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RESIDENTIAL ENERGY DEMAND: A MULTIPLE DISCRETE-CONTINUOUS EXTREME VALUE MODEL USING ITALIAN EXPENDITURE DATA

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Residential Energy Demand: a Multiple Discrete-Continuous Extreme Value Model using Italian Expenditure Data

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Abstract

The economic analysis of energy consumption is mostly focused on single components of total expenditure in energy-consuming services. The discrete-continuous models, following the formulation of Hanemann (1984), consider the case of perfect substitute goods: the maximization process leads to extreme corner solutions in which only one alternative is selected. According to this model the literature on energy consumption is limited to study some components of total energy consumption, i.e. space and water heating or transportation. Following the path opened by Pinjari and Bhat (2010), the goal of this paper is to build a multiple discrete-continuous model of residential energy demand based on Italian expenditure data. A non-linear utility structure, originally used in Kim et al. (2002) and extended in Bhat (2005), is implemented within the Kuhn-Tucker multiple-discrete economic model of consumer demand proposed by Wales and Woodland (1983). The paper here presented is the first application of this model to Italian expenditure data. The model predict parameters stability over time and low price elasticities for electricity (0.56) and natural gas (1.17). Considerble variations in natural gas expenditures (+54%) are predicted in case of climate changes measured of increases in Heating Degree Days (+15%).

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1 Introduction

The traditional discrete-continuous models, following the formulation of Hanemann(1984), consider the case of perfect substitute goods or ”extreme corner solution problems”: the maximization process leads to solutions in which only one alternative is selected. By construction these models exclude the possibility to deal with ”generalized corner solution problems” defined by Hanemann(1978) as the situations in which multiple alternatives may be chosen simultaneously.

Several human behaviours and activities are characterized by multiple discreteness, i.e. the choice if and how to consume our time or money, purchase and investment decisions. A crucial methodological issue is here involved and it concerns the procedure to model the choice of consumption bundles where each quantity (or expenditure) can be either zero or positive. When there are only two goods (typically one good of interest and a residual expenditure), the problem is typically solved by applying the procedure originally proposed by Tobin (1958) (the so-called Tobit model, or some version of it); similar models have been developed and applied in different fields (labour supply, aggregate energy demand, infrequent purchases etc.). The problem becomes much more difficult when more than 2 goods are considered. Looking at Kuhn-Tuckers First Order Conditions, we see that in general each goods demand function depends on the others quantities being zero or positive, thus generating $2M1$ possible alternatives, where M denotes the number of goods and at least one quantity must be positive. Wales and Woodland (1983) proposed the first general framework for treating this case. From the first order conditions the choice probabilities of consumption patterns are derived allowing for zero and positive consumption outcomes and ensuring a theoretically and behaviourally consistent formulation. The main limitation of this approach is the estimation of a complicated likelihood function that includes multi-dimensional integration. Due to computational difficulties, the Wales Woodland model has been considered impractical for many years. Kim et al. (2002) proposed the use of the Geweke-Hajivassiliou-Keane (or GHK) simulator to evaluate the multivariate normal integral involved.

A very pragmatic alternative was proposed by Train et al. (1987) with an application to telephone demand. The main idea consists of applying a Multinomial Logit model to a discrete representation of the whole opportunity set, where the zeroes are treated symmetrically as the other (positive) discrete alternatives. Finally an alternative approach is proposed by Hendel (1999) and Dube (2004), the first using the definition of "multiple discreteness"; they model the purchase among multiple alternative products as the result of a sequence of expected future consumption decisions.

In this contest, the contribution of Bhat (2005) is of considerable importance as it provides a simple and appealing econometric procedure to recover a closed form solution for the choice probabilities expression. He built the model on the generalized variant of the translated CES utility function with a multiplicative log-extreme value error term. For the readers familiar with the standard Multinomial Logit (MNL) the Bath's model, named Multiple Discrete-Continuous Extreme Value (MDCEV) model, represents the multiple discrete version of MNLs. Furthermore, as shown in §2.2, the MDCEV collapses to the MNL when each individual decides to consume only one alternative.

Following the path opened by Bhat (2005) and Pinjari and Bhat (2010), the goal of this paper is to build a multiple discrete-continuous model of residential energy demand using Italian expenditure data. A non-linear utility structure, originally used in Kim et al. (2002) and extended in Bhat (2005), is implemented within the Kuhn-Tucker multiple-discrete economic model of consumer demand proposed by Wales and Woodland (1983).

The empirical application presented is fourfold and tries to fill the gaps leaved opened by previous literature using this model. This is, up to my knowledge, the first empirical analysis of italian households energy demand using micro data. Second, the inclusion of data on gasoline consumption allows to analyse a more complete consumption bundle with the inclusion of demand for transportation services. Third, the use of a time series of cross section allowed to investigate the energy demand over time and its stability. Fourth, the structure of dataset used allowed to perform some scenarios' analysis to evaluate the reaction of demand to shocks on climate and tariffs.

The paper is organised as follow: in the first section the Kuhn-Tucker conditions approach is introduced. Section 2.2 describes the Multiple Discrete Continuous model, in section 2.3 a snapshot of the Italian energy sector and dataset is provided. Section 2.4 presents and comments the results and section 2.6 offers concluding remarks.

2 Khun-Tucker conditions approach

Models of consumers' behaviours are conventionally based on the assumptions that individuals have a continuously differentiable, strictly increasing, and strictly quasi-concave utility function[1] denoted by:

$$U = U\left(x, q, z, \beta, \epsilon\right) \tag{1}$$

where x is a M$-$*dimensional* vector of consumption levels, q is a $M \times k$ matrix of attributes for the vector of commodities and z is the Hicksian good. β is a vector of parameters and ϵ is the vector of unobserved components.

Given a vector of prices (p) and a level of income (y), the maximization problem for each

[1]The assumption of a quasi-concave utility function is a traditional assumption to ensure the indifference curves to be convex with respect to the origin Deaton and Muellbauer (1980).

individual is:

$$\begin{aligned} & max_{x,z} U(x,q,z,\beta,\epsilon) \\ & s.t. \quad p'x + z = y, \qquad x \geq 0. \end{aligned} \tag{2}$$

Consumers maximize their utility subject to a linear budget constraint. The assumption of an increasing utility function implies that income is completely spent and almost one good is consumed.

The first order Kuhn-Tucker conditions are:

$$\begin{aligned} & \frac{\partial U}{\partial x_k} \leq \frac{\partial U}{\partial z} p_k \quad k = 1, ..., M \\ & x_k(\frac{\partial U}{\partial x_k} - \frac{\partial U}{\partial z} p_k) = 0 \quad k = 1, ..., M \\ & x_k \geq 0 \end{aligned} \tag{3}$$

Assuming an additive error term eq. 2.3 can be rewritten as:

$$\begin{aligned} & \epsilon_k \leq g_k(x,q,p,\beta) \\ & x_k(\epsilon_k - g_k(x,q,p,\beta)) = 0 \\ & x_k \geq 0 \end{aligned} \tag{4}$$

where $g(\bullet)$ is the function containing the deterministic component of utility. If we define $\hat{x}_n$ the vector of observed zero or positive consumption levels of goods k for individual n: $\hat{x}_{nk} = (x_1, ..., x_n)$, the probability of observing an individual consuming just the first k elements of the vector is:

$$f\hat{x}_{nk} = \int_{-\infty}^{g_M} \therefore \int_{-\infty}^{g_{k+1}} f_\epsilon(g_1, .., g_k, \epsilon_{k+1}, .., \epsilon_M) x \, |J| \, d\epsilon_{k+1} ... d\epsilon_M \tag{5}$$

where $f_\epsilon(\bullet)$ is the joint density function of the error terms and J_k is the Jacobian of the transformation. For the goods that are consumed we know that: $\epsilon_k = g_k(x, \mathbf{q}, \mathbf{p}, \beta)$, for the rest of the goods that are not consumed we just know that $\epsilon_k \leq g_k(x, \mathbf{q}, \mathbf{p}, \beta)$ (see equation 2.4).

