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Empirical Analysis of Influencing Factors of Rural Biomass Energy Consumption

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This paper takes the biomass energy consumption in rural areas in Jiangsu Province as an example to analyse the influencing factors of biomass energy in rural areas in China. This paper refers to the time series data of rural areas in Jiangsu Province from 2000 to 2011 and studies the influencing factors of rural biomass energy consumption in Jiangsu Province through the data model and regression analysis method, are studied. The research results show that the research model has good fit with multiple dependent variables, indicating that the energy consumption of rural residents in Jiangsu Province is greatly influenced by factors like income level, energy price and local renewable energy. Therefore, China should increase the cost performance of rural biomass energy use and improve the biomass energy consumption structure of rural residents.

1. Introduction

The problems of air pollution and energy consumption have gradually drawn the attention of our residents. Meanwhile, more and more countries and regions have begun to pay attention to the development of biomass energy and thus China needs to increase the analysis and research of rural biomass energy. With the proposal of the "12th Five-Year Plan", China advocates the scientific development of energy and the building of a moderately prosperous society in all aspects calls for the implementation of scientific outlook of development. Thus, it can be seen that it is of great practical significance to study the influencing factors of rural biomass energy consumption.

2. Literature review

There is a very limited empirical research examining the impact of media and content types on stakeholders' engagement on social media platforms, and basically none within the public sector. Strategic Management Journal seeks to encourage rigor of thought and analysis in empirical research. They discussed quantitative empirical research in the paper. There are different approaches to rigor, and rigor does not necessarily mean complicated (Bettis et al., 2014). The central question is whether routine activity theory (RAT) can be used as an analytical framework to study cybercrimes. Both a theoretical analysis and an analysis of empirical studies have thus far failed to provide a clear answer. The multivariate analysis presented tries to avoid some of the limitations of other RAT-based studies (Leukfeldt and Yar, 2016).
Kumar, A. et al. discussed biomass energy resource, its potential, energy conversion and policy for promotion implemented by Government of India. The study reveals that India has large potential for bio mass feed stock from different sources. Government of India deployed different policies and executed that the strategies for biomass power generation. Such approaches have included the whole biomass energy sector which incorporated the bio gas, bio diesel etc. in the policies. Government of India has focused on the deployment and development biomass energy sector with strategic policy and program which is notable portion of this review paper (Kumar et al., 2015). Bilgili, F. et al revealed the long run dynamics of biomass energy consumption and GDP growth through homogeneous and heterogeneous variance structures for G7 countries. The results confirmed the growth hypothesis in which biomass energy consumption have positive effects on economic growth of G7 countries. As a policy implication, energy policies which improve the biomass energy infrastructure and biomass supply are the appropriate options for G7 countries since biomass

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energy consumption increases the economic growth (Bilgili and Ozturk, 2015). India has a huge potential of biomass resources to reduce the dependence on fossil fuels and to produce electrical and heat energy. As part of furthering the development of biomass technology, it is essential to understand the environmental merits and demerits of biomass. It also aims to increase the use of biomass energy for domestic purposes. The interest behind the review is boosted by the rapid development of biomass conversion techniques and continual increase of biomass energy generation (Herbert and Krishnan, 2016). The potential of biomass energy in Sabah, Malaysia was analysed by data which was established from literature, statistic data and available documents for estimating the potential of biomass energy derived from oil palm, coconut shell, rice, livestock and forest. Nowadays, the issue of solid biomass residues including effluent from the palm oil milling process has become a big concern for the industry and the public in Sabah, because oil palm residues provide a huge potential of biomass energy in Sabah. Their paper showed that biomass energy potential in Sabah was around 267,179,818 GJ/year in total, which was derived from oil palm EFB, shell, OPF (oil palm frond), OPT (oil palm trunk), coconut shell, rice, livestock and forest. Potential of biomass energy from oil palm, coconut shell, rice, livestock and forest was 263,635,079 GJ/year, 95,713 GJ/year, 710,028 GJ/year, 750,696 GJ/year and 1,988,301 GJ/year, respectively. Most biomass energy came from oil palm, which was around 98.7% of total potential. If this total energy potential is applied at a power plant with efficiency ratio of 25% and 8000 h per year of operation, this has potential of 2,288 MW, which is equivalent to around 3.8 times of total supply of electricity in 2010 in Sabah. Their paper also suggests that relevant policy and innovative technology be developed based on the result to effectively utilize biomass. (Suzuki et al., 2017).

