



Estimation of urban residential electricity demand in China using household survey data



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HIGHLIGHTS

- We estimate price and income elasticities in China using household survey data.
- The current study is the first such study in China at this level.
- Both price and income are inelastic.
- Behavior factors have important impact on electricity consumption.

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ABSTRACT

This paper uses annual urban household survey data of Sichuan Province from 2007 to 2009 to estimate the income and price elasticities of residential electricity demand, along with the effects of lifestyle-related variables. The empirical results show that in the urban area of Sichuan province, the residential electricity demand is price- and income-inelastic, with price and income elasticities ranging from -0.35 to -0.50 and from 0.14 to 0.33 , respectively. Such lifestyle-related variables as demographic variables, dwelling size and holdings of home appliances, are also important determinants of residential electricity demand, especially the latter. These results are robust to a variety of sensitivity tests. The research findings imply that urban residential electricity demand continues to increase with the growth of income. The empirical results have important policy implications for the Multistep Electricity Price, which been adopted in some cities and is expected to be promoted nationwide through the installation of energy-efficient home appliances.

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1. Introduction

In the past decades, China has been experiencing the rapid growth of electricity consumption, along with the booming economy as well as the acceleration of the industrialization and urbanization processes. According to World Bank (2013), the total electricity consumption in China reached 4.2 trillion kWh in 2010, a little below 4.35 trillion kWh of the electricity consumed in the United States of America (USA). Considering the double-digit growth of electricity consumption in China in the past decades, its consumption was expected to exceed that of the USA around 2011, making it the largest electricity-consuming country in the world.¹ Among various sectors, the industrial sector has been the

biggest contributor, accounting for over 70% of electricity consumption since 1990. The implementation of a series of policies related to energy saving and emission reduction was emphasized in the 11th Five-year Plan (2006–2010). The total electricity consumption of the industrial sector has shown a declining trend in recent years, decreasing by 1.75 percentage points from 2005–2009. This trend is expected to continue in accordance with the 12th Five-year Plan (2011–2015).

Comparatively, the household sector has started to increase its proportion of total electricity consumption by 1.59 percentage points from 2005 to 2009, amounting to 13.2% of total electricity consumption in 2009. Although this share is much smaller than that of the industrial sector, the growth rate of electricity demand in the household sector is very high, with an annual rate of 14.0% from 2005 to 2009. This is significantly higher than those of the other sectors. The high growth trend is expected to continue along with the increase in the number of rich Chinese households and their adoption of modern lifestyles. Therefore, policy concerns over the rapid growth of residential electricity consumption have begun to emerge.

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¹ According to World Bank (2013), the average growth rate of electricity consumption in China from 2000 to 2010 is 12.0%, and 0.8% for USA during the same period.

The existing pricing system for residential electricity in China is not efficient and should be reformed. Recently, China's regulatory authority, the National Development and Reform Commission, announced that the Government is planning to implement nationwide the Multistep Electricity Price (MEP) for household electricity consumption, in order to encourage electricity saving, but without sacrificing the welfare of poor families. Before this announcement, the MEP scheme had already been implemented since 2004 in several provinces, including Fujian, Sichuan, and Zhejiang.

Although the MEP has gained much attention and has been widely discussed in China, knowledge about how household electricity consumption responds to electricity price is still limited. Specifically, although the MEP has been implemented for several years in the aforementioned regions, its effect has yet to be strictly evaluated apart from several reports that have been published recently. For example, the household electricity consumption in Sichuan increased by only 0.11% in the first year after using MEP. However, whether or not such reduction is caused by other factor changes during that year remains unclear.

MEP is a non-linear electricity pricing scheme comprising various qualities and charges. Here, each consumer can choose the quantity of electricity to consume. Non-linear pricing is advantageous when price and income elasticity differ among consumers. The estimation performed in the current work provides empirical evidence that can be used in making policies pertaining to the MEP; in turn, such information can help predict the increase of residential electricity demand in the future. This paper uses household survey data from Sichuan Province to estimate the residential electricity demand of urban households, focusing mainly on incomes, price elasticities, and the effects of lifestyle-related variables. This current study uses annual micro household-level data from 17 counties or cities in Sichuan Province, covering a period of three years from 2007 to 2009. Two criteria were used in choosing the data from Sichuan Province. First, a significant disparity in the economic development among these regions must exist. For example, the per capita GDP in the richest region must be approximately 6.2 times more than that of the poorest region. Second, the household sector in Sichuan must have adopted the MEP since 2006.

