Residential energy consumption: A convergence analysis across Chinese regions ☆

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ABSTRACT

The process of urbanization and the raise of living standards in China have led an increasing trend in the patterns of residential consumption. Projections for the population growth rate in urban areas do not paint a very optimistic picture for energy conservation policies. In addition, the concentration of economic activities around coastal areas calls for new prospects to be formulated for energy policy. In this context, the objective of this paper is twofold. First, we analyse the effect of the urbanization process of the Chinese economy in terms of the long-run patterns of residential energy consumption at national level. By using the concept of club convergence, we examine whether electricity and coal consumption in rural and urban areas converge to the same long-run equilibrium or whether in fact they diverge. Second, the impact of the regional concentration of the economic activity on energy consumption patterns is also assessed by source of energy across Chinese regions from 1995 to 2011. Our results suggest that the process of urbanization has led to coal being replaced by electricity in urban residential energy consumption. In rural areas, the evidence is mixed. The club convergence analysis confirms that rural and urban residential energy consumption converge to different steady-states. At the regional level, we also confirm the effect of the regional concentration of economic activity on residential energy consumption. The existence of these regional clusters converging to different equilibrium levels is indicative of the need of regional-tailored set of energy policies in China.

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1. Introduction

Convergence refers to the reduction of the disparities between countries or regions. In economic growth and environment literature this aspect has been the focus of a large body of empirical research, as an assumption of convergence lies behind any economic or environmental policy (Herrerias, 2013, Islam, 2003). In contrast, convergence has received less attention in the energy economics literature despite the important implications for energy policy. Previous works on this area have focused on the analysis of convergence in different indicators used for energy policy such as energy efficiency, energy consumption and carbon dioxide emissions (Herrerias, 2013, Herrerias and Liu, 2013, Jakob et al., 2012, Mohammadi and Ram, 2012). To the best of our knowledge, this paper provides a first insight

on the convergence patterns related to per capita residential energy consumption in urban and rural Chinese areas on the one hand, and across Chinese regions on the other. This paper aims to fill the gap in the existing literature by analysing the effect of urbanization and regional economic concentration on residential energy consumption in China.

In China, the growing trend in residential energy consumption is a relatively recent phenomenon. While energy consumption is still dominated by the industrial sector and more specifically by heavy industry as the most energy intensive industries,[1] the rapid industrialization and urbanization process has resulted in an average growth in residential energy consumption of 8% over the last two decades. Considering the demand of electricity, the figure rose by 12.35% in 2012 (Zheng et al., 2014). Projections of this demand do not paint a very optimistic picture for energy conservation policy. In 2013,

[1] In 2009, eight industries in China consumed 72.5% of the national total: non-metallic mineral products, petroleum, coking and nuclear fuel processing, paper and paper products, ferrous metals, metal products, textiles, non-ferrous metals, and chemical products (see further details in Yao and Luo, 2014).

46.3% of the population lived in rural areas and this figure continues to fall, while the forecast for the urban population living in cities is around 60% by 2020 (Zhao et al., 2012). Among the relevant factors that can explain this expected strong demand for energy, three in particular are worth highlighting: China's economic development, the improvement of standard of living and the National Urbanization Plan.

The exceptionally steady and rapid growth of the Chinese economy has been based on two main factors: capital accumulation and export orientation policy over the last three decades (Herrerias and Orts, 2010). However, it has been argued that one of the main flaws of this growth model is the weak internal demand that hinders the achievement of sustainable development. The new urbanization plan may be one option for strengthening this aspect and encouraging household consumption. While there is no doubt that economic development has significantly improved people's living standards by raising per capita income, and therefore changing consumers' preferences, the new challenge for the Chinese economy is to balance the ambition of the urbanization process with energy programmes to achieve a low carbon economy. Continuous price reforms, deregulation of energy sector, energy efficiency policies and Chinese citizen's awareness of a green economy may curtail the growth rate of residential energy consumption. However, the effectiveness of such policies may have limited effects if the paths of growth differ across regions in China. Understanding the regional differences and analysing the possible existence of groups among Chinese regions can help to design specific energy programmes targeting each identified club.

