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THE DEMAND FOR ENERGY OF ITALIAN HOUSEHOLDS

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Abstract

This paper studies the impact of demographic shifts, energy prices and climate factors on Italian households' energy budget. The pattern of energy expenditure of Italian households is studied using the Italian Household Budget Survey. The expenditure for heating, private transport and electricity are jointly modelled and the relevant parameters are simulated under different scenarios. According to this exercise, the ageing of the Italian population - coupled with the increase in energy prices and surface temperature - could reduce the share of energy-related expenditure by about 2 percentage points in the next few decades and increase its polarization. Energy policies should take into consideration households' characteristics and behaviour, and in turn the impact of this heterogeneity on the demand for energy.

JEL Classification: D11, J11, Q41, Q47, Q54.
Keywords: household energy demand, demographics, climate change.

Contents

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The flow of energy should be the primary concern of Economics.
Frederick Soddy, 1933.

1 Introduction

Energy is a fundamental input for everyday consumer activities. Energy services include heating and cooling, cooking, lighting, food conservation and the possibility to use many different kinds of electrical appliances: from washing machines and dishwashers to computers and video equipment. Also private transportation, dominated by cars, makes heavy use of energy and is a culprit for greenhouse gas emission.

According to Eurostat, Italian households use about 20 per cent of the energy available for final use in the country - excluding private transportation - 0.472 tons of oil equivalent (toe) per individual.[1] This compares with 0.615 toe in the EU27 and 0.837 in the US. Italy exhibits - together with Japan - one of the lowest energy intensities (i.e. quantity of energy per unit of output) in the world and this is also the reflection of household behaviour.

A number of factors will influence household energy demand in the near future. In this paper I examine the impact of three of them: demographic structure, energy prices and climate change. A fourth set of issues, those relating to innovation and energy efficiency, is not considered due to a lack of available information (some contributions on the topic can be found in Kratena et al., 2008).

The contribution of this paper is twofold. First it gathers information for the last decade (1997-2008) from multiple sources: energy expenditure of Italian households at micro level - from the Household Budget Survey (HBS); data on monthly and semi-annual energy prices for different energy goods (electricity, gas, gasoline and gasoil); monthly information on average surface temperatures in Italy. This information is then used to estimate an energy demand equation simultaneously modelling the shares of household expenditure for heating, electricity and liquid fuels for private transport.

[1] Final energy means the energy received by consumers and businesses. It does not include the energy losses due to conversion and distribution. The toe corresponds to the amount of energy released by burning one tonne of crude oil - approximately 42 billion joules (Gj).

Finally, by simulating different patterns in demographic structures and using scenarios on changes in energy prices and temperatures, the paper provides insights on the evolution of energy-related expenditure in the next few decades.

The structure of the paper is the following. Section 2 enumerates the main drivers of household energy demand. In Section 3 energy expenditure estimates based on HBS microdata are presented. In Section 4 a model for energy demand is introduced and estimated using a quadratic version of an Almost Ideal Demand System (AIDS) model (Deaton and Muellbauer 1980). In Section 5 the model is simulated allowing for different developments in the demographic structure, energy prices and surface temperatures. Section 6 draws the main conclusions and sets the future research agenda.

2 Structural factors affecting household energy use

Household final energy consumption amounted in 2008 to almost 47 million toe, a third of the total energy use in Italy (Figure 1).[2] Overall the energy use of Italian households increased at an average yearly rate of 1.3 per cent from the 1970s. Energy demand dropped significantly during the oil shocks, the 1993-1994 recession and after 2005. This decline can be ascribed to the reduction in gas consumption due to milder winter temperatures (between 2005 and 2008 the Heating Degrees Day - the number of degrees that a day's average temperature is below 18 °C - decreased in Italy by 14 per cent) and a weak demand for liquid fuels determined by buoyant oil markets (between 2002 and 2008 prices increased by more than 30 per cent for gasoline and almost 60 per cent for gasoil) (Figure 2). Household energy demand has been

[2] In the Italian Energy Balance, compiled yearly by the Minister of the Economic Development, Households and Services are grouped together including all uses of electricity and fuels for space and water heating by households, but excluding the consumption of liquid fuels for private transport. Combining the official data on Italian Energy Balance - available since 1971 - and data from Eurostat - available since 1990 - it is possible to estimate the energy use of the household sector. The share of final energy consumption of households on the Households and Services item is applied to 1971-1989 data. To include the energy used by households for private transport, I use data on motor vehicles gasoline and gasoil consumption, transformed in toe using the appropriate net calorific values, assuming that 90 per cent of the demand arises from households. Data on gasoline and gasoil consumption are taken from Unione Petrolifera (UP) and the Italian Automobile Club (ACI).

increasingly satisfied with natural gas, which has progressively substituted the use of liquid fuels for heating needs. Gas use increased during the 1980s and 90s at an average rate of 5 per cent (when the price of oil stagnated) and then its growth rate stabilized during the first decade of 2000 at around 1 per cent.

The recent EU energy and climate initiatives are going to affect Italian household energy use in the years to come. The development of carbon markets with a full-auctioning of emission permits from 2012 might lead to an increase in energy prices if ambitious carbon reduction targets are set. This will add upward pressure on prices, which are estimated to increase also because the relative scarcity of "cheap" fossil fuels - in terms of costs of extraction - , a source of energy that accounts for more than 80 per cent of the Italian energy basket. In 2030, according to the International Energy Agency (IEA) estimates, oil will cost 120 USD per barrel (in 2007 dolars) - twice the value registered in 2007 - and a record level for the energy markets (IEA 2008).

Technological innovation, induced by the signal of carbon pricing or by higher energy efficiency standards, will improve the efficiency of households' capital stock. In 2006 the EU Commission Action Plan on Energy Efficiency launched a number of measures to improve the energy performance of products, buildings and services and in 2008 it proposed reinforcing existing efficiency standards on buildings and energy-using products as part of the Second Strategic Energy Review package. In the transport sector, from 2015 all vehicles marketed in the EU should emit no more than 130 g/km of carbon dioxide, and this implies a consumption of 5.4 l/100km for gasoline engines and 4.9 l/100km for diesel engines, compared with 7.7 l/100km and 6.5 l/100km, respectively, registered in 2005 (ENEA 2007).

Changes in population structure can alter the demand for energy. The Italian population, with one of the highest life expectancies in the world, is ageing. According to the Italian Statistical Office (Istat), in 2020 24 per cent of the population will be aged 64+ (in 2030 more than 28 per cent). This can influence energy demand in two opposite directions: elderly people spend more time at home, and this increases the demand for heating and electricity; on the other hand, older people uses less energy for private transport.

Another demographic trend is the progressive reduction of Italian households size. Since the 1980s the number of households have been increasing at a faster rate than the population: it changed from 17.3 million in 1977 to 23.6 million in 2007. Using projections on the population and a simple extrapolation of the time trend of household size, the number of Italian households may exceed 30 million between 2020 and 2030.[3] The lower economies of scale would imply an increasing demand for heating services and electricity.

Finally, climate change will affect the demand for energy, reducing the request for heating services, but increasing the energy needs for cooling. According to the environmental agency of the Italian Government, in the last half-century the average surface temperature in Italy has increased by almost 1°C and the number of "tropical nights" (at least >20°C) rose by 50 per cent (APAT 2006). More recently, an Istat report showed that the surface temperatures in the last decade (2000-2009) were 0.8°C higher than in the period 1971-2000 (ISTAT 2010).

