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Abstract

Household low-quality coal consumption is a main contributor to air pollution in China. In response, governmental subsidies on high-quality coal and promotion of new-type coal stoves have been implemented. However, to date, little is known about the effectiveness of these policies and determinants of consumption behavior between low-quality and high-quality coals. To fulfill this paucity, we conducted face-to-face surveys with 602 households in rural Beijing and collected the information of coal consumption, socioeconomic, cognitive and psychological factors. With the data, we empirically characterize the determinants of coal consumption and its switching behavior between high-quality and low-quality coals by bivariate probit and Tobit regressions, yielding the following principal results: (1) prosocial people are more likely to consume high-quality coal, and critical thinking disposition positively affects the probability to choose high-quality coal; (2) local environmental concern plays an important role in consumption behavior, but global environmental concern does not; (3) government policies appear to be efficient in that subsidies on high-quality coal reduce the likelihood of choosing low-quality coal and the promotion of new-type coal stoves facilitates the transition from low-quality to high-quality coal. Overall, the results suggest that cognitive, psychological factors and promotion policies can be considered significant in coal consumption behavior. Public education on critical thinking, local environment and prosociality as well as new-type coal stoves should be further promoted to accelerate the transition from low-quality to high-quality coal.

Key Words: Coal; air pollution; China

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Nomenclature

PM Particulate matter

RMB Renminbi, Chinese currency

SVO Social value orientation

1 Introduction

China is the leading coal consumer in the world by sharing $48.0\,\%$ of global coal consumption in 2015 (Enerdata, 2016). Coal burning is the most important contributor to ambient $PM_{2.5}$ and has caused $366\,000$ deaths in China during the year of 2013 (GBD MAPS Working Group, 2016).[1] It is also reported that coal quality is a main cause of serious air pollution in China (Litvinenko, 2016), and raw coal burning by rural households is responsible for even higher emission than that from industrial sectors (Zhi et al., 2015, Chai et al., 2016). Cheng et al. (2016) prove that due to incomplete combustion emissions, high concentrations of CO and $PM_{2.5}$ are from residential coal use. Hence, special attention on low-quality coal emission is required since it is a key to control haze pollution in rural China (Zhi et al., 2015). Beijing takes the lead in promoting high-quality coal by providing price subsidies and the

[1] PM (particulate matter) is the sum of all solid and liquid particles suspended in air. Particles sized in 2.5 micrometers and smaller in diameter denoted by $PM_{2.5}$ pose the greatest health risks.

adoption of new-type coal stove (General Office of Beijing Municipal People's Government, 2013). The subsidies are even increased and diversified in terms of different policies across Beijing's rural districts since 2015 (Gao, 2015). These policies are expected to be important in accelerating the transition from low-quality to high-quality coal and in mitigating the haze pollution. This paper address the policies and the factors influencing household coal consumption behavior with respect to coal quality in China.

In recent years, several studies focus on energy consumption structure involving coal consumption in rural China. Li et al. (2015) find that coal is still the main source for heating; renewable energy has been widely utilized for cooking and reduces the emissions significantly in Zhangziying town of Beijing. Wang and Jiang (2017) conduct field surveys in 30 rural counties among 25 provinces of China. They demonstrate that most rural residents use coal for heating and fuelwood for cooking, suggesting a boost of income level and necessity of renewable energy development in rural China. Several previous works analyze fuel switching behavior from non-commercial one, such as biomass, to modern and cleaner one. Peng et al. (2010) focus on energy sources for cooking in rural Hubei, documenting that income, fuel price and sociodemographic characteristics affect fuel switching from biomass to cleaner fuel. Rahut et al. (2014) identify that households with a better-educated or female head with higher income living in urban households have a higher probability of switching to clean energy use, while poor and rural households with low level of education are constrained to consume dirty energy in Bhutan.

