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Impact of dynamic pricing strategy of electricity on residential energy consumption decisions in China: Empirical evidence from a household survey

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Abstract:

By facing the growing demand of residential electricity consumption caused by the rapid growth of urbanization in China, the residential electricity pricing mechanism problem has existed in a long period including unreasonable price structure and serious cross subsidization. Simultaneously, expansion of the demand for electricity caused by the growing industrialization aggravate the status of electricity shortage. In order to deal with the issue of cross subsidies and pressure on energy supply, several dynamic pricing systems of electricity, including the Tiered Electricity Pricing system (TEP) and Time-of-use (TOU) program, was introduced in residential electricity consumption area. In this study, based on the data of 3,653 households from the Chinese General Social Survey of 2015, impact of implementation of TEP mechanism, and the TOU program on energy consumption decisions of households are analyzed by Probit model. Last, the energy consumption determinants of households are estimated. Furthermore, we discussed on whether such impact of dynamic pricing strategies of electricity on energy consumption differ by registered locations of households.

According to estimation results, energy consumption behaviors of residents are significantly differed by registered locations of households. Residents located in rural area are more likely to consume energy source that is cheaper but with higher health risk and potential of releasing carbon dioxide emissions. Moreover, we conclude that the adoption of TEP system may lead to increase in carbon dioxide emissions at household level caused by substitution of nature gas by coal gas consumption, while the TOU program caused the exact opposite effects.

Keywords: rural households, energy consumption, consumer consumption behavior, tiered electricity pricing, Time-of-use pricing

1. Introduction

As the 13th Five Year Plan for economic development has been unveiled, China is likely to be in the process of rapid industrialization and urbanization in the foreseeable future, which may result in the continuous increase in electricity consumption (Shi, 2019). Electricity consumption is dominated by industry and commercial sectors in China, the share of residential sector is less than 15% of the total consumption mix (IISD, 2015). However, as in other developing countries, the electricity tariffs in China are characterized by the higher rates for industrial and commercial customers than for residential customers. In the traditional electric industry, the government usually requires electric utilities to supply the residential customers with the electricity at low rates for some social reasons, thus electric utilities have to recover their losses through the cross-subsidies profits from the industrial customers who pay the higher rates (Qi et al., 2008). The cross-subsidies for residential electricity consumption twist the price and hinder the electricity marketization reform. Moreover, as there is no price differentiation for households with different incomes, the universal subsidies tend to be regressive, disproportionally benefit the rich (Lin and Jiang, 2012). Simultaneously, expansion of the demand for electricity caused by the growing industrialization aggravate the status of electricity shortage. In order to promote the efficiency of residential electricity consumption and phase out untargeted energy subsidies, the tiered electricity pricing (TEP) system has been formally implemented in China since July 2012. Under the TEP system, residential electricity prices will be set in three tiers based on the volume of electricity consumption. The first and second tiers include more than 80% consumption demand of residential users, to ensure the electricity price stable for majority residential users in China (Wang et al., 2017).

In our review of previous literature, we found that most of the empirical studies have been conducted on energy saving effects of the TEP system. For instance, by randomly selecting 816 samples from the residents in Beijing, Wang et al. (2010) concluded that it is necessary to implement TEP to enhance the energy saving willingness of residents and promote energy conservation and a reduction in its consumption. Yu and Guo (2016) examine the electricity-saving potential of rural households in China and find that saving potential is affected by fast information feedback and social-demographic characteristics, instead of by the electricity price, or energy efficiency labelling signals. Zhang and Lin (2018) investigate the effectiveness of the TEP by discussing whether the TEP has attained its anticipated electricity conservation outcome. The survey data demonstrated that there were more than half of the respondents (52.8%) affirmed that the TEP had encouraged them to save electricity. From the aspects of research perspectives and methods, existing studies provide effective references for the adoption effect of dynamic pricing plan on electricity consumption behavior of residents in China. However, few empirical studies have been focused on such policy impact on energy sources other than electricity. Aiming at this short-coming, from the perspective of evaluating effect of the policy on energy consumption behavior of residents, this paper analyses the factors influencing the consumption choices of five categories of energy sources, including fuel wood, coal, LPG, coal gas, and nature gas. In this way, this study provides a theoretical basis for improving current TEP policy.

