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CANADIAN Building Energy End-Use DATA AND ANALYSIS CENTRE
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An Econometric Analysis of Irish Residential Energy Expenditures

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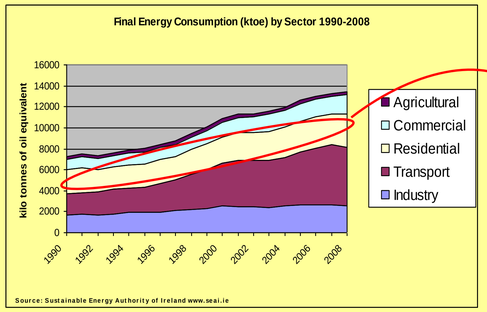
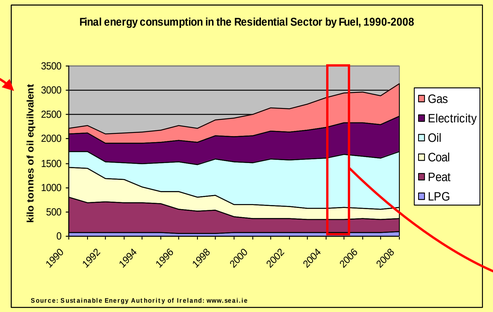
Context – Ireland's Energy Consumption in the 1990-2008 period:





- Between 1990 and 2008 final energy consumption increased by 185% (5.3% per annum). Main contributors to this growth were gas (increased by 291% or 9.3% per annum) and oil (increased by 215% or 6.6% per annum).
- Main energy using sectors in 2008: Transport (41.8% share), Residential (23.7%) and Industry (18.7%).
- Main fuel shares in 2008: Oil (63.5%), Electricity (17.1%) and Gas (12.3%)

- Between 1990 and 2008 residential energy consumption increased by 141% (2.9% per annum). Main contributors to this growth were gas (increased by 572% or 15.6% per annum) and oil (increased by 314% or 10% per annum).
- Main fuel shares in 2008 in the residential sector were Oil (38.6%), Electricity (23%) and Gas (21%)
- An analysis of a cross section of the above can provide useful insights about the underlying determinants of residential energy expenditures.

Data: 2004/05 Household Budget Survey Energy Expenditures

Energy expenditures are recorded in the HBS under the heading of 'Fuel and Light' which is taken to mean energy used in the home for power, heat and light. The main fuels recorded include gas, electricity, oil, coal, turf, and lpg

The HBS also records certain expenditures under the 'Transport' category, namely, petrol and diesel. Given the large increases in transport energy use, these expenditures are also included in the analysis.

		Urban	Rural	State
Number of Households in Survey		4532	2352	6884
Average Household Expenditure	€/week	839.60	764.22	816.82
Average Energy Expenditure	€/week	28.87	34.76	30.65
	% of average household expenditure	3.4%	4.6%	3.8%
Of which:				
Gas Expenditure	€/week	5.65	0.12	3.98
	% of average energy expenditure	19.6%	0.4%	13.0%
Electricity Expenditure	€/week	12.67	13.16	12.82
	% of average energy expenditure	43.9%	37.9%	41.8%
Oil Expenditure	€/week	5.42	11.12	7.15
	% of average energy expenditure	18.8%	32.0%	23.3%
Coal Expenditure	€/week	2.25	3.26	2.56
	% of average energy expenditure	7.8%	9.4%	8.3%
Turf Expenditure	€/week	1.12	4.01	1.99
	% of average energy expenditure	3.9%	11.5%	6.5%
LPG Expenditure	€/week	0.56	1.73	0.92
	% of average energy expenditure	2.0%	5.0%	3.0%
Petrol Expenditure	€/week	21.06	28.39	23.27
	% of average household expenditure	2.5%	3.7%	2.8%
Diesel Expenditure	€/week	3.1	10.82	5.43
	% of average household expenditure	0.4%	1.4%	0.7%

Methodology:

An issue in using household micro data in the prevalence of zero expenditures. The Tobit model (Tobin, 1958) was the original model developed to analyse dependent variables with zero values. The Tobit model however assumes that the same stochastic process determines both the consumption and participation decision (since they are modelled as one equation). It may be more reasonable to assume that the size and nature of the factors that affect the participation decision will be different that those that affect the consumption decision. For example, age can play a part in the decision to purchase but not necessarily in the decision of how much to consume.

As a result, many generalisations to the Tobit model have been developed. One such generalisation is the double hurdle model, originally formulated by Cragg (1971). It postulates that individuals must pass two separate hurdles before they are observed with a positive level of consumption. The first hurdle corresponds to factors affecting participation in the market for the good and the second to the level of consumption of the good.