3 Italian Households' energy expenditure

According to Unione Petrolifera (UP), in 2008 the national energy bill sky-rocketed reaching almost 60 billion euros (it was 47 billion in 2007), 3.8 per cent of GDP and 6.5 per cent of household expenditure (UP 2009). Between 2007 and 2008, the cost of imported oil increased by roughly 40 per cent[4] while the demand of oil products decreased by 4 per cent, in particular because of the shrinking demand for liquid fuels by the transport sector. Because oil products are heavily taxed (e.g. taxes account for roughly 65 per cent of liquid fuels consumer price) it is not clear how much households actually pay for energy services.

The impact of energy use on Italian households' bills can be analysed using the Household Budget Survey (HBS), run yearly by Istat. The HBS collects information on a very detailed basis for about 24,000 households interviewed in different periods of the survey year (roughly 2,000 households are interviewed each month). HBS data collection is very precise and it involves a combination of personal interviews with diaries or logs maintained by households on a weekly basis. Households' expenditure on goods and services include indirect taxes (VAT and excise duties).[5]

[3] Household size is estimated using the Bank of Italy Survey on Household Income and Wealth (SHIW) while population figures are derived from the Istat website demo.istat.it.

[4] The average CIF price of imported oil amounted to €70.2 per barrel in 2007 and increased to €96.8 in 2008 (dgerm.sviluppoeconomico.gov.it/dgerm/costogreggio.asp).

[5] In the present study HBS data are examined starting from 1997. In fact, although

Let us define energy expenditure for household i as all the resources households earmark for electricity (${C^e}_i$), heating (${C^h}_i$) and private transport (${C^t}_i$).[6] An estimate of the share of energy expenditure on total expenditure C_i can be derived using the mean estimator:

$$w_E = \sum_i^n \frac{d_i}{\sum_i^n d_i} \frac{{C^e}_i + {C^h}_i + {C^t}_i}{C_i}. \tag{1}$$

where d_i are the survey weights of household i.

According to estimator (1), the average household spends around 11 per cent of total expenditure on energy, a fraction roughly constant in the period 1997-2007 but which reached almost 12 per cent in 2008, an increase statistically different from zero (Figure 3).[7]

Energy shares increase with the size of the household and of the principal residence. Shares of single-person households and those living in small dwellings have increased in the last ten years. They are lower for the households located at the top of the equivalent expenditure distribution (7.9 per cent) and they reach a maximum for the poorest households (about 13 per cent).[8] Over the last 10 years the energy shares of the households located in the tails of the expenditure distribution have increased by 1 percentage point (pp), while that of the median household increased by 0.3 pp (Table A.2).

In 2008, the households with the highest energy shares are those with a reference person (RP) under 65 years, self-employed, with a secondary school education or residing in the South and Islands; in the last decade the households living in Southern Italy experienced an increase of 1.3 pp, driven by the demand for cooling: electricity shares increased by 0.5 pp against the 0.3 pp increase for heating (Table A.3 and A.5).

Transport (gasoline and gasoil) represents half of the energy expenditure, followed by heating (30 per cent) and electricity (17 per cent). Households located in the middle of the equivalent expenditure distribution, headed by

HBS microdata are available since 1990, only those from 1997 are fully comparable because a major restructuring of the survey took place in 1995.

[6]The detailed items considered in the computation of these aggregates are reported in Table A.1.

[7]As a term of comparison, energy-related expenditure is about half of food expenditure and amounts to the combined expenditure for clothing and footwear and recreation and culture.

[8]Equivalent expenditure is computed as the ratio of household total expenditure to the square root of household size.

a RP aged 50 or less or residing in the South show a higher than average share of private transport expenditure (Table A.4). Heating and electricity shares are higher for poorer households, headed by an elderly RP. Compared with the national average, households residing in the South earmark a higher share of their expenditure for electricity and for private transport.

With the exception of electricity, energy expenditure is more unequally distributed than total expenditure (Table 1). Heating and transport shares are more dispersed. The Gini index of energy expenditure decreased slightly from 0.383 in 1997 to 0.376 in 2008. Both heating and electricity expenditure contributed to this reduction while the degree of inequality of transport-related expenditure increased, probably due to the rise in the share of households with zero expenditure (25.7 per cent in 1997 against 28.7 in 2008) due to the ageing of the Italian population.[9]

Table 1. Distribution of energy-related expenditure

	Expenditure	**Total Energy**		**Heating**		**Transport**		**Electricity**	
	Gini	Gini	Share	Gini	Share	Gini	Share	Gini	Share
1997	0.356	0.383	11.0%	0.561	3.7%	0.504	5.3%	0.414	2.0%
2002	0.352	0.379	11.1%	0.552	3.7%	0.517	5.3%	0.370	2.1%
2007	0.340	0.375	10.9%	0.542	3.4%	0.520	5.3%	0.331	2.2%
2008	0.334	0.376	11.7%	0.537	3.8%	0.521	5.6%	0.333	2.4%

Source: Based on HBS data.

4 A model for energy demand

In order to study the relation between energy use and households characteristics in more depth, I propose a model to estimate the determinants of households' energy expenditure.

Let's define the share of energy expenditure w_{ij}^E as the share of expenditure devoted by households i to pay for the fuel j (where $j = 1$ is natural gas or gasoil for heating, $j = 2$ electricity and $j = 3$ gasoline and gasoil for private transport). For the $i-th$ household the share of energy expenditure is $w_i^E = \sum_j^J w_{ij}^E$

[9]There is a strong negative association between the age of the RP and the use of private transport: in the HBS, the probability of a household owning a car decreases by 20 per cent if the RP is 65 or older.

For each $i - th$ household this share can be represented as a function of a set of variables (time subscripts are omitted for clarity):

$$w_{ij}^{E} = f(\mathbf{P}, \mathbf{Z_i}, \mathbf{B_i}, \mathbf{T}) \tag{2}$$

where $\mathbf{P}$ is a vector of prices, $\mathbf{Z_i}$ a set of characteristics of the $i-th$ household, $\mathbf{B_i}$ consumer preferences and $\mathbf{T}$ some exogenous variables related to climatic conditions.

Prices ($\mathbf{P}$): in the short term, energy demand is rather inelastic with a low degree of substitution, while in the medium term, the rise of energy prices induces households to invest in energy-efficient appliances (or switch to less expensive fuels). The efficiency gain might be crowded out by an increase in energy demand - a phenomenon known in the literature as the *rebound effect*. In other words, the increased energy efficiency is more than compensated by an increase in the frequency of use or in the number of energy consuming goods (Kratena, Meyer, and Wuger 2008).

Demographics ($\mathbf{Z_i}$): descriptive analysis has shown that demand for energy services is different across households. Energy demand increases with the number of household members and with the presence of pre-school children and elderly people who spend more time at home. Households where members commute using private transport, demand more energy and those living in small towns have fewer options as regards public transport services; households located in southern regions use private transport more intensely for this reason (ISTAT 2009).

