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The changing effects on domestic energy expenditure from housing characteristics and the recent rapid energy price movements.

Sotirios Thanos and Neil A. Dunse

School of Built Environment, Heriot-Watt University

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About the Authors

Sotirios Thanos

Sotirios Thanos is a researcher in the School of Built Environment, Heriot-Watt University. Dr Thanos' research interests lie in the areas of environmental and urban economics, with expertise in stated preference methods, logit models, hedonic pricing, cross-sectional and spatial econometrics. Dr Thanos has published articles in the Journal of Environmental and Resource Economics and the Journal of Environmental Economics and Policy. He has undertaken and contributed research projects for EUROCONTROL, EC, EPSRC and RICS.

Neil Dunse

Neil Dunse is currently a Reader in the School of Built Environment, Heriot-Watt University. Dr Dunse's research interests include property market analysis and public policy, real estate valuation, and the impact of public policy on land values. Dr Dunse has published articles in a number of journals including Journal of Property Research, Journal of Property Valuation and Investment, and Urban Studies. He has undertaken research projects for the ODPM, Scottish Parliament and RICS.

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RICS EXECUTIVE SUMMARY

Introduction

Investment in energy efficiency is an important policy target area, with the domestic sector being a major contributor to the total UK energy consumption, but also having potential for significant reductions.

This research estimates econometric models for the domestic energy expenditure in the UK. These models include a number of relevant household socioeconomics characteristics along with income levels. Exploiting the gaps in the literature, we specifically focus on the effects of dwelling attributes on energy spending, aiming to produce policy relevant results. We also consider the significant events in the recent years that have directly and indirectly affected domestic energy use, such as the soaring oil and energy prices, the subsequent economic crisis and the Russia–Ukraine gas dispute.

This report can inform all stakeholders who are interested with the intersection between housing and energy consumption. Our models provide monetary estimates for the effects on energy expenditure by a number of dwelling attributes. This can be useful for example to local authorities in informing their housing policy objectives or developers and housing market participant who have energy efficiency targets.

Methodology and Data

This study employs the latest data from the English Housing Conditioning Survey (EHCS) of 30,926 observations collected from April 2006 to March 2010. This is a combination of four annual cross-sectional datasets across England. Except the energy expenditure and full family income, the dataset also includes: tenure, occupation, number of families in a dwelling, number of children and elderly in the household, length of residence in dwelling, number of rooms, region, construction period of the dwelling, dwelling type, attic or basement, double glazing, type of fuel and heating system/equipment, age of the heating system/equipment, loft insulation, payment method of energy bills and council tax band.

We employ the model of conditional demand to derive an econometric model for energy expenditure. We use energy expenditure per square meter as the depended variable and a double-log functional form. First a pooled model across all study years is employed. We subsequently estimate separate models for each year.

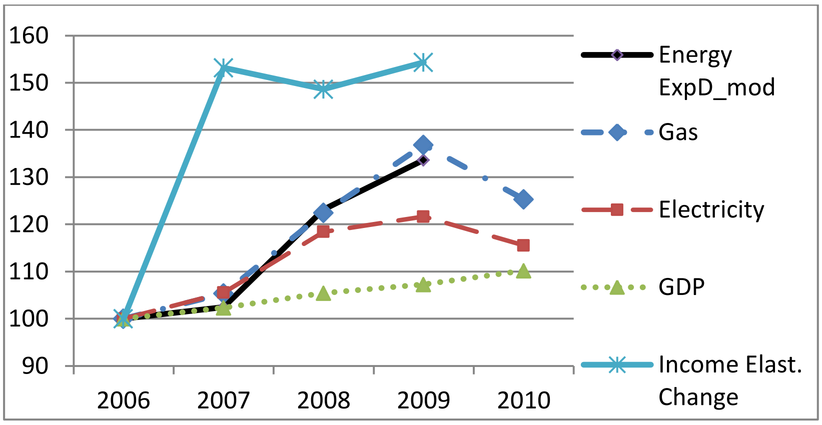
Results

All the models have very good overall goodness of fit, all coefficients are of the expected sign and most are statistically significant. Socioeconomic characteristics, such as occupation, number of children and elderly in the household, number of families in a dwelling and length of residence in dwelling, have a statistically significant effect in our pooled model and are in line with the literature.

We also find evidence of incentive asymmetry between tenants and landlords that is theoretically consistent, with private renters paying more than owner occupiers.

An income elasticity of 0.021 is estimated, which is in line with the literature. This low income elasticity denotes very limited adjustments in energy expenditure spending from changes in household income levels. However, there is a 50% increase in income elasticity, following the soaring energy prices and a background of world economic crisis. This is shown in Figure 1.

Figure 1: Energy prices, energy expenditure, GDP and income elasticity, 2006=100



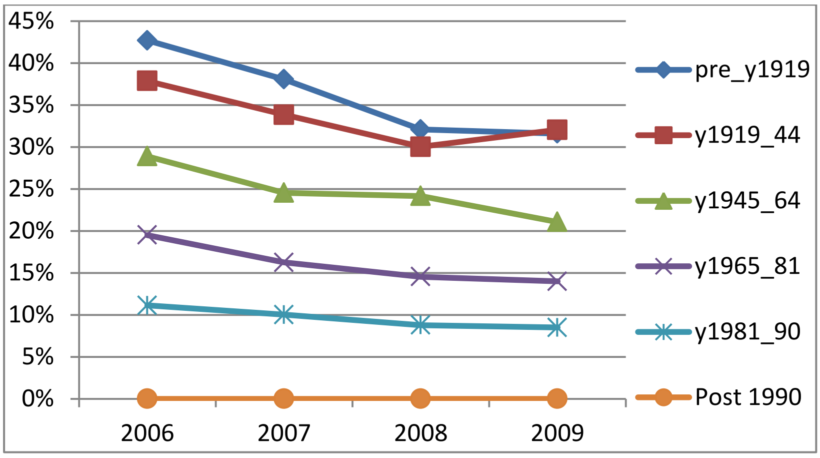
Highlighting some of the housing characteristics' effects, energy expenditure is significantly affected by the type of dwelling. Furthermore, detached houses seem to have more capacity for reducing energy expenditure than other house types, when households are faced with soaring energy prices and economic downturn.

A major factor in determining energy expenditure is the fuel and heating equipment type and age of the heating system/equipment. Insulation has also a significant effect on energy expenditure.

As expected, older buildings in our models increase considerably the annual energy expenditure. The important finding here concerns the periods when households are faced with energy price increases and economic downturn. During those periods in our data, the decline of energy expenditure in buildings of older construction is much steeper to newer dwellings. This is illustrated in Figure 2. Notwithstanding this energy expenditure decline in older buildings, there is still considerable capacity for improvement.

Another key finding in this study is that the payment method of energy bills can amount to a significant additional cost over the annual energy expenditure. This is expected to affect households in the lower income groups and can contribute to fuel poverty.