Given a distribution function for the error term and a functional form for the utility function, it is possible to build the likelihood function to estimate. The great contribution of the series of papers of Bhat (2005,2006,2010), presented in the following section, is the derivation of a closed form solution for this maximization problem that incorporates the multiple discreteness in a simple and parsimonious fashion.

3 The Multiple Discrete Continuous Choice Model

This paragraph is strictly based on Bhat (2005), Bhat et al. (2006) and Pinjari and Bhat (2010) but I propose a reformulation in the context of energy demand. Following the general set up of a discrete/continuous choice model, the selection of the optimal portfolio simultanesously represents a discrete and a continuous choice. The discreteness is embodied in the decision of which fuel to consume and the continuous choice determines the quantity of energy to consume, or as in this case the expenditure level for each fuel. The model assumes a direct stochastic specification of the utility function: the stochastic KT first order conditions provide the basis to derive the probabilities of each possible combination of corner solutions for some goods and interior solutions for other goods.

Suppose there are M categories ($m = 1, 2, ..., M$; with m=electricity, oil, gas, etc.). According to the general assumption on the utility function, consider the presence of a subsistence category that is always consumed[2]. In this application the subsistence category is a residual category representing the portion of income left after energy expenditures. The others $M-1$ categories are the alternatives of the multiple discrete choice: the household decides

[2]The subsistence category has been defined also as "outside good" or "Hicksian good".

to spend a positive ammount of money e_m, or zero, in each M-1 category. We can specify an utility function, U, across the M categories as follow:

$$U\left(\psi_1 e_1, ..., \psi_M e_M\right) \tag{6}$$

where e_m is the expenditure for fuel m, ψ_M represent the quality of each alternative m as perceived by households, the specific expression of ψ will be discussed below. The budget constraint is given by:

$$\sum_{m=1}^{M} e_m = E \tag{7}$$

where E is the total expenditure.

The utility function used is a special case, namely a Linear expenditure system formulation, of the linear Box-Cox version of a translated CES direct utility function Pinjari and Bhat (2010), whose generic form is:

$$\begin{aligned} &U(x) = \frac{1}{\alpha_1}\psi_1(x_1)^{\alpha_1} + \sum_{m=2}^{M} \frac{\gamma_m}{\alpha_m}\psi_m \left\{ (\frac{x_m}{\gamma_m} + 1)^{\alpha_m} - 1 \right\}; \\ &\psi_m > 0, \qquad 0 \leq \alpha_m \leq 1, \qquad \gamma_m > 0 \end{aligned} \tag{8}$$

where $U(x)$ is the utility derived by the consumption of x amount of m categories available to decision maker. ψ_m is the baseline utility deriving from the consumption of category m and it is function of observed characteristics associated to each alternative m. A higher baseline utlity for category m implies less likelihood of corner solution for that category, in other words positive consumption. Moreover let's consider two goods i and j characterized by the same unit price: a higher baseline marginal utility for one good implies that an individual will increase overall utility more by consuming this good rather than the other. The $\alpha' s$ are satiation parameters representing the rate of diminishing marginal utility of spending money in category m. As α_m decreases the satiation effect for good m increases and when $\alpha \to -\infty$ there is immediate and full satiation.

The parameter γ_m can be also interpreted as a satiation parameter: it shifts the position of the point at which the indifference curves are asymptotic. The indifference curve becomes steeper as the value of γ increases.

Summarizing, the baseline utility function discriminates the categories to which allocate positive expenditure, γ permits the presence of corner solutions and both α and γ act as satiation parameters through different mechanisms. When α and γ are equal 1 for each category this means that there is no satiation and the function collapses to the case of perfect substitutes (single discreteness), equation (2.8) becomes:

$$U(x) = \sum_{m=1}^{M} \psi_m(x_m) \tag{9}$$

Intuitively, when there is no satiation and the unit good prices are all the same, the consumer will invest all expenditure on the single good with the highest baseline (and constant) marginal utility (i.e., the highest ψ_m value). This is the case of single discreteness.

Consistently with the single discrete-continuous literature of Hanemann (1984), we assume that the randomness comes into the model because of the difficulty for the analyst to describe the quality and the actractiveness of each altrenative, so the random term is introduced as a multiplicative element in ψ:

$$\psi(x_m, \epsilon_m) = exp(\beta' z_m + \epsilon_m) \tag{10}$$

The overall random utility function takes the following form:

$$\tilde{U} = \frac{1}{\alpha_1}[exp(\beta' z_1 + \epsilon_1)]x_1^{\alpha_1} + \sum_{m=2}^{M} \frac{\gamma_m}{\alpha_m}[exp(\beta' z_m + \epsilon_m)] \left\{ (\frac{x_m}{\gamma_m} + 1)^{\alpha_m} - 1 \right\} \tag{11}$$

s.t. the budget constraint $\sum_{m=1}^{M} = E$.

Finally we express our utility function in terms of expenditures (e_m) and prices (p_m) as:

$$\tilde{U} = \frac{1}{\alpha_1}[exp(\beta' z_1 + \epsilon_1)](\frac{e_1}{p_1})^{\alpha_1} + \sum_{m \notin B} \frac{\gamma_m}{\alpha_m}[exp(\beta' z_m + \epsilon_m)] \left\{ (\frac{e_{mj}}{\gamma_m p_m} + 1)^{\alpha_m} - 1 \right\} \tag{12}$$

The Lagrangian function for the maximization of the utility function subject to the budget constraint is:

$$\mathscr{L} = \tilde{U} - \lambda \left[\sum_{m=1}^{M} e_m - E \right] \tag{13}$$

where the λ is the lagrangian multiplier, and the first order Kuhn-Tucker conditions are:

$$\begin{array}{ll} \psi_1(\frac{e_1}{p_1})^{\alpha_1 - 1} - \lambda = 0 & since \quad e_1^* > 0 \\ \psi_m(\frac{e_m}{\gamma_m p_m} + 1)^{\alpha_m - 1} - \lambda = 0 & since \quad e_{m \notin B}^* > 0 \\ \psi_m(\frac{e_m}{\gamma_m p_m} + 1)^{\alpha_m - 1} - \lambda < 0 & since \quad e_{m \notin B}^* = 0 \end{array} \tag{14}$$

For the m categories consumed the associated expenditure is such that the marginal utilities are the same across fuels at the optimal expenditure allocation. The second set of conditions ensure that for categories to which zero expenditure is associated the marginal utility at zero consumption is less than the one associated to positive consumption of other fuels. From the Kuhn-Tucker condition for the first category (first line in equation 2.14) we obtain the lagrangian multiplier:

$$\lambda = exp[\beta' x_1 + \epsilon_1)](\frac{e_1}{p_1} + 1)^{\alpha_1 - 1} \tag{15}$$

substituting for λ in the f.o.c., taking logarithmic transformation:

$$\begin{aligned} V_m + \epsilon_m &= V_1 + \epsilon_1 \qquad if \quad e_m^* > 0 \\ V_m + \epsilon_m &< V_1 + \epsilon_1 \qquad if \quad e_m^* = 0 \end{aligned} \tag{16}$$

where

$$\begin{aligned} V_1 &= \beta' z_1 + (\alpha_1 - 1) ln(\tfrac{e_1^*}{p_1}), \\ V_m &= \beta' z_m + (\alpha_m - 1) ln(\tfrac{e_m^*}{\gamma_m p_m} + 1) \end{aligned} \tag{17}$$

Finally, some assumption to ensure identification are necessary. For one of the m categories we cannot identifies a constant. This condition is similar to the one we meet in the standard discrete choice model, but if the origin in the single discrete choice is the possibility to transform the model in differences, in the Bhat's multiple discrete case is due to the adding up condition or budget constraint in the optimization problem.