Consumer behaviour ($\mathbf{B_i}$): energy demand is also different according to individual preferences. Some consumers are more environmentally aware and buy more efficient appliances or "green" products. Principal-residence owners have more incentives to renovate their dwellings in order to increase the energy efficiency of their homes. Furthermore, because energy is a complementary input of the consumer utility function, households with a large number of electrical appliances use more energy.[10]

Climatic conditions ($\mathbf{T}$): the use of energy is also affected by the change in surface temperature. The increase in temperature reduces heating demand

[10]For this reason, some scholars chooses to model the demand for energy services instead of the demand for energy (Kratena, Meyer, and Wuger 2008). Although this approach has the advantage of explicitly taking into account the role of energy efficiency, it requires the specification of a number of key parameters, such as the energy efficiency and the lifespan of different categories of appliances, information that is often not available or is of poor quality.

but increases the request for cooling and this primarily affects households residing in Southern Italy. The increasing importance of this factor is witnessed by the fact that in 2006 the peak demand for electricity was registered - for the first time in Italy - during the summer (Zorzoli 2008).

I estimate a model for three categories of energy demand (j=1,2,3: heating, transport and electricity). Following Banks et al (1997) I choose a quasi-quadratic Almost Ideal Demand System (QAIDS) as a functional form, a modification of the AIDS (Deaton and Muellbauer, 1980). Using this strategy the model allows for different elasticities throughout the expenditure distribution.

The specification of the j-th energy expenditure share for the i-th household is the following:

$$w_{ij}^E = a_j + \sum_j b_j log\left(\frac{P_j}{P*}\right) + c_j log\left(\frac{C_i}{P*}\right) + d_j log\left(\frac{C_i}{P*}\right)^2 + f_j t + \mathbf{e_j D_i^T} + \epsilon_{\mathbf{ij}} \quad (3)$$

Where a_j is the share "subsistence level", P_j is the price of the j-th energy good, C_i is the total household expenditure, $P*$ the price level, t is a measure of the monthly national surface temperatures[11] and $\mathbf{D_i^T}$ is a vector of dummy variables that describes the characteristics of the $i-th$ households (it modifies the value of the subsistence level).

HBS data are integrated with information on energy prices - at monthly or semi-annual level. For the demand for heating I use Eurostat half-yearly gas prices (euro cents per cubic meter tax included) for a household consuming 83.7 Gj (2 toe or 2,000 cubic meters) per year.[12] For electricity I use half-yearly prices from Eurostat (euro per kWh for a household consuming 3,500 kWh per year). For transport demand I use the average of the gasoil and gasoline monthly quotation (dgerm.sviluppoeconomico.gov.it).

The dataset also contains climatic data using the information on the monthly level of surface temperatures - at national level - elaborated by the National Oceanic and Atmospheric Administration (NOAA).[13]

[11]Ideally, temperatures should be modelled at a more disaggregated level (at least at the nuts1 level) but at the moment this level of detail is not available for Italy.

[12]According to HBS data, in 1997-2007, 70-80 per cent of households used gas for heating. Data are available from 2002. Data for 1997-2001 are estimated using electricity, Brent quotations and seasonal dummies as covariates.

[13]www.cdc.noaa.gov/data/timeseries. Data on surface air temperature (°C). Latitude range: 42.5 to 37.5; longitude range: 7.5 to 15.0.

In order to control for the possibility of structural shifts in the correlation between shares and prices, equation (3) is estimated - using the SURE technique - separately for two periods of “low” and “high” energy prices, respectively 1997-2004 (with an average real oil price of 26.7 EUR/bbl) and 2005-2007 (with an average real oil price of 62.4 EUR/bbl). Tables A.6 and A.8 reports the estimates of the parameters grouped according to RP and household characteristics; its position in the expenditure distribution and the size of its principal residence; its geographical location; the average surface temperature; and the price of the energy service.

The shares of expenditure for heating and private transport increase non-linearly with total expenditure; the opposite is true for electricity. The effect of prices on the shares is negative for heating and positive for private transport. For electricity the effect is negative for the 1997-2004 period and positive for the 2005-2007 subsample, possibly indicating a regime switch linked to the liberalizations of the electricity market.[14] The ownership of air conditioning is, as expected, positively correlated with the demand for electricity.[15] The effect of cross prices is significantly different from zero only for heating and this is related to the high correlation between electricity and gas prices (in Italy about 55 per cent of gross electricity production uses gas).

- Heating shares are greater for older RP and increases with the presence of dependants - children (aged under 6 years) and elderly people (75+) more prone to spend time at home - and with the size of the principal residence; they are also higher for households in the middle range of the expenditure distribution and residing in the northern part of the country. Households with a highly educated RP spend less on heating services. The increased average surface temperature, together with increasing energy prices, reduces the share of expenditure for heating.

- Electricity shares shows a pattern very similar to heating. Furthermore the self-employed, who are more likely to work at home, spend more on electricity. This is true also for Southern households (probably with higher demand for cooling) and for the poorest households.

[14] In Italy the wholesale electricity market has been liberalized since 2004; consumers have been free to choose their supplier from 2007.

[15] In the decade 1997-2007, the share of households with air conditioning increased almost fivefold.

- Climate change has a negative - although negligible - effect on electricity shares (not consistent with the increasing demand for cooling due to higher surface temperatures), that are in turn positively correlated with household size.

Shares on transport-related expenditure exhibit a rather different pattern that can also be related to the higher number of households with zero expenditure (more than a quarter against 6.7 for heating and 0 for electricity).

- Those headed by a young RP, who is employed - especially if self-employed - and the poorest households earmark a higher share of expenditure for private transport and this is also true for households living in the South and in bigger dwellings (perhaps because this variable, along with the number of durables, is a proxy for household wealth) and for larger households.

- The presence of dependants decreases the shares for private transport, which is also lower for households located in the upper part of the expenditure distribution.

4.1 Robustness check

Using SURE to estimate the shares in energy expenditure has the advantage of reproducing consumer behaviour more accurately: it is reasonable to assume that the decision concerning the purchase of a given energy service is related to all the other expenses. SURE deals satisfactorily with this simultaneous planning but the resulting estimator can suffer from two possible weaknesses.

A first concern regards the sensitivity of the results. For this reason I estimate the same model for the period of "high price" over different sub-samples determined by two geographical areas (North and South) and two age classes (RP aged below 64, RP aged 64+). The parameters estimated in the full sample (and their statistical significance) appear fairly stable both across different macroareas and the two age classes considered.

A second problem arises from the high number of structural zeros in the transport shares. Estimates using a tobit model to deal with this left-censoring, substantially confirms the result of the SURE regression: all the coefficients exhibit the same sign and only a few covariates are not different from zero (those regarding the RP's job status and those regarding the size of the household and of the dwellings).

These results substantially support the stability of the SURE estimator that will therefore be used to assess households' energy demand in the next years.[16]

5 Households' energy demand in the coming decades

The results of the previous section can help in studying the evolution of Italian households' future energy demand. Forecasting is always a daunting task and energy demand is no exception.[17] Using the econometric relations previously estimated it is possible to evaluate how demographic changes, energy prices and surface temperatures might affect households' energy expenditure.

The simulation strategy follows Labandeira et al. (2004). The system of equations estimated for the 2005-2007 period is fitted on the 2007 sample.[18]

In order to simulate scenarios for 2020 and 2030, the 2007 sample is modified as follows.

1. Survey weights are calibrated to incorporate ISTAT projection on the distribution by sex and age of the Italian population and the number of Italian households obtained projecting the trend in household size estimated using 1977-2008 microdata of the Bank of Italy Survey on Household Income and Wealth.[19]

2. Gas, electricity and liquid fuel prices are increased according to the projections reported in the 2008 World Energy Outlook (IEA 2008).

