

## Rising wages and energy consumption transition in rural China

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### ABSTRACT

Residential energy consumption in rural China is undergoing a transition from traditional biomass energy to modern commercial energy. This paper examines the impact of rising wage rates on energy consumption mix in rural China. Using a unique panel data set from our two-round surveys of 409 rural households in 4 provinces, the results show that the wage rate at the village level has a significant negative impact on traditional biomass energy consumption and significant positive effects on consumption of electricity and new renewable energy in rural China. As traditional biomass energy is mainly collected with family labor and is relatively labor intensive, an increase in rural wage rates would enhance the opportunity costs of traditional biomass energy, leading to a reduction in biomass energy consumption. Continuously rising rural wage rates could accelerate the transition from biomass energy to electricity in rural areas. These findings could have important policy implications, not only for indoor air quality and environmental and health issues in rural areas but also for greater security in rural energy supply and policies to incentive farmers to better utilize biomass resource after harvest.

### 1. Introduction

Rural energy consumption has raised serious concerns about health and environment (Bruce et al., 2000; Zhou et al., 2008; Kandlikar et al., 2009). In rural China, traditional biomass energy, including firewood, straw, animal dung and other crop residues, accounts for a major source of household energy consumption (Jiang and O'Neill, 2004). Burning solid biomass, often in traditional cooking stoves, produces a variety of pollutants including particulate matter (pm) and carbon monoxide (co), resulting in indoor air pollution and environment pollution. For instance, the use of biomass fuel in rural energy consumption has been considered as a major factor for lung cancer and cardiovascular and respiratory diseases (WHO, 2002; Duflo et al., 2008). In some areas, particularly those ecologically vulnerable ones, growth in firewood consumption has resulted in forest degradation, loss of biodiversity and soil erosion, threatening sustainable development there.

The good news is that rural energy consumption in China has been in a transition from traditional biomass energy to modern commercial energy (such as electricity) and new renewable energy (such as solar energy). The proportion of biomass fuel in rural energy consumption has been declining over time, though it still accounts for more than 50% of total residential energy use in rural areas (Jiang and O'Neill, 2004). On the other hand, consumption of electricity, gas, and coal in rural China has been increasing (Pachauri and Jiang, 2008). For instance,

between 1980 and 2014, rural residential electricity consumption increased at an annual rate of 10.7% (NBSC, 1980–2015). Furthermore, new renewable energy such as biogas and solar energy has been promoted in rural areas by the Chinese government, to mitigate health and environmental issues (Sun et al., 2014).

Moreover, to facilitate the transition from traditional biomass energy to modern commercial energy, especially the reduction in crop straws, several policies have been implemented in rural China. For instance, the Chinese government started to reform China's electricity market and grid system to provide farmers better access to electricity (Wang and Zhang, 2012). Also, a substantial amount of governmental subsidy was provided to promote the adoption of new renewable energy, such as biogas, in rural areas (Sun et al., 2014). Regarding the utilization of traditional biomass, the Chinese governments initiated a pilot policy in 2008, known as the Crop Residue Retention Program, which aims to reduce the burning of grain straws as an energy source and retain them in lands to improve soil quality. This program subsidizes farmers' practice of crop residues retention including equipment purchase. In addition, policies were announced that encourage firms to use crop straws as raw material to produce feedstuff, organic fertilizer, and fuel. By 2020, the Chinese government aims to utilize at least 85% of crop straws nationally (NDRC, 2015). However, implementation of those policies, which involve a significant amount of resources, requires a clear understanding of the factors driving the ongoing transition in

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rural China and their impact on the trend of rural energy consumption in the future.

The ongoing transition in energy consumption in rural China has been investigated, both theoretically and empirically, from different perspectives including the Energy Ladder Theory (Pachauri and Jiang, 2008; Zhang et al., 2011), the estimation of household energy demand function based on household models (Chen et al., 2006; Zhang and Koji, 2012; Demurger and Fournier, 2011), and the Computable General Equilibrium models (Shi et al., 2009). These studies highlight important roles of such factors as household wealth, energy prices, access to modern energy, energy technology, and institutional weaknesses on rural energy transition in China. Besides these studies, other studies also show that household characteristics, such as labor endowments, education level, age and gender of family members, also influence the choice of household energy use (Farsi et al., 2007).

This paper highlights another important factor, rising wages in rural areas, in the ongoing transition away from traditional biomass fuels. There has been a massive labor migration from rural to urban areas; consequently, rural wage rates have increased rapidly. The average wage rate in rural China increased at an annual rate of 9.5% between 2000 and 2014 (NDRC, 2015). Because collecting traditional biomass is quite labor intensive, we expect that rising rural wages significantly increase the opportunity cost of collecting biomass energy, accelerating the transition away from traditional biomass in rural China.