None of these studies analyze the determinants of household coal consumption behaviors across different coal qualities within a single analytical framework. While direct switch from low-quality coal to another source of cleaner energy such as electricity or the renewable is known to be time-consuming due to the requirements of sound infrastructures and huge government investment, promotion of high-quality coal is regarded as an important and necessary step for practical energy transition in China (Xiao, 2016). Along with the government policies on high-quality coal consumption in rural Beijing, air pollution problems have become a prominent issue facing the developing worlds such as China and India. Given this state of affairs, this paper seeks to analyze the effectiveness of the government policies, household coal consumption and its switching behavior between low-quality and high-quality coal in rural China.

To this end, we conducted face-to-face surveys with 602 households in rural Beijing and collected the information of coal consumption, socioeconomic, cognitive and psychological factors. With the data, we empirically characterize the determinants of coal consumption and its switching behavior between high-quality and low-quality coals by bivariate probit and Tobit regressions, yielding the following principal results: (1) prosocial people are more likely to consume high-quality coal, and critical thinking disposition positively affects the probability to use high-quality coal; (2) local environmental concern plays an important role in switching behavior, but global environmental concern does not; (3) subsidy policies appear to be efficient in reducing low-quality coal consumption, while promotion of new-type coal stoves further stimulates high-quality coal consumption from low-quality one. The results suggest that cognitive, psychological factors and promotion policies can be considered significant in coal consumption behavior. Public education on critical thinking, local environment and prosociality as well as new-type coal stoves should be further promoted to accelerate the transition from low-quality to high-quality coal.

2 Data and methodology

As China's capital city, Beijing comprises 16 administrative county-level districts, among which, 6 are urban districts and 10 are suburban and rural districts. Beijing has a total area of $16\,410.5\,\mathrm{km}^2$; in addition to the relatively small urban areas of $1368.3\,\mathrm{km}^2$, the rest are broad rural areas (Beijing Municipal Government, 2012). Beijing is also a typical region that heavily relies on coal as a heating resource in rural areas and has suffered from severe haze pollution since 2013. Therefore, Beijing actively takes countermeasures to cope with the air pollution problems, such as promotion of high-quality coal and new-type coal stoves. Due to a huge difference in geographical and socio-economic levels across Beijing's rural areas, it is expected that we can obtain sufficient variation of data by implementing field surveys. We have covered 5 rural and suburban areas in our survey: Yanqing, Miyun, Pinggu, Fangshan and Daxing (see figure 1).

[Figure 1 about here.]

In the March of 2016, we conducted household field surveys in rural Beijing. Overall, 602 house-

holds were randomly selected and the decision makers of each household were interviewed. The respondents were asked to answer whether they use low-quality and/or high-quality coals during the February of 2016, and these answers generate the two binary variables yielding four possible outcomes: 1. low-quality coal = high-quality coal = 1 if a household consumes both low-quality and high-quality coals, 2. low-quality coal = high-quality coal = 0 if a household consume neither low-quality nor high-quality coals, 3. low-quality coal = 1 & high-quality coal = 0 if a household consumes only low-quality coal and 4. low-quality coal = 0 & high-quality coal = 1 if a household consumes only high-quality coal. In addition, we have elicited the corresponding consumption on low-quality and/or high-quality coals, respectively. The questionnaire contains additional three parts: (1) socioeconomic characteristics: income, household size, heating area, and education; (2) cognitive and psychological variables: social value orientation (SVO), critical thinking disposition and environmental concerns; (3) policy variables: possession of new-type coal stoves and price subsidies on high-quality coal. Table 1 provides the definition of every variable used in this paper.

[Table 1 about here.]