The unique feature of the double hurdle model is that it allows for the possibility that zero expenditures could be due to either non participation or participation but non-consumption.

Following Jones (1989) the specification of the double hurdle model can be written as follows:

(i) Observed Consumption: $y_i = d \cdot y^{**}_i$

(ii) Participation Equation: $y^*_{i1} = W_i\alpha + u_i$ $\quad d = \begin{cases} 1 & \text{if } y^*_{i1} > 0 \\ 0 & \text{otherwise} \end{cases}$

(iii) Consumption Equation: $y^*_{i2} = X_i\beta + v_i$ $\quad y^{**}_i = \begin{cases} y^*_{i2} & \text{if } y^*_{i2} > 0 \\ 0 & \text{otherwise} \end{cases}$

Empirical Results:

- Double hurdle model is run on eight energy expenditures, gas, electricity, oil, coal, turf, lpg, petrol and diesel (using new 'craggit' ML command in STATA).
- Independent variables include total household expenditure and a range of house and household characteristics (location, family composition, head of house characteristics, type and age of dwelling). A number of independent variables cover the type and extent of energy using items in the home for central heating, water heating, cooking and transport purposes.
- ML estimates are used to calculate discrete effects for the binary variables and elasticities for the continuous variables (following Newman et al, 2003, and Aristei and Pieroni, 2008).

Prob – refers to the effect on the probability of participation for a change in an explanatory variable.
Cond – refers to the effect on the conditional level of expenditure (i.e. for y > 0) for a change in an explanatory variable.
UnCond - refers to the effect on the unconditional level of expenditure (all values of y) for a change in an explanatory variable. Measures the **total effect** on y for a change in x.

- Coal estimates are not presented as no discrete effects or elasticities were significant.

GAS	Prob	Cond	UnCond
Binary Variables:			
urban	0.226**		3.48*
bordermidwest		-0.776***	
dublin	0.321***		4.954***
child	0.045**	1.828**	1.138**
unskilledagri	-0.029*	-0.088*	-0.301*
ch pipedgas	0.591***	7.186***	9.173***
cook gas	0.45***		6.851***
waterheat electric	-0.087*	-2.209*	-1.489*
Continuous Variables:			
numrooms	1.249***	0.299***	1.548***
ageHOH	7.456***		7.712***
ageHOH squared	-3.47***		-3.6**
yearbuilt	-0.305**	-0.071**	-0.376**
total HH exp	0.264*	0.073*	0.338*

ELECTRICITY	Prob	Cond	UnCond
Binary Variables:			
urban	-0.017**	-0.777*	-0.973*
dublin	0.028***	0.426***	0.563***
male	0.049*	1.236*	1.589*
child	0.243***	6.029***	7.761***
detached	0.061***	1.897***	2.394***
othertenure	-0.037*	-1.339*	-1.684*
ch pipedgas	-0.029*	-1.067*	-1.326*
ch lpg	0.063*	1.917*	2.332*
ch electric	0.059***	1.108***	1.409***
chotherinclrenew	0.001*	-0.448*	-0.498*
ch none	-0.063***	-1.174***	-1.586***
cook gas	-0.091***	-2.258***	-2.878***
cook lpg	-0.068***	-1.455***	-1.891***
cook solidfuel	-0.124**	-2.165**	-2.772**
cook other	-0.021***	-0.478***	-0.583***
waterheat electric	0.023***	0.582***	0.699***
waterheat solidfuel	-0.112*	-2.375*	-3.075*
Continuous Variables:			
numadults 18	0.26***	0.33***	0.59***
numadults 18 squared	-0.046***	-0.059**	-0.105***
numrooms	0.154***	0.219***	0.374***
ageHOH	1.175***	0.947***	2.122***
ageHOH squared	-0.828***	-0.602***	-1.431***
yearbuilt	-0.039***	-0.057***	-0.096***
total HH exp	0.097***	0.191***	0.288***
elec index	0.288***	0.361***	0.65***