3. Surface temperature is modified using the rate of change forecast by OECD (Burniaux et al., 2008).

[16]The details of these alternative estimates are not reported for the sake of brevity but are available from the author upon request.

[17]A scholar attending an OECD meeting postulated that *Energy forecasts are not worth even the cost of the cheapest acid paper on which they get printed* (Smil 2006).

[18]Because the explained variance is limited - in a range of 15 to 30 per cent of total variance - the residuals of the model are added to the fitted values as an observable fixed effect.

[19]Survey weights are calibrated to match the sample marginal distributions with known values using the raking ratio technique (Kalton and Flores Cervantes 2003).

4. Household expenditure, a predictor in the system of equations, is increased in real terms using 40 per cent of the projected real GDP growth (for the EU) according to the projections reported in the 2008 World Energy Outlook (IEA 2008).

Table A.9 reports the main results of the simulation. In the A-scenario the energy-related shares of total expenditure are simulated changing demographics, energy prices and surface temperatures. In the B and C scenarios, changes in demographics or in prices and climate are alternatively excluded.

Under the A-scenario, energy-related shares decrease - in comparison with 2007 - by 1.8 percentage points (pp) in 2020 and by 2.2 pp in 2030. The reduction is largely driven by prices and climate dynamics (under scenario C shares are reduced by 0.1-0.2 pp if compared to 2007). In 2030, simulated electricity shares slightly increase (+0.2 pp), transport shares decrease (-0.5 pp) while there is a major reduction in the share of heating (-1.9 pp) (Table A.10).

The reduction in transport shares is largely driven by demographics: under the C-scenario, in 2030 35 per cent of Italian households exhibits zero expenditure for private transport (+6 pp in comparison with 2007).

Simulated energy expenditure is higher for larger households, those residing in the South, with a younger or working RP and for households located in the bottom part of the expenditure distribution.

The effects of prices and climate change have a different influence on energy expenditure (Table A.10). The increase in surface temperatures reduces the demand for heating and apparently counterbalances the higher demand for electricity induced by the demand for cooling (a phenomenon probably more pronounced in the northern part of the country).

The distribution of the shares in 2020 and 2030 becomes more unequal: the Gini index (0.314 in 2007) increases to 0.358 in 2030. Demographic trends give a small contribution towards increasing the inequality in the distribution of the energy-related expenditure (Figure 4 and Table A.9).

In conclusion, only if the projections regarding future trends regarding climate and energy prices prove wrong or unless a major structural shift in households' behaviour takes place, the ageing of the Italian population coupled with climate change and rising energy prices are going to exercise downward pressure on energy expenditure per unit of consumption, increasing the dispersion of energy expenditure.

Improvements in energy efficiency, not considered in the present analysis, should reinforce these findings: while there are good chances of significantly reducing the energy losses for heating (insulation of buildings) and electricity (low consumption electrical appliances, “intelligent” stand-by and lighting systems), any improvement in car combustion engines is going to be marginal, due to the fact that, in Italy, cars already have a high level of energy efficiency (Fig. 5).

6 Conclusions

This paper explores households’ energy bills using micro data. The purpose of the study was twofold. An evaluation of the importance of three different energy services (heating, transport and electricity) on the household budget. The details available in the HBS allow us to analyse how these energy shares are associated with households’ socio-economic traits. The modelling of these shares and the model-projections can be analysed to appraise the impact of different scenarios for demographic shifts, prices and climate change in the decades to come.

The reduction in demand for energy, linked to improvements in energy efficiency, will be reinforced by the ageing of the population and by higher energy prices. The latter will be determined by the increasing cost of fossil fuels, carbon pricing and the incentives that energy users will pay to support renewable energy deployment. The expected trend in surface temperatures will increase the demand for cooling and decrease that for heating.

According to the result of the simulation, prices, climatic and demographic factors will decrease energy demand in particular thanks to a reduction in heating and transport, while the share of expenditure on electricity will increase slightly.

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APPENDIX: Tables and Figures

Table A.1. Description of the energy expenditure items in the HBS

	Name of the variables in HBS microdata		
Monthly expenditure for ...	Principal residence	Other dwellings	Total
...Heating			
Natural gas (network)	$c3402$	$c3422$	$c3402 + c3422$
Natural gas (cylinder)	$c3403$	$c3423$	$c3403 + c3423$
Gasoil	$c3404$	$c3424$	$c3404 + c3424$
Solid fuels (coal/wood)	$c3405$	$c3425$	$c3405 + c3425$
Centralized heating	$c3406$	$c3426$	$c3406 + c3426$
... Electricity	$c3401$	$c3421$	$c3401 + c3421$
... Private transport			
Gasoil			$c6209$
Gasoline			$c6210$

Source: HBS questionnaire.

Table A.2. Mean energy share and household characteristics

	1997	2002	2007	2008
Deciles of equivalent expenditure				
1st	12.1	12.1	12.4	13.1
2nd	12.2	12.2	12.1	13.1
3rd	12.3	12.1	12.3	13.1
4th	12.1	12.2	12.1	12.8
5th	12.0	12.0	11.4	12.3
6th	11.8	12.0	11.3	12.3
7th	11.0	11.0	10.8	11.6
8th	10.4	10.5	10.6	10.9
9th	9.4	9.5	9.4	10.2
10th	7.0	6.8	6.8	7.9
Age of the RP				
up to 35	11.5	11.5	11.0	12.4
36-50	11.4	11.4	11.3	12.2
51-64	11.5	11.5	11.4	12.4
65+	10.1	10.2	10.2	10.6
Job status of the RP				
Employed	11.3	11.4	11.3	12.2
Self-employed	11.7	11.6	11.3	12.6
Not-Employed	10.6	10.6	10.6	11.1
Education of the RP				
Primary	11.1	11.1	11.0	11.5
Secondary	11.7	11.6	11.7	12.5
High-school+	10.4	10.5	10.3	11.3
Household size				
1	9.7	9.9	10.0	10.8
2	11.1	11.1	11.0	11.7
3	11.7	11.6	11.6	12.3
4+	11.5	11.6	11.5	12.6
Principal residence size (rooms)				
1	8.9	9.4	10.3	10.1
2	9.8	10.0	9.7	10.8
3	10.5	10.6	10.7	11.3
4	11.1	11.1	11.0	11.7
5+	11.6	11.5	11.3	12.2
Geographical area				
North	11.0	11.1	10.6	11.5
Centre	11.2	11.0	10.9	11.5
South	11.0	11.0	11.5	12.3
Total	**11.0**	**11.0**	**10.9**	**11.7**

Source: Based on HBS data.
RP=Reference Person.