The present paper is the first to use micro household-level data to explore residential electricity consumption in China. Similar to many previous studies, this current study focuses mainly on the estimates of income and price elasticities. These data are important to policy makers who design the pricing scheme of household electricity consumption. In addition, this current study also empirically examines the effects of lifestyle-related variables, such as demographic factors, dwelling size and holdings of home appliances, on household electricity consumption. Compared with macro studies, micro studies are more valuable in estimating the residential demand for electricity. The usage of micro household-level data provides the researchers more flexibility to better understand consumer response and the impact of behavior factors, such as household attributes, family size, age distribution, education, and so on. In particular, the inclusion of these behavior factors is crucial in avoiding biased estimates of price and income elasticities, and in gaining a better understanding of the changes in energy demand within the residential sector. Second, a micro-economic approach to electricity demand also enables more extensive examination of the variations in electricity consumption, such as perspective of demographic attributes and income level, across different heterogeneous household groups.

This paper has several key findings. First, the empirical results reveal that if a few structural factors that reflect the changes in household lifestyle are controlled (e.g., household demographic attributes, dwelling size, and the holdings of home appliances), household electricity consumption becomes both price- and

income-inelastic. Second, lifestyle-related variables significantly affect household electricity consumption. For example, household electricity consumption tends to be higher in households that own more home appliances, whose dwelling size is larger, and whose heads are older than 50 and have an educational background higher than primary school. Specifically, aside from the effect of the growth of household income, these structural factors are expected to propel household electricity consumption in urban areas in China. This means that the increase in electricity consumption can be attributed to the larger dwelling size, the rising popularity of home appliances (e.g., computers and air conditioners), the rising proportion of old households brought about by the ageing population, and the declining percentage of households whose heads have completed primary school or below due to the educational development in China.

The empirical evidence on household electricity consumption also present several policy implications toward electricity saving in the residential sector in a coordinate and coherent manner. First, as implied by the low price elasticity, the marginal increase in electricity price should progressively increase and should be sufficiently large for the design of MEP toward electricity saving in the residential sector. Apart from the MEP scheme, a diversified policy package is required to curb the growth of residential electricity demand without sacrificing the welfare of the household. For example, certain preferential policies can be applied, such as phasing out low-efficiency home appliances by subsidizing high-efficiency ones (especially for refrigerators and computers), in order to improve the energy efficiency of home appliances.

Second, the low income elasticity also indicates that electricity service is a necessity for residents and household income growth that does not directly cause a substantial increase in residential electricity demand. Likewise, if there is a decrease in income², residential electricity demand does not necessarily decrease, although the burden of expenditure on electricity consumption may increase significantly. In particular, the low income elasticity implies that the burden of electricity expenditure could be high for low-income families (e.g., families with the qualification of Minimum Living Standard) and the implementation of the MEP scheme may reduce household welfare. Therefore, in order to mitigate the burden of expenditure on electricity consumption in such families, some preferential policies on residential electricity price can be applied meant especially for low-income families.

The remainder of this paper is organized as follows. Section 2 presents a brief literature review on residential electricity demand. In Section 3, the econometric model and data are introduced, and several stylized facts on the distribution of electricity price and electricity demand are provided. Section 4 presents the estimation results. The concluding remarks are given in the final section.

2. Literature review

Empirical studies on residential electricity consumption have received considerable attention in both developed and developing countries. Table 1 summarizes several previous studies on residential electricity demand that mainly focus on the estimates of income and price elasticities. Most of these studies use aggregated time series data, and only a few micro studies use the available household-level data. Among these, only two studies use micro-level data, namely, urban households in India (Filippini and Pachauri, 2004) and Seoul households in Korea (Yoo et al., 2007).

² For example, household income may decline significantly when family members quit the labor market because of retirement or health problems.

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