Factors that affecting energy consumption behavior of residents have also been discussed in previous researches. Du et al. (2015) compared the residential electricity consumption data before and after the implementation of TEP in China, and found that the energy price, household income, and demographic attributes have significant impacts on residential electricity consumption. Zou and Luo (2019) estimated the energy consumption determinants of rural households. Results reveal that household head characteristics such as health situation, age, job type, education level, and household size and economic condition are essential factors that influence choices of consumers.

Moreover, even though the dynamic pricing policies of electricity were implemented as national level strategies, only households with separate electricity meter can be affected by the policy. Martiskainen and Coburn (2011) proved that smart meters has significant influence to residents of electricity efficiency and can guide electricity behavior to make the users realize the unreasonable electricity consumption. Xu et al. (2015) found that the effect of smart meters for residential energy saving is remarkable, by analyzed the household's smart meters sample of Shanghai, China. The current application of smart meters in China was still under stage of alternative popularization. Thus, we assume that adoption of the smart electricity meter is another essential factor that affect the policy impact on residential energy consumption. Additional analyzation that including indicators of utilization status of smart meter will be discussed in the update version of our study.

Contributions of our study can be summarized as follows: first, by adopting the econometric model established based on microscopic survey data, the research evaluates the effects of dynamic pricing policies on energy consumption structures of local residents. Second, this study accesses the changes in consumption of energy sources other than electricity, after implementing the policies that aimed at arising the energy efficiency. Third, energy consumption characteristics and the policy impacts are discussed by rural and urban area.

The remainder of this study is organized as follows: Section 2 introduces the dynamic pricing strategies implemented in China, which includes the TEP system and TOU program. Section 3 describes the analysis framework, including descriptions of the Probit model with interaction terms. Descriptions of data and the CGSS 2015 survey are represented in Section 4. Estimation results and discussions are provided in Section 5. Finally, our conclusions and research implications are drawn in Section 6.

2. The dynamic pricing system of electricity in China

In 2007, the electricity consumption of residents was about 36,080 billion kWh, accounting for about 11.08% of the total electricity consumption of entire society. By 2017, residential electricity consumption was increased to more than 87,025 billion kWh, accounting for approximately 13.68% of total electricity consumption (see Figure. 1). By facing the growing demand of residential electricity consumption, the electricity pricing mechanism problem of China has existed in a long period including unreasonable price structure and serious cross subsidization (Wang et al., 2017). Qi et al. (2008) point out that the reduction or elimination of cross-subsidies through an increase of the residential electricity tariff as well as a slight decrease of the industrial tariff could improve the economic efficiencies and the social welfare.

[Figure 1]

The cross subsidies for residential electricity consumption twist the price and hinder the electricity marketization reform. Moreover, as there is no price differentiation for households with different incomes, the universal subsidies tend to be regressive, disproportionally benefit the rich (Lin and Jiang, 2012). Cross-subsidization not only leads to the imbalance of electricity pricing structure and the long-term revenue loss of the power enterprise, but also reduces the social electricity utilization efficiency. According to Bhattacharyya and Ganguly (2017), Removal of cross subsidies in electricity sector will increase inflation in India. Goldthau (2013) suggests that the TEP system is essential for incentivizing energy-saving in the process of energy regulatory reforms in China.

The residential TEP system has been formally implemented in China since July 2012. Electricity consumption of households was divided into three tiers by the TEP system. The first tier guarantees the most basic electricity demand of family life. The second tier increases 50–140% from first tier, and the third tier is about 150–230% of the first tier. The prices for second tier and third tier increase 0.05 CNY and 0.3 CNY from the basic price (Wang et al., 2017). Due to differences in level of economic development and energy demand among different regions in China, the standard for each tier and basic price was set up specifically in each province.

Simultaneously, along with the expansion of the demand for electricity, the unbalanced distribution of demand has brought the huge pressure on power supply as well (Strbac, 2008). In order to reduce the power consumption and the power supply pressure, the TOU system has been getting more and more attention. The time-of-use electricity price is a strategy that is intended to help shift electricity use from peak hours to off-peak hours through demand response. Thus the electricity price for peak hours under the TOU will be higher than that of the off-peak hour. It is said to result in more efficient use of energy resources and less pollution. Faced by increasingly severe energy situation, the TOU program was adopted as a national level policy by the Chinese government in 2004[1].The price difference between peak and off-

[1]Notice of the General Office of the State Council on dealing with the peak-time electricity shortage issue on summer time [2004] http://www.gov.cn/xxgk/pub/govpublic/mrlm/200803/t20080328_32384.html (in Chinese), accessed on 29 May, 2020

peak hours differs from provinces and municipalities. As described in Liu et al. (2016), TOU can effectively encourage users to transfer electricity load, reduce the rate of electricity load during peak hours, and reduce the supply pressure during peak periods. The TOU program thereby considered to be able to improve the utilization efficiency of the system equipment capacity.