Figure 2: Construction period and changing energy expenditure



Recommendations

A number of policy recommendations and priorities come out of this study, highlighting a few in order of importance:

- Heating fuel and equipment is a major issue, with electric portable or fixed room heaters having the by far highest impact on energy expenditure from any other attribute. There ought to be a policy strategy specifically against the use of such equipment as the main heating system. A related issue is the age of the heating system that is also shown to have a considerable effect on energy expenditure.
- A corollary is the significant capacity for energy expenditure reductions in old buildings. Adapting older buildings closer to modern standards can have huge benefits, given that the majority of the domestic housing stock in the UK was constructed before 1980.
- An obvious policy priority is insulation (either double glazing or loft insulation) that has a significant effect on energy expenditure.
- Socially orientate policies can target the issue of the additional cost of different payment methods. This can amount to a considerable additional cost over the annual energy expenditure and is expected to affect household in the lower income groups that are prone to fuel poverty, exacerbating these effects.

1. Introduction

The importance of climate change in the UK policy is amply demonstrated by being one of the first countries in the world to set legally binding targets on emission reductions, 34% by 2020 and at least 80% by 2050. The potential instruments for achieving these targets include investment in energy efficiency, renewable and nuclear energy, carbon capture and storage (HM Government, 2008; DECC, 2010). The domestic sector has been repeatedly identified as having one of the lowest costs, largest impacts and potential for reducing CO_2 emissions (DCLG, 2007; DECC, 2009). In 2010 domestic consumption was 32% of total UK final energy consumption (DECC, 2011a).

Policies targeting domestic energy use effects on climate change are expected to impact domestic energy prices. DECC (2010) estimated that the effect of such policies will push up by 18% the domestic retail gas prices and 33% the electricity prices by 2020, compared to the no additional policy scenario. Energy and carbon emission reductions can be achieved by improving the efficiency of domestic energy use and thus decreasing household energy expenditure. However, the best approach for achieving these CO_2 reductions is still under debate (Kelly, 2011).

Bernard et al. (2010) argue that economic modelling estimates of domestic energy use are quite specific to the data generating process such as region, time period, and level of data aggregation. Concerning economic modelling of domestic energy demand/expenditure in the UK, Hunt et al. (2003) focus on price and income effects on energy demand. Baker and Blundell (1991), Baker et al. (1989) and Meier and Rehdanz (2010) introduce a few housing structural characteristics, along with socioeconomics characteristics of the household, income and price levels. A more detailed analysis on the effects of housing characteristics in energy use is employed for the UK by Druckman and Jackson (2008) and Dresner and Ekins (2006). However, the two latter studies do not employ economic modelling and regression analysis, but are limited to a more descriptive approach of correlation coefficients between energy use, CO_2 emissions and the various housing and socioeconomic characteristics.

This research estimates econometric models for the domestic energy expenditure in the UK. These models include a number of relevant household socioeconomics characteristics along with income levels. Exploiting the gap in the literature specified above, we specifically focus on the effects of dwelling attributes on energy spending, aiming to produce policy relevant results. Furthermore, the rapid fuel/energy price movements between 2006 and 2010 provide a unique opportunity to examine the households' behaviour in response to these unprecedented economic conditions.

The structure of this report is as follows, section 2 provides the background in the energy and housing markets and the general economic conditions during the study period. Section 3 discusses the literature on the economic models domestic energy use. Section 4 presents the methodology and the data. Section 5 illustrates and discusses the modelling results and in section 6 the conclusions and recommendations are found.

2. Background of Energy Price Movements

There have been very significant events in the recent years that have directly and indirectly affected domestic energy use. For example, the recent (or still ongoing) economic crisis started with the U.S. subprime crisis in August 2007. It deteriorated rapidly after the dramatic blowout of the financial crisis in September 2008, following the default by a large U.S. investment bank, leading to the deepest post–World War II recession by far in 2009 (IMF, 2009). In the UK, the first signs of this financial turmoil appeared in September 2007 with the first run on a British bank since 1866 and a near meltdown in the banking system 12 months later. The credit crunch, the effects of which have been amplified by the bursting of the UK's decade-old house price bubble, also caused the country's first recession in 17 years during 2009. Increases in unemployment and reductions in the household disposable income were expected effects of this crisis, even after the deployment of quantitative easing policy instruments (Hodson et al., 2009).

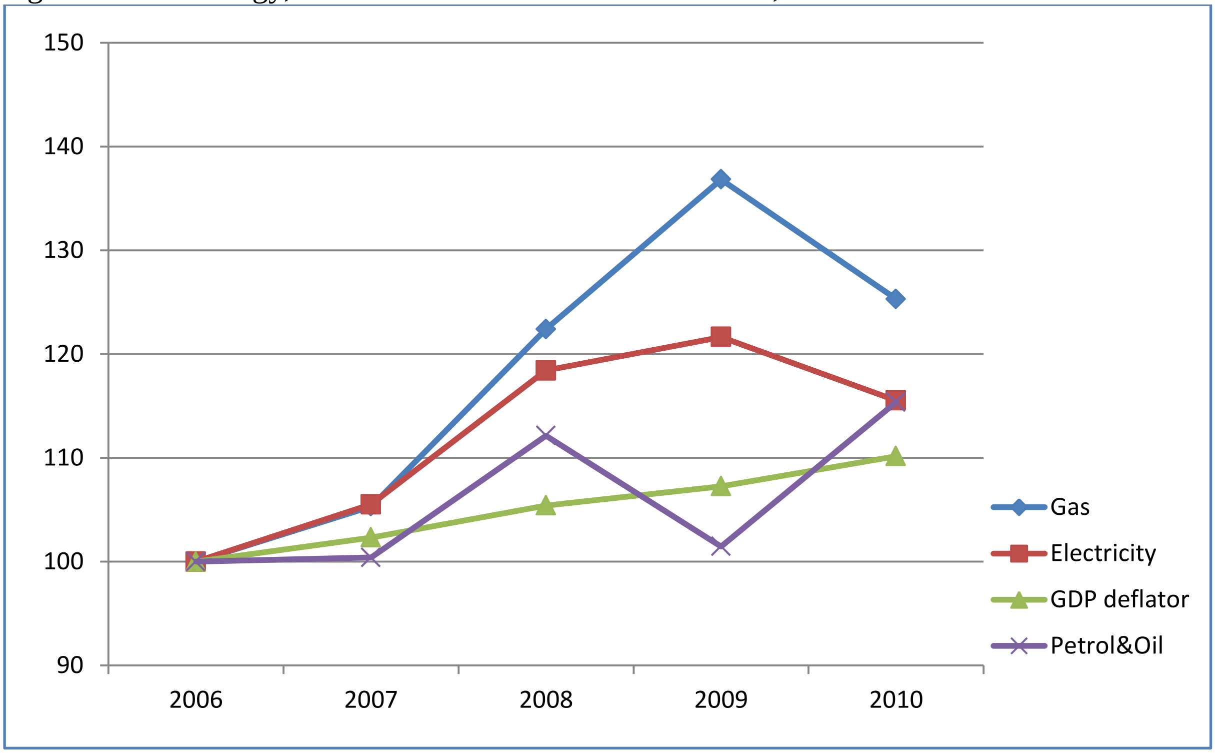
Energy prices, especially the real prices faced by the consumer, did not closely follow the trend of GDP. Oil and petrol prices were indeed severely affected in the wake of the financial crises, with crude oil price deflating at half the peak of $147 it reached in July 2008, near $70 a barrel on November (The Economist, 2008). However, natural gas prices did not immediately follow oil's depreciation in Europe. During 2006 to 2008 Gazprom was given impetus by a new surge in oil prices to drive European prices up. Instead of the gas prices following oil in the end of 2008, the Russia–Ukraine gas dispute, by far the most serious of its kind, reached its peak (Pirani et al., 2009). The result was interruption of gas supply in Europe and soaring gas prices. The dispute began in 2008 with a series of failed negotiations and Russian gas exports were cut off on 1 January to Ukraine and subsequently to the whole of Europe, restarting supply after 20 days and an international agreement (Pirani et al., 2009).