The second assumption refers to the satiation parameters: α_m that must be bounded between 0 and 1, γ grater than zero. We can parametrize α_m as $1/1[1 + exp(-\delta_m)]$ where δ can be a function of individual characteristics in order to allow the satiation parameter to vary across individuals. We can also simply model α as $1/1[1 + exp(-\alpha_m)]$ just to guarantee the satiation parameter to be bounded.

3.1 Error distribution

A large variety of error distributions can be accommodated as mixture logit or GEV structure to allow for the violation of the IIA assumption. Different specifications have been tested in particular Nested Logit and Mixture Logit but MNL has proved to be the most efficient in this application. Therfore the error term ϵ is asumed to be identically standard extreme value distributed.

The marginal choice probabilities to participate to the first K alternatives in the M categories of consumption ($K \geq 1$) with positive expenditure allocations become:

$$P(e_1^*, e_2^*, e_3^*, ..., e_M^*, 0, 0, ..., 0) = |J| \frac{1}{\sigma^{M-1}} \left[\frac{\prod_{m=1}^{K} e^{\frac{V_m}{\sigma}}}{\left(\sum_{k=1}^{M} e^{\frac{V_k}{\sigma}} \right)^M} \right] (M-1)! \qquad (18)$$

J is the jacobian:

$$J_{im} = \frac{\partial \left[V_1 - V_{i+1} + \epsilon_1 \right]}{\partial e_{m+1}^*}; \qquad i, m = 1, 2, 3, ..., K-1 \qquad (19)$$

whose determinant is defined as:

$$|J| = \left[\prod_{m=1}^{M} r_m \right] \left[\sum_{m=1}^{M} \frac{1}{r_m} \right], \qquad where \qquad r_m = \left(\frac{1-\alpha_m}{e_m^* + \gamma_m} \right) \qquad (20)$$

The scale parameter σ is normalized to one as no variation in unit prices across alternatives is assumed. The *V's* in equation 2.18 and 2.19 are expressed as in equation 2.17.

3.2 Forecasting and policy evaluation

The model built so far can be used to determine optimal allocations conditional on explanatory variables and exogenous shocks. Policies for energy conservation and energy efficiency can be evaluated predicting expenditure behaviours. This prediction analysis can be conducted through a constrained optimization of the following maximization problem:

$$\begin{aligned} Max\tilde{U}_i = & \int_{\epsilon_{i1}} \int_{\epsilon_{i2}} .. \int_{\epsilon_{iM}} \frac{1}{\alpha_1} [exp(\beta' x_{i1} + \epsilon_{i1})] (\frac{e_{i1}}{p_{i1}})^{\alpha_1} + \\ & \sum_{m=2}^{M} \frac{\gamma_m}{\alpha_m} [exp(\beta' x_{im} + \epsilon_{im})] \left\{ (\frac{e_{mj}}{\gamma_m p_m} + 1)^{\alpha_m} - 1 \right\} dG(\epsilon_{i1}) dG(\epsilon_{i2}) ... dG(\epsilon_{iM}) \end{aligned} \qquad (21)$$

s.t. $\sum_M e_{im} = E_i$, with i the individuals.

The procedure appears to be very cumbersome and time consuming in particular when large datasets are considered. For this reason the efficient forecasting procedure provided by Pinjari and Bhat (2010) is implemented in the empirical section of the paper. The theoretical insights and the steps of the forecasting procedure are provided in Annex 2.2.

4 Households' energy demand in Italy: empirical evidences

The Italian primary demand for energy in 2009[3] was around 180 Mtep. The decreasing trend started in 2006 seems to be confirmed in the following years in particular for oil and solid fuels. The only exceptions are renewables and electricity recording respectively an increase of 13% and 11%. Italy presents peculiarities with respect to the rest of european conuntries: energy demand composition is mainly oriented towards natural gas , oil (80%).

Final consumption by sectors mirrors the primary energy demand of figure 1. Starting from 2006 a continuous and accelerating process of decrease is triggered (Figure 2). A certain degree of correlation with climeate conditions can be supposed: in 2006 and 2007 mild winters have been the cause of a reduced demand for space heating and conditioning while for 2008 and 2009 cold winters resulted in an increase of energy demand[4]. Peculiar, and somehow worrying, is the path followed by industrial sector which according to the decreasing trend of production has been the hardest hit by the worldwide economic crisis.

The residential sector is dominated by the use of natural gas and electricity for several European countries, in particular for Italy (85%, see figure 4 for Italy). This is the reason

[3]The 2009 is the last year for which a official statistics are available.

[4]It's important to notice that space and water heating account for the 70/80% of energy demand in all the developed countries located in temperate zones

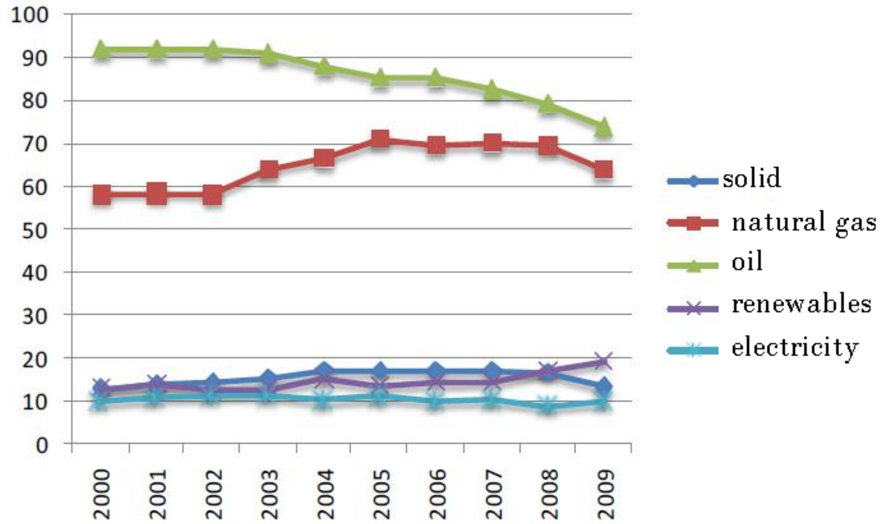


Figure 1: Final Total Energy Demand Trends by Fuel

why there have been many attempts to regulate the markets of these two energy sources.

The market structure The European liberalization process in the electricity and natural gas market born to create the conditions for an effective competition among players. Before the deregulation national markets were characterized by a vertically integrated industry, in which regulators fixed prices as a function of generation, transmission and distributional costs. In most cases the energy sectors were characterised by natural monopolies.