OIL	Prob	Cond	UnCond
Binary Variables:			
urban	-0.093**	-2.38***	-3.058***
bordermidwest	0.038***	0.985***	1.277***
dublin		0.116***	0.116***
male		0.248***	
ownaccountfamers	0.069**	1.679**	2.154**
working	0.055*	1.174*	1.518*
detached	0.141***	3.293***	4.269***
otheraccomd	0.086***	2.589***	
othertenure	-0.193***	-3.529***	-4.645***
ch pipedgas	-0.116***		-3.881***
ch lpg	-0.46***		-8.426***
ch solidfuel	-0.299***	-5.184***	-6.88***
ch electric	0.043***		0.804***
ch otherinclrenew	0.034***	-0.064***	0.031***
ch none	0.102***	2.278*	2.949***
cook gas	-0.112**	-2.648	-3.462*
cook oil	0.174***	7.26***	8.748***
waterheat electric	0.024***	0.617***	0.781***
waterheat electricch	0.064***	1.084***	1.465***
waterheat solidfuel	-0.124***	-2.411***	-3.17***
waterheat other	-0.122***	-2.481***	-3.237***
Continuous Variables:			
numadults 18	0.096***	0.21**	0.306***
numadults 18 squared	-0.045***	-0.101***	-0.147***
numrooms	0.073***	0.285***	0.358***
total HH exp	0.048***	0.22***	0.268***

TURF	Prob	Cond	UnCond
bordermidwest		3.019*	
ch solidfuel		5.348*	

LPG	Prob	Cond	UnCond
Binary Variables:			
bordermidwest	0.147**	3.814**	
othersocialstatus	0.092*	2.532*	
cook lpg	0.006**		0.132*
cook solidfuel	0.249*		
Continuous Variables:			
total HH exp	0.147*	0.533*	

PETROL	Prob	Cond	UnCond
Binary Variables:			
urban	-0.077***	-4.693***	-5.901***
dublin	-0.077***	-4.693***	-5.901***
educ third level	0.095**	3.034**	3.947**
unskilledagri	-0.001*	1.077*	1.284*
ownaccounfarmers	0.062***	2.806***	3.387***
detached	0.178*	9.168*	11.651*
other tenure	-0.146**	-6.468**	-8.38**
carsnone	-0.536***	-19.033***	-23.891***
cars2	0.35***	14.762***	19.666***
cars3	0.368***	37.351***	44.703***
Continuous Variables:			
numadults18	0.168***	0.266***	0.434***
ageHOH	0.505***	0.473**	0.978**
ageHOH squared	-0.35***	-0.337***	-0.687***
yearbuilt	0.048***		0.066**
total HH exp	0.195***	0.339***	0.535***
annual mileage	0.053***	0.097***	0.15***

DIESEL	Prob	Cond	UnCond
urban	-0.151***		-7.033***
bordermidwest	0.085***	3.541*	4.239***
educ secondary	-0.015*	-0.71*	-1.057*
ownaccounfarmers		1.899***	
detached	0.193***	7.639*	8.609***
carsnone	-0.342***		-12.374**
cars2		7.27*	
Continuous Variables:			
numadults18	0.221***		0.426**
numadults18 squared	-0.065**		-0.112*
numchildren8	0.046*	0.098*	0.144*
yearbuilt	-0.051***	-0.13***	-0.181***
total HH exp	0.194***	0.519***	0.713***
annual mileage		0.089***	0.224***

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

Conclusions 1:

- Location (urban/rural and regional) is a significant factor across all fuels in affecting both what type of fuel a household consumes and the amount it consumes.
- The type of heating systems (space and water), cooking appliance and level of possession of electrical appliances are also important factors in determining what type of fuel a household consumes and the amount it consumes. Similarly possession (and level of possession) of cars affects petrol and diesel consumption.
- Age of the HOH, household size and house size all positively affect energy use. Some evidence of non linearitys in the age of the HOH and household size. In the case of the age of the HOH it would imply that middle aged households consume more than young households and that older households consume less than middle aged households (see gas, electricity and petrol).
- Also some evidence that new homes consume less energy (see gas and electricity equations).
- No apparent trends of significance in other non economic variables.

Conclusions 2:

- Income (as measured by total household expenditure - values highlighted) elasticities are positive and significant for all fuels except coal, turf and lpg. Size of elasticties indicate fuels are necessities which is the expectation. Petrol and Diesel elasticties slightly higher relative to other fuels indicating a higher response to income changes.
- There is some evidence to suggest that the decision to separate the decision process into a participation element and a consumption element is justified as the ML estimates from the double hurdle model indicate that different factors affect the two decisions (e.g. for gas being in a urban location affects the decision to participate but not to consume).
- The appropriateness of the double hurdle model is assessed using a simple LR test comparing the Tobit with the Double Hurdle (represented by a combination of log likelihoods from a probit and truncated model). In all cases, except for lpg, the Double Hurdle model was preferred to the Tobit.
- Insignificance of coal (and to some extent turf) models may be due to the fact that these fuels are playing a decreasing role in household energy use. In economic terms they may be considered as inferior fuels. This is consistent with the graph of residential energy use given above which illustrates the shift in preferences from solid fuels toward oil and gas over the 1990 to 2008 period.

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