The events discussed above are very relevant to the UK, since fossil fuel prices (gas, coal and oil) are the primary drivers of wholesale energy costs, which make up over 60% of domestic energy prices (DECC, 2010). The fuel mix for domestic consumption in 2010 is 69% natural gas and 21% electricity. The majority of energy consumed in the domestic sector is for spacing heating, which in 2009 is 61% of total domestic consumption. Water heating and lighting appliances accounted for a further 18% each with cooking accounting for a further 3% (DECC, 2011a).

Figure 1 illustrates the real price movements of gas electricity and oil/petrol against GDP. We see the very slow increase in GPD across all years. Oil/petrol prices inflate rapidly in 2008 only to plummet at an almost equal rate in 2009 and soar again in 2010. Conversely, gas and electricity prices increase all the way to 2009, starting to converge with oil/petrol price levels in 2010. The effects of Russia–Ukraine dispute are obvious in the gas price levels of 2009, possibly also affecting electricity prices.

Gas and electricity price increase in Figure 1 was much steeper than GDP until 2009 and remained much higher the general price level in 2010. This directly affects the budget of individual households, who mostly see soaring energy prices cutting into their income levels that are non-increasing or reducing due to the wider economic conditions. Hence, we might expect changes in the household behaviour concerning energy use, adapting in different ways to these conditions.

Figure 1: Real Energy, Fuel Price and GDP Indices 2006-10, 2006=100



Source: DECC (2011b)

3. Domestic Energy Expenditure/Demand in the Literature

The theme of empirical energy expenditure/demand modelling in the domestic sector has attracted plenty of academic interest over the years. Reviews of such studies published until the 90s can be found in Dahl (1993), Madlener (1996) and Atkinson and Manning (1995). Given the disaggregate microeconomic nature of this research, we are mostly interested in relatively recent studies, as energy technology, distribution, price levels and demand characteristics have shifted over the last 40 years.

We can categorise the energy expenditure/demand studies in to two wider modelling approaches. The first uses aggregate time-series data on the level of a country or region, usually employing data on energy consumption, price and income, along with some other additional factors such as climate or urbanization (Halicioglu, 2007). A few recent examples of aggregate time-series studies are Dergiades and Tsoulfidis (2008) for the US, Zachariadis and Pashourtidou (2007) for Cyprus, Halicioglu (2007) for Turkey, De Vita et al. (2006) for Namibia, Bushnell and Mansur (2005), for the US, Narayan and Smyth (2005) for Australia;

Galindo (2005) for Mexico, Holtedahl and Joutz (2004) for Taiwan, Kamerschen and Porter (2004) for USA, Hondroyiannis (2004) for Greece and Hunt et al. (2003) for the UK. Even though, aggregate time series have desirable features such as reliability and coverage, they lack the capacity to link between energy use and individual household/dwelling characteristics (Bernard 2010), which is the major theme of our study. The main focus of time-series studies is to derive long-term price and income elasticities for the study area, along with patterns of energy use across time.

The second approach of domestic energy expenditure/demand modelling employs microeconomic disaggregate data with a variety of variables and approaches. There has been a recent trend in the literature with studies that employ panel data, such as Albertini et al (2011) for the US, Reiss and White (2008) for San Diego, Labenderia et al. (2011) for Spain, Meier and Rehdanz (2010) for the UK, Rehdanz (2007) for Germany and Berkhout et al. (2004) for Netherlands. Bernard et al. (2010) used cross-sections over time, composing of observations on the same area (cluster) units at different periods to create a "pseudo-panel" dataset for Quebec. They argue that this set of information is more appropriate to analyze dynamic and static aspects of economic behaviour. However, panels may suffer from usual problem of having short-time series for prices, which generates the potential for under-identification of price effects (Labenderia et al. 2011).

Other microeconomic disaggregate studies use cross-sectional data that usually contains more information on individual dwelling and socioeconomic characteristics Examples of such studies are Larsen and Nesbakken (2004) for Norway, Baker et al (1989) for the UK and Filippini and Pachauri (2004) India. A further twist to this approach is a two stage model, with the first stage being a choice model often between heating system or fuel (Dubin and McFadden, 1984; Nesbakken, 1999; Baker and Blundell, 1991). A shortcoming of cross-sectional data is that the dynamic nature energy use cannot be easily analysed, along with often inadequate cross-sectional variation of energy prices (Bernard et al., 2010).

Boonekamp (2007) follows a different approach. He employs a bottom-up simulation of the energy trends between 1990 and 2000, examining several scenarios of changes in energy prices resulting from new policy measures during the past decade in the Netherlands. He argues that higher prices will have only a minor effect on energy consumption in the future.

Increasing incomes will compensate these gains, especially for electricity. He also recommends energy labels for appliances as a good first step in providing cost information at the right time, place and in the right form.

Kelly (2011) touches on this issue from a different angle. He uses English Housing Conditioning Survey (EHCS) from 1996 that includes 2531 observations of metered information on electricity and gas consumption. This is the only dataset in the UK with such information, but it is too old for the purposes of our research. Kelly (2011) employs a structural equation model (SEM) for residential energy consumption, the benefit of which is its capacity to explain complex relationships between variables through direct, indirect and total effects. He finds residential energy consumption to be driven by the number of household occupants, floor area, household income and household heating pattern. Interestingly though, energy consumption has reciprocal causality with SAP. SAP is the standard assessment procedure in the UK for measuring the energy efficiency of dwellings and its banded version is used in the energy performance certificate (EPC) that is a form of energy labelling.

Kelly (2011) shows SAP to have a negative effect on energy consumption and conversely, homes with a propensity to consume more energy also have higher SAP rates. This raises two issues: firstly, this seems consistent to Jevon's paradox; namely that he impact of improved energy efficiency on reducing energy use might be (partially) offset, when increased competitiveness and income effects stimulate energy demand (Hanley et al. 2009 Sorrell, 2009). Secondly, how appropriate is to include SAP into our domestic energy expenditure/demand modelling? This question is further discussed in the methodology section.

A major modelling problem in most approaches is that the data may contain sufficient variation on prices, expenditure or income. Such variation is usually attained by selecting a broad geographic area and/or a sufficient long period of time, but in some cases identification is made possible by abrupt changes in prices due to supply conditions (Albertini et al 2011). Reiss and White (2008) and Bushnell and Mansur (2005) exploit the energy crisis and rapidly inflation in electricity rates in California during 2000-01.