Table A.3. Mean energy share and household characteristics: heating

	1997	**2002**	**2007**	**2008**
Deciles of equivalent expenditure				
1st	4.1	4.2	4.0	4.1
2nd	4.1	4.2	3.7	4.2
3rd	4.1	4.1	4.0	4.4
4th	4.0	4.2	4.0	3.9
5th	4.0	4.1	3.6	4.1
6th	3.9	3.8	3.7	4.0
7th	3.6	3.6	3.1	3.7
8th	3.4	3.4	3.2	3.5
9th	3.1	3.1	2.8	3.1
10th	2.3	2.1	2.1	2.5
Age of the RP				
up to 35	3.0	2.8	2.6	3.3
36-50	3.1	3.1	2.9	3.3
51-64	3.5	3.5	3.1	3.6
65+	4.7	4.6	4.3	4.5
Job status of the RP				
Employed	3.0	3.0	2.9	3.3
Self-employed	3.2	3.2	2.8	3.4
Not-Employed	4.3	4.3	4.1	4.2
Education of the RP				
Primary	4.4	4.4	4.3	4.5
Secondary	3.4	3.4	3.2	3.7
High-school/College	3.1	3.2	2.9	3.3
Household size				
1	4.5	4.4	4.1	4.2
2	4.1	4.0	3.6	4.0
3	3.3	3.3	3.1	3.4
4+	2.9	3.0	2.7	3.2
Principal residence size (rooms)				
1	2.6	3.7	2.8	3.0
2	3.7	3.6	3.3	3.6
3	3.4	3.5	3.4	3.6
4	3.6	3.6	3.3	3.7
5+	3.8	3.8	3.6	4.0
Geographical area				
North	4.5	4.5	3.9	4.4
Centre	3.5	3.5	3.4	3.6
South	2.6	2.5	2.6	2.9
Total	**3.7**	**3.7**	**3.4**	**3.8**

Source: Based on HBS data.
RP=Reference Person.

Table A.4. Mean energy share and household characteristics: private transport

	1997	**2002**	**2007**	**2008**
Deciles of equivalent expenditure				
1st	3.9	3.9	4.1	4.2
2nd	5.2	5.1	5.4	5.5
3rd	5.8	5.5	5.7	5.9
4th	6.0	5.8	5.8	6.3
5th	6.1	6.0	5.8	6.0
6th	6.2	6.3	5.8	6.2
7th	5.8	5.9	5.9	6.0
8th	5.6	5.7	5.8	5.7
9th	5.1	5.2	5.2	5.6
10th	3.8	3.8	3.8	4.3
Age of the RP				
up to 35	6.8	6.9	6.5	6.9
36-50	6.4	6.5	6.4	6.7
51-64	6.0	6.0	6.2	6.4
65+	3.1	3.2	3.4	3.5
Job status of the RP				
Employed	6.5	6.5	6.5	6.8
Self-employed	6.5	6.5	6.4	6.9
Not-Employed	4.0	4.0	4.1	4.2
Education of the RP				
Primary	4.4	4.2	4.0	4.1
Secondary	6.3	6.2	6.2	6.4
High-school+	5.6	5.7	5.6	6.0
Household size				
1	3.1	3.3	3.6	4.0
2	5.1	5.1	5.3	5.4
3	6.5	6.3	6.3	6.6
4+	6.5	6.6	6.6	6.9
Principal residence size (rooms)				
1	4.1	2.9	5.0	4.1
2	3.9	4.1	3.9	4.7
3	5.0	4.9	5.1	5.1
4	5.4	5.5	5.5	5.7
5+	5.8	5.7	5.6	5.9
Geographical area				
North	5.0	4.9	4.8	5.2
Centre	5.7	5.5	5.4	5.6
South	5.7	5.8	6.0	6.1
Total	**5.4**	**5.3**	**5.3**	**5.6**

Source: Based on HBS data.
RP=Reference Person.

Table A.5. Mean energy share and household characteristics: electricity

	1997	2002	2007	2008
Deciles of equivalent expenditure				
1st	4.1	4.0	4.3	4.8
2nd	2.9	2.9	3.1	3.4
3rd	2.4	2.5	2.6	2.8
4th	2.1	2.2	2.3	2.5
5th	1.9	2.0	2.0	2.2
6th	1.7	1.8	1.9	2.0
7th	1.6	1.6	1.7	1.9
8th	1.4	1.4	1.5	1.7
9th	1.2	1.3	1.4	1.5
10th	0.9	0.9	1.0	1.1
Age of the RP				
up to 35	1.7	1.8	1.9	2.2
36-50	1.9	1.9	2.0	2.2
51-64	2.0	2.0	2.1	2.4
65+	2.3	2.4	2.5	2.7
Job status of the RP				
Employed	1.8	1.8	1.9	2.1
Self-employed	2.0	2.0	2.0	2.3
Not-Employed	2.2	2.2	2.4	2.7
Education of the RP				
Primary	2.3	2.5	2.7	2.9
Secondary	2.0	2.0	2.2	2.4
High-school+	1.6	1.7	1.8	2.0
Household size				
1	2.1	2.2	2.3	2.5
2	2.0	2.0	2.1	2.4
3	1.9	1.9	2.1	2.3
4+	2.1	2.0	2.1	2.4
Principal residence size (rooms)				
1	2.2	2.8	2.4	3.0
2	2.2	2.3	2.4	2.5
3	2.1	2.2	2.3	2.6
4	2.0	2.0	2.1	2.4
5+	1.9	2.0	2.1	2.3
Geographical area				
North	1.5	1.7	1.8	1.9
Centre	1.9	2.0	2.0	2.2
South	2.7	2.7	2.9	3.2
Total	**2.0**	**2.1**	**2.2**	**2.4**

Source: Based on HBS data.
RP=Reference Person.

Table A.6. Shares of the energy items on total expenditure.
SURE estimates (1997-2004: "low oil price").

	Heating		*Transport*		*Electricity*	
	Parameter	Std.Error	Parameter	Std.Error	Parameter	Std.Error
Intercept	0.02195	(0.02156)	-0.76643***	(0.02348)	0.18919***	(0.00848)
Age	-0.00001	(0.00004)	0.00107***	(0.00005)	0.00043***	(0.00002)
Age squared	0.000003***	(0.00000)	-0.00001***	(0.00000)	-0.00000***	(0.00000)
Employed	-0.00158***	(0.00029)	0.00393***	(0.00031)	-0.00117***	(0.00011)
Self employed	0.00013	(0.00034)	0.00543***	(0.00037)	0.00101***	(0.00013)
University degree	-0.00042	(0.00035)	-0.00651***	(0.00038)	-0.00028*	(0.00014)
More than 2 HH members	-0.00060*	(0.00025)	0.00471***	(0.00027)	0.00373***	(0.00010)
Dependants (age$<$6 or age$>$74)	0.00192***	(0.00034)	-0.00676***	(0.00037)	0.00010	(0.00013)
More than 4 rooms	0.00697***	(0.00020)	0.00134***	(0.00022)	0.00195***	(0.00008)
Houseowner	0.00116***	(0.00024)	-0.00231***	(0.00026)	-0.00085***	(0.00009)
Expenditure $<$ P20	-0.00159***	(0.00035)	0.00357***	(0.00038)	0.00473***	(0.00014)
Expenditure $>$ P80	-0.00308***	(0.00032)	-0.00491***	(0.00034)	-0.00037**	(0.00012)
North	0.01021***	(0.00025)	-0.00444***	(0.00027)	-0.00240***	(0.00010)
South	-0.02118***	(0.00073)	0.00178*	(0.00080)	0.00367***	(0.00029)
Surface temperature	-0.00163***	(0.00002)	0.00012***	(0.00003)	-0.00002	(0.00001)
Surface temperature (South)	0.00052***	(0.00004)	0.00020***	(0.00004)	0.00001	(0.00002)
log(expenditure)	0.02651***	(0.00254)	0.21594***	(0.00277)	-0.04159***	(0.00100)
log(expenditure) squared	-0.00264***	(0.00017)	-0.01459***	(0.00018)	0.00202***	(0.00007)
Air conditioning	-0.00157***	(0.00030)	-0.00411***	(0.00032)	0.00265***	(0.00012)
Number of durables	0.00062***	(0.00010)	0.00726***	(0.00011)	0.00093***	(0.00004)
log of price for heating (gas)	-0.00878**	(0.00267)	0.00104	(0.00291)	-0.00130	(0.00105)
log (price for electricity)	-0.02323***	(0.00285)	0.00869**	(0.00310)	-0.01238***	(0.00112)
log (price for liquid fuels)	-0.01935***	(0.00193)	0.01340***	(0.00210)	-0.00102	(0.00076)
Observations	190,000		190,000		190,000	
Parameters	22		22		22	
RMSE	0.0398		0.0433		0.0157	
R Squared	0.1366		0.1898		0.2576	

Parameters statistically different from zero at 1 % (***), 5 % (**) and 10 % (*) confidence level.