3. Methodology

Main objective of this study is to analyze the effects of TEP and TOU on energy consumption behavior of rural and urban households in China. We mainly focus on five categories of energy sources which account for over 90% of local households' total energy consumption, including the consumer motivation on consumption of fuel wood, coal, LPG, coal gas, and nature gas.

The regression model is established by using the energy consumption indicators, policy variables, and corresponding independent variables. Due to the dependent variables are dummy variables, the measurement model is known as a Probit model. The model uses the quasi-maximum likelihood function method to estimate the coefficient of the independent variables. The general form of estimation model is as follows:

$$y_{i,k} = \begin{cases} 1 & if\ household\ i\ use\ energy\ source\ k \\ 0 & if\ household\ i\ do\ not\ use\ energy\ source\ k \end{cases}$$

$$pr(y_{i,k} = 1) = \alpha TEP_i + \beta TOU_i + \delta rural_i + \gamma Controls_i + \lambda_p + \epsilon_i, \qquad (1)$$

where i denotes the number of observations and k represents the type of energy sources. $y_{i,k}$ refers to the indicators of consumption behavior of energy source k of household i. The energy consumption indicators include the usage of fuel wood, coal, LPG, coal gas, and nature gas. TEP_i and TOU_i are dummy variables for households adopted the TEP system and TOU program. After implementation of these policies, $y_{i,k}$ = 1 when residents i choose to use energy source k and 0 otherwise. Our coefficient of interest, α and β, measure the changes in $y_{i,k}$ if households adopted the dynamic pricing policies.

$rural_i$ is used to capture the registered location of households, which accounts for 1 if households registered in rural areas. The features of household and household head are captured by $Controls_i$. Information on socio-economic and demographic characteristics of households include number of household members, number of children, household's annual income and expenditure, annual electricity consumption amount, access to central heating, and dwelling area. The features of household head include gender, age, education level, and type of job. λ_p are regional dummies which used to capture potential political and economic differences of sampled provinces. Term ϵ_i is the error term that assumed to be independent of the covariates $Controls_i$.

In addition, to investigate the effects of dynamic pricing strategy of electricity on the energy consumption characteristics by different registered locations of households, we adopt an approach that using the interaction term of policy indicators and registered location dummy variable in our fixed effect Probit model:

$$pr(y_{i,k}=1)= \alpha_0 TEP_i+\alpha_1 TEP\times rural_i + \beta_0 TOU_i+\beta_1 TOU\times rural_i+\delta rural_i \\ +\gamma Controls_i+\lambda_p+\epsilon_i, \qquad (2)$$

where $TEP \times rural_i$ and $TOU \times rural_i$ are interaction terms between policy indicator TEP_i and TOU_i and registered location dummy $rural_i$. Assume $IMTEP_{i,k}$ is used to capture impact of TEP_i on $y_{i,k}$, the following formula can be obtained:

$$IMTEP_{i,k}=\frac{\partial pr(y_{i,k}=1)}{\partial TEP_i}= \alpha_0+\alpha_1 rural_i\ ,$$

$$IMTEP_{i,k}=\begin{cases}\alpha_0+\alpha_1 & if\ rural_i=1\\ \alpha_0 & if\ rural_i=0\end{cases}\ .$$

Hence, the coefficient α_0 capture the effects of TEP system on energy consumption behaviors of urban households, and $\alpha_0+\alpha_1$ capture such effects on rural households. Similarly, β_0 denotes the effects of TOU program on urban households, and $\beta_0+\beta_1$ can be used to capture that of TOU program on rural households.

4. Data and characteristics of residential energy consumption

Estimation data of this study is gathered from the Chinese General Social Survey (CGSS) of 2015. The CGSS, which was jointly promoted by National Survey Research Center of Renmin University and the Survey Research Center of Hong Kong University of Science and Technology, has been periodically conducted since 2003.