In this framework, the case of the Italian electricity market was characterised by the liberalization introduced with the legislative decree 79 in 1999, also called Bersani Decree. The liberalization process has introduced different changes on both the demand and the supply side. On the demand side, the decree classifies consumers as "eligible clients" or "small consumers". The former includes large consumers to who the State has recognised the legal capacity to purchase or sell electricity. The latter includes household consumers

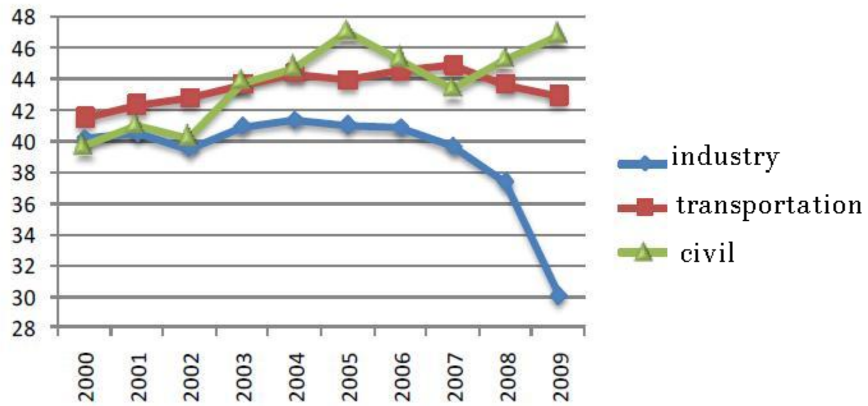


Figure 2: Final Total Energy Demand Trends by Sector

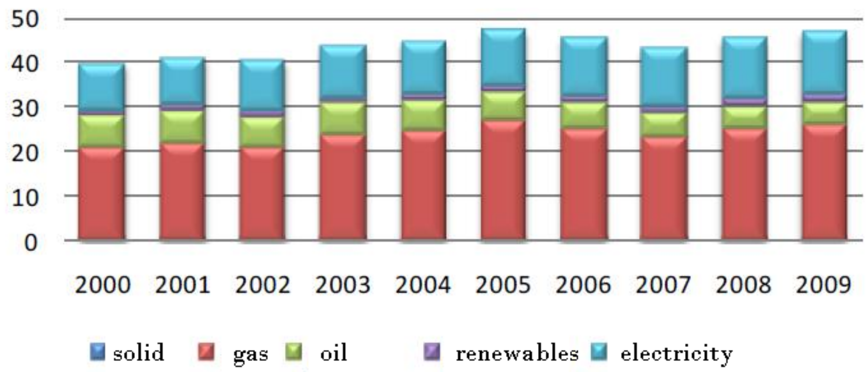


Figure 3: Consumption Distribution among fuels in the Residential sector

which have to remain the captive market of local distributors until the 1st July 2007. Starting from July 2007 consumers can freely have access to "open market" and leave the condition of protected prices (in Italian "maggior tutela" condition). Actually, data furnished by the Electricity and Natural Gas Authority (AEEG) show the presence of *inertia* in this transition process: less than 20% of Italian consumers moved to open market.

4.1 Data

The Survey on Households Consumption comes form the Italian Institute of Statistics (ISTAT(2005)) and collects information on monthly families' expenditure. Information on houses, appliance stock and families' characteristics are also provided. Three cross-section for years 2003, 2004, 2005 are employed to investigate the presence of statistical relations among demand for fuels and italian household's characteristics and to verify time stability of these relations.

In table 2.1 and table 2.2 some descriptive statistics are provided. In column 2 of table 2.1 are reported the total number of individuals participating in each category (fuels) and in column 3 the average expenditure. As required by the theoretical model the residual category is always consumed with an average expenditure per month of 2282 Euro. All families in the sample owns at least one electric device for which a positive amount of money (on average 37.98 Euro) in electricity is spent. Oil and wood and lpg are very uncommon but with higher expenditure levels.

Table 1: Descriptive Statistics fuel expenditure participation

Expenditure category	Total number (%) of individual participating	Mean Expenditure*
Residual	73,960 (100%)	1860
Electricity	73,960 (100%)	37.98
Natural Gas	52,412 (70.87%)	67.13
Lpg	14198 (19.19%)	36.32
Oil	3,429 (4.63%)	154.39
Wood	3,800 (5.10%)	100.46
Gasoline	49,344 (66.71%)	164.17
Diesel (for transportation)	11,127 (15.06%)	128.20

*The mean expenditure is measured just for individuals with non zero consumptions.

Table 2.2 collects some descriptive statistics of houses and households in the sample. The italian families live in 2/3 people in popular/medium apartments (80%) with four rooms (60-70 square meters) mainly in town or cities (81.95%). The owners are more than 70% and their monthly expenditure is around 2000 euros.

Table 2: Households' Descriptive Statistics

	Freq.	Percentage	Cum.
Town	60,605	81.95	81.95
Group of Houses	8,412	11.37	93.32
Campaign	4,943	6.68	100.00
Manor	5,206	7.04	7.04
Detached House	6,267	8.47	15.51
Popular House	59,137	80.01	95.52
Rural House	3,314	4,48	100.00
North-West	18,618	25.17	25.17
North-East	15,680	21.20	46.37
Center	14,392	19.46	65.83
South	19,875	26.87	92.71
Islands	5,395	7.29	100.00
	Obs.	Mean	St.dev.
Rooms	73,960	4.33	1.47
Components	73,960	2.63	1.28
Total expenditure (log)	73,960	2,093	1633.72
Number of cars	73,960	1.23	0.85

5 Results

The section presents the results of a model specification that is slightly different from the one presented in section 2.2 (eq. 2.12). In particular I will use the so called γ-profile utility function in which the satiation parameter α tends to zero and the utility function assumes the Linear Expenditure System (LES) structure. Positive values of γ permit corner solutions and the slope of γ determines its role as satiation parameter. Higher values shape the indifference curve steeper impying stronger preference, hence lower satiation, for the good:

$$\tilde{U} = [exp(\beta' z_{res} + \epsilon_{res})]e_{res} + \gamma_m \sum_{m=el,gas,lpg,...} [exp(\beta' z_m + \epsilon_m)]ln(\frac{e_m}{\gamma_m p_m} + 1) \tag{22}$$

Table 2.3 collects the results of the MDCEV model[5]. The satiation parameters (γ) are all significantly different from one rejecting the linear utility structure employed in standard discrete choice model, the model confirms there is a clear satiation effect for each fuel analysed. Electricity is the category with the lowest satiation level confirming his hicksian role in the consumption bundle.

All the baseline utility constants are strongly negative implying that the baseline propensity to consume in the outside category is higher than the one for the other categories. The effects of the households characteristics in general confirm my expectations: the demand for fuels increase with the household and apartment dimension, both the number of components and the number of rooms can be indicator of higher demand for services as space heating, water heating and lightning. The logarithmic transformation of expenditure, interpreted as a proxy of monthly income, has a negative effect on all the baseline utilities associating to the residual expenditure category an higher utility level. Richer

[5]The model was estimated using Gauss Aptech and some modification of the code provided by Bhat http://www.caee.utexas.edu/prof/bhat/MDCEV.html

families are more likely to spend less for energy than for other goods. My interpretation is in the light of the following two considerations: first, higher income groups could have access to more efficient equipments and buildings reducing expenditures but not consumption; second, environmental sustainable behaviours are more diffused among rich families because of higher education level but also for weaker budget constraint (green products and efficient technologies are on average more expensive). Living in house with centralized heating systems reduces the demand for fuels. For these families there is a sort of bias in dataset as the expenditures for space heating are managed at a building level and are not included in the expenditure for fuels declared. Climate conditions are introduced in the model as logarithmic transformation of Heating Degree Days (HDD) and Conditioning Degree Days (CDD), the former presents results coherent with my expectations the latter displays no statistical significance for all fuels. Families react to an increase in HDD with higher energy demand in particular for space heating purposes. CDD seem to have no effects on energy exenditures.
Families living out of towns or cities (grouped houses and campaign variables) consume more energy than those who lives within the cities. It's plausible to think they live in bigger houses (higher space heating expenditures) and use more frequently mothorized vehicles. The coefficients related to different houses typologies do not permit a univocal interpretation, the reference is the manor category with respect to which the families living in other house categories seem to spend less for the two main fuels (electricity and natural gas).