Table A.7. Descriptive statistics of the variables used in the regression analysis.
(2005-2007: "high oil price")

Variable	Obs	Mean	Std.Dev.	Min	Max
C^h	71010	0.037	0.041	0	0.577765
C^t	71010	0.054	0.050	0	0.461325
C^e	71010	0.022	0.017	0	0.420486
Age	71010	55.659	15.344	16	77
Age squared	71010	3333.398	1696.515	256	5929
Employed	71010	0.390	0.488	0	1
Self-employed	71010	0.131	0.338	0	1
University degree	71010	0.094	0.292	0	1
More than 2 HH members	71010	0.442	0.497	0	1
Dependants (age$<$6 or age$>$74)	71010	0.152	0.359	0	1
More than 4 rooms	71010	0.365	0.481	0	1
Houseowner	71010	0.822	0.383	0	1
Expenditure $<$ P20	71010	0.200	0.400	0	1
Expenditure $>$ P80	71010	0.300	0.458	0	1
North	71010	0.484	0.500	0	1
South	71010	0.321	0.467	0	1
Surface temperature	71010	17.291	4.892	9.363	25.443
Surface temperature (South)	71010	5.547	8.532	0	25.443
log(expenditure)	71010	7.602	0.626	4.641116	10.60833
log(expenditure) squared	71010	58.188	9.538	21.53996	112.5367
Air conditioning	71010	0.255	0.436	0	1
Number of durables	71010	3.103	1.144	0	6
log of price for heating (gas)	71010	6.567	0.068	6.465243	6.643526
log (price for electricity)	71010	-1.541	0.066	-1.624552	-1.453289
log (price for liquid fuels)	71010	0.186	0.050	0.052146	0.280265

Table A.8. Shares of the energy items on total expenditure.
SURE estimates (2005-2007: "high oil price")

	Heating		*Transport*		*Electricity*	
	Parameter	Std.Error	Parameter	Std.Error	Parameter	Std.Error
Age	-0.00001	(0.00008)	0.00140***	(0.00010)	0.00032***	(0.00003)
Age squared	0.000003***	(0.00000)	-0.00002***	(0.00000)	-0.000003***	(0.00000)
Employed	-0.00060	(0.00047)	0.00161***	(0.00056)	-0.00116***	(0.00018)
Self employed	0.00061	(0.00056)	0.00212***	(0.00066)	0.00075***	(0.00021)
University degree	-0.00154**	(0.00051)	-0.00846***	(0.00060)	-0.00074***	(0.00019)
More than 2 HH members	0.00095**	(0.00041)	0.00328***	(0.00048)	0.00393***	(0.00015)
Dependants (age$<$6 or age$>$74)	0.00199***	(0.00045)	-0.00549***	(0.00053)	-0.00002	(0.00017)
More than 4 rooms	0.00696***	(0.00032)	0.00117***	(0.00038)	0.00260***	(0.00012)
Houseowner	0.00018	(0.00040)	-0.00442***	(0.00047)	-0.00036**	(0.00015)
Expenditure $<$ P20	-0.00244***	(0.00056)	0.00609***	(0.00066)	0.00372***	(0.00021)
Expenditure $>$ P80	-0.00309***	(0.00049)	-0.00471***	(0.00058)	-0.00008	(0.00018)
North	0.00751***	(0.00039)	-0.00329***	(0.00046)	-0.00177***	(0.00015)
South	-0.02015***	(0.00117)	0.00960***	(0.00138)	0.00440***	(0.00044)
Surface temperature	-0.00113***	(0.00004)	0.00018***	(0.00005)	-0.00004**	(0.00002)
Surface temperature (South)	0.00041***	(0.00006)	0.00002	(0.00007)	-0.00001	(0.00002)
log(expenditure)	0.01147***	(0.00435)	0.25713***	(0.00515)	-0.06788***	(0.00163)
log(expenditure) squared	-0.00170***	(0.00028)	-0.01681***	(0.00033)	0.00356***	(0.00010)
Air conditioning	-0.00196***	(0.00035)	-0.00410***	(0.00041)	0.00236***	(0.00013)
Number of durables	0.00054***	(0.00016)	0.00751***	(0.00019)	0.00066***	(0.00006)
log of price for heating (gas)	-0.11132***	(0.00679)	-0.01378*	(0.00804)	-0.00124	(0.00254)
log (price for electricity)	0.09083***	(0.00685)	0.00296	(0.00811)	0.00641**	(0.00257)
log (price for liquid fuels)	-0.00349	(0.00373)	0.01437***	(0.00441)	0.00220	(0.00140)
Observations	71,010		71,010		71,010	
Parameters	22		22		22	
RMSE	0.0383		0.0454		0.0144	
R Squared	0.1278		0.1758		0.3262	

Parameters statistically different from zero at 1 % (***), 5 % (**) and 10 % (*) confidence level.

Table A.9. Simulation under different scenarios (total share=100)