This study considers cognitive and psychological factors as possible determinants for household coal consumption including environmental concerns, critical disposition and social value orientation. Environmental concerns consist of two types of measurement: global and local environmental concerns (Nakagawa, 2017). According to Nakagawa (2017), global environmental concern is measured by 12 questions (see table 2). Apart from the 11 questions applied in Nakagawa (2017), one more question of concern on global warming is added, since the burning of fossil fuel leads to global warming problem and we are interested in how households are concerned about coal consumption and its association to global warming. Each question is 5 point scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. In theory, global environmental concern ranges from 12 to 60. Local environmental concern consists of 6 questions on the specific environmental issues in Beijing (see table 3). In addition to the 4 point scale for question 6, all other questions are based on 5 point scales: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. Hence, local environmental concern ranges from 6 to 29. Following Nakagawa (2015), critical thinking disposition

comprises 13 questions by focusing on the subscale of logical awareness ability (see table 4). Each question is based on 5 point scale: $1 =$ strongly disagree, $2 =$ disagree, $3 =$ neutral, $4 =$ agree and $5 =$ strongly agree, and the critical thinking disposition ranges from 13 to 65.

[Table 2 about here.]

[Table 3 about here.]

[Table 4 about here.]

Following Van Lange et al. (1997, 2007), we introduce social value orientation (SVO) to measure people's social preferences. The participants are randomly paired where the identity of the other in the pair is unknown, and they are asked to play the game containing 9 questions. Each question comprises a triple-dominance decomposed game because each participant is asked to make a single choice among three options of A, B, C. Each option is a matrix of numerical outcomes for oneself and the other in the pair (see table 5). In table 5, option A represents a competitive orientation since the subjects who choose A tend to maximize the gap between oneself and the other ($500 - 100 = 400$). The subjects who choose option B are identified to be a prosocial orientation because of their tendency to maximize the joint outcome ($500 + 500 = 1000$). Option C is an individualistic orientation since the subjects with this option tend to maximize own outcome at 550, regardless of the other's outcome. All of the 9 questions in SVO game are designed by the same logic in the example of table 5. According to Van Lange et al. (1997, 2007), when the participants make 6 or more consistent choices among the 9 questions with a particular orientation, they are identified to be one type from prosocial, competitive or individualistic orientations. Otherwise, they will be categorized into "unidentified."

Before the SVO game, we organized an oral instruction to the respondents in the field surveys. Each respondent has been informed that all the numbers in the game have meanings, and the more numbers the respondent receives, the more money oneself will get. After finishing the questionnaires, their choices have been paired and matched randomly. To elicit the subject's real choices in the SVO game, we provided the real money by calculating the subject's total numbers from the 9 questions of own choices and partner's choices and by applying an experimental exchange rate to the total payoff

each respondent gains from the SVO games.[2] Because we implemented the individual household field surveys, a post-survey for the SVO game was organized to pay the monetary reward to each respondent. The maximal individual gain is 10 RMB (≈ 1.54 USD) and the mean of that is 8 RMB (≈ 1.24 USD).[3] As noted by Sutterlin et al. (2013), we expect that prosocial people are more likely to conserve energy than individualists and competitors, and thus, this paper highlights the comparison between prosocial people and other value-oriented people.

[Table 5 about here.]

We apply two types of regressions (bivariate probit and Tobit models) by using the same set of independent variables. The bivariate probit model is specified as follows:

$$C^*_{ki} = \boldsymbol{\alpha}_k \mathbf{x}_{ik} + \boldsymbol{\beta}_k \mathbf{p}_{ik} + \boldsymbol{\delta}_k \mathbf{s}_{ik} + \epsilon_k, \quad k = \{h, l\}, i = \{1, 2, \ldots, 602\} \tag{1}$$
$$(\epsilon_h, \epsilon_l) \sim N[\mathbf{0}, \boldsymbol{\Omega}]$$

where subscript $k = \{h, l\}$ represents high-quality and low quality coals, respectively, subscript i is the ID number of households, C^*_{hi} and C^*_{li} are latent variables of high-quality and low-quality coal consumption for household i. The binary variables of high-quality and low-quality coal consumption are represented by the indicator functions of $C_{ki} = 1_{[C^*_{ki}>0]}$ in bivariate probit regression. $\mathbf{x}_{ik}$ is a vector of socioeconomic variables, $\mathbf{p}_{ik}$ is a vector of cognitive and psychological variables, $\mathbf{s}_{ik}$ is a vector of policy variables and ϵ_h, ϵ_l are error terms for high-quality and low-quality coal, respectively with means $\mathbf{0}$ and covariance matrix $\boldsymbol{\Omega}$.[4] Finally, $\boldsymbol{\alpha}_k, \boldsymbol{\beta}_k$ and $\boldsymbol{\delta}_k$ are the vectors of parameters associated with socioeconomic, cognitive, psychological and policy variables to be estimated through maximum likelihood for C_{ki}, respectively.