The CGSS 2015 covered 478 villages in 22 provinces, 4 autonomous regions, and 4 municipalities of China. A total of 10,968 households were selected through the procedure of the multiple step stratified random sampling, and detailed information about socioeconomic situations, demographic characteristics and so on for households were provided, suggesting that the sample for the survey is highly representative (Zou and Luo, 2019). In addition to the demographic and socioeconomic characteristics, the energy module in the CGSS 2015 survey, was firstly designed and conducted by the China Residential Energy Consumption Survey Center of the Renmin University. While only 3,653 households, nearly one-third of the respondents, were randomly selected to answer the energy module. Questions of energy module covered a total of six areas: household characteristics, dwelling characteristics, household appliances, space heating and cooling, patterns of private transportation, and electricity billing, metering, and pricing options.

[Table 1]

Table 1 demonstrates the descriptive statistics of our estimation data. As shown by the statistics, explained variables are indicators that used to capture household's energy consumption behavior. The number of households that have fuel wood consumption is 959, which is about 26.3% of the survey sample. LPG is the energy source that had been mostly used (32.7%), while only 364 (9.96%) households contribute to coal consumption. The average of policy indicator TEP and TOU is 0.597 and 0.53, respectively. These number reflect that only about a half of the households had adopted the TEP system and TOU program. We assume it could due to the lack of smart meter application in China. There were 2,258 (61.8%) respondents accommodated in rural areas and 1,395 respondents (38.2%) respondents lived in urban districts. The average age of household head is around 55, indicating that most of the respondents are middle-aged residents. Respondents' education levels were mainly centered at the primary and high school levels. Only a few respondents had undergraduate education experiences or above. Figure 2 illustrates utilization rates of five categories of energy sources by rural and urban households. We find that the utilization rate[2] of fuel wood is 40.43% in rural households and 3.30% in urban households. On the other hand, that of nature gas is about 52.6% in urban households but only 10.8% in rural households. It reveals that the inequality of opportunity in energy consumption still exist in China between rural and urban households. Residents living in remote areas may have relatively poor access to modern energies. A heterogeneity analysis was conducted by Shi (2019), and the results show that more disadvantaged families are facing more unequal opportunities in energy consumption in China. The rural-urban status and region of birth are the two largest contributors to inequality of opportunity.

[Figure 2]

5. Results and discussions

5.1 Impact on residential energy consumption behaviors

We estimate the effects of two dynamic pricing strategies of electricity on consumers' energy consumption decisions using the Probit model. Table 2 reports the regression results regarding the consumers' consumption behaviors of five energy sources, including fuel wood, coal, LPG,

[2] Utilization rates of energy sources are share of households responded "yes" when they were asked about whether the household is using that kind of energy source in the whole sample.

coal gas, and nature gas. All the panel report specification that includes controls for regional characteristics by adopting the province dummy variable.

[Table 2]

Our estimates imply that the dynamic pricing strategies, including the TEP system and TOU program, has significantly affected the energy consumption behaviors of households in China. As shown in column (4) of Table 2, the residential usage of coal gas was significantly increased by the adoption of TEP system. On the contrary, the specification reported in column (5) suggests a statistically significant and negative effect of the TEP system on consumption of nature gas. These results illustrate that the three-tier pricing will lead to transfer of energy consumption intention to comparatively cheaper gas energy sources. On the other hand, according to the results in column (1) and column (3) of Table 2, implementation of the TOU program will result in reduction in usage of fuel wood and LPG. In column (5), the coefficient of TOU is positive and statistically significant, which suggest that the adoption of TOU encourages the usage of nature gas. The results imply that the TOU program has transferred residential energy consumption behaviors to energy source that has relatively higher price but less environmental externalities. This is due to households are able to save the expenditures on electricity consumption by shifting electricity use to off-peak time under the TOU program. It increases the capability of local residents improve their living conditions by purchasing energy sources with higher prices.

Controls for demographic and socio-economic characteristics are adopted in all regressions as well. According to coefficient of *rural* in column (1), consumption of fuel wood in rural households is significantly higher than that of the urban households. This result illustrates that the energy consumption characteristics are differed by registered locations of households. Besides, coefficients of *central heating* in Table 2 shows a negative and statistically significant impact of central heating system on usage of fuel wood, and positive impacts on consumption of gas energy sources. It indicates that residents tend to choose convenient and cleaner energy sources instead of energy source with potential health risk, if the households locate in areas with central heating system. Moreover, we found that increase in age and education experiences of household head will lead to increase in consumption of gas energy source. On the contrary, according to coefficients of *household size* in column (2) and (3), households with more family members tend to have larger consumptions on coal and LPG. At last, the results show that households with higher income level will result in reduction in fuel wood consumption and increase in coal gas consumption, while households with higher expenditure level will have higher consumption on nature gas.