Households living in regions of North-Est of Italy have in general less propensity to consume energy (with the exception of diesel and electricity) rather than families located

Table 3: MDCEV

	(I) Residual	(II) Electricity	(III) Natural Gas	(IV) Lpg	(V) Oil	(VI) Wood	(VII) Gasoline	(VIII) Diesel
Household's components	-	0.125***	0.006***	0.035***	0.018***	0.015***	0.024***	0.035***
		(0.002)	(0.002)	(0.003)	(0.004)	(0.005)	(0.005)	(0.002)
Rooms	-	0.057***	0.0146***	0.014***	0.049***	0.0345***	-	-
		(0.001)	(0.001)	(0.002)	(0.004)	(0.004)		
Log Income	-	-0.9027***	-0.9161***	-1.07***	-1.035***	-1.046***	-0.838***	-0.747***
		(0.004)	(0.004)	(0.006)	(0.012)	(0.011)	(0.004)	(0.004)
Renewal	-	0.107***	0.095***	0.02	0.11**	0.255***	-	-
		(0.02)	(0.02)	(0.04)	(0.059)	(0.04)		
Number of cars	-	-	-	-	-	-	0.191***	0.15***
							(0.003)	(0.05)
Centralized H.S.	-	-0.038***	-0.257***	-0.052***	-0.233***	-0.358***	-	-
		(0.005)	(0.05)	(0.009)	(0.018)	(0.022)		
North-Est	-	0.0283***	-0.022***	-0.028***	-0.028**	-0.102***	-0.028***	0.130***
		(0.006)	(0.006)	(0.011)	(0.113)	(0.015)	(0.018)	(0.006)
Center	-	0.0933***	0.065***	0.055***	-0.158***	-0.319***	0.012**	0.062***
		(0.006)	(0.006)	(0.012)	(0.124)	(0.016)	(0.018)	(0.006)
South	-	0.120***	-0.146***	0.095***	-0.211***	0.024*	0.088***	0.061***
		(0.008)	(0.008)	(0.014)	(0.108)	(0.025)	(0.022)	(0.008)
Islands	-	0.2498***	-0.4470***	0.689***	-0.563***	-0.847***	-0.039***	-0.1979***
		(0.013)	(0.020)	(0.017)	(0.04)	(0.072)	(0.012)	(0.021)
HDD (Heating Degree Days)	-	0.0011*	0.0002***	0.012***	0.03***	0.059***	-	-
		(0.003)	(0.001)	(0.001)	(0.002)	(0.003)		
CDD (Cooling Degree Days)	-	-0.0015	0.005	0.035*	0.023	-0.009*	-	-
		(0.001)	(0.003)	(0.006)	(0.006)	(0.008)		
Year 2004	-	-0.005*	-0.001	0.164***	0.003	0.063***	0.014**	0.014*
		(0.005)	(0.005)	(0.008)	(0.015)	(0.014)	(0.005)	(0.009)
Year 2005	-	0.052***	0.1186***	-0.04***	0.123***	0.003	0.077***	0.1749***
		(0.005)	(0.007)	(0.012)	(0.02)	(0.02)	(0.007)	(0.012)
Detached House	-	-0.0918***	0.003	-0.128***	-0.083***	-0.121***	-0.006	-0.01
		(0.010)	(0.014)	(0.018)	(0.047)	(0.026)	(0.03)	(0.016)
Popular house	-	-0.156***	-0.05***	0.023*	-0.059***	0.008	0.038***	0.037**
		(0.008)	(0.08)	(0.014)	(0.03)	(0.019)	(0.021)	(0.008)
Rural house	-	-0.097***	-0.38***	0.021***	-0.033***	0.192***	0.004***	0.074***
		(0.012)	(0.015)	(0.017)	(0.066)	(0.029)	(0.026)	(0.013)
Group of Houses	-	0.065***	-0.169***	0.286***	0.212***	0.251***	0.057***	0.093***
		(0.06)	(0.007)	(0.006)	(0.066)	(0.015)	(0.015)	(0.006)
Campaign	-	0.105***	-0.525***	0.473***	0.242***	0.355***	0.037***	0.1514***
		(0.08)	(0.011)	(0.011)	(0.066)	(0.019)	(0.017)	(0.009)
Constant	-	-0.905***	-5.321***	-2.421***	-3.226***	-3.167***	-1.181***	-2.904
		(0.03)	(0.03)	(0.04)	(0.08)	(0.08)	(0.03)	(0.05)
$\gamma_{residual}$	-	-	-	-	-	-	-	-
γ_{elec}	-	1.746***	-	-	-	-	-	-
		(0.029)						
γ_{gas}	-	-	4.45***	-	-	-	-	-
			(0.009)					
γ_{lpg}	-	-	-	4.019***	-	-	-	-
				(0.013)				
γ_{oil}	-	-	-	-	5.974***	-	-	-
					(0.022)			
γ_{wood}	-	-	-	-	-	5.533***	-	-
						(0.021)		
$\gamma_{gasoline}$	-	-	-	-	-	-	5.602***	-
							(0.009)	
γ_{diesel}	-	-	-	-	-	-	-	5.986***
								(0.014)
σ	-	-	-	-	-	-	-	0.325***
								(0.002)

Standard errors in parenthesis,***p≤0.01,**p≤0.05,*p≤0.1.

in Center or South of Italy who display positive coefficients for five fuels out of seven. People living in the Islands shows negative coefficients for all fuels but electricity and lpg, in this specific case the estimates could represent a sort of snapshot of the distribution networks of fuels in these regions for which water is a natural barrier.

The year dummies are introduced in the pooled model to control for year fixed effects. If 2004 fixed effect displays an ambiguous and in some case statistically not significant behavior, in 2005 households tend to spend more for fuels with respect to 2003 that is the reference year and with respect to the outside category. In the following section the demand stability over time is investigated comparing the estimates for each of the three years considered.

6 Testing demand stability over time

The procedure proposed byNesbakken (1999) is followed to test parameters stability: the MDCEV model is estimated for each of the years from 2003 to 2005. The confidential intervals of the parameter estimated are compared at the 95% level, in case of overlapping of these intervals stability in parameters can be assumed. In annex 2.3 the estimates for the three years are provided. The analysis of the confidential intervals suggest that the parameters estimates are stable over time with some exceptions. The baseline utility constants highlight a decreasing propensity to consume in fuels for transportation from 2003 to 2005. The effect of centralized heating systems is decreasing from 2003 and 2005, households living in houses heated by centralized systems spend less for gas and lpg in 2005 with respect to 2004 and 2003. The number of households components and house dimension has a lower impact in 2005 with respect to the other years in terms of wood expenditure. However in all the previous cases the confidential intervals of parameters overlap suggesting they are not significantly different among years.

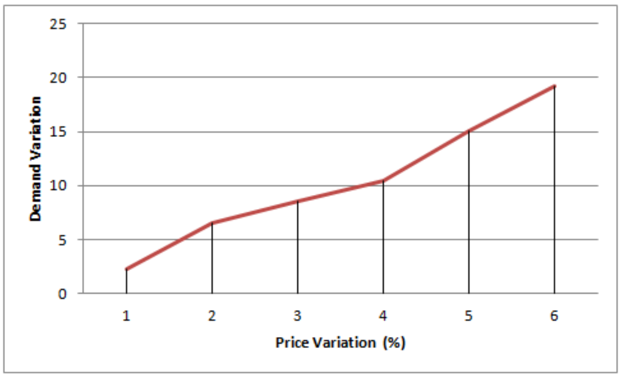
The geographical dummies introducing regional fixed effects are the covariates presenting the highest differences in estimates and they fail our test for stability. The reason why we encounter this instability is probably due to a problem of mispecification or collinearities with other explanatory variables.

