ESTIMATING ENERGY AND WATER DEMAND ELASTICITIES FOR SUSTAINABLE CONSUMPTION POLICIES: CHINA SAMPLE EVIDENCE

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China has been running large-scale interventions in the some public sectors e.g. energy and water sectors for long time. Still, there is a dearth of reliable and readily available price and income elasticities of demand to base these on, especially for domestic use of water and energy. This study uses the Full Nonlinear Almost Ideal Demand System using expenditure survey data of urban household across China. Expenditure elasticities for water, electricity and fuel are 0.44, 0.60 and 0.44 respectively, own price elasticities of them are negative sign and so small that they are almost no-elasticity. These can be used to evaluate recent and current correlative price and environmental policies oriented towards sustainable household consumption in China.

Key Words: *AIDS, household demand, Income, Price; Elasticity, Sustainable consumption,*

1. INTRODUCTION

The main objective of this paper is to estimate the income and price elasticities of household demand for water, electricity and fuels in China. There are a number of motivations for this. Firstly water and energy is an important necessity for any household in the same time they are the environmental impacts of specific goods. In China the households need to choose not only how much but also which energy to use. These decisions can have important consequences for the household budget, time allocation and health. They can also lead to negative environmental externalities at local, regional or global level. Secondly Price and income elasticities of demand are important for the choice of domestic price and environmental policies and also these polices have a serious influence on household consumption behaviors. Finally all environmental and resource problems can ultimately be traced back to consumption and life-styles, this causes sustainable consumption has gained more and more popularity , Design of policies oriented towards sustainable consumption requires information about the sensitivity of consumption to variables that can be influenced or controlled by policies[1)].

Given the policy importance of these elasticities, it is striking that there is such a dearth of reliable and readily available estimates for water and energy in China. Of course There are a number of studies have examined the elasticities of water and energy in other countries, e.g. Haripriya (2008) [2)], Runar (2007) [3)], Ada (2004) [1)] and Linderhof (2001) [4)].

The estimations are made using the full nonlinear Almost Ideal Demand System[5)] on urban household data from 1995 to 2006 in China. Instead of income we consider the total household expenditure as a proxy. The AIDS model has been widely used for analysing demand for various commodities in the world. In this study we use a two-stage budgeting process to obtain the elasticities of water and energy. In the first stage it is assumed that the household decides how much to spend on seven consumption groups (categories) and in the second stage it is specialized to assume how the household allocate expenditure to water, electricity and fuel. This study is an empirical contribution to the domestic water and energy literature in China.

This paper is organized as follows: Section 2 presents the two-stage budgeting model and data specification. Section 3 presents the empirical results and Section 4 concludes with the policy implications.

2. THE MODEL AND DATA

In our model we assume a two-stage budgeting process. In the first stage total expenditures are allocated in seven consumption groups: (i) food; (ii) clothing; (iii) household appliances and services; (iv) medicines and health care; (v) transport and communication; (vi) education, cultural and recreation; (vii) housing. The second stage comprises the allocation of housing expenditure on individual goods, in this case house, housing service, water, electricity and fuel.

In the specification of the demand system, we apply Deaton and Muellbauer(1980)Almost Ideal Demand model (AID model)[5]. Denoting budget shares by w, total expenditure by X, and commodity prices by p (j) and incorporating time and regional dummy, we can write the demand for commodity i in budget share form as

$$W_i=\alpha_i+\beta_i\ln(X/P)+\sum_j\gamma_{ij}\ln(p_j)+\sum_k d_{ik}T_{ik}+\sum_\lambda dz_{i\lambda}Z_{i\lambda}+\varepsilon_i \quad (1)$$

where the price index, ln(P), is here approximated using:

$$\ln(P)=a_0+\sum_{i=1}^{n}a_i\ln(p_i)+1/2\sum_i\sum_j\gamma_{ij}\ln(p_i)\ln(p_j) \quad (2)$$

T_{ik} is annual dummy (k=1,2,3…,11), $Z_{i\lambda}$ is regional dummy (λ= 1,2,3). We divide Chinese urban area into four regions using classify analysis according to their expenditure structure by SPSS software, ε_i is the error term.