In the second regression, we analyze high-quality and low-quality coal consumption by applying Tobit regression. The Tobit regression uses the same set of independent variables as the bivariate probit

[2]The details of how to calculate the total individual payoff in the SVO game are explained in Van Lange et al. (1997).

[3]In the March of 2016, the exchange rate is 1 USD ≈ 6.48 RMB.

[4]The bivariate probit regression takes account of the correlation between ϵ_h and ϵ_l by estimating covariance ρ. The estimation result yields $\hat{\rho} = -0.807$ at the $1\,\%$ significance, implying negative association and substitutability between low-quality and high-quality coal.

regression of equation (1), but the dependent variables in the Tobit regression are the quantities of high-quality and low-quality consumption denoted by Q_{hi} and Q_{li}, respectively, noting that the consumption data contain a considerable portion of zero observations (table 6). The Tobit regression is expressed as

$$Q^*_{ki} = \mathbf{a}_k \mathbf{x}_{ik} + \mathbf{b}_k \mathbf{p}_{ik} + \mathbf{d}_k \mathbf{s}_{ik} + \varepsilon_k, \quad k = \{h, l\}, i = \{1, 2, \ldots, 602\}$$

where Q^*_{ki} is an latent variable satisfying the relation of $Q_{ki} = \max\{0, Q^*_{ki}\}$ and $\varepsilon_k \sim N[\mathbf{0}, \mathbf{\Omega}]$ is an error term so that the probability distribution of Q_{ki} is normally distributed over positive support and censored at zero over negative support. Under the assumptions, the vectors of parameters associated with socioeconomic, cognitive, psychological and policy variables, $\mathbf{a}_k$, $\mathbf{b}_k$ and $\mathbf{d}_k$, shall be estimated with the maximum likelihood for Q_{ki} in the Tobit regression (Wooldridge, 2008, 2010). The bivariate probit and Tobit regressions are utilized for analysis because we are interested in characterizing consumption and its switching behavior between high-quality and low-quality coals, qualitatively and quantitatively. The bivariate probit regression enables us to qualitatively analyze households' switching behavior between the two types of coals, considering four possible outcomes of $(C_{hi}, C_{li}) = \{(1,1), (1,0), (0,1), (0,0)\}$ within a single framework. In particular, the bivariate probit regression estimates marginal probability for households to choose one type of coals with a change in an independent variable. In the Tobit regression, we can quantitatively identify the marginal impact of key independent variables on high-quality, low-quality coal consumption and their substitution.

3 Results

Summary statistics

Table 6 presents the frequency of binary choices on low-quality and high-quality coals. The 75 ($12.46\,\%$) households do not use any type of coals, and the 46 ($7.64\,\%$) households consume both types of coal. The table also reveals that 306 ($50.83\,\%$) households only consume low-quality coal, and the 175 ($29.07\,\%$) households only consume high-quality coal. This result may indicate that governmental policies in rural Beijing have stimulated some rural households' switch to high-quality coal consump-

tion. However, the dominant heating resource appears to be still low-quality coal. Table 7 gives an overview on one-month low-quality coal and high-quality coal consumption during the February of 2016. The mean and median for low-quality coal consumption are $0.64\,\mathrm{t\,month^{-1}}$ and $0.5\,\mathrm{t\,month^{-1}}$, respectively. The mean and median for high-quality coal consumption are low at $0.38\,\mathrm{t\,month^{-1}}$ and $0\,\mathrm{t\,month^{-1}}$, respectively. Considering that high-quality coal is still on its early stage of its introduction as demonstrated in table 7, it shall take more time for high-quality coal to be widely accepted and consumed by local people in rural Beijing.