5.2 Impacts for rural and urban households

This section discusses about whether the effect of TEP system and TOU program differ by the registered location of households. In addition to the policy indicators described above, cross term of rural household dummy and policy indicators are adopted as additional explanatory variables in the regression model. This approach allows us to separate the policy impact on energy consumption by rural and urban households.

[Table 3]

Table 3 illustrates the Probit regression results with additional policy indicators. Policy impact on energy consumption in rural area can be calculated by summarize the coefficients of policy indicator and the interaction term. For instance, as presented by the coefficients of *TEP* and *rural* × *TEP* in column (2) of Table 3, coal consumption of rural households caused by the implementation of the TEP system is positive and significant[3]. On the contrary, the coefficient of *TEP* is negative and statistically significant, suggests that the TEP system reduce coal consumption of urban households. This result indicates that introduction of the TEP system induce the increase in usage of energy sources with potential negative environmental externality in remote area. According to the coefficients of *TEP* and *TOU* in column (5) of Table 3, in contrast with the statistically significant and negative impact of the TEP, implementation of TOU program tends to increase the nature gas consumption of urban households. These results suggest that the available expenditure on energy consumption of urban households may decrease by the existence of TEP system, and finally cause the reduction in usage of energy source with relatively higher retail price. At last, similar to the main regression, fuel wood consumption of rural households is statistically significantly higher than that of the urban households. This result illustrates that household located in remote area may have relatively poor access to modern energy.

6. Conclusions

By focusing on residential energy consumption among five categories of energy sources, including fuel wood, coal, LPG, coal gas, and nature gas, this study estimates whether the implementation of dynamic electricity pricing policies also affect consumption of energy other than electricity of local residents. Such effects are estimated by adopting the fixed effect Probit model, in addition, the additional interaction terms between policy indicators and registered location of households, help us to consider how the estimated impacts differ by rural and urban households.

According to the estimation results, adoption of the TEP system and TOU program significantly changed the structure of energy consumption of local residents in China. We found

[3] In this case, coefficient of impact of TEP system on coal consumption of rural households is 0.656***, which is calculated by coefficient of *rural* × *TEP* (6.668***) summarized by coefficient of *TEP* (-6.012***).

that the TEP system, which is aiming to improve the utilization efficiency of electric power, has the potential on inducing negative environmental externalities. To be specific, the usage of coal gas was increased after the implementation of TEP, while that of the nature gas was decreased. Local residents, especially the rural households, tend to chose energy types with lower costs under the TEP system, even it may result in potential health risks. On the other hand, our results present a positive relationship between implementation of the TOU program and nature gas consumption. Our results suggest that the TOU program, which is adopted for achieving peak electricity demand remission, can promote the transition of households' energy consumption by substitute the usage of fuel wood and LPG by nature gas consumption. Monyei and Adewumi (2017) implies a possible reduction in household expenditure on electricity can be found by using dynamic pricing over TOU pricing. A reduction in electricity bill for households frees up money can be deployed for other activities capable of improving their quality of life (Chakravarty and Massimo, 2013; Kanagawa and Nakata, 2007; Pachauri et al., 2004). For instance, in our case, residents tend to purchase the energy sources with less potential of indoor air pollutions under the TOU pricing.

In general, natural gas has been seen as one of the most cost-effective energy sources, which can be used to maintain energy supplies while reducing carbon dioxide emissions. Substitution of coal use through increased utilization of existing nature gas power plants provides a relatively low-cost, short term opportunity to reduce carbon dioxide emissions of power sector by up to 20% in the US, while also reducing emissions of criteria pollutants and mercury (MIT Energy Initiative, 2011). According to the emissions factors of greenhouse gas inventories reported by the Energy Protection Agency (EPA) of the US, CO_2 released by per mmBtu[4] of coal coke is 113.67 kg, and that of wood and wood residuals is 93.8 kg. On the other hand, CO_2 emission by per mmBtu of nature gas is 53.6 kg, which is nearly half of the former ones (EPA,2014). Therefore, our study conclude that the adoption of TEP system may lead to increase in greenhouse gases emissions at household level caused by substitution of nature gas by coal gas consumption, while TOU program caused the exact opposite effects.

Additionally, since the access to central heating is a key factor in the local residents' decision of energy consumption, it is of great importance for the government to increase coverage of central heating system, which may improve households' ability for a positive energy transition from traditional fuels to modern energy sources.