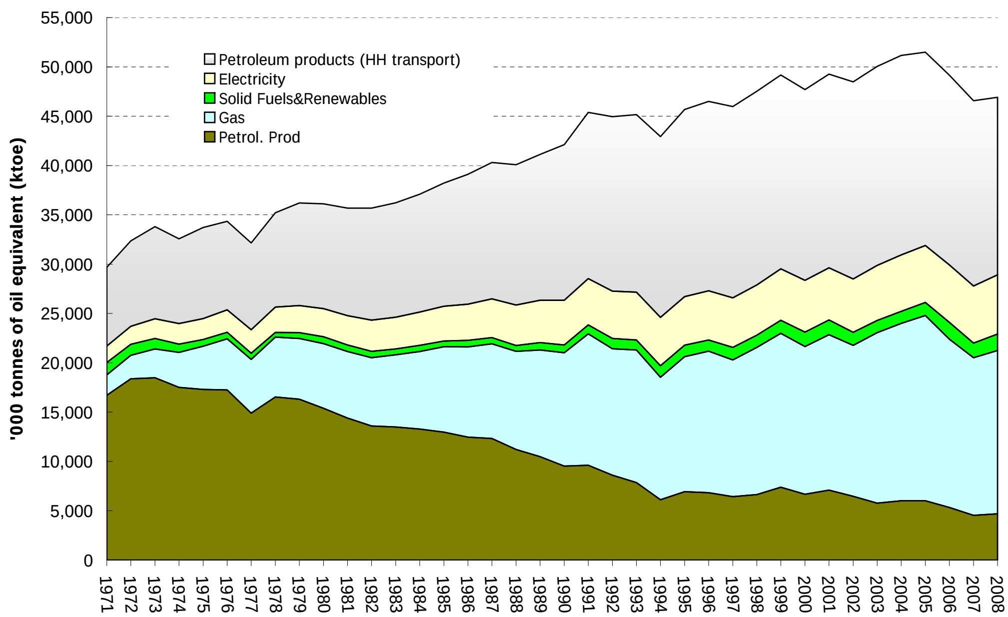
Scenarios	A		B		C		
	2020	2030	2020	2030	2020	2030	2007
	Deciles of equivalent expenditure						
1st	114	112	116	116	112	110	100
2nd	111	108	113	112	109	107	112
3rd	115	114	114	114	114	113	112
4th	110	110	111	110	110	110	110
5th	104	105	104	104	105	105	106
6th	105	104	104	103	105	104	105
7th	98	101	98	99	98	100	99
8th	96	97	96	96	97	97	94
9th	85	87	84	85	87	88	83
10th	60	63	59	60	64	64	57
	Age of the RP						
up to 35	104	108	103	104	102	103	101
36-50	106	109	105	106	104	105	103
51-64	107	109	105	106	105	106	104
65+	91	89	91	89	93	93	93
	Job status of the RP						
Employed	106	109	104	106	104	105	103
Self-employed	106	109	105	106	104	105	103
Not-Employed	94	92	95	94	96	95	97
	Education of the RP						
Primary	98	96	99	97	100	99	100
Secondary	108	109	108	109	107	107	107
High-school+	95	97	95	95	95	96	95
	Household size						
1	89	87	90	88	90	90	92
2	101	102	100	100	101	102	100
3	108	111	106	107	107	108	106
4+	108	112	107	109	106	107	105
	Principal residence size (rooms)						
1	98	101	96	96	96	97	94
2	87	87	88	88	88	88	89
3	97	97	98	99	97	97	98
4	100	101	101	101	100	100	100
5+	104	104	103	102	104	105	103
	Geographical area						
North	96	95	95	93	98	98	97
Centre	98	97	98	98	99	98	99
South	108	109	109	111	104	103	105
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Share	*9.1*	*8.7*	*9.2*	*9.0*	*10.8*	*10.7*	*10.9*
Gini (of the share)	*0.354*	*0.358*	*0.349*	*0.346*	*0.319*	*0.323*	*0.314*

A=Changes in demographics, prices and climate.
B=Changes in prices and climate only.
C=Changes in demographics only.

Table A.10. Simulated energy expenditure per age of the RP. "A" scenario

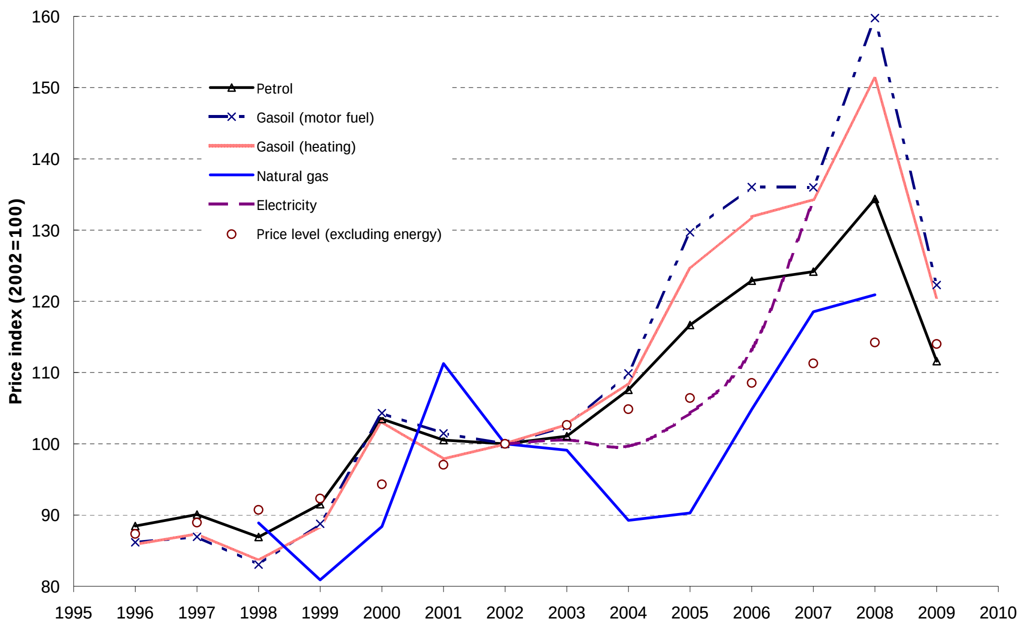
Age of the RP	**Total Expenditure** *euro 2007 per month*	**Energy**	**Heating** *shares*	**Electricity**	**Transports**
			2007		
up to 35	2,433	11.0	2.6	1.9	6.5
36-50	2,815	11.3	2.9	2.0	6.4
51-64	2,863	11.4	3.1	2.1	6.2
65+	1,890	10.2	4.3	2.5	3.4
Total	2,476	10.9	3.4	2.2	5.3
			2020		
up to 35	2,778	9.5	1.1	2.1	6.3
36-50	3,222	9.7	1.2	2.2	6.3
51-64	3,242	9.7	1.4	2.3	6.0
65+	2,098	8.3	2.4	2.7	3.1
Total	2,753	9.1	1.7	2.4	5.0
			2030		
up to 35	3,039	9.4	1.0	2.0	6.4
36-50	3,535	9.5	1.1	2.0	6.3
51-64	3,525	9.4	1.2	2.2	6.0
65+	2,282	7.7	2.0	2.6	3.0
Total	2,952	8.7	1.5	2.4	4.8

Figure 1. Households' final energy consumption



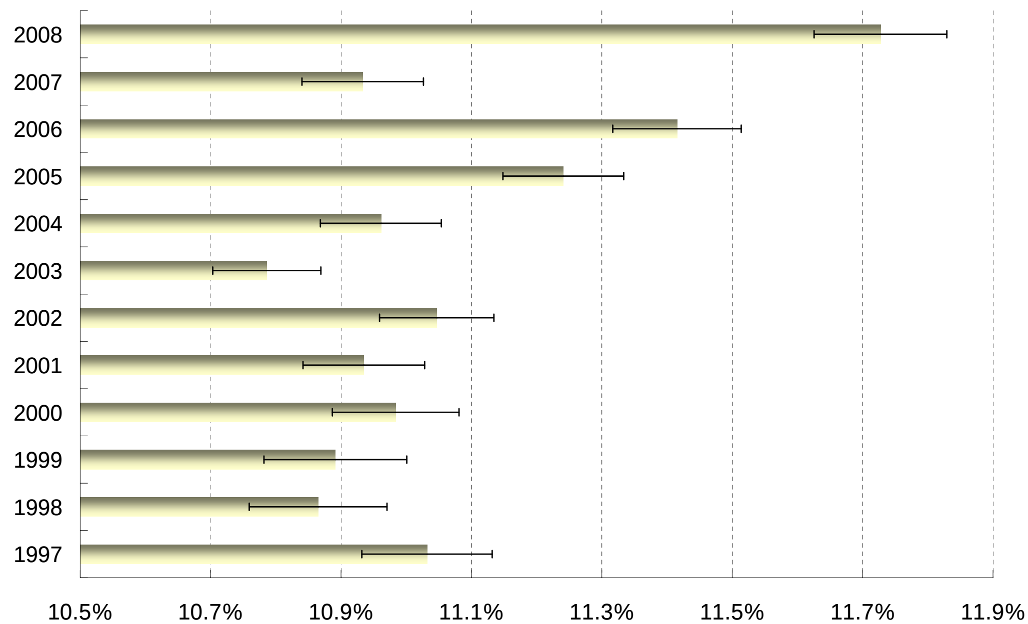
Source: Based on data from Eurostat, Italian Ministry of Economic Development, ACI, UP.