Bushnell and Mansur (2005) examined how customers respond to noisy and volatile tariffs by measuring deregulated retail rates' impact on electricity consumption in San Diego, using a time series dataset (1997-2000). They found that a doubling in retail price, accounted for a 6% reduction in consumption. However, their evidence show that consumers primarily base their expectation of current prices upon the prices reflected in recent bills, essentially responding to lagged price increases. Conversely, Reiss and White (2008), using five year panel data 46,800 households, argue that consumers are more responsive to shifts electricity prices than policy-makers envision. They found average household energy consumption reducing by 13% over a short span of about 60 days in response to an unannounced price increase. However, their argument of consumer price responsiveness is dampened by the 130% price increase that given the 13% energy consumption implies low price elasticity. Another interesting point is that typical San Diegan's energy use declined steadily by 7% over a six-month period, absent any pecuniary incentive to do so, since the authorities capped electricity prices during that period.

We discuss further the Meier and Rehdanz (2010) study, as we are primarily interested in the UK. They employ a panel covering 15 years and 64,155 cross-sectional observations. They model space heating expenditure and include in their models individual household characteristics, such as income and tenure, residential region, average age of occupants, changes in energy prices and weather conditions. Gas price elasticities between -0.34 and -0.56 and oil price elasticities between -0.40 and -0.49 are obtained. This finding of energy expenditure/demand being relatively inelastic to price movements is common in the literature. Albertini et al (2011) provides a very recent review of own short and long-run price elasticities in the literature. Due to the limitation of our data we cannot obtain price elasticity in this study, thus we focus on income elasticities instead.

According to economic theory energy consumption should increase with income. This is found in the literature, but in many studies the income elasticity is very low, especially in the short term. For example, Meier and Rehdanz (2010) derived short-run income elasticities ranging from 0.01 to 0.04 for the UK and Baker et al. (1989) estimates range from 0.115 to 0.131. Albertini et al (2011) find an income elasticity of electricity consumption only about 0.02 in the US and only when they remove dwelling characteristics from the right-hand side of the regression it reaches 0.05. Bernard (2010) finds a short-run income elasticity of 0.08

for Quebec (long-run elasticity is not significant). Rehdanz (2007) finds short-run income elasticities for Germany between 0.01 and 0.10, Holtedahl and Joutz (2004) find 0.23 for Taiwan, Hondroyiannis (2004) 0.2 for Greece, Narayan and Smyth (2005) 0.01 for Australia and Nesbakken (1999) 0.01-0.04 for Norway.

These very low income elasticities denote that increase in household income will only mean very small increases in energy expenditure/demand and the same goes for reductions. The household is committed to a certain levels of energy spending in the budget, with limited room for adjustment in the short-run, as for example reducing thermal comfort levels below a certain levels might not be an option. Only Filippini and Pachauri (2004) derived relatively higher short-run income elasticity levels, 0.60 - 0.64, for India.

Drawing from the literature review we see the importance of socioeconomic characteristics, such as income level to the demand for domestic energy. Previous studies have looked at the effects of policy interventions to energy demand. However, we can identify three opportunities to contribute to the current literature:

1. The very limited number of recent domestic energy expenditure studies in the UK.
2. The limited focus structural housing characteristics that may affect domestic energy expenditure.
3. The rapid fuel/energy price movements between 2005 and 2009 provide a unique opportunity to examine the households' behaviour in response to these unprecedented economic conditions. This has already been already pursued in the literature in a different situation and with different methodology and focus.

4. Methodology and Data

Unfortunately, we do not have enough information to derive a choice model for the selection of fuel, but this is not a major issue here as we are focused on the effects of the socioeconomic and dwelling characteristics on energy expenditure. Hence, we model the whole expenditure for energy, which is not unreasonable since the household is faced with bills for all the energy consumption and rarely has accurate information on the split of uses.

Dwelling size varies across households, and energy expenditure can be assumed to increase by dwelling size (Larsen and Nesbakken, 2004). We want to avoid our models being dominated by the monotonic relationship between energy expenditure and dwelling/household size. The dependent variable used by Baker et al. (1989) is the share of the expenditures for a certain fuel type related to the household's income. Meier and Rehdanz (2010) address this issue by taking as the dependent variable in their models to be expenditure per room. Rehdanz (2007), with availability to more detailed data on dwelling size, uses expenditure per square meter as the dependent variable. We adopt this approach, as this information is also available in our data. Hence, our dependent variables will be more efficiently related to house size, taking the form of expenditure per square meter.

Although there is no consensus in the literature about the most appropriate functional form, it is likely that expenditures will be non-linear in prices and income (Baker and Blundell; 1991). Hence, we adopt the double-log functional form, commonly used in the literature (Rehdanz, 2007; Meier and Rehdanz, 2010; Labenderia et al. 2011), with the added advantage of being a constant elasticity model (i.e. coefficients of continuous variables are equivalent to the elasticities).

We use the Baker et al. (1989) theoretical model of conditional demand; a two-stage budgeting expenditure decisions structure by the household, first allocating income between fuels/energy and non-fuel/energy commodities and then determine their disaggregated fuel consumption. To our knowledge, the model of conditional demand has not been widely used in the UK (e.g. Meier and Rehdanz 2010; Baker et al. 1989). The necessary assumption in this model is constant technology over the study period (Rehdanz, 2007), which not unreasonable given the relatively (compared to panel studies) short period of this study. We estimate the following model of energy expenditure model pooled across all study years:

$$LnE_j = \beta_0 + \beta_1 LnY_j + \boldsymbol{X_j\gamma} + \boldsymbol{Z_j\psi} + \beta_2 G_j + \beta_3 T_j + \varepsilon_j \qquad (1)$$

where LnE is the natural logarithm of domestic energy expenditure per square meter for household j, Y is the household income and the coefficient β_1 is also the income elasticity. $\boldsymbol{X}$ is a vector of all other household socioeconomic characteristics, such as tenure type, employment status, method of energy bill payment, number of children and elderly or multi-family households. *Z* is a vector of the structural characteristics of the household's *j* dwelling that include insulation, type, fuel and age of the heating system. *G* is the area and *T* the year of observation *j*, which is obviously dropped in the annual models in section 5.2.

In section 3 the issue of including SAP into our domestic energy expenditure modelling was raised. SAP is a standardised measure of energy efficiency of buildings and includes many assumptions on the effects of different dwelling characteristics on energy consumption. We primarily interested on the effect of each of these dwelling characteristics on energy expenditure and the simultaneous inclusion of SAP introduces to multicollinearity. SAP does not usually enter in the decision structure of the domestic energy consumer. Even in the case of home improvements, certain characteristics of the building that increase energy efficiency are improved. It seems unlikely that a certain value of SAP (or even an EPC category) will be targeted a priori by any improvements.

The only case where SAP enters consumer choice is in the form of an eco-label (as EPC), when buying or renting a house, thus it should be included in housing market models. EPC is an asset rating, which is intended to inform potential buyers or occupiers about the intrinsic energy performance of a building and its associated services (Fuerst and McAllister, 2011). Brounen and Kok (2011), conducting a hedonic pricing study, indicate that they were not able to distinguish between the intangible effects of labelling itself and the economic effects of energy savings. Furthermore, Fuerst and McAllister (2011) argue that the EPC rating indicates only the intrinsic energy performance of the building based on its design, which may lead to uncertainty among market participants as to the operational cost savings potential. Given the discussion above, we do not include SAP into our domestic energy expenditure modelling.