Climate change and global warming as the main human societies' threats are fundamentally associated with energy consumption and GHG emissions. The residential sector, representing 27% and 17% of global energy consumption and CO2 emissions, respectively, has a considerable role to mitigate global climate change. Ten countries, including China, the US, India, Russia, Japan, Germany, South Korea, Canada, Iran, and the UK, account for two-thirds of global CO2 emissions. Thus, these countries' residential energy consumption and GHG emissions have direct, significant effects on the world environment. It was found that global residential energy consumption grew by 14% from 2000 to 2011. Most of this increase has occurred in developing countries, where population, urbanization and economic growth have been the main driving factors (Nejat et al., 2015). This study investigates the causal relationship between energy consumption, carbon dioxide emissions, economic growth, trade openness and urbanization for a panel of new EU member and candidate countries over the period 1992–2010. The results also indicate that there is a short-run unidirectional panel causality running from energy consumption, trade openness and urbanization to carbon emissions, from GDP to energy consumption; from GDP, energy consumption and urbanization to trade openness; from urbanization to GDP, and from urbanization to trade openness. As for the long-run causal relationship, the results indicate that estimated coefficients of lagged error correction term in the carbon dioxide emissions, energy consumption, GDP, and trade openness equations are statistically significant, implying that these four variables could play an important role in adjustment process as the system departs from the long-run equilibrium (Kasman and Duman, 2015).

3. Research principles and methods

Jiangsu is a major energy-consuming province, whose energy consumption accounts for about 7% of the country. However, Jiangsu's energy resources are scarce. The self-sufficiency rate of primary energy is between 20% and 25% and presents a declining trend year by year. Among them, the self-sufficiency rate of raw coal is about 25% and that of crude oil is only about 10%. Therefore, the development and utilization of biomass resources is a strategic option for the sustainable development of socio-economic and energy environment in Jiangsu Province. As an important biomass energy, methane has become an important part of energy consumption in rural life and many scholars have confirmed this point of view. For example, based on the researches in Jiangsu and Anhui provinces, Wang et al. (2007) pointed out that methane is mainly used for cooking in rural areas. In some areas, about one third of the energy used by rural households came from methane and methane has become the primary source of energy consumption for rural households.

Based on the research on the rural energy consumption in Yunnan Province, it was pointed that methane would be one of the key areas for rural energy development in the future. Rural biomass energy was an important part of household energy consumption for rural residents and it was affected by many factors. The income level was an important influencing factor for the household energy consumption of rural residents, which was mainly reflected in the total energy consumption and energy consumption structure: impact of income level on household energy consumption. This paper mainly uses methane as the representative of biomass energy, discusses the status of rural biomass energy consumption and methane consumption in Jiangsu Province and analyses the influencing factors based on the actual situation in Jiangsu so as to provide relevant policy suggestions for the development of biomass energy.