Figure 2. Energy prices for households



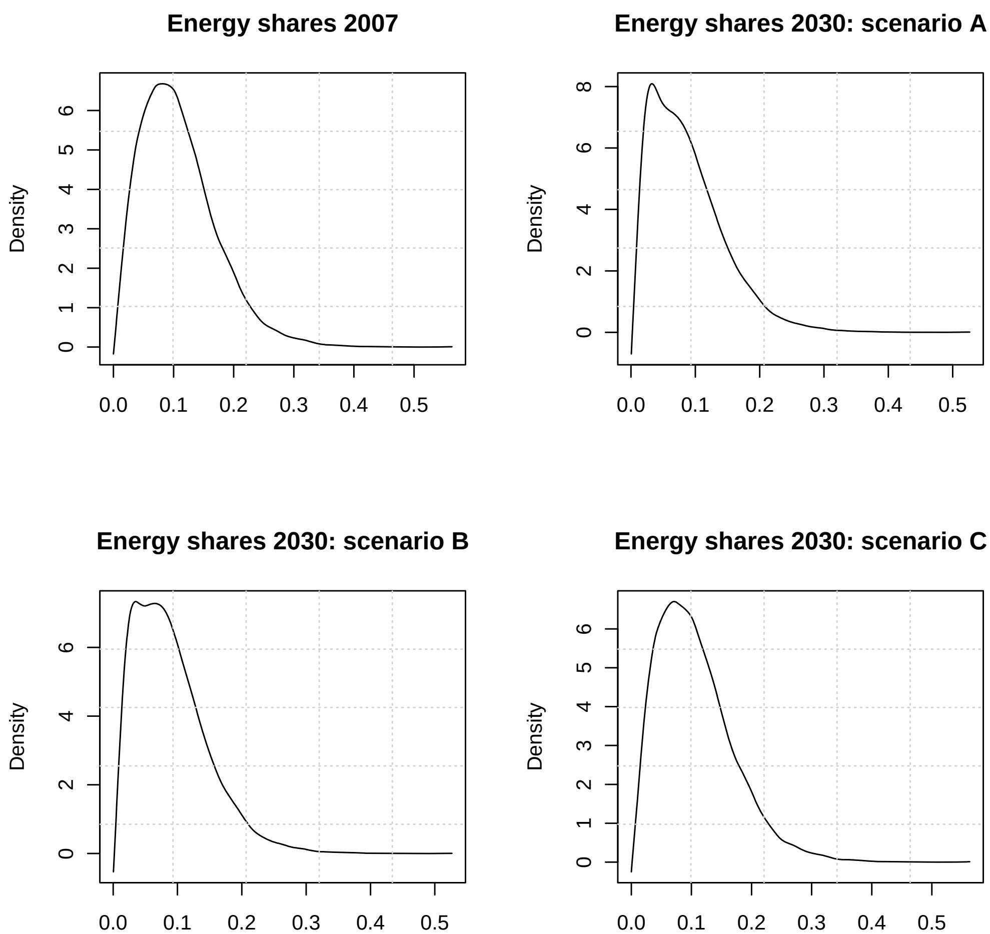
Source: Based on data from Eurostat and Italian Ministry of Economic Development.

Figure 3. Households' share of expenditure on energy



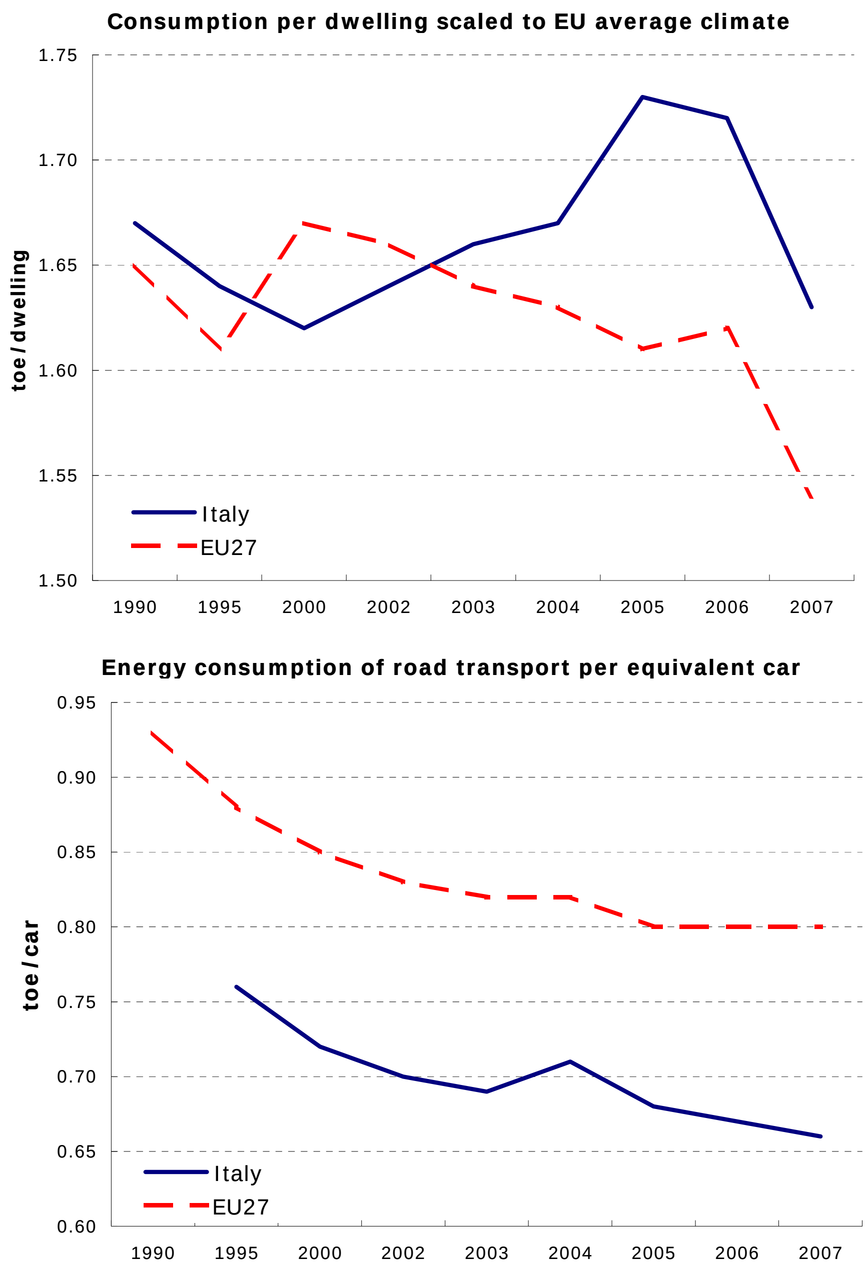
Source: Based on HBS data. Yearly mean values and 95 per cent confidence level.

Figure 4. Distribution of energy shares: 2007 and 2030



Source: Based on HBS data. A=Changes in demographics, prices and climate. B=Changes in prices and climate only. C=Changes in demographics only.

Figure 5. Energy efficiency of buildings and cars in Italy



Source: Based on data from ODYSSEE database.

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