Given this structure of weak separability, the econometric model consists of five separate systems of budget share equations. In the estimation adding up, homogeneity and symmetry restrictions are imposed for each demand system. The basic demand restrictions are expressed in terms of the model's coefficients.

Adding up: $\sum_i\alpha_i=1,\sum_i\beta_i=0,\sum_i\gamma_{ij}=0$

Homogeneity: $\sum_j\gamma_{ij}=0$

Symmetry: $\gamma_{ij}=\gamma_{ji},\forall i(i\neq j)$

Given estimates of the parameters at each "level", we can calculate price and expenditure elasticities, totally and conditional on the expenditures for commodity i. Following Edgerton et al[6], the expenditure and uncompensated price elasticities are:

$$\eta_i=1+\frac{\beta_i}{w_i} \quad (3)$$

$$e_{ij}=\frac{\gamma_{ij}-\beta_i w_j}{w_i}-\delta_{ij} \quad (4)$$

where η_i denotes the expenditure elasticity and e_i the uncompensated price elasticity; δ_{ij} is equal to one when i =j and zero elsewhere.

Let us denote the expenditure elasticity in the first state as η_{i1}, the expenditure elasticity in the second stage as η_{i2}, and the total expenditure elasticity for the *i*th good within its belonging group of goods as η_i^*, with an equivalent definition for the budget shares, *w*. In this case, we can calculate the total expenditure elasticity as

$$\eta_i^*=\eta_{i1}\times\eta_{i2} \quad (5)$$

In the same way, we can denote the price elasticity in the second stage between the ith and jth goods as e_{ij2}, the price elasticity in the first state as e_{ij1} and the total price elasticities for the ith good within its belonging group of goods as e_{ij}^*. The within group price elasticity assumes that group expenditure is unchanged in spite of the price change, while the total price elasticity allows for the relevant changes in group expenditure, and is given by

$$e_{ij}^{*} = \delta_{ij}e_{ij2} + \eta_{i2}w_j(\delta_{ij} + \eta_{ij1}) \quad (6)$$

If we look at Eq. (6) for two goods within the same group, we can see that the total price elasticity consists of two components. The first part is a direct effect, which represents the subgroup elasticity, while the second part is an indirect effect, which is a product of three factors. The first measures the relative change in the group price index when the price of the jth good changes; the second factor measures the effect a change in the price index has on group expenditure, while the third factor measures the effect this change in within group expenditure has on the consumption of the ith good .

We can also observe that if the own between group price elasticity $e_{ii1} = -1$, then the group expenditure is unaffected by the price change and $e_{ij}^{*} = e_{ij2}$. On the other hand, if $e_{ii1} = 0$, then the price change produces a proportional effect on group expenditure.

The data used in this study are time series data from 1995 to 2006 on living expenditure of Chinese urban household that taken from a yearly survey carried out by the National Bureau of Statistics of China [7]. The expenditure for 1996 to 2006 in current price was converted to the constant price of 1995. The panel data is comprised 31 provinces data in China.

3. RESULTS

(1) Income development and consumption demand for water and energy in china

Before presenting the results of this study a brief description on income development and water, electricity and fuels requirement in China from 1995 to 2006 is given Table 1. The growth of per capital annual disposable income is about 1.6% per year as same as the growth of the per capital annual consumption expenditure from 1995 to 2006. But Per capital annual water and electricity expenditure increased over 7% per year while per capital annual fuels expenditure almost unchanged. One of the causes is the rise of water price faster than the drop of water consumption, the other reason is electricity consumption increase more than electricity price fall.

Fig.1 shows per capital consumption for water, electricity and fuels from 1995 to 2006. The water and fuels consumption declined about 3.3%and 2.3% per year while the electricity consumption increased 12.3% per year. It implies more and more urban household is transiting toward clean fuels (like nature gas, PLG and electricity).