[Table 6 about here.]

[Table 7 about here.]

As seen in table 7, the range of household size and house heating areas exhibit wide variation from 1 to 11 and 12 to 500, respectively. A huge income gap can also be observed since the annual household income ranges from 2000 RMB to $120\,000$ RMB in year of 2015. On an average, the annual household income reaches $25\,600$ RMB, which is higher than the median, suggesting that poor households are dominant in rural Beijing. With respect to the education status, the rural residents are educated only up to primary schools on the average. The average levels of global environmental concern and local environmental concern are 43.96 and 20.48, respectively. Critical thinking disposition score varies from 27 to 46, and the average score is 41.72. With respect to social value orientation (SVO), $60\,\%$ of the participants are identified to be prosocial in rural Beijing. The relative price of high-quality coal to low-quality coal ranges broadly from 0.23 to 1.77. The average relative price is 0.71, indicating that the subsidized high-quality coal prices can be even cheaper than low-quality coal prices. The possession rate for the new-type coal stove is $13.0\,\%$ (See table 7).[5]

Regression results

The marginal effects of bivariate probit regression and Tobit regression are listed in table 8. The results of these two regressions are qualitatively consistent with each other. In general, local environ-

[5]The possession of the new-type coal stoves depends on whether each household know the promotion policies or not. Most households that possess new-type coal stoves know the policies, while those who do not possess neither know nor care about it from the beginning.

mental concern, SVO and possession of new-type coal stove are identified to be very important factors in people's choice and consumption behavior between low-quality and high-quality coal. Household income and relative coal price only affect the probability of choosing low-quality coal, and critical thinking disposition only affects the probability of choosing high-quality coal. The heating areas are estimated to have a small economic significance on the quantity change of low-quality coal consumption.

[Table 8 about here.]

Regarding household income, Tobit regression does not show any effect. The bivariate probit regression estimates a negative relationship between household income and people's probability of choosing low-quality coal. When annual household income is increased by $10\,000$ RMB, people tend to decrease the likelihood of choosing low-quality coal by $2.200\,\%$. This evidence indicates an importance of economic growth on people's motivation to quit low-quality coal in rural China. However, since higher-income people can have more options to replace low-quality coal, it is not much clear whether they switch to use high-quality coal or other cleaner energy such as electricity and renewable energy.

Household size does not show marginal effects on whether or not people choose low-quality and high-quality coals in bivariate probit regression, but positively brings about the change on high-quality coal consumption in Tobit regression. The results exhibit that with one more family member, the households tend to consume $0.105\,\mathrm{t\,month^{-1}}$ more of high-quality coal. For those who have adopted high-quality coal, a large-size family may demand more high-quality coal to sustain the indoor temperature. On the other hand, the more members there are in a household, the longer time it may take to achieve a decision on whether to change the heating source or not. The education status is found to have no significant impact on both low-quality and high-quality coal consumption.

Regarding house heating areas, bivariate probit regression shows its positive effect on the likelihood of choosing low-quality coal, but no effect on that of high-quality coal. In Tobit regression, the house heating areas only positively affect low-quality coal consumption correspondingly. Specifically, when the house heating areas increase by $1\,\mathrm{m^2}$, people are more likely to choose low-quality coal by $0.100\,\%$ and accordingly consume $0.004\,\mathrm{t\,month^{-1}}$ more of low-quality coal. Finally, one standard deviation ($\approx$

$58.825\,\mathrm{m}^2$) for the house heating areas is applied to see the practical impact on daily life of a household in the analysis. We find that when the house heating areas increase by $58.825\,\mathrm{m}^2$, people's probability to choose low-quality coal shall be increased by $5.883\,\%$ ($0.100 \times 58.825 \approx 5.883\%$), and accordingly, low-quality coal consumption will be increased by $0.235\,\mathrm{t\,month}^{-1}$ ($0.004 \times 58.825 \approx 0.235$). It is reasonable that the households with larger heating areas have traditionally used more of low-quality coal for warmth in their houses than those with smaller heating areas. In other words, they are more familiar with low-quality coal and uncertain about the heating costs with high-quality coal. Therefore, they might be cautious to switch to high-quality coal.