We can conclude that in the years cosidered, the parameters are in general stable over time with some minor exceptions.

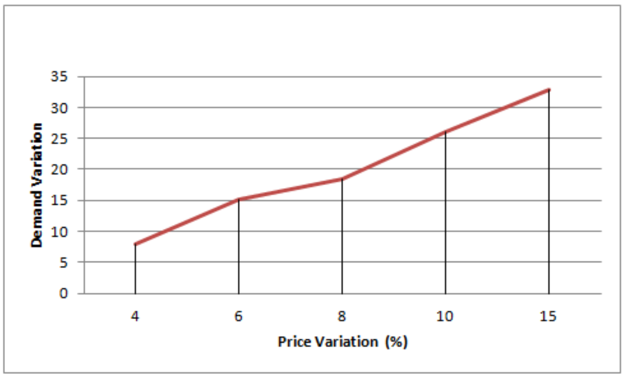
7 Climate changes and price variations: what can we expect?

The forecasting procedure depicted in ANNEX 2.2 can be applied to several policy simulations or scenarios' analysis. In this section we present two scenarios performed using 50 sets of standard error draws for each household to simulate unobserved heterogeneity. The first refers to price variation for electricity and natural gas. The elasticity of electricity demand for small increases in price is in line with short run elasticities presented in the literature (between 0.45 and 0.56, see Nesbakken (1999) for a review of price elasticities estimated). The demand decrease more rapidly if we simulate bigger variations. An increase of electricity price between the 15% and 20% reduces electricity demand of 15-19% with an elasticity close to unity.

Demand for gas is even more sensitive to price variation and also small increases can determine consistent decreases in natural gas demand. An increase of 1% of the price for gas leads to a demand decrease of 1.7%, the effect remains stable also for bigger variations:



an increase of 20% the model predict a reduction of 32% in gas demand.



In both cases the forecasting procedure seems to suggest there is room for policy maker to reduce energy consumption through price manipulation. If we consider the case of electricity the introduction of an hypothetical tax shifting the price of 20% (exactly as the level of VAT in Italy) this would determine a decrease in electricity consumption of about 19%. In the case of natural gas demand the result of a price intervention could be also higher if we think that a 20% increase in price determines a 32% decrease.

The second scenario analysed refers to climate changes and in particular variations in Heating Degree Days. The International Energy Agency has recently published the World Energy Oulook 2011 (IEA(2011)) in which different policy scenarios are investigated: in the base case primary energy demand will increase by one-third between 2010 and 2035, and CO_2 emissions will increase by 20% due to global warming (+3.5°C). From these data I perform my simulations permorming variations in HDD of 10% and 15%. Moreover if we think on how the HDD measure has been created[6] we can interpret variations in HDD as different habits in space heating, in fact higher HDDs represent the preference for higher inside temperature. The effects are visible on all the fuels considered and also on the

Expenditure category	Predicted Mean Expenditure (+15% in HDD)	Variation (%) (+15% in HDD)	Predicted Mean Expenditure (+10% in HDD)	Variation (%) (+10% in HDD)
Residual	1843.54	-3.57	1848.36	-3.33
Electricity	45.74	26.64	46.24	25.26
Natural Gas	81.11	60.35	78.19	54.17
Lpg	7.93	35.55	8.09	38.35
Oil	9.42	3.4	9.6	1.6
Wood	7.16	9.75	7.44	5.56
Gasoline	128.6	4.04	128.57	4.08
Diesel (for transportation)	23.86	-1.63	23.86	-1.59

residual category. In particular the demand for fuels used for space heating reacts sensibly. Natural gas is the most elastic with an increase of 54% in the case of 15% increase in HDD (an average increase of 2.7°C, in line withe the IEA forecasts for the period 2010-2035). Households reduces their expenditure in the residual category to save money for energy consumption suggesting the presence of substitution effects among expenditure categories.

8 Concluding remarks

The paper presents an application of the Multiple Discrete Continuous Model following the formulation of Bhat (2005).

Stability of the parameters over time has been studied estimating the model for the three cross sections in the dataset separately. The comparison of the confidence intervals at 95%

[6] The heating degree days are calculated as the difference between the in-house temperature, conventially 18°C, and the outdoor temperature. It's a proxy of how nuh we need to heat our house in terms of Celsius degree.

suggest that the estimates are not statistically different from each other with the unique ecxeption of geographical fixed effects.

The forecasting procedure of Pinjari and Bhat (2010) has been employed to evaluate electricity and natural gas price elasticities. The demand for electricity decreases of 0.56% for an increase in price of 1%. This measure seems to increase with bigger shifts in price: if price increase of 20% the demand decreases of 19%. Natural gas is more sensitive to price variations, an increase of 1% in its price causes a demand drop of 1.7%.

These results suggest to policy makers there is the possibility to reduce electricity and natural gas consumption manipulating prices (i.e. the introduction of a new tax).

Climate changes are investigated considering variations in Heating Degree Days, as we expected the model predict a redistribution of total expenditure towards the fuels used for space heating. For an increase of a 15% in HDD we would expect an increase of 27% and around 50% for natural gas. The residual category expenditure decreases to accommodate the increased demand for energy and a certain substitution among expenditure categories occurs.

Over the last decade the focus of economic analysis began to shift from forecasting future demand to limiting growth in demand through efficiency policies. Hence the need for models incorporating a detailed representation of consumer decisions in regard to appliance purchases and end-use consumption. From these consideration the need for future research to investigate the entire bundle of energy using services promoting a new methodological approach to the study of energy demand incorporating the appliance discrete decisions.

Annex 2.2

The forecasting procedure is based on the properties of the Khun-Tucker conditions presented in chapter two. Let's recall the Lagrangian function for the maximization problem:

$$L = \frac{1}{\alpha_1}\psi_1(\frac{e_1}{p_1})^{\alpha_1} + \sum_{m=2}^{M} \frac{\gamma_m}{\alpha_m}\psi_m \left\{ (\frac{e_{mj}}{\gamma_m p_m} + 1)^{\alpha_m} - 1 \right\} - \lambda(\sum_{m=1}^{M} e_m - E) \tag{23}$$

The f.o.c. for optimal expenditures are:

$$\begin{array}{ll} \frac{\psi_1}{p_1}(\frac{e_1^*}{p_1})^{\alpha_1 - 1} - \lambda = 0 & since \quad e_1^* > 0 \\ \frac{\psi_m}{p_m}(\frac{e_m^*}{\gamma_m p_m} + 1)^{\alpha_m - 1} - \lambda = 0 & since \quad e_k^* > 0 \\ \frac{\psi_m}{p_m}(\frac{e_m^*}{\gamma_m p_m} + 1)^{\alpha_m - 1} - \lambda < 0 & since \quad e_k^* = 0 \end{array} \tag{24}$$

The forecasting procedure is performed in 5 steps.

Step 1.

First of all assume that each individual consumes just the Hicksian good.

Step 2.

Given dataset and estimated parameters in MDCEV model, the price normalized utility values ($\frac{\psi_m}{p_m}$) for all alternatives as follow:

$$\begin{array}{lll} \frac{\psi_1}{p_1}(\frac{e_1^*}{p_1})^{\alpha_1 - 1} = \lambda & & \\ \frac{\psi_m}{p_m}(\frac{e_m^*}{\gamma_m p_m} + 1)^{\alpha_m - 1} = \lambda & if \quad e_k^* > 0 & forallchosengoods \\ \frac{\psi_m}{p_m} < \lambda & if \quad e_k^* = 0 & forallnotchosengoods \end{array} \tag{25}$$

Then rearrange the M alternative in a descending order of their price normalized utilities.

