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The impact of income on the household energy consumption and behavior-Analysis basing on the urban of Beijing

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ABSTRACT

As the capital of China, the industrialization and urbanization of Beijing has been in the forefront of the nation, which has entered the late stage. The proportion of the industrial sector has declined in the energy consumption sectors, while the household sector has gradually increased. Therefore, the focus of energy saving would gradually shift to the household sector. While the household energy consumption behaviors of the residents with different income levels are different, the policy measures guiding energy saving behaviors should be varied too. Firstly, basing on the statistical data collected, the relationships between the Beijing urban residents' income and household energy consumption were analyzed using the co-integration. The results show that the higher the income of urban household, the larger one's household energy consumption. Then, a survey on the Beijing urban households of different income has been conducted and then the questionnaires were analyzed. The results show that there are significant differences between the higher and the lower income households in energy consumption behavior. The higher-income households tend to buy high energy-consuming products.

KEYWORDS

Beijing; Household income; Household energy consumption; Energy consumption behavior.

INTRODUCTION

The energy problem has gotten great concern all over the world. As a major consumer, China is facing with higher and higher pressure on energy saving and emissions reduction. With the completion of urbanization, the key area of energy saving and emissions reduction has shifted to household sector in the developed countries. China is in the stage of rapid development of urbanization currently. The economic develops quickly and the income of both urban and rural households continuously increases. The energy consumption structure has been upgraded and household energy consumption increase rapidly. As the economic, political and cultural center of our country, Beijing's permanent population has reached 20.693 million in 2012, while the total energy consumption reached to 71.777 million tons of standard coal, and the terminal household energy consumption has reached to 13.987 million tce, which accounted for about 20% of the total energy, and was higher than the national average of 10%. The per capita household energy consumption of Beijing has reached to 684.3 kg standard coal, while the per capita household energy consumption of the national was 278.3 kg. Beijing is far higher than the national average. It is very necessary to know the Impact of income level on the household energy consumption and behavior and reasonable guide the household energy consumption behavior.

Foreign research on household energy consumption and energy saving behavior started early. Since the early 70s, scholars began to study the household energy consumption and discussed the affecting factors of household energy consumption and behavior. Among them, income level was one the most important. A previous study showed that with the continuous growth of income and the level of people's consumption, some modern equipments came into the urban and rural households, which increased direct and indirect households energy consumption and carbon emissions (Long Liang; Wenliang Wu, 2006)[1]. TinYue' research showed that income level was a major factor to household energy consumption and carbon emission (TinYue et al., 2013)[2]. Manfred Lenzen evaluated the effects of income growth on household energy consumption with the methods of multiple regression and input-output analysis from a global perspective. The research found that the effects were differences in different countries (Manfred Lenzen, 2005)[3]. Shonali Pachauri proved that there was a continued increase in both total and per capita household energy consumption because of the growth of per capita spending and population (Shonali Pachauri et al., 2002)[4]. Jane Golley studied the relationship between household income and carbon dioxide for Chinese urban households. The results showed that the impacts of income level on energy consumption behavior were significant differences, which was the higher the income were, the greater the emissions of carbon dioxide. Therefore, the government can adjust the income redistribution to achieve the income equality and the win-win effect of energy saving and emission reduction (Jane Golley; Xin Meng, 2012)[5].

There were some researchs on the effects of income level on household energy consumption and behavior in China. Such as LU Hui based on survey data analyzed the impact of peasant's income level on rural household energy consumption structure, which showed that families with different income levels had different household energy consumption (LU Hui; LU Li,2008)[6]. HE Renfei used China's 30 provinces, municipalities and autonomous regions as study unit to analyze the data of per capita energy consumption and income, which concluded that: the group of people who are higher household income, there are more possibilities for them to consume household energy. (HE Renfei et al., 2012)[7]. ZHANG Xin described the household energy consumption structure reflected the differences in income levels, and then concluded that families with higher income levels had more household energy consumption (ZHANG Xin et al., 2011)[8]. FU Jianchao collated and analyzed the data of urban residents' income and major household energy consumption in Beijing. The results indicated that the changes in income of urban households caused changes in household energy consumption behavior (FU Jianchao et al., 2012)[9]. WU Gang found that the people in Beijing would be more inclined to buy higher energy-consuming products: with income increasing, such as houses and cars. So the energy-saving awareness of the public should be further strengthened (Wu Gang et al., 2011)[10]. SUN Yan used 705 urban residents in Shenyang and Dalian as samples to discuss the effects of heterogeneities of family (family

income, family size and family structure et al) on energy saving behavior by the investigation questionnaires. The research showed that the income was lower when the energy-efficient was higher (SUN Yan, 2013)[11].