In contrast to Herrerias and Liu (2013), we contribute to the existing literature by analysing the effects of Chinese urbanization and regional economic concentration on residential energy consumption patterns. To examine the effects of urbanization, we use a cluster analysis to test for convergence or divergence in the residential consumption of coal and electricity in rural and urban areas, whereas for the impact of regional economic concentration we test for convergence or divergence in the residential consumption of coal, electricity and liquid gas across Chinese regions over the period 1995–2011. By using the log t test proposed by Phillips and Sul (2007), we test the convergence behaviour across regions and examine whether club convergence is present in the data-generating process for the different sources of energy considered in this paper. This approach offers a number of interesting features when dealing with Chinese data. First, we endogenously determined the number of groups of regions as well as the provinces that belong to each club. Second, we consider explicitly the heterogeneity of our data generating process across regions and also over time. This aspect is assigned considerable importance due to the significant changes relating to China's energy reform and path of economic development which led to the well-known unbalanced growth among Chinese regions. Finally, we estimate the transition growth paths of energy consumption and their evolution over time. Findings from this research would be of great interest not only to academics but also to policy-makers as the very existence of clubs may indicate that a common energy policy cannot be effective; if different groups of regions show different convergence patterns it would be very challenging to design energy programmes for each identified club. Our results suggest the existence of club convergence for both urban and rural data at national level as well as residential energy consumption at regional level. First, we found that rural and urban areas display different convergence patterns depending on the source of residential energy consumption considered. Economic reforms initiated at the end of the 70s, rapid industrialization and, more recently, urbanization can explain these findings. Second, once the economic geography is explicitly considered in the analysis for each of the three sources of residential energy consumption examined, we found that there are four convergence clubs in the case of coal and two for both electricity and liquid gas.

Divergence was not found in any of the cases. The results do not allow much room for optimism, since, looking at the transition paths of residential energy consumption, a growing trend is observed at those clubs with a significant number of provinces. The rapid urbanization process to promote internal demand in the Chinese economy should work in coordination with energy and environmental programmes, which in turn should target specific regions according to the identified club.

The rest of the paper is organised as follows. Section 2 reports an overview of the different notions of convergence in the empirical literature. Data and Methodology are described in Section 3. Results are presented in Section 4, while we draw our conclusions in Section 5.

2. Literature review

Economic reforms initiated at the end of the 70s in China led to fast economic growth over the last three decades. However, it has been argued in the literature that, as a result of the creation of special economic zones, which encouraged the entry of multinationals in these regions with fiscal stimulus created unbalanced growth between coastal and non-coastal areas. This scenario is not so different from most other countries as the economic activity is concentrated in coastal areas for trading purposes with other countries. Economic prosperity, the relaxation of the Hukou system, and the pursuit of better standards of living push Chinese citizens to move from rural to urban areas. In 1978, 82.1% of population lived in rural areas, while only 17.9% lived in urban ones. These figures are in sharp contrast with the ones in 2013, when 46.3% of the population was living in rural areas and 53.7% in urban areas. Not only has the urban population, but the degree of urbanization is not homogeneous across regions, making it even more challenging to set economic policies in China. Considering recent data on urbanization for 2013, the provinces of Beijing (86.30%)[2], Tianjin (82.01%), Shanghai (89.60%), Liaoning (66.45%), Jiangsu (64.11%), Zhejiang (64%) and Guangdong (67.76%) show the highest rates of urbanization compared with regions like Guangxi (44.81%), Yunnan (40.48%), Gansu (40.13%) and Tibet (23.71%), which show the lowest rates. If we take into account the population density of urban areas in 2013, the provinces of Heilongjiang[3] (4922), Shanghai (3809), Jiangxi (4542), Henan (4982) and Shaanxi (5541) appear in the top positions, while regions such as Ningxia (1253), Tibet (1820), Chongqing (1847), Guangxi (1543) and Inner Mongolia (1059) show the lowest levels of urban population density. The Chinese government is encouraging these trends by means of the National Urbanization Plan, although it also aims to promote inland regions by relocating industry to those areas address the well-known unbalanced growth. The projections of these urbanization and industrialization trends may suggest that residential consumption will tend to increase and therefore active prospects for energy policy will be required.

This paper applied methods primarily developed in the economic growth literature to test for convergence. Islam (2003) provides a detailed description of the different concepts of economic convergence and surveys the existing methods of testing for its presence. In the area of energy economics, as pointed out by Kim (2015), per capita electricity consumption may be a better indication of the nature of standard of living than income. The analysis of the relationship linking energy consumption and income has prompted a large body of empirical research (see Herrerias and Joyeux, 2014) that has nevertheless produced conflicting results on the direction of the causality between these two macro-magnitudes. Such research has been useful for the design of energy policies across countries and regions, however the explicit assumption behind these studies is that

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[2] Share of urban population over total population shown in brackets.
[3] Density measure in persons per square kilometre shown in brackets.