4.1. Data Description

This study employs the latest data from the English Housing Conditioning Survey (EHCS) of 30,926 observations collected from April 2006 to March 2010. This is a combination of four annual cross-sectional datasets across England, with the peculiarity that each year starts on April of a calendar year and finishes in March of next calendar year (i.e. 2006/07, 2007/08, 2008/09, 2009/10).

Except the energy expenditure and full family income, the dataset used in this study also includes: tenure, occupation, number of families in a dwelling, number of children and elderly in the household, length of residence in dwelling, number of rooms, region, construction period of the dwelling, dwelling type, attic or basement, double glazing, type of fuel and heating system/equipment, age of the heating system/equipment, loft insulation, payment method of energy bills and council tax band.

We use a Consumer Price Index to adjust all monetary values to 2006 price levels (ONS, 2011). The mean annual household energy expenditure is £1281, the average dwelling floor size is 86.22 square meters and the mean annual household income in our data is £25050. Appendix 1 provides detailed description and descriptive statistics for all the data employed in this study.

There are some limitations to this data; firstly, we have no information on either the energy prices faced by the household or their energy consumption. The second issue is that we do not exact information for the location of each household, except Government office region. Hence, we cannot examine any energy price or temperature variation, beyond the use of a dummy variable for the region that covers both these aspects. The same issue comes up in the temporal aspect, as we have only information on the year the data was gathered, thus the yearly dummies account both price and average temperature variation over the years, but we do not expect the latter having a very large effect.

5. Energy Expenditure Models

5.1. Pooled Model

Looking at the pooled model in Appendix 2, we note that all coefficients[1] are of the expected sign and most are statistically significant[2]. The overall goodness of fit is 60% that is

[1] We dropped from the models the "household reference person" age, as it did not produce any statistically significant estimates. We also dropped the number of dwelling occupants, as it introduced multicollinearity, being highly correlated with number of bedrooms, number of children, number of elderly persons and income among other variables.
[2] The null hypothesis of homoskedasticity was rejected at the 99% level, hence we used White's (1980) robust standard errors correcting for heteroskedasticity.

consistent and a bit higher to studies with similar data/models, such as Baker et al. (1989) with 34% - 41% overall model fit and Larsen and Nesbakken (2004) with 48%.

To visualise the expenditure changes during the study period, we graph the energy expenditure estimate of our pooled model along the real energy prices and GDP, all adjusted to an index value of 100 in 2006. This is presented in Figure 2, where the black line is the estimate of our model. We see energy expenditure to soaring in 2008 and 2009, much closer to the gas prices levels than anything else, not been affected by falling oil prices in 2009. As seen in section two, the continuing gas price increases after the summer of 2008 could be attributed to the Russia–Ukraine gas dispute, which seems to have significantly affected energy expenditure in the UK. Furthermore, the soaring energy expenditure levels shown here can be expect to cut into the household income levels that are not increasing with the same rate if not reducing due to the economic crisis. The next section will further examine this issue, constructing annual models to determine whether there are any patterns of adaptation/adjustment by the households.

Figure 2 is just for expositional purposes and is not as accurate as we would have liked, keeping in mind the peculiar annual nature of our data, the year starting from April and finishing in March.

As expected, the coefficient of income in the pooled model is positive and statistically significant at the 99% level. The resulting income elasticity of 0.021 is in line with the 0.01-0.04 estimates of Meier and Rehdanz (2010) for the UK, as well as many other studies in the literature (Albertini et al, 2011; Bernard, 2010; Rehdanz, 2007; Narayan and Smyth, 2005; Nesbakken, 1999). As seen in section 3, this low income elasticity value denotes very limited adjustments in energy expenditure spending from changes in household income levels.

Table 1 presents the annual marginal effects of the remaining continuous socioeconomic variables in our model. For example, an extra child will on average increase the annual energy expenditure of the household by £167.78. This effect is in line with the theory, where a child requires more time at home by the adults and commonly found in the literature (Meier and Rehdanz 2010; Baker et al. 1989).

Figure 2: Energy prices, modelled energy expenditure and GDP, 2006=100

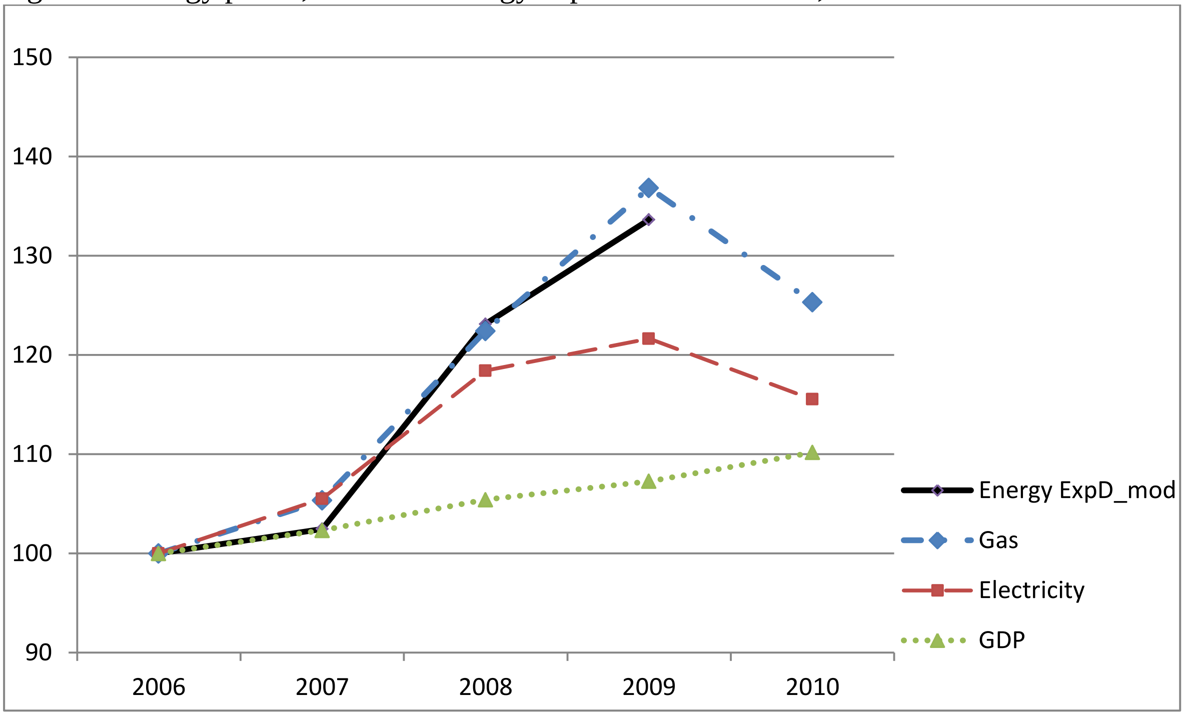


Table 1: Annual marginal effects of socioeconomic household characteristics

Variable	Annual marginal effect on an average dwelling size
Number of children	£167.78***
Number of people over 60	£35.09***
Number of families in a dwelling	£132.57***
Length of residence in years	£5.45***

*** significant at $p < 0.01$; ** significant at $p < 0.05$; * significant at $p < 0.1$

A household that has an additional person over 60, compared to a similar household ceteris paribus, can be expected to spend £35 more annually in energy bills. This consistent with Liao and Chang (2002) who find that the elderly require more natural gas and fuel oil but less electricity, the demand for space heating increases as the elderly get older.