Related researches both in home and overseas showed that the household income had a significant impact on the household energy consumption and behavior. Beijing is the most urbanized city in China. What impact does the household income on household energy consumption and behavior in Beijing? This article will be divided into two aspects to discuss. The first part puts stress on data analysis, which collated and analyzed the income and household energy consumption of urban household in Beijing over 1991-2012. This part mainly analyzes the correlation of household income and household energy consumption through the method of co-integration analysis. The second aspect is the empirical test, which take sample surveys for urban residents' income and household energy consumption behavior in Beijing through questionnaire and interviews and analysis the results qualitatively. Then prove the relevant viewpoints for the part of the data analysis, eventually, forming the conclusions.

MEASURE OF THE EFFECT OF INCOME GROWTH ON HOUSEHOLD ENERGY CONSUMPTION

Data sources

This article used EVIEWS to study the relationship between income and household energy consumption for the period 1991-2012. The relationship was analyzed using its statistical analysis function and tabular analysis report. Two indicators were selected, the first one was DR which characters the Per capita disposable income of urban population; the second one was DN which characters per capita household energy consumption of urban residents. The data comes from the Beijing Statistical Yearbook.

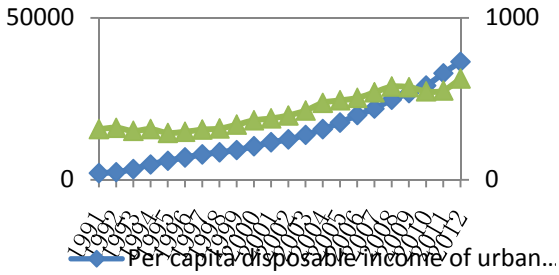

Figure 1 : The relationship between per capita income and household energy consumption of urban population.

The trend graph was drown, with per capita disposable income and household energy consumption of urban residents as the vertical while year as the horizontal (shown as in Figure 1). This figure shows that there is a positive correlation between them. In other words, with the per capita disposable income growth, the per capita household energy consumption also rose in Beijing.

Empirical analysis

Statistical analyses suggested that there was a close correlation between the per capita income and household energy consumption of urban residents in Beijing. Although there is a strong correlation between them, which can be analyzed by establishing a regression equation, if the classical regression model was direct used without considering the stationary of time series data to analysis non-stationary time series, it will result in "spurious regression". In other words, the regression equation can't reflect the true relationship between then. While Co-integration analysis can elegantly solve such problems[12].

(1)Unit root test

Because most of the time series are non-stationary, the unit root test must be conducted before co-integration test[13]. Test results of ADF are shown in TABLE 1:

TABLE 1 : The ADF unit root test of time series of DR and DN

variable	ADF	Critical value	Critical value	Test form (c,t,k)	conclusion
DR	-2.575773	-4.616209	-3.710482	(c,t,4)	unstable
DN	-3.116597	-4.498307	-3.658446	(c,t,1)	unstable
DDR	-2.440800	-4.498307	-3.658446	(c,t,0)	unstable
DDR	-2.708851	-4.532598	-3.673616	(c,t,1)	unstable
D2DR	-2.364877	-2.708094	-1.962813	(c,0,2)	stable
D2DN	-3.496457	-2.699769	-1.961409	(c,0,1)	stable

Note: c, t and k represent constant, tend and lag period respectively.

Test results show that the ADF inspection values of DR and DN were greater than the threshold levels of 1% and 5%. So we can't reject the null hypothesis. The sequence of DR and DN were non-stable. After the first-order difference was conducted, the inspection values of DDR and DDN were still greater than the threshold levels of 1% and 5%. The sequences of DDR and DDN were non-stationary. After second-order difference was conducted, the inspection values of D2DR and D2DN were less than the threshold levels of 1% and 5%. The sequences of D2DR and D2DN were stationary. In summary, the unit root test results show that the sequences after the second-order difference are stationary, which indicated that they are two order integrations.

(2) Co-integration test

Because DR and DN both are unstable sequence with two order integration, so one linear combination between them may be stable. There are two methods that test the co-integration relationship between them, One is the EG two-step method, the other is the Johansen maximum likelihood estimation[13]. The EG two-step method was used in this paper. The test results were shown in Figure 2 and 3.

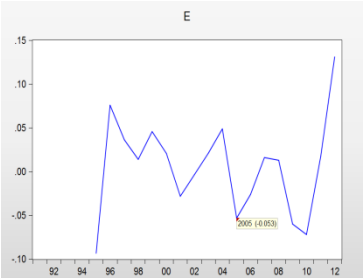

Figure 2 : Sequence diagram of e.