Table 1 China's Income development and consumption demand

Item	1995	2006	Annual growth rates in %
Urban population(10000 person)	35174.0	57706.0	4.6
Urban household size	3.2	3.0	-0.8
Per capita annual disposable income at 1995 price (Yuan)	4283.0	5095.2	1.6
Per capita annual consumption expenditure at 1995 price (Yuan)	3537.6	4202.9	1.6
Per capita annual water consumption expenditure at 1995 price (Yuan)	13.9	30.4	7.4
Per capita annual electricity consumption expenditure at 1995 price (Yuan)	55.3	119.8	7.3
Per capita annual fuel s consumption expenditure at 1995 price (Yuan)	72.1	77.5	0.7
Share of water consumption in total expenditure (%)	0.4	0.7	6.0
Share of electricity consumption in total expenditure (%)	1.6	2.9	5.8
Share of fuel consumption in total expenditure (%)	2.0	1.9	-0.7
per capital consumption of water(ton)	73.3	50.7	-3.3
per capital consumption of electric power(kW. h)	137.9	483.7	12.1
Per capital consumption of fuel s(GJ)	4.9	3.8	-2.3
Average price of water at 1995 price(Yuan/ton)	0.6	0.9	3.8
Average price of electricity at 1995 price(Yuan/kW. h)	0.4	0.2	-3.7
CPI of water, electricity and fuels(1995 price index =100)	100.0	210.7	7.0

Source: China urban life and price yearbook, 1995-2007; China energy statistical yearbook, 1995-2007

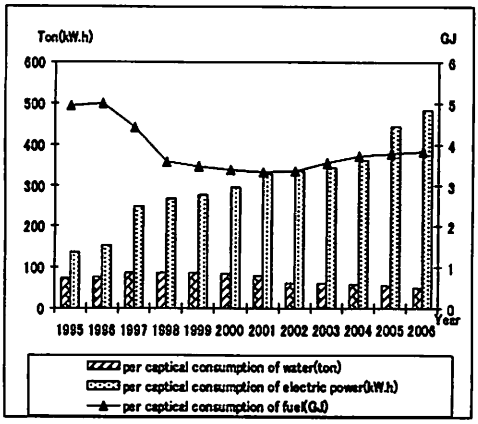

Fig.1. Per capital consumption for water, electricity and fuels from1995 to 2006

(2) Own price and expenditure elasticities of demand

The estimation results using Chinese 31 provinces consumption data for the period 1995-2006. We have tested linear approximate and full nonlinear models within the AID family, and find nonlinear models performed better than the linear model. Given the parameter estimates, expenditure and price elasticities have been calculated according to Eqs. (3), (4), (5) and (6). The resulting elasticities are presented in Table 2.

As the table reveals, own price elasticities for water, electricity and fuels have a negative sign. In most cases the own price elasticities lie between 0 and − 1, which implies that a higher price of a good (with the other prices held constant) leads to an increase of the budget share for the same good, in spite of lower consumption of that good. Moreover, all goods have positive expenditure elasticities, implying that they are considered as normal goods.

The last column of Table 2 shows that the demand for "water" ,"electricity" and "fuels"is relatively insensitive to changes in the own price. For example, if the price of "water" increases by 10%, "water" demand will decrease by 1.5%. A corresponding increase in the price for "fuels" reduces the demand for "fuels" by 3.1%. The lower total expenditure elasticities are found for water, electricity and fuels. It means they are necessities for urban household

(3) The demand trend for water, electricity and fuels

The estimated total own-price and expenditure elasticities for different period: 1995-1997, 1998-2000, 2001-2003 and 2004-2006 for urban household are presented in Fig.2 and Fig.3. We can see from Fig.3 that own-price elasticities for water and electricity change positive sign to negative sign. It Implies that the demand for water and electricity becomes to reduce with price rising from keeping consumption although price rising. And the absolute value of own-price elasticity for fuels reduces from 0.50 to 0.25, it means the effect of price for consumption becoming less and less. Actually it is fit for Chinese consumption rule. Water electricity and fuels as living necessaries are consumed in both high and low income period, now the income is high enough to pay their consumption, but the related price policies have not changed with this trend. For example we compare the price polices for water and electricity and find the rising of water price reduce the per capital water consumption