Step 3.

Compute λ:

$$\lambda = \frac{E + \sum_{k=2}^{M} p_k\gamma_k}{p_1(\frac{\psi_1}{p_1})^{\frac{1}{1-\alpha}} + \sum_{k=2}^{M} p_k\gamma_k(\frac{\psi_k}{p_k})^{\frac{1}{1-\alpha}}}^{\alpha - 1} \tag{26}$$

Step 4.

If $\lambda > \frac{\psi_{M+1}}{p_{M+1}}$ the optimal allocation of the first M alternatives are computed as follows:

$$\frac{e_1^*}{p_1} = \frac{(\frac{\psi_1}{p_1})^{\frac{1}{1-\alpha}}(E + \sum_{k=2}^M p_k\gamma_k)}{p_1(\frac{\psi_1}{p_1})^{\frac{1}{1-\alpha}} + \sum_{k=2}^M p_k\gamma_k(\frac{\psi_k}{p_k})^{\frac{1}{1-\alpha}}} \tag{27}$$

and

$$\frac{e_k^*}{p_k} = (\frac{(\frac{\psi_k}{p_k})^{\frac{1}{1-\alpha}}(E + \sum_{k=2}^M p_k\gamma_k)}{p_1(\frac{\psi_1}{p_1})^{\frac{1}{1-\alpha}} + \sum_{k=2}^M p_k\gamma_k(\frac{\psi_k}{p_k})^{\frac{1}{1-\alpha}}} - 1)\gamma_k \tag{28}$$

Step 5.

If $M = K$ compute the optimal allocation of step 4 and stop, else restart from step 3.

Annex 2.3

Table 4: MDCEV for 2003

	(I) Residual	(II) Electricity	(III) Natural Gas	(IV) Lpg	(V) Oil	(VI) Wood	(VII) Gasoline	(VIII) Diesel
Household's components	-	0.11***	-0.03***	0.02***	-0.08***	-1.01***	0.05***	0.13***
		(0.002)	(0.002)	(0.003)	(0.004)	(0.014)	(0.005)	(0.002)
Rooms	-	0.04***	0.012***	-0.05***	-0.37***	-1.09***	-	-
		(0.001)	(0.001)	(0.002)	(0.004)	(0.004)		
Renewal	-	0.06***	-0.048***	-0.13	-0.11***	0.5*	-	-
		(0.03)	(0.02)	(0.04)	(0.03)	(0.04)		
Number of cars	-	-	-	-	-	-	0.0191	0.15***
							(0.003)	(0.05)
Centralized H.S.	-	-0.04***	-0.16***	0.41***	-0.18***	-0.1***		
		(0.01)	(0.05)	(0.009)	(0.04)	(0.03)		
North-Est	-	0.05***	-0.01***	0.25***	-1.05***	-0.26***	0.01	0.02*
		(0.001)	(0.006)	(0.011)	(0.113)	(0.015)	(0.018)	(0.006)
Center	-	0.08***	-0.038***	-1.08***	-0.158***	0.01	-0.012	0.0*
		(0.001)	(0.006)	(0.012)	(0.124)	(0.016)	(0.018)	(0.006)
South	-	0.09***	-0.093***	0.02*	-0.05	0.024***	0.02*	0.013***
		(0.001)	(0.008)	(0.014)	(0.108)	(0.025)	(0.022)	(0.008)
Islands	-	0.18***	-0.025***	0.06*	-0.21***	0.29***	0.03*	-0.1***
		(0.01)	(0.020)	(0.017)	(0.04)	(0.072)	(0.012)	(0.021)
HDD (Heating Degree Days)	-	0.0022*	0.01***	0.01	-0.39***	0.02*	-	-
		(0.003)	(0.001)	(0.001)	(0.002)	(0.003)		
CDD (Cooling Degree Days)	-	0.01***	0.02***	-0.06***	-0.07***	-0.009*	-	-
		(0.001)	(0.003)	(0.006)	(0.006)	(0.008)		
Detached House	-	-0.1***	-0.033	0.01***	0.03***	0.02**	0.018***	-0.01
		(0.010)	(0.014)	(0.018)	(0.047)	(0.026)	(0.03)	(0.016)
Popular house	-	-0.14***	-0.0006	0.01*	-0.03***	0.07***	0.017***	0.037**
		(0.008)	(0.08)	(0.014)	(0.03)	(0.019)	(0.01)	(0.008)
Rural house	-	-0.007***	-0.04***	0.04***	-0.011***	0.15***	0.019***	0.074***
		(0.002)	(0.015)	(0.017)	(0.066)	(0.029)	(0.026)	(0.013)
Group of Houses	-	0.07***	0.01***	-0.02*	-0.14***	0.05***	0.01*	0.093***
		(0.01)	(0.007)	(0.006)	(0.04)	(0.015)	(0.015)	(0.006)
Campaign	-	0.1***	-0.07	0.12***	0.03***	0.02***	0.03***	0.1514***
		(0.01)	(0.011)	(0.011)	(0.066)	(0.019)	(0.017)	(0.009)
Constant	-	-1.24***	-5.23***	-2.13***	-2.92***	-2.567***	-1.02***	-2.39
		(0.04)	(0.04)	(0.07)	(0.12)	(0.12)	(0.05)	(0.08)
$\gamma_{residual}$	-	-	-	-	-	-	-	-
γ_{elec}	-	2.42***	-	-	-	-	-	-
		(0.03)						
γ_{gas}	-	-	4.6***	-	-	-	-	-
			(0.01)					
γ_{lpg}	-	-	-	4.15***	-	-	-	-
				(0.02)				
γ_{oil}	-	-	-	-	6.07***	-	-	-
					(0.04)			
γ_{wood}	-	-	-	-	-	5.65***	-	-
						(0.03)		
$\gamma_{gasoline}$	-	-	-	-	-	-	5.73***	-
							(0.02)	
γ_{diesel}	-	-	-	-	-	-	-	6.09***
								(0.02)
σ	-	-	-	-	-	-	-	0.29***
								(0.002)

Standard errors in parenthesis, $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$.