Null Hypothesis: E has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.445615	0.0019
Test critical values:	1% level	-2.717511	
	5% level	-1.964418	
	10% level	-1.605603	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 16

Figure 3 : The test results.

DR and DN both are two order integrations, which satisfy the premise of the co-integration test. The co-integration relation of DR and DN was conducted using the EG two-step method, which

identifies whether the regression residual e is a smooth sequence. The test equation without constant term and trend term was selected, according to the sequence diagram of e. The optimal lag order was determined according to the AIC and SC minimum criterion to determine the optimal lag order. The ADF testing value of residual sequence e is -3.445615, which is less than the threshold levels of 1%, 5% and10%. The result shows that the residual sequence e is smooth, which indicated that there is a co-integration relationship between DR and DN.

(3) Granger causality test

There is a co-integration relationship between DR and DN sequence. Whether there is a Granger causality between the per capita disposable income and household energy consumption of urban residents in Beijing was determined by Granger causality test usingEviews7.2. The test results were shown in Figure 4:

Pairwise Granger Causality Tests
Date: 03/20/14 Time: 19:55
Sample: 1991 2012
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Prob.
DR does not Granger Cause DN	18	3.32586	0.0621
DN does not Granger Cause DR		0.84300	0.5318

Figure 4 : The test results.

The test results show that the per capita disposable income is the reason for the increasing of household energy consumption, while per capita household energy consumption is not the reason for the growth of per capita disposable income. There is a one-way Granger causality between them.

(4) Establish co-integration regression equation

Set up the regression model using Eviews 7.2. The variable is per capita disposable income of urban residents and the dependent variable is per capita household energy consumption.

$$DN = 3.342702 + 0.286015DR$$

$$(0.0000)\ (0.0000)$$

$R^2 = 0.803194$, Adjusted $\bar{R}^2 = 0.793354$, $F = 81.62315$, $DW = 0.273466$

The value of DW is only 0.273466, which is less than the threshold level d_L of 1%. It is demonstrated that there is an autocorrelation in residual sequences. The generalized differential regression model is set using the generalized difference which solves the autocorrelation.

$$DN = 2.6362DR + 2.06074 + [\text{ar}(1) = 0.717976]\ (0.0001)\ (0.0194)\ (0.0000)$$

$R^2 = 0.960572$, Adjusted $\bar{R}^2 = 0.956192$ **Error! Reference source not found.**, $F = 219.2667$, $DW = 1.354136$

The generalized differential regression results show that the test value of DW increased to 1.354136, which is less than threshold level of 1%, namely $d_u < DW < 4 - d_u$,which indicated that the equation eliminated autocorrelation. Base on the model obtained, it can be found that per capita household energy consumption could increase by 2.6 percent with the urban residents' per capita disposable income increasing by 1 percent. Similar findings already have been provided by Shonali Pachauri (2002). This is because with the incomes increasing, the spending patterns of consumer will

evolve, and the reliance on air-conditioning, washing machine and car will increase. So the per capita household energy consumption increases.

INVESTIGATION ON THE DIFFERENCES OF ENERGY CONSUMPTION BEHAVIOR WITH DIFFERENT INCOME LEVELS

Sampling Method and the Sample Description

According to the longitudinal analysis above, the household household energy consumption will subsequently increase with incomes rising. However, Is there a significant difference of the household energy consumption in families with different incomes according to the horizontal analysis? The Beijing urban households were researched using live interview and questionnaire survey. 500 questionnaires were distributed and 469 of them were valid, which accounted for 93.8% of the total number. The sample distribution is shown in the TABLE 2.

The questionnaires were given out in eight districts in Beijing, including Dongcheng District, Xicheng District, Haidian District, Chaoyang District, Tongzhou District, Fengtai District, Shijingshan District and Fangshan District.

Statistics and analysis of survey results

As the research on domestic and foreign present literature shows, the differences of family income have a significant effect on the household energy consumption. According to the questionnaires collected form the Beijing urban families, firstly we assume: If the per-capita family income is different, there is a significant difference in the household energy comsumption. Secondly, the hypothesis was validated using the SPSS9.0 software. The monthly family per capita disposable income were divided into not exceeding 3000 yuan RMB, 3000-5999 yuan RMB, 5999-8999 yuan RMB, 9000 yuan RMB and above, and they were represented by 1, 2, 3, and4 respectively. The statistical results are shown in TABLE 3. The significant corresponding value is 0, which is not more than 0.05. It indicates that the original hypothesis that there is a significant difference in household energy consumption behavior of families with different income levels is tenable.