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Table 1. Descriptive Statistics

	Unit	Obeservations	Mean	Std. Dev.	Min	Max
Explained variable						
fuel wood	dummy	3,653	0.263	0.440	0.000	1.000
use - 1		959.0				
not use - 0		2,694				
Coal	dummy	3,653	0.100	0.300	0.000	1.000
use - 1		364.0				
not use - 0		3,289				
LPG	dummy	3,653	0.327	0.469	0.000	1.000
use - 1		1,193				
not use - 0		2,460				
Coal gas	dummy	3,653	0.041	0.198	0.000	1.000
use - 1		149.0				
not use - 0		3,504				
Nature gas	dummy	3,653	0.268	0.443	0.000	1.000
use - 1		978.0				
not use - 0		2,675				
Policy variable						
TEP	dummy	1,179	0.597	0.491	0.000	1.000
have - 1		704.0				
not have - 0		475.0				
TOU	dummy	800.0	0.530	0.499	0.000	1.000
have - 1		424.0				
not have - 0		376.0				
Controls						
Panel A : household characteristics						
rural	dummy	3,653	0.618	0.486	0.000	1.000
rural - 1		2,258				
urban - 0		1,395				
household size	person	3,642	2.865	1.401	1.000	13.00
number of child	count	3,653	1.535	0.722	1.000	3.000
0		2,198				
[1,2]		957.0				
>3		498.0				
household income (1,000 yuan)	count	3,342	3.004	1.412	1.000	5.000
<15 - 1		607.0				
[15,30] - 2		778.0				
(30,50] - 3		678.0				
(50,80] - 4		553.0				
>80 - 5		726.0				
household expenditure	10,000 yuan	3,072	4.249	26.09	0.000	1000
electricity consumption	1,000 kWh	2,929	0.136	0.149	0.000	3.000
central heating	dummy	3,653	0.179	0.384	0.000	1.000
central heating - 1		655.0				
self heating - 0		2,998				
dwelling area	100㎡	3,653	1.163	0.872	0.050	10.50

Table 1. Descriptive Statistics ***- continued***

	Unit	Obeservations	Mean	Std. Dev.	Min	Max
Controls						
Panel B: Household head characteristics						
gender_male	dummy	3,653	0.471	0.499	0.000	1.000
male -1		1,720				
female - 0		1,933				
age	year	3,653	55.76	16.83	23.00	98.00
education level	count	3,653	1.815	0.728	1.000	4.000
≤ primary school - 1		1,331				
high school - 2		1,705				
undergraduage - 3		579.0				
> undergraduate - 4		38.00				
off-farm job	dummy	3,653	0.367	0.482	0.000	1.000
off-farm - 1		1,341				
farm - 0		2,312				

Table 2. Probit Model Regression Result

	Explained variable				
	fuel wood	coal	LPG	coal gas	nature gas
	(1)	(2)	(3)	(4)	(5)
TEP	-0.167	-0.438	0.293	1.022***	-0.766***
	(0.314)	(0.699)	(0.200)	(0.390)	(0.255)
TOU	-1.209***	0.293	-0.349*	0.397	0.890***
	(0.344)	(0.794)	(0.201)	(0.378)	(0.267)
rural	1.272***	-1.079	0.017	0.405	-0.343
	(0.333)	(0.947)	(0.192)	(0.380)	(0.221)
electricity consumption	0.793	1.223	0.576*	0.563	-0.555
	(0.486)	(2.084)	(0.325)	(0.345)	(0.372)
central heating	-1.955***	0.000	-0.171	1.226**	2.081***
	(0.724)	(.)	(0.300)	(0.527)	(0.345)
dwelling area	0.382**	0.136	0.068	-0.989***	-0.145
	(0.166)	(0.360)	(0.124)	(0.321)	(0.139)
gender_male	-0.381	-0.466	0.038	0.256	-0.292
	(0.262)	(0.492)	(0.166)	(0.283)	(0.189)
age	0.023	-0.065*	-0.002	0.026**	0.005
	(0.015)	(0.035)	(0.009)	(0.013)	(0.010)
education level	-0.097	-0.392	-0.345**	0.664***	0.121
	(0.249)	(0.782)	(0.149)	(0.255)	(0.170)
off-farm job	0.253	-1.206*	0.143	-0.510*	-0.389
	(0.315)	(0.616)	(0.200)	(0.284)	(0.240)
household size	0.097	0.500*	0.168**	-0.124	-0.017
	(0.111)	(0.273)	(0.077)	(0.183)	(0.088)
household income	-0.334**	(0.077)	(0.023)	0.267*	0.055
	(0.130)	(0.252)	(0.083)	(0.150)	(0.090)
household expandature	-0.008	0.020	-0.061**	-0.098*	0.148***
	(0.065)	(0.027)	(0.025)	(0.054)	(0.037)
Observations	292	101	372	301	339
province dummy	YES	YES	YES	YES	YES
pseudo R2	0.521	0.578	0.311	0.338	0.461