In multi-family dwellings, an extra family can raise energy expenditure by £133. The length of residence in a particular dwelling on average raises energy expenditure by £5.45 for an extra year of staying in the same house. This can be attributed to lengthy tenures limiting the chances of renovations and house improvements.

The coefficient (β) for each of the dummy variables in the pooled model (Appendix 2) can be interpreted as the relative effect (% change) on annual energy expenditure per square meter compared to the base category. However, the correction of Halvorsen and Palmquist (1980) is first applied, since the relative effect of a dummy variable in a logarithmic functional form is not its coefficient β, but ($e^{\beta} - 1$). The interpretation of these effects can be confusing, thus we estimate for the average dwelling size, the annual value in £s for most effects. Table 2 presents the monetary values of these effects for a dwelling of average size (86 m^2) in relation to the base category.

Occupation is very important for energy expenditure, as it affects income and time spent at home. The expected effect of higher energy expenditure when in unemployment is recovered here. Having controlled for the number of elderly people, we find that retirement reduces energy expenditure. We agree with Meier and Rehdanz (2010), who attribute this finding to tighter income constraints. Part-time work seems to push down expenditure, possibly also due to income effects. Other occupation categories do not have a statistically significant effect.

Private renters pay on average £31 annual more than owner occupiers. This is due to incentive asymmetry between tenant and landlord, with the latter having no incentive to improve energy efficiency in a rented dwelling that someone else pays the energy bills for. Rehdanz (2007) finds the same incentive asymmetry in Germany. Conversely, Meier and Rehdanz (2010) in their UK data find owner occupiers paying more, which is attributed to higher energy expenditure for this group. However, in her previous paper Rehdanz (2007) contended that this result (owner occupiers paying more) in other studies (e.g. Baker et al., 1989) was due to missing information/variables and proxy unobservables, as also Baker et al. (1989) noted, and we agree.

Even more interestingly, Local Authority (LA) owned and Registered Social Landlord (RSL) dwellings have on average lower energy expenditure than owner occupied dwellings. This could be attributed to these variables picking up unobservables, possibly income effects and/or some LAs and RSLs may have programs for dwelling improvements that for example provide incentives to have the properties insulated. We do not have data to confirm such conjecture.

Table 2: Annual values of socioeconomic and dwelling characteristics compared to the base category for the average dwelling size

Occupation of the household reference person					
Fulltime work	Part-time work	Retired	Unemployed	Fulltime-edu	Other
base category	-£13.41**	-£33.50***	£22.92***	£19.89	-£3.35
Tenure					
Owner occupant	Rented	LA owned	RSL		
base category	£30.95***	-£59.06***	-£61.31***		
Construction period of the dwelling					
Post-1990	1981-90	1965-81	1945-64	1919-44	Pre-1919
base category	£122.62***	£206.15***	£319.48***	£435.54***	£468.46***
Dwelling type					
Semi-detached	Terraced	Detached	Flat		
base category	-£93.69***	£54.00***	-£175.22***		
Extend of double glazing (DG)					
No DG	DG < 50%	DG >50%	Full DG		
base category	-£28.608***	-£101.279***	-£124.141***		
Type of fuel and heating system/equipment					
Gas central heating	Electric storage heater	Electric all other systems	Other fuel		
base category	£196.30***	£897.74***	£90.72***		
Age of the heating system/equipment					
age<3 years	3 yrs<age<12yrs	age > 12 years			
base category	£54.20***	£147.88***			
Loft insulation					
Insulated Loft	Non-insulated Loft	No loft			
base category	£132.48***	-£68.50***			
Electricity payment method					
Direct Debit	Standard credit	Prepayment meter			
base category	£62.89***	£91.31***			
Gas payment method					
Direct Debit	Standard credit	Prepayment meter	No gas		
base category	£59.18***	£97.57***	£112.05***		

*** significant at $p < 0.01$; ** significant at $p < 0.05$; * significant at $p < 0.1$

As expected, insulation has very significant effect on energy expenditure. Even partial coverage of double glazing can make a difference and an un-insulated loft can be very costly in terms of energy expenditure. Other housing characteristics also have a very considerable effect on energy expenditure. As seen in Table 2, the construction period of the building can have a major contribution to energy expenditure, especially for older buildings.

The effects of dwelling type on energy expenditure are significant and consistent with Table 3 that shows the average heat loss of each dwelling type and with the literature (e.g. Meier and Rehdanz, 2010). This justifies the difference of £229 between detached houses and flats in energy spending per year.

Table 3: Typical average heat loss of dwelling types

Type of dwelling	Heat loss (Watt/°C)
Detached	365
Semi-detached	276
Terraced	243
Flat	182

Source: Shorrock and Utley (2003, p. 34).

Looking at dwelling attributes not in Table 2, an attic or basement can have a considerable effects, as it provides insulation and reduce the per square meter energy expenditure, as they are often not heated. Houses in higher council tax bands show lower expenditure levels. This may pickup otherwise unobservable characteristics or missing information on construction and equipment quality. The bedroom number in the pooled model captures decreasing energy expenditure per square meter in larger dwellings.

Concerning regional effects, South West has on average the lowest energy expenditure, with South East that is the base category a far second. West Midlands, Yorkshire and North East in turn exhibit the highest expenditure. These effects are consistent with weather conditions, with colder areas showing the higher energy spending. London is the exception to this, having on average the highest expenditure of all regions, which could only be accounted for as a localised effect of London, possibly due to higher income levels per square meter of dwelling or price effects. We also find a small positive effect, of £9.11 annually on average, for dwellings in suburban residential area, compared to an urban/city-centre area. We cannot recover a statistically significant effect for houses in a rural area.

Another major factor in determining energy expenditure has to be the fuel and heating equipment type and indeed it is. The highest contributor to energy expenditure in the whole model is heating the dwelling with an electric portable or fixed room heater, which can cost annually on average almost £900 more than gas central heating. The age of the heating system/equipment is also important, with an older system inflating annual energy expenditure by almost £150.

A key finding here, not commonly looked at in the literature, is that the payment method of energy bills can amount to a significant additional cost over the annual energy expenditure. This annual cost is over £90 when a prepay meter is used instead of the direct debit method. A pricing strategy by suppliers, controlling for the risk of non-payments, might well be the reason for this. However, some households can get into vicious circle of extra cost, due to their trouble paying, which contributes further to having trouble paying the bills.

5.2. Yearly Models of Energy Expenditure

As mentioned in section 5.1, we want to construct annual models in order to determine whether there are any patterns of adaptation/adjustment by the households. Before we proceed to discussing the results, we first need to test whether the annual models are statistically different form each other or we have to content with just the pooled model. The Chow test[3] (Chow, 1960) is employed of whether the coefficients in two linear regressions on different data sets are equal and the results are in Table 3. Hence, we can reject at the 99% level the null hypothesis of equality between the regression coefficients of all yearly expenditure models.