4. Research results and analysis

4.1 Establishment of data model

Population factor is one of the factors that affect the energy consumption of rural residents, which is mainly reflected in two aspects: first, the population size has a positive impact on household energy consumption. Namely, the increase in population will lead to the increase in household energy consumption (Wang Guixin et al., 2005). Second, the energy consumption concept or consumption habits of residents will influence the variety and structure of household energy consumption. Rural household energy consumption may also be affected by the quantities of energy resources and the stability of supply in rural areas. Some studies have pointed out that despite the continuous increase of commercial energy consumption, most rural households will still take biomass energy as the major source of household energy consumption for a long time to come (Wang et al., 2006). This indicates that the status of traditional biomass resources such as firewood and straw and the supply of commercial energy such as coal and liquefied gas will exert significant impact on the household energy consumption of rural residents.
Based on the above research results, rural biomass energy consumption may be influenced by factors such as population size, income level, status of local available energy resources, concepts or habits of energy consumption and the quantities of biomass resources (as is shown in Figure 1). For ease of comparison and availability of data, this paper takes the rural biomass energy consumption as the dependent variable (represented by the methane consumption in rural areas) and quantifiable factors like the per capita net income of rural residents as the explanation variable. The following model is established:

$$Y=C_0+C_1X_1+C_2X_2+C_3X_3+C_4X_4+C_5X_5+u \quad (1)$$

In the formula, Y represents the per capita methane consumption of rural residents; X1 represents the per capita net income of rural residents; X2 represents the local available straw resources; X3 represents the local available firewood resources; X4 represents the local commercial energy price; X5 represents the per capita quantity of methane production of biomass resources. Among them, the local available straw resources X2 is represented by the per capita crop planting area; the local available firewood resource X3 is represented by the per capita orchard area.

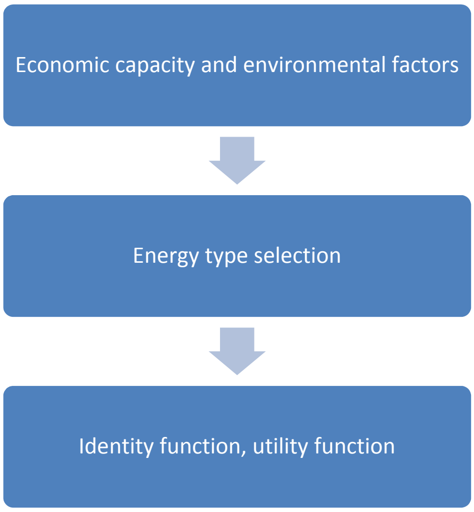

Figure 1: Rural household energy consumption research framework

4.2 Statistics of data

This paper uses the year 2000-2011 series data of rural areas in Jiangsu Province to conduct the empirical analysis, as is shown in Table 1. The per capita methane consumption of rural residents is calculated by dividing the rural household methane consumption and the rural population. Among them, the household methane consumption (physical consumption) comes from the “China Energy Statistical Yearbook”; and the rural population comes from “Statistics Yearbook of Jiangsu Province”; the annual per capita net income, the crop planting area and the orchard area data of rural residents all come from “Statistics Yearbook of Jiangsu Province”. Since the raw material for methane production is mainly organic waste such as human and animal manure, the amount of biomass resources for methane production can be calculated from the sum of manure produced by human beings, pigs and cattle in rural area. The amount of manure of human beings is 0.03 tons of dry matter/year; the amount of manure of pigs is 0.22 tons of dry matter/year; and the amount of manure of cattle is 1.10 tons of dry matter/year (Yuan Zhenhong et al. 2005); the number of pigs and cattle can be represented by the amount of livestock on hand at the end of the year in each region. The data source is the State Statistics Bureau. Considering the availability of data, the rural commercial energy price is represented by the rural consumer price by category (hydropower, fuel) in each region, which is derived from the “Statistics Yearbook of Jiangsu Province”.

Table 1: Indicators of rural energy consumption in Jiangsu province from 2000 to 2011

Influencing factors	Rural areas experience development levels X1	Population X2	Income level X3	Rural residents' employment situation	
				X4	X5
index	Rural GDP	Rural Population	Per- capita -net income of rural residents	Agricultura-l practitioner-rs	Non-Agricultural practitioners

4.3 Analysis of model regression results

This paper uses EViews software to perform regression analysis on the model and the economic analysis of the estimated results is conducted. The specific results are as follows (Table 2, 3):

Table 2: Model regression results

	Parameter Estimation	Statistics
C	6.4008	1.7915
X1	0.0011	4.0540***
X2	-8.3030	-2.3719*
X3	75.7537	2.1603*
X4	-0.0242	-0.7397
X5	32.2324	1.9096
R2	0.979940	
F	58.62113***	

Note: *, **, and *** are significant at the significance levels of 10%, 5%, and 1%, respectively.