Note: Robust standard errors are in parentheses. *p < 0.1, ** p < 0.05, and ***p < 0.01

Table 3. Regression results with interaction term

	Explained variable				
	fuel wood	coal	LPG	coal gas	nature gas
	(1)	(2)	(3)	(4)	(5)
TEP	-0.846	-6.012***	0.349	0.695	-0.985***
	(0.622)	(0.936)	(0.270)	(0.434)	(0.295)
rural × TEP	0.828	6.668***	-0.126	9.938***	0.703
	(0.715)	(1.422)	(0.393)	(3.532)	(0.537)
TOU	-0.911	-1.883	-0.256	0.592	0.676**
	(0.850)	(1.398)	(0.292)	(0.425)	(0.328)
rural × TOU	-0.347	1.907	-0.172	-1.386	0.411
	(0.953)	(1.536)	(0.399)	(0.863)	(0.535)
rural	1.040**	-2.214*	0.174	-8.132**	-1.011***
	(0.435)	(1.254)	(0.293)	(3.290)	(0.356)
electricity consumption	0.750	-3.228	0.559*	2.228*	-0.450
	(0.518)	(3.918)	(0.328)	(1.194)	(0.356)
central heating	-1.949***	0.000	-0.155	1.181**	2.003***
	(0.706)	(.)	(0.301)	(0.567)	(0.346)
dwelling area	0.376**	0.309	0.071	-1.097***	-0.163
	(0.162)	(0.409)	(0.124)	(0.339)	(0.145)
gender_male	-0.339	-0.83	0.035	0.306	-0.296
	(0.259)	(0.558)	(0.166)	(0.304)	(0.190)
age	0.019	-0.0810**	-0.001	0.0320**	0.002
	(0.015)	(0.036)	(0.009)	(0.015)	(0.010)
education level	-0.125	0.456	-0.349**	0.803***	0.138
	(0.262)	(0.875)	(0.150)	(0.296)	(0.173)
off-farm job	0.233	-1.594*	0.161	-0.588**	-0.376
	(0.313)	(0.834)	(0.204)	(0.299)	(0.241)
household size	0.099	0.892**	0.169**	-0.160	-0.051
	(0.110)	(0.429)	(0.077)	(0.183)	(0.090)
household income	-0.308**	0.091	-0.022	0.276*	0.055
	(0.135)	(0.265)	(0.083)	(0.161)	(0.093)
household expandature	-0.018	0.095	-0.061**	-0.134**	0.145***
	(0.067)	(0.079)	(0.025)	(0.062)	(0.037)
Observations	292	101	372	301	339
province dummy	YES	YES	YES	YES	YES
pseudo R2	0.525	0.616	0.312	0.373	0.472

Note: Robust standard errors are in parentheses. *p < 0.1, ** p < 0.05, and ***p < 0.01