By comparing global and local environmental concern, we find that local environmental concern is an important factor affecting both people's choice and consumption behavior between two types of coal, while global environmental concern does not exhibit any significant impact. The bivariate probit regression estimates that when local environmental concern increases by one score, people tend to decrease the likelihood of choosing low-quality coal by $2.200\,\%$ and to increase the likelihood of choosing high-quality coal by $1.800\,\%$. Accordingly, Tobit regression reveals that people with one more score in local environmental concern tend to consume $0.047\,\mathrm{t\,month}^{-1}$ less of low-quality coal, but $0.061\,\mathrm{t\,month}^{-1}$ more of high-quality coal. This result reflects an importance of local environment concern on the transition from low-quality to high-quality coal. People who care more about local environment shall be more motivated to create better living conditions and thus take real actions to change their energy consumption behavior on the basis of daily and hand-on experiences. On the one hand, those with higher global environment concern might not actively choose high-quality coal because their cognition and knowledge on global environment mostly comes from books or public media instead of personal experience.

One interesting finding is that prosocial people are more likely to consume high-quality coal than low-quality coal. Bivariate probit regression also reveals that, compared with other value-oriented people, prosocial people tend to decrease the probability of choosing low-quality coal by $8.5\,\%$ and to increase the probability of choosing high-quality coal by $15\,\%$. Tobit regression also exhibits that prosocial people consume $0.231\,\mathrm{t\,month}^{-1}$ less of low-quality coal and $0.392\,\mathrm{t\,month}^{-1}$ more of high-quality coal. By definition, prosocial people are more concerned about the benefit of other people and

the whole society. Due to the reason, they might become more eager to switch to high-quality coal and to consume more. With respect to critical thinking disposition, people with one more score are more likely to choose high-quality coal by $0.800\,\%$. Higher critical thinkers are known to have better abilities in logical and comprehensive understanding. Thus, they might consume high-quality coal because of their deep understanding on the necessity to save the environment.

The promotion of new-type coal stove is identified to perform effectively in transitioning from low-quality to high-quality coal. Specifically, the households with new-type coal stoves are less likely to choose low-quality coal by $22.2\,\%$, but more likely to choose high-quality coal by $32.6\,\%$. Likewise, they tend to consume $0.486\,\mathrm{t\,month^{-1}}$ less of low-quality coal, but $0.972\,\mathrm{t\,month^{-1}}$ more of high-quality coal. The new-type coal stoves are mainly designed for better indoor and outdoor environment. It is also known that the performance shall be optimized when the high-quality coal is used for burning. Although such new-type coal stoves are proven to be highly effective, many households in our study neither know nor care about the stoves. Therefore, the further promotion shall be necessary to disseminate the new stoves.

The promotion policies of subsidies on high-quality coal are estimated to be effective in reducing the likelihood of choosing low-quality coal. Specifically, a decrease in relative coal price reduces people's probability of choosing low-quality coal by $27\,\%$, but has no impact on the probability of choosing high-quality coal. Tobit regression also shows its insignificant effect on both low-quality and high-quality coal consumption. This finding indicates that the subsidies on high-quality coal price are effective for households to quit low-quality coal use, but does not bring about people's acceptance of high-quality coal. In summary, we obtain the following results. First, income is a key factor to reduce low-quality coal consumption, and critical thinking disposition positively influences the likelihood of choosing high-quality coal. Second, prosocial people are more likely to consume high-quality coal than low-quality coal. Third, local environmental concern is important for switching from low-quality coal to high-quality coal, while global environment concern does not have any significant effect. Fourth, the government policies perform effectively. In particular, the new-type coal stoves are demonstrated to be effective for the transition from low-quality to high-quality coal consumption in rural Beijing.