Table 3: Correlation coefficient of each independent variable and dependent variable

	Y	X1	X2	X3	X4	X5
r	1	0.952	-0.281	0.997	0.567	0.901
P	-	0.002	0.431	0	0.087	0

It can be seen from Table 3 that X and Y are not related, while other independent variables and dependent variables are significantly correlated at the significance level of 0.01 and its positive and negative values are also consistent with the practical economic significance. The remaining indexes include rural GDP (X1), per capita rural net income (X3) and non-agricultural employees (X5).

From the measurement results, the R2 value of the model is very close to 1 and the goodness of fit is good; except for the local commercial energy price and per capita biomass energy for methane production that fail the t-test, other variables all pass the t-test. The per capita net income of rural residents is significant at the 1% significance level and the local available straw resources and local available firewood resources are significantly at the 10% significance level; it can be seen from the F test that the regression equation is significantly established.

The regression coefficient of per capita income of rural residents is positive, indicating that with the increase of income level, the awareness of rural residents in pursuit of convenient and clean energy consumption has also increased. Therefore, many rural residents have chosen methane, which can not only liberate rural residents from the traditional cooking, but make good use of waste materials and develop circular economy (as is shown in Figure 2).

Figure 2: Usage of rural biogas

The per capita crop planting area represents the availability of crop straw resources in the local area, namely the possibility that rural residents use crop straw as a source of household energy. The regression coefficient of X2 is negative, indicating that this index has a reverse and significant impact on the per capita methane consumption in rural areas, indicating that the increase in the use of crop straw will lead to the decrease of methane for rural residents. This shows that methane and straw are alternative sources of household energy.
The index of per capita orchard area represents the availability of fuelwood as a source of household energy. From the regression results, this index has a positive and significant impact on the per capita methane consumption in rural areas, indicating that rural residents will not reduce the methane consumption with the increase of firewood. This shows that compared with the straw, methane is more popular among rural residents. To some extent, the development of methane in rural areas plays a positive role in stopping deforestation and protecting the ecology.
Local commercial energy price has a negative impact on per capita methane consumption in rural areas, which is inconsistent with the empirical view. This may be because the price data used in this paper is the price index of hydropower and fuel and cannot fully reflect price information of energy, coal, and liquefied gas, leading to unsatisfactory estimation results. In addition, considering the labor cost factor for methane production, it can be understood that the increase of water, electricity and fuel price leads to the increase of construction cost and labor cost of methane tanks, so farmers are reluctant to spend more money to produce (use) methane (as is shown in Figure 3), resulting in the decrease of methane consumption.

Figure 3: Construction of a rural biogas energy source

The per capita biomass resource has a positive effect on the per capita methane consumption in rural areas, indicating that the more livestock the households keep, the more consumption of methane for rural residents. This variable is not significant, indicating that an important link – methane tank cannot be ignored when studying the relationship between methane consumption and biomass resources. If relatively large quantities of biomass resources cannot be converted to methane through the tank, it is impossible to achieve large amount of methane consumption.

5. Conclusions

The research results show that the research model has good fit with multiple dependent variables, indicating that the biomass energy consumption of rural residents in Jiangsu Province is greatly influenced by factors like income level, energy price and local renewable energy. Some rural areas vigorously promote clean energy such as methane, but if the cost of methane tank construction is high, some rural residents will still choose traditional energy like liquefied gas and hydropower.

In general, there are many factors that influencing the biomass energy consumption of rural residents in China, so there is still a long to go in the improvement of the biomass energy consumption structure of rural residents in China. The Chinese government can promote the consumption of rural residents by increasing the cost performance of biomass energy.

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