To empirically investigate the impacts of rising wages on household energy consumption in rural China, we implemented two rounds of surveys on rural households in 4 provinces in China. We collected detailed information on rural households' consumption of a set of energy sources including traditional biomass, commercial energy (electricity, coal, and LPG (liquefied petroleum gas)), and modern renewable energy (solar and biogas). A system of equations method and a fixed effect model are used to empirically estimate the impact of wage rates on energy consumption, in addition to other factors, such as household income growth, access to modern energy, and household characteristics. We find that as local wage rates increase, the demand for traditional biomass energy decreases. More specifically, an increase of one thousand Yuan in monthly wage rate at the village level leads to a reduction of 48.74 kg standard coal equivalent (SCE) per capita in traditional biomass consumption, and an increase of 8.14 and 14.15 kg SCE per capita in electricity and new renewable energy consumption, respectively.

To our knowledge, this paper is the first one to highlight rural wage rates as an important factor in explaining changes in rural energy consumption. The findings and insights about the effects of rising wages on rural energy transition are of important policy implications, allowing policy makers to better understand the dynamics of the structural changes in rural residential energy consumption and make more informed rural energy policies. As wage rates in rural China are expected to continue the rising trend, the transition from biomass energy to electricity in rural areas might as well continue or even accelerate. This would be beneficial for improving indoor air quality and addressing environmental and health issues related to the burning of biomass, but meanwhile requires greater security in rural energy supply and policies for farmers to utilize biomass resources after harvest.

Empirically, unlike previous studies (Zhang and Koji, 2012; Chen et al., 2006; Liu et al., 2008), our study involves a unique panel data set, which enable us to conduct more rigorous estimations to understand the transition of rural household energy consumption. Moreover, unlike previous studies that often examine rural consumption of electricity, coal and firewood (Chen et al., 2006; Shi et al., 2009; Liu et al., 2008), our study covers a more comprehensive range of energy resources including electricity, LPG, coal, oil, biogas, solar energy, firewood, straw, and other types of biomass energy. Thus, it better captures rural energy consumption and the substitution among different energy types.

The remainder of this paper is organized as follows. Section 2 introduces the background on residential energy consumption in rural

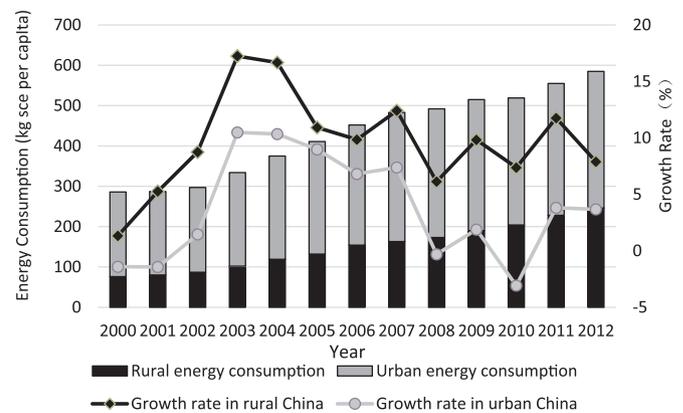


Fig. 1. Energy consumption and growth rates in China from 2000 to 2012. Data sources: China Energy Statistical Yearbooks (2001–2013).

China. In Section 3, we discuss conceptually the linkage between the wage rate and household energy consumption. We then present the survey data, sampling procedure and descriptive analysis in Section 4. Section 5 discusses our empirical models and estimation methods. Section 6 reports our results. Conclusions and policy implications are presented in Section 7.

## 2. Background: residential energy consumption in rural China

Due to its rapid economic growth, China's rural residential energy consumption has been rising rapidly since 2000. According to China Energy Statistical Yearbooks, the total residential energy use in rural China reached 246 kg SCE in 2012, more than tripled the consumption in 2000 (NBSC, 2001–2013). Although the absolute amount of residential energy consumption in rural areas has been small relative to that of urban households, it grows much faster than the latter (see Fig. 1). During the period of 2000–2012, the average annual growth rate of rural residential energy consumption in China was 11%, while the annual growth rate in urban China was only 5%. The accelerated growth in rural energy consumption indicates an increasing and potentially large demand for energy in rural China.

It is worth noting that the rural energy consumption reported in China Energy Statistical Yearbooks may be much underestimated because only commercial energy (including coal, electricity, natural gas, and LPG) is included in the official statistics. Firewood, agricultural residual, straws, biogas, and solar energy, though commonly used in rural China, are not covered. Thus, the actual residential energy consumption in rural China may be much larger than that reported in Fig. 1.

According to China Yearbook of Household Survey, another official statistics that report disaggregated data on coal, LPG, electricity, as well as non-commercial energy such as firewood, residential energy consumption in rural China also exhibits a similar expanding trend from 2004 to 2012.<sup>1</sup> As shown in Table 1, the consumption of electricity increased at an annual rate of 18.2% during the period of 2004–2012; the use of LPG increased from 48.7 Yuan per household in 2004–165.3 Yuan per household in 2012. By contrast, the use of coal, firewood, and dry weed decreased in general, but with a large variation over the same period.

Another interesting observation is that residential energy consumption varies largely across regions in rural China. In general, households in more developed areas use more electricity and LPG, while households in less developed provinces mainly rely on coal and firewood. Table 2 reports residential electricity consumption, LPG, coal,

<sup>1</sup> The consumption data of different types of energy after 2012 are not reported by this yearbook.

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