4 Conclusion

The promotion of high-quality coal is an important countermeasure to reduce air pollution caused by low-quality coal consumption in rural China. Together with governmental policies, consumers' cognitive, psychological and socioeconomic factors are hypothesized to be important determinants for coal consumption across different coal qualities. In this regard, this paper has empirically characterized the determinants of people's coal choice and consumption between low-quality and high-quality coal in rural Beijing. We find the following principal results: Income is important in the reduction of low-quality coal consumption. Cognitive and psychological factors of critical thinking disposition, local environmental concern and prosociality of social value orientation (SVO) positively affects coal consumption behavior. Whereas global environmental concern does not show any significance, local environmental concern is a significant determinant on the transition from low-quality to high-quality coal consumption. The governmental promotion policies on high-quality coal are effective.

These findings suggest that economic development is necessary for reducing low-quality coal consumption in rural China. On the other hand, to accelerate the transition from low-quality to high-quality coal, more public education on local environmental awareness, critical thinking disposition and prosociality are required. Although it takes time to educate people, it is worthwhile to guide such instructions in the societies. Regarding the policies, to stimulate a wider use and consumption of high-quality coal in rural China, new-type coal stoves could be more encouraged and promoted. While we believe that this study provides an important evidence on coal consumption behaviors, we admit that there are some limitations in our analysis. We examine the transition from low-quality to high-quality coal and the associated policy impacts on coal consumption in rural Beijing. However, we did not consider other environmentally-friendly energy sources such as electricity and renewable energy in the analysis for further stages of energy transition. For the future research, such environmentally-friendly energy sources should be considered together to visualize a whole picture for the transition of energy consumption in rural China.

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Figure 1: Administrative divisions of Beijing

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Table 1: Descriptions of the variables

Variable	Description
Socio-economic variable	
Household size	A number of household or family members.
Heating area	Area of square meters that needs to be heated in winter.
Education	It takes 1 when a respondent is educated as primary school, 2 is middle high school, 3 is high school, 4 is university.
Income	Annual household income for the year of 2015 in $10\,000\,\mathrm{RMB}$.
Cognitive & psychological factors	
Global environmental concern	It is a score of 12 global environmental issues ranging from 12 to 60.
Local environmental concern	It is a score of 6 local (Beijing) environmental concerns ranging from 6 to 29.
Critical thinking disposition	It is a score of the answers from 13 questions ranging from 13 to 65.
Prosocial	It takes 1 when a respondent is prosocial people, otherwise, 0.
Policy variables	
New-type coal stove	It takes 1 when a household possessed the new-type coal stove. Otherwise, 0.
Relative coal price	High-quality coal price after the subsidies divided by low-quality coal price.

Table 2: Measures for global environmental concern

Questions	Description
1	I am concerned about the global warming.
2	I am concerned about the relationship between energy and the environment.
3	I am concerned about environmental protection.
4	I like reading books about environmental problems.
5	I want to consider environmental problems proactively.
6	I would like to learn more about environmental problems.
7	I watch TV programs or read articles on the environment with interest.
8	I am interested in the biosphere.
9	I am interested in natural energy such as solar energy.
10	I would like to be actively engaged in environmental problems.
11	I am concerned about energy problems.
12	I am interested in the protection of species in danger of extinction.

Table 3: Measures for local environmental concern

Questions	Description
1	I am concerned about air quality in Beijing.
2	I am concerned about water/soil pollution problem in China.
3	I am concerned about news or knowledge to air pollution control.
4	I am concerned about the harmful effect of air pollution to health.
5	I am concerned about the daily Air Quality Index forecast.
6	I am concerned about tradeoff between life convenience and energy conservation: a. Life convenience always has higher priority. b. Conserve the energy without sacrificing life convenience. c. Conserve the environment even if sacrificing life convenience to some extent. d. Environmental conservation always weighs more.