Table 4: Chow F-tests for differences across yearly expenditure models

	2006/07	2007/08	2008/09
2006/07			
2007/08	13.080***		
2008/09	68.010***	59.640***	
2009/10	130.340***	116.740***	15.700***

*** significant at p < 0.01; ** significant at p < 0.05; * significant at p < 0.1

[3] $F = \frac{(e_S-(e_1+e_2))/k}{(e_1+e_2)/(N_1+N_2-2k)}$ (df: N_1+N_2-2k). Where e_s is sum of squared residuals from the combined data, e_1 be the sum of squared residuals from the first group, and e_2 be the sum of squared residuals from the second group. N_1 and N_2 are the number of observations in each group and k is the total number of parameters.

It is noted in the literature that studies of cross-sectional (e.g. Filippini and Pachauri, 2004) as well as panel (e.g. Meier and Rehdanz, 2010; Rehdanz, 2007) micro-data break up their pooled models usually across regions or years without providing any formal statistical testing for this.

The resulting annual models for the 4 years of our study period are found in Appendix 3 to Appendix 6, from earlier to latter year. Looking at the models, the overall goodness of fit is over 53% in all cases and all coefficients are of the correct sign. Smaller data samples mean that the precision of some estimates is lost, so there will be a few more coefficients not statistically significant than in the pooled model. However, the vast majority of the important and highly statistically significant effects discuss in section 5.1 remain relatively stable and statistically significant in all annual models. The objective in this section is not to go through 5 models and compare random coefficient differences that can be well explain by the different samples used. As mentioned in previous sections, we want to examine whether there are any patterns of adaptation/adjustment by the households over the study period, given the background of energy price movements in section 2. Hence, looking at the annual models, we can pick up three effects that seem to have a pattern over the study period, consistent to the theory and the background.

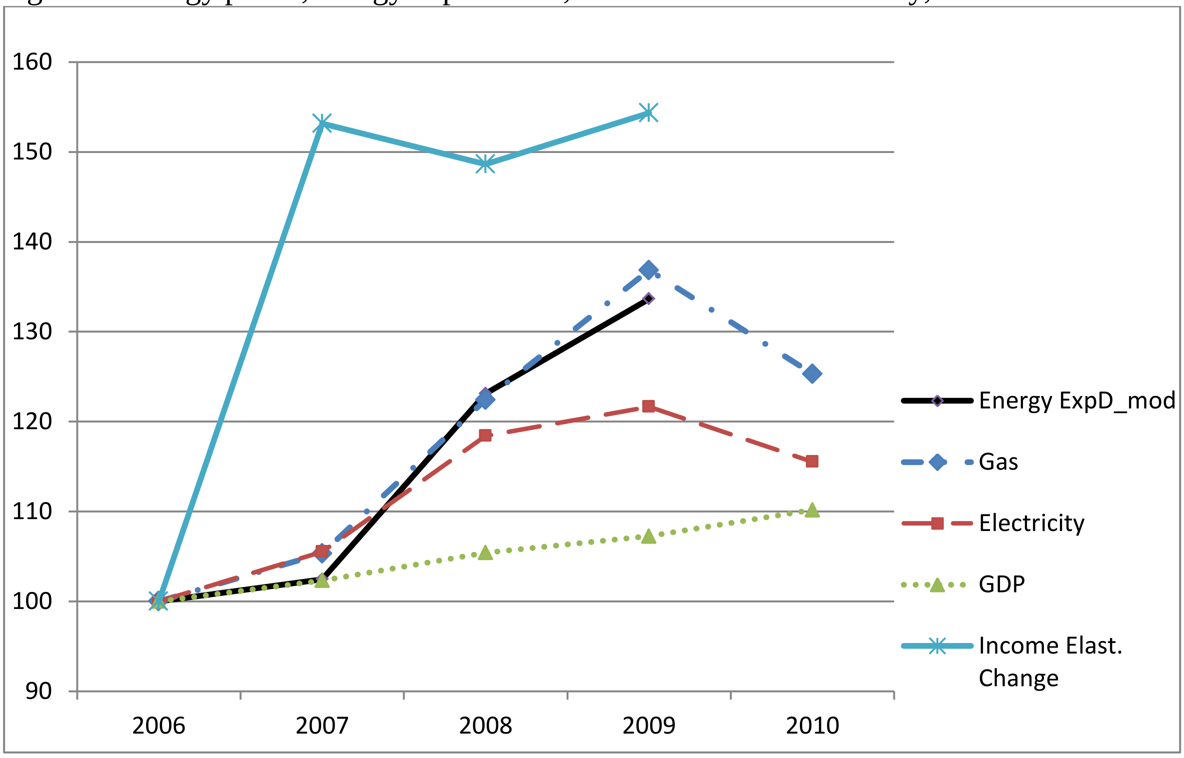
The first observable pattern in our results is the income elasticity increase. From 0.0158 2006/07 it rises by about 50% and keeps that level consistently in the following 3 years ranging from 0.0234 to 0.0243. To illustrate this, we include this income elasticity change in our standard price graph by transforming the 2006/07 elasticity to 100.

The resulting Figure 3 demonstrates the extent of this change, compared to the price and expenditure changes in the study period. This is consistent with the expectation that soaring energy expenditure cuts into the household income levels that are increasing by a much slower same rate. This denotes a reduction in disposable income, budget constraints becoming stringent that in turn affect the household sensitivity to changes in energy prices.

The increased sensitivity to soaring energy prices was demonstrated in Reiss and White (2008) and Bushnell and Mansur (2005). Even though the low income elasticity value denotes very limited adjustments in energy expenditure spending from changes in household income levels. We show here that there is a significant increase in these adjustments, following energy prices increases and a background of world economic crisis.