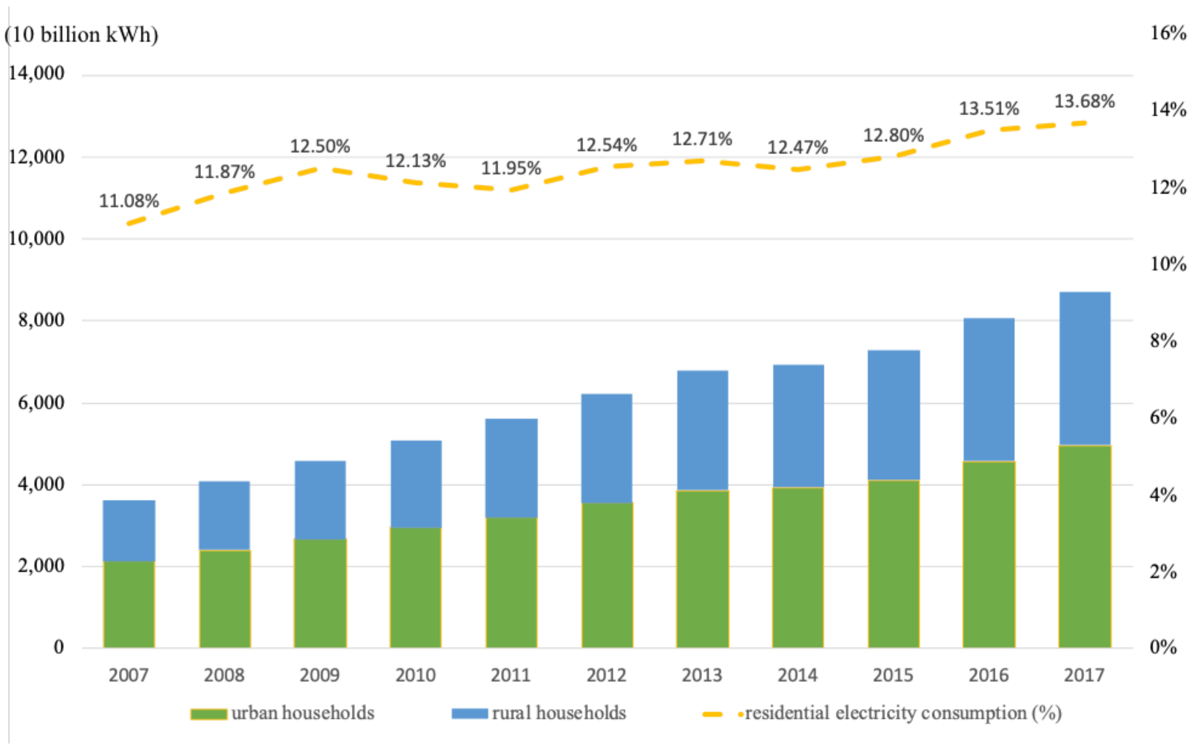

Figure 1. Trends in amount of residential electricity consumption (10 billion kWh) and its share in total electricity consumption (%)

Source: The Compilation of Power Industry Statistics 2007 - 2017

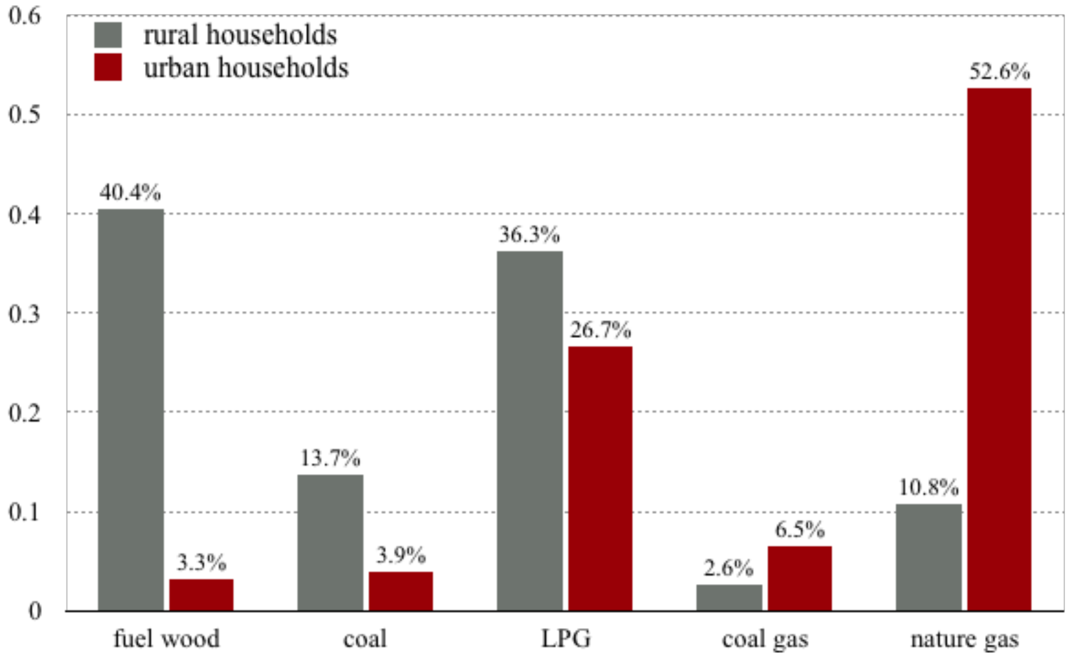

Figure 2. Utilization rates of energy sources by rural and urban households in 2015
Source: energy consumption module of CGSS 2015, calculated by authors

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