Table 2 Estimated Expenditure elasticity and Own price elasticity

	Expenditure elasticity	Own price elasticity	Total expenditure elasticity	Total own price elasticity
Main groups				
Food	1.11(0.04)	-0.16(0.09)		
Clothing	0.12(0.11)	-0.55(0.18)		
Appliances	1.13(0.13)	-0.13(0.34)		
Health care	0.47(0.10)	0.10(0.18)		
Transport	1.34(0.08)	0.25(0.11)		
Education	1.27(0.07)	0.27(0.10)		
Housing	1.17(0.10)	0.03(0.21)		
Housing				
Water	0.38(0.04)	-0.21(0.08)	0.44	-0.15
Electricity	0.52(0.03)	-0.38(0.05)	0.60	-0.11
Fuel	0.37(0.03)	-0.44(0.05)	0.44	-0.31

Note: The figures in the parentheses are standard error

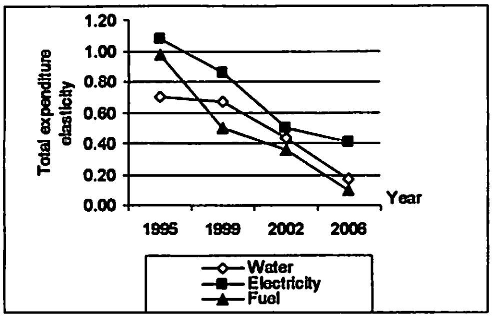

Fig.2. Total expenditure elasticity for water, electricity and fuels in urban household from1995 to 2006

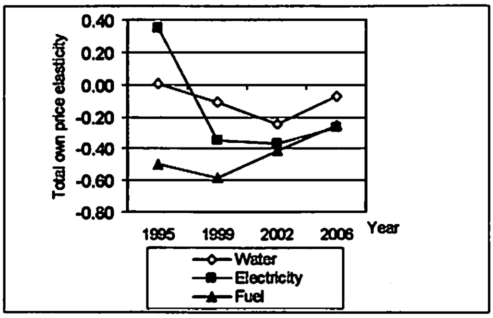

Fig.3. Total price elasticity for water, electricity and fuels in urban household from1995 to 2006

while the declining electricity price increases its consumption.

Fig.2. shows expenditure elasticities for water, electricity and fuels declined year by year, it implies all of them became living necessary, especially, expenditure elasticity for electricity declined from 1.07 to 0.34. These results suggest that electricity became living necessary from luxury with the use popularization and income increase.

4. CONCLUSIONS AND DISCUSSION

In this study we estimated the household demand equations for water, electricity and fuel from 1995-2006 in China. The main conclusions can be summarized as follows: (1) the Income elasticities for water, electricity and fuel declined year by year, it means water, electricity and fuel became necessaries with the use popularization and income increasing. (2) The own-price elasticities for water, electricity and fuel also become smaller and smaller, it implies the effect of price to consumption will became less with the income increasing; (3) the sign of the own-price elasticities for water and electricity change to negative from positive, it means the demand will reduce with the price raising.

Based on the price and expenditure elasticities estimated we conclude that ladder prices on energy and water is an effective instrument to reduce the consumption of energy and water. However one policy is not sufficient, the other policy like peak-hour and off-peak hour price and pollution water fee should be integrated implemented. Information about how to change the current consumption behavior should be available as well. Sustainable household consumption is our finally goal.

The results from this exercise can be used in a number of ways, depending on the policy objective in mind. For a country like China, with a tradition of implicit and explicit government interventions that affect the prices of domestic energy and water, the impact of such interventions on demand can be analysed based on price elasticities of demand. Similarly, if the desired policy objective is reduce to use water and energy resource, then these elasticities can prove useful in identifying the most cost-efficient-environment policy.

There are still a number of improvements that could be made to this approach. The estimation would probably also be greatly improved if it were possible to combine the household characters data which could be used for much more disaggregated analysis than what has been made here.

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