Table 5: MDCEV for 2004

	(I) Residual	(II) Electricity	(III) Natural Gas	(IV) Lpg	(V) Oil	(VI) Wood	(VII) Gasoline	(VIII) Diesel
Household's components	-	0.11***	-0.02***	0.01***	-0.12***	-0.95***	0.06***	0.07***
		(0.002)	(0.002)	(0.003)	(0.004)	(0.005)	(0.005)	(0.002)
Rooms	-	0.05***	0.04***	0.02*	0.049***	-1.07***	-	-
		(0.001)	(0.001)	(0.002)	(0.004)	(0.004)		
Renewal	-	0.03***	-0.43***	-0.015***	0.18***	0.255***	-	-
		(0.02)	(0.02)	(0.04)	(0.059)	(0.04)		
Number of cars	-	-	-	-	-	-	-0.11***	-0.8***
							(0.003)	(0.05)
Centralized H.S.	-	-0.02***	-0.16***	0.034***	-0.04*	-0.358***	-	-
		(0.005)	(0.05)	(0.009)	(0.018)	(0.022)		
North-Est	-	-0.02*	-0.06***	2.17***	-1.09***	-0.33***	0.07***	0.13***
		(0.006)	(0.006)	(0.011)	(0.113)	(0.015)	(0.018)	(0.006)
Center	-	0.07***	-0.26***	-1.08***	-0.2***	0.27***	-0.001	0.05***
		(0.006)	(0.006)	(0.012)	(0.124)	(0.016)	(0.018)	(0.006)
South	-	0.11***	-0.94***	-0.08***	0.13***	0.016***	0.02**	0.06***
		(0.008)	(0.008)	(0.014)	(0.108)	(0.025)	(0.022)	(0.008)
Islands	-	0.24***	-0.19***	0.03***	0.17***	-0.847***	-0.01	0.08***
		(0.013)	(0.020)	(0.017)	(0.04)	(0.072)	(0.012)	(0.021)
HDD (Heating Degree Days)	-	0.0015**	0.001***	0.01***	-0.21***	0.02*	-	-
		(0.003)	(0.001)	(0.001)	(0.002)	(0.003)		
CDD (Cooling Degree Days)	-	-0.01**	0.02	-0.01	-0.09 ***	0.04*	-	-
		(0.001)	(0.003)	(0.006)	(0.006)	(0.008)		
Detached House	-	-0.06***	-0.026	0.01***	0.01***	-0.03***	0.13	-0.01
		(0.010)	(0.014)	(0.018)	(0.047)	(0.026)	(0.03)	(0.016)
Popular house	-	-0.13***	0.0036***	0.02**	0.03***	0.0028	0.09***	0.037**
		(0.008)	(0.08)	(0.014)	(0.03)	(0.019)	(0.021)	(0.008)
Rural house	-	-0.06***	-0.03***	0.04***	-0.033*	0.111***	0.014***	0.074***
		(0.012)	(0.015)	(0.017)	(0.066)	(0.029)	(0.026)	(0.013)
Group of Houses	-	0.065***	0.05***	-0.02*	-0.07*	0.18***	0.02***	0.13***
		(0.06)	(0.007)	(0.006)	(0.066)	(0.015)	(0.015)	(0.006)
Campaign	-	0.05***	0.01***	0.19***	0.03*	0.02***	0.03***	0.06***
		(0.08)	(0.011)	(0.011)	(0.066)	(0.019)	(0.017)	(0.009)
Constant	-	-1.24***	-5.28***	-2.21***	-2.50***	-2.73***	-0.75***	-2.33
		(0.03)	(0.03)	(0.04)	(0.08)	(0.08)	(0.03)	(0.05)
$\gamma_{residual}$	-	-	-	-	-	-	-	-
γ_{elec}	-	2.46***	-	-	-	-	-	-
		(0.029)						
γ_{gas}	-	-	4.68***	-	-	-	-	-
			(0.009)					
γ_{lpg}	-	-	-	4.25***	-	-	-	-
				(0.013)				
γ_{oil}	-	-	-	-	6.21***	-	-	-
					(0.022)			
γ_{wood}	-	-	-	-	-	5.71***	-	-
						(0.021)		
$\gamma_{gasoline}$	-	-	-	-	-	-	5.83***	-
							(0.009)	
γ_{diesel}	-	-	-	-	-	-	-	6.14***
								(0.014)
σ	-	-	-	-	-	-	-	0.27***
								(0.002)

Standard errors in parenthesis, $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$.

Table 6: MDCEV for 2005

	(I) Residual	(II) Electricity	(III) Natural Gas	(IV) Lpg	(V) Oil	(VI) Wood	(VII) Gasoline	(VIII) Diesel
Household's components	-	0.095***	-0.012***	0.046***	-0.017***	-0.46***	0.03***	0.15***
		(0.002)	(0.002)	(0.003)	(0.004)	(0.005)	(0.005)	(0.002)
Rooms	-	0.04***	0.013***	-0.034***	-0.042***	-0.098***	-	-
		(0.001)	(0.001)	(0.002)	(0.004)	(0.004)		
Renewal	-	0.018***	-0.38***	-0.02	0.059**	0.218***	-	-
		(0.02)	(0.02)	(0.04)	(0.059)	(0.04)		
Number of cars	-	-	-	-	-	-	-0.20***	0.15***
							(0.003)	(0.05)
Centralized H.S.	-	-0.038***	-0.12***	0.42***	0.058***	0.105***	-	-
		(0.005)	(0.05)	(0.009)	(0.018)	(0.022)		
North-Est	-	0.031***	-0.15***	0.23***	-0.028**	-0.277***	0.038***	-0.018***
		(0.006)	(0.006)	(0.011)	(0.113)	(0.015)	(0.018)	(0.006)
Center	-	0.0933***	-0.42***	-1.07***	-0.158***	0.164***	0.011**	0.026***
		(0.006)	(0.006)	(0.012)	(0.124)	(0.016)	(0.018)	(0.006)
South	-	0.119***	-0.94***	-0.06***	-0.211***	0.162*	0.057***	0.024***
		(0.008)	(0.008)	(0.014)	(0.108)	(0.025)	(0.022)	(0.008)
Islands	-	0.24***	-0.21***	-0.02***	-0.563***	0.315***	0.032***	0.11***
		(0.013)	(0.020)	(0.017)	(0.04)	(0.072)	(0.012)	(0.021)
HDD (Heating Degree Days)	-	0.0009*	0.016***	-0.07***	-0.364***	-0.046***	-	-
		(0.003)	(0.001)	(0.001)	(0.002)	(0.003)		
CDD (Cooling Degree Days)	-	-0.01	0.001	-0.018*	-0.023	-0.036*	-	-
		(0.001)	(0.003)	(0.006)	(0.006)	(0.008)		
Detached House	-	-0.03***	-0.31*	0.008***	-0.083***	-0.0027***	0.066	-0.01
		(0.010)	(0.014)	(0.018)	(0.047)	(0.026)	(0.03)	(0.016)
Popular house	-	-0.08***	-0.002***	0.012*	-0.059***	-0.0039	-0.07***	0.037**
		(0.008)	(0.08)	(0.014)	(0.03)	(0.019)	(0.021)	(0.008)
Rural house	-	-0.065***	-0.37***	0.038***	-0.033***	- 0.14***	0.069***	0.074***
		(0.015)	(0.017)	(0.066)	(0.029)	(0.026)	(0.013)	(0.019)
Group of Houses	-	0.04***	-0.014***	0.04***	0.212***	0.053***	0.028***	0.093***
		(0.06)	(0.007)	(0.006)	(0.066)	(0.015)	(0.015)	(0.006)
Campaign	-	0.11***	-0.04***	0.15***	0.242***	0.022***	0.03***	0.1514***
		(0.08)	(0.011)	(0.011)	(0.066)	(0.019)	(0.017)	(0.009)
Constant	-	-1.205***	-5.003***	-2.22***	-3.27***	-3.44***	-0.54***	-1.945
		(0.03)	(0.03)	(0.04)	(0.08)	(0.08)	(0.03)	(0.05)
$\gamma_{residual}$	-	-	-	-	-	-	-	-
γ_{elec}	-	1.746***	-	-	-	-	-	-
		(0.029)						
γ_{gas}	-	-	4.45***	-	-	-	-	-
			(0.009)					
γ_{lpg}	-	-	-	4.019***	-	-	-	-
				(0.013)				
γ_{oil}	-	-	-	-	5.974***	-	-	-
					(0.022)			
γ_{wood}	-	-	-	-	-	5.533***	-	-
						(0.021)		
$\gamma_{gasoline}$	-	-	-	-	-	-	5.602***	-
							(0.009)	
γ_{diesel}	-	-	-	-	-	-	-	5.986***
								(0.014)
σ	-	-	-	-	-	-	-	0.325***
								(0.002)

Standard errors in parenthesis, $***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.1$.

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