Table 4: Critical thinking disposition

Questions	Description
1	I am good at thinking about complex problems in an orderly fashion.
2	I am good at collecting my thoughts.
3	I am confident in thinking about things precisely.
4	I am good at making persuasive arguments.
5	I am confused when thinking about complex problems.
6	I am the one to make decisions because my peers believe I can make fair judgments.
7	I can concentrate on grappling with problems.
8	I can continue working on a difficult problem which is not straight forward.
9	I can think about things coherently.
10	My shortcoming is that I am easily distracted.
11	When I think about a solution, I cannot afford to think about other alternatives.
12	I can inquire into things carefully.
13	I am constructive in proposing alternatives.

Table 5: An example of numerical outcomes for oneself and the other in a pair

	A	B	C
You get	500	500	550
Other get	100	500	330

Table 6: Frequency of choices for low-quality coal and high-quality coal

		High-quality coal		Total
		0	1	
Low-quality coal	0	75 (12.46 %)	175 (29.07 %)	250 (41.53 %)
	1	306 (50.83 %)	46 (7.64 %)	352 (58.47 %)
Total		381 (63.29 %)	221 (36.71 %)	602 (100 %)

Table 7: Summary Statistics of the variables with 602 observations

	Average (Median)[1]	SD[2]	Min	Max
Dependent variables (ton/month)				
Low-quality coal consumption	0.64 (0.5)	0.67	0	3.5
High-quality coal consumption	0.38 (0)	0.62	0	5
Independent variables				
Household size (persons)	3.28 (4)	1.57	1	11
Heating areas (square meters)	106.32 (90)	58.83	12	500
Education	1.85 (2)	0.78	1	4
Income ($10\,000$ RMB/year)	2.56 (2)	1.85	0.2	12
Global environmental concern (12-60)	43.96 (44)	7.25	24	60
Local environmental concern (6-29)	20.48 (21)	4.07	7	29
Critical thinking disposition (13-65)	41.72 (41)	5.73	27	61
Prosocial (Yes $= 1$)	0.6 (1)	0.49	0	1
New-type coal stove (Yes $= 1$)	0.13 (0)	0.37	0	1
Relative coal price[3]	0.71 (0.69)	0.16	0.23	1.77

[1] Median in parentheses.
[2] SD refers to standard deviation.
[3] high-quality coal price after the subsidies divided by low-quality coal price.

Table 8: Marginal effects of bivariate and Tobit regressions

	Bivariate probit		Tobit	
	Low-quality coal	High-quality coal	Low-quality coal	High-quality coal
Socio-economic variables				
Household size	0.016	0.021	0.039	0.105**
	(0.015)	(0.015)	(0.030)	(0.044)
Heating areas	0.001**	−0.001	0.004***	−0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Education	0.010	−0.038	0.092	−0.003
	(0.028)	(0.027)	(0.056)	(0.083)
Income	−0.022*	−0.013	−0.036	−0.049
	(0.012)	(0.012)	(0.026)	(0.036)
Cognitive & psychological variables				
Global environmental concern	0.000	0.002	−0.008	0.008
	(0.003)	(0.003)	(0.007)	(0.010)
Local environmental concern	−0.022***	0.018***	−0.047***	0.061***
	(0.006)	(0.006)	(0.117)	(0.018)
Critical thinking disposition	−0.002	0.008*	−0.004	0.02
	(0.004)	(0.004)	(0.008)	(0.013)
Prosocial	−0.085**	0.150***	−0.231***	0.392***
	(0.044)	(0.043)	(0.088)	(0.133)
Policy variables				
New-type coal stove	−0.222***	0.326***	−0.486***	0.972***
	(0.065)	(0.064)	(0.137)	(0.175)
Relative coal price	0.270*	−0.122	0.310	−0.365
	(0.159)	(0.148)	(0.295)	(0.456)

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level.