years causes energy transition and may independently contribute to the drop of emission in China.

Furthermore, our analysis of urban household survey data shows that per capita residential energy use in the 1990s did not follow the path of rises and falls of the overall energy consumption, but increased continuously in the 1990s. It may hint that even an EKC might have occurred for the national total energy use; however, per capita energy consumption at residential sector does not follow the same path or does not reach the turning point yet at the household level. Those hypotheses are not tested in the existing studies, mainly due to data limitation.

Therefore, this research aims at:

- Studying the general trends of energy consumption in China, and pay particular attention to the residential energy use
- Analyzing the relationships between residential energy use and household, testing the applicability of EKC to China energy use at household level
- Studying the relative importance of changes in population and household composition to the increase of per capita residential energy use
- Comparing energy use between urban and rural households, gaining insights of the effect of urbanization on emission

[2] For instance, Panayotou (1993, p.14) points out environmental degradation tends to firstly increase as the structure of the economy changes from rural to urban, from agricultural to industrial.

- Combining population and household projection results, predicting future residential energy consumption under different scenarios of economic development, urbanization and demographic events

2. Data

Data used in this study are from the National rural and urban Household Survey, an annual survey conducted by the China Rural Socio-Economic Survey Division and Urban Socio-Economic Survey Division of the State Statistical Bureau respectively. The survey started in 1965 and covered a national sample of households. Each household was required to keep a record of income and expenditures and received a small payment in return. The survey ceased during the Cultural Revolution in 1966-1976, and resumed in 1977. Before 1990, the household surveys did not contain useful information on energy use. Since 1990, questions regarding energy use were gradually included in the survey. By the end of the 1990s, the questionnaire included sufficient detail to provide a general picture of household energy use. However, beginning in 2000, the rural survey no longer included information on total biomass use, which is still the major energy source for rural households. We obtained 80%-90% random samples of the 1990, 1999 and 2000 rural household survey data sets, 1992 and 1996, 1999 and 2001 urban household survey data sets. The dataset contains variables on household's and all household members' demographic characteristics, income, expenditure, and durable goods. Energy-related information is provided by fuel, separately for purchased energy and total energy use.

At aggregate level, we also obtained historical socio-economic data and date of energy use from: (1) Department of Industry and Transportation Statistics, National Bureau of Statistics, 2001: China Energy Statistical Yearbook 1997-1999, China Statistics Press; (2) Comprehensive Statistical Data and Materials on 50 Years of New China, 1999, China Statistics Press; (3) China Energy Databook, v. 6.0, (CD-Rom) Lawrence Berkeley National Laboratory, Energy Research Institute, 2004; (4) China Statistical Yearbook, 2002, China Statistics Press.

3. Methods:

(1) Based on the time series statistics, we study the general trend of energy use and emission by sectors since the early 1980s. We pay close attention to the household sector which represents the second largest sector (after industrial) for commercial energy consumption, accounting for 12-18% of total consumption in the past two decades. Taking into account biomass use, it would increase the residential share of total energy use in 1996 by a further 12 percentage points. All told, residential energy use therefore accounts for about 26% of total energy use in 1996. The emission from household energy use will also be calculated.

(2) Given that 1999 is the only year from the rural household survey containing complete information on energy use while urban household surveys have better coverage, we weight the 1999 rural and urban household survey data and combine them into one dataset. We compare the amount and mix of fuel use between rural and urban households,

and between regions (provinces and prefectures). Exploiting statistical method, we analyze the energy use of the rural and urban households by economic status (income and expenditure), education, occupation, industry, and other demographic characteristics (age, sex, household size and structure). We also take into account other factors, such as fuel prices, geographic conditions, forest coverage, regional fuel production, population density, regional environmental situations (waste emission, disasters, environment accidents), and temperatures. In particular, adopting logistical regression model, we carefully study the determinants of biomass use among the households, examine the importance of income growth and urbanization in the process energy transition from biomass to modern clean fuels.

(3) Based on the 1992, 1996, 1999 and 2001 urban household survey data, we study the changes of urban residential energy use with the economic development. Comparing the amount and mix of fuel use by the urban households over different time points, we analyze why the N-shaped curve change of overall energy consumption did not happened among urban households, and study the economic and demographic factors contribute to the increase of per capita residential energy use. Based on the statistical analysis, we try to understand the future tendency in energy consumption among urban households.

(4) Applying macro dynamic household projection model ProFamy, we conduct household projection for China under different urbanization and economic development scenarios. Combining the detailed household projection results with information from previous steps, we project the future residential energy use and emission for China. Using standard decomposition method, we analyze the net impact of urbanization on energy use and emission.

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