TABLE 3 : Analysis of difference in the energy-saving behavior with different family income levels

variable	clasify	percentage	average	standard deviation	significance
The monthly per capita disposable income	Not exceeding 3000yuan RMB	4.2	3.952	0.467	0.000
	3000-5999yuan RMB	38.7	3.776	0.735	
	5999-8999yuan RMB	43.8	3.642	0.465	
	9000yuan RMB and above	13.3	3.012	0.528	

The impacts of the income level on household energy-saving behavior were further analyzed using the multiple variance analysis comparison method. The monthly family per capita disposable income were divided into four parts, not exceeding 3000 yuan RMB, 3000-5999 yuan RMB, 5999-8999 yuan RMB, 9000 yuan RMB and above. Every two parts were compared, and there were $C_4^2 = 6$ comparisons. The average difference, the standard deviation and the significance were calculated respectively. The results shown in table 3 indicated that there is a significant difference in the household energy consumption with different income level. Comparing the monthly per capita family income of less than 3000 yuan RMB with that of 3000-5999 yuan RMB, 6000-9000 yuan RMB and more than 9000 yuan RMB respectively, the significance results were 0.000, 0.001, 0.003 respectively. This

indicates that the household energy consumption with monthly per capita income of 3,000 yuan or less is better than the other three cases. Overall, the low-income families saving behavior are significantly better than higher income families.

TABLE 4 : Multiple variance analysis comparison method (monthly family per capita disposable income as the variable)

Income level	monthly family per capita disposable income	monthly family per capita disposable income	Average differenc	Standard deviation	significance
Low income	Less than 3000yuan RMB	3000-5999yuan RMB	0.176	0.086	0.000
		6000-9000yuan RMB	0.310	0.107	0.001
		More than 9000yuan RMB	0.940	0.098	0.003
low and middle-income	3000-5999yuan RMB	Less than 3000yuan RMB	-0.176	0.086	0.000
		6000-9000yuan RMB	0.134	0.058	0.032
		More than 9000yuan RMB	0.764	0.076	0.000
Middle high income	6000-9000yuan RMB	Less than 3000yuan RMB	-0.310	0.107	0.001
		3000-5999RMB 3000-5999yuan RMB	-0.134	0.058	0.032
		More than 9000yuan RMB	0.630	0.072	0.005
High income	More than 9000yuan RMB	Less than 3000yuan RMB	-0.940	0.098	0.003
		3000-5999yuan RMB	-0.764	0.076	0.000
		6000-9000yuan RMB	-0.630	0.072	0.005

According to the analysis above, the household energy-saving behavior in low-income families are significant better than that of high-income families. This is mainly caused that the differences in household energy consumption with different income levels are significant. The higher-income families tend to believe that the quality of life is the most important, and they prefer the more comfortable and convenient life. They will not improve the energy-saving behavior to ensure the life quality, even if they know that energy conservation is very necessary.

CONCLUSION AND DISCUSSION

Conclusion

Through the above investigation and analysis of the energy consumption behavior and the research on the urban families' energy consumption of Beijing, the following conclusions were obtained:

(1) The unit root test results show that Beijing urban residents per capita disposable income and per capita household energy consumption are both second-order single whole.

(2) There is cointegration relationship between the Beijing urban residents' per capita disposable family income and urban residents' per capita household energy consumption, which is one-way Granger causality.

(3) It can be known by generalized difference regression equation that the per capita household energy consumption could increase by 2.6 percent with the urban residents' per capita disposable income increasing by 1 percent.

(4) There are significant differences in the household energy consumption behavior with different income level families of different income levels. The higher-income families tend to buy energy-intensive products such as housing, cars, etc., while the lower-income families tend to low energy consumption, such as savings, daily consumption, etc..

(5)The higher income level of the family, the more one prefer to the quality of life. They will not take measures of saving energy to ensure the life quality, even if they know that energy conservation is very necessary.

Discussion

(1) This paper studies the effects of the urban residents' income level on the household energy consumption and energy consuming behavior in Beijing. The following research could focus on the study of the effects of the rural residents' income level on the household energy consumption and energy consuming behavior. And the comparison between the urban and rural could be conducted.

(2) The price leverage should play a full role in the energy saving for low-income families. The gradient pricing policy could extend to naturan gas and other household energy to guide the user to improve the energy consumption behavior to save energy.

(3) Associated publicity and education should be further increased in the upscale community. And make it really get into the higher income families to enhance this part of the price-insensitive group of social responsibility, raise awareness of energy conservation and rationally guide its establishment of conservation type of consumer behavior patterns.

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