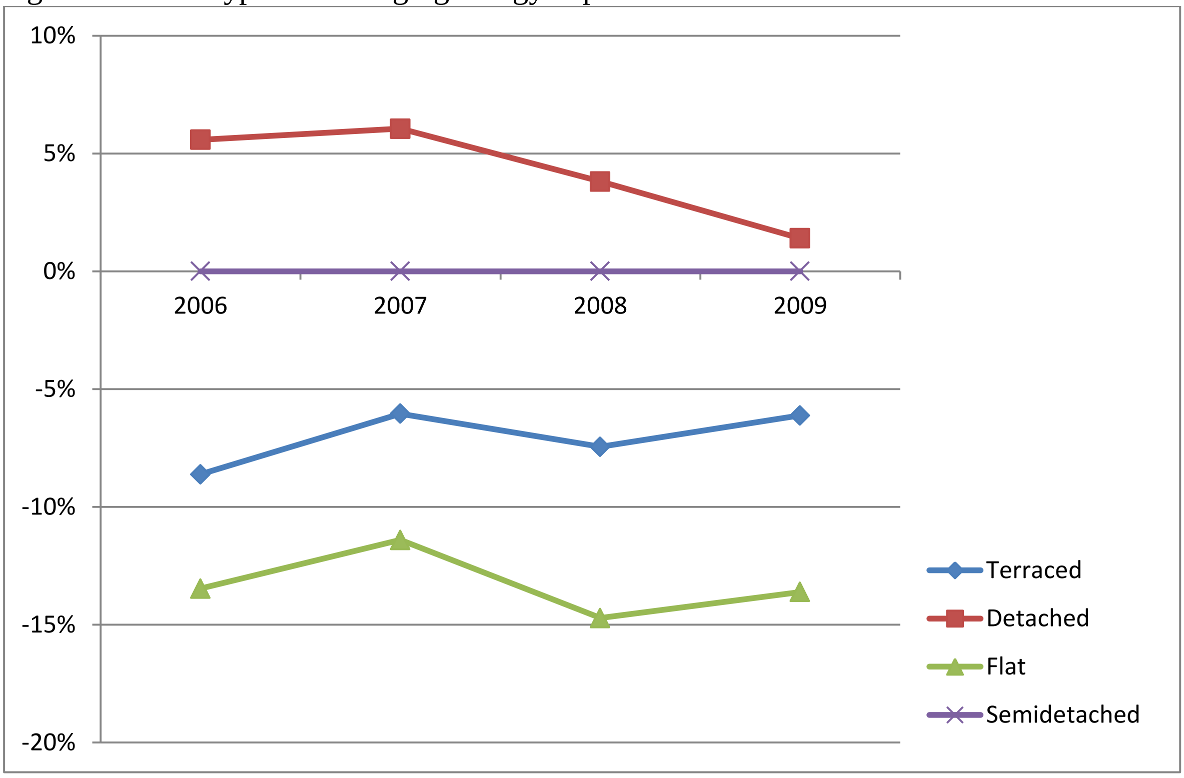
Income elasticity seems to jump up before the other indices; the peculiar annual nature of our data may play a role here, since 2007 in the Figure 3 is April 2007 to March 2008. In the latter part of this period the financial turmoil started to become apparent, as seen in section 2.

Figure 3: Energy prices, energy expenditure, GDP and income elasticity, 2006=100



Dwelling type is another attribute we look to for patterns over the time period. We illustrate the percentage changes of each house type compared to the base category (semi-detached) over the study period in Figure 4. There does not seem to be a distinct pattern in the energy expenditure of terraced and flats, compared to semi-detached houses. However, energy expenditure seems to distinctly sloping downwards after 2007/08 in detached dwellings, compared to semi-detached and indeed all house types. This is an interesting finding. One possibility might be that energy expenditure for some of these households started to gain some significance in their budget, only after the effects of the economic crisis. Another explanation might be that detached dwellings have on average more space and rooms, so those households can more easily (say than a flat) adjust their energy expenditure, without reducing thermal comfort to inhabitable levels (e.g. reduce or stop heating certain rooms/areas).

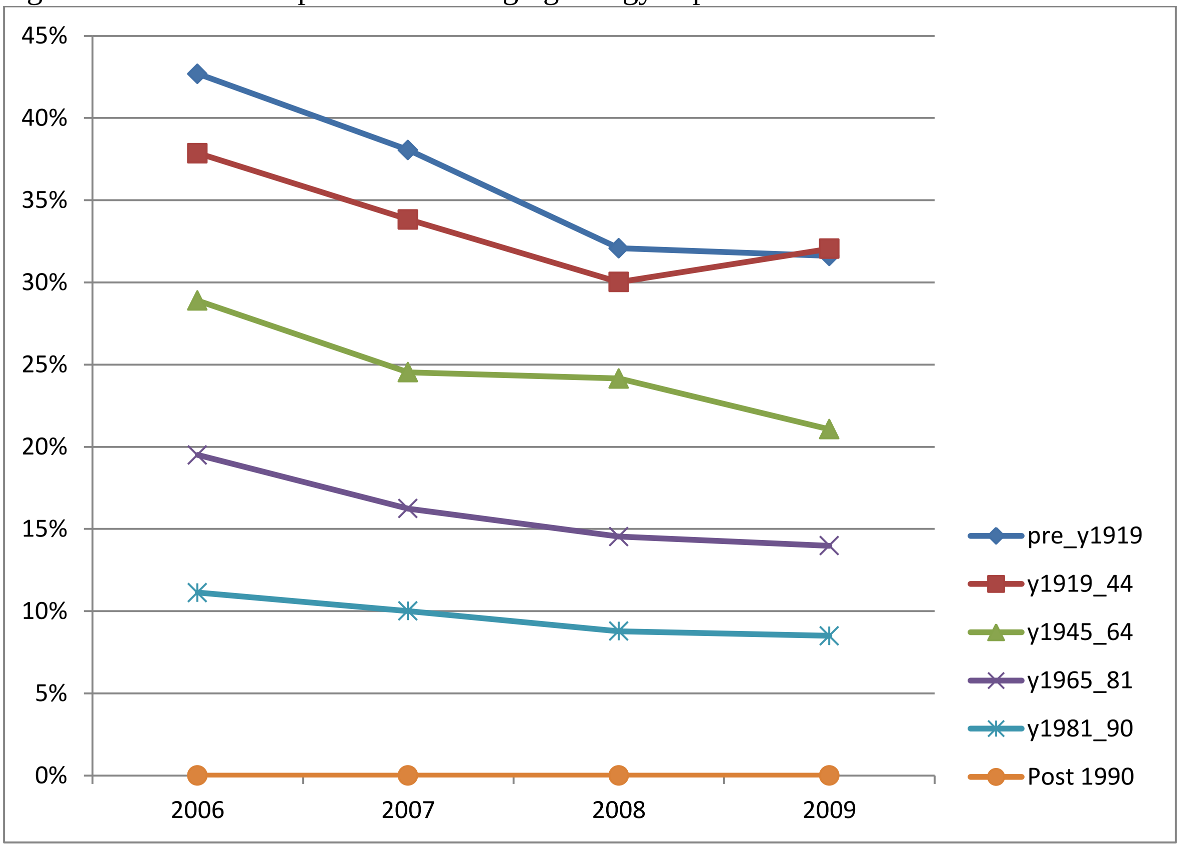
Figure 4: House type and changing energy expenditure



Looking at the effects of construction period and changing energy expenditure, the percentage changes of each period from the base category (after 1990) are illustrated in Figure 5. The decline in energy expenditure in buildings of older construction is much steeper to newer dwelling. For example, energy expenditure drops during the study by more than 10% in pre 1919 buildings, compared to dwellings built after 1990. Even after this reduction in energy expenditure of older buildings, there is still considerable capacity for improvement.

This is an issue where new policy initiatives can focus and it does not require any cutting edge technology or technological progress. This is illustrated by Bell and Lowe (2000) examining the energy-saving results of a demonstration project of low rise housing modernisation in York. They indicate that modernisation schemes can be important in reducing CO_2 emissions and that improvements in the region of 50% can be achieved at modest cost using well proven early 1980s technology. Adapting older buildings closer to modern standards huge benefits, given more than 80% of buildings in our data were constructed before 1980 and only about 10% after 1990.

Figure 5: Construction period and changing energy expenditure



6. Conclusions and Recommendations

Investment in energy efficiency is an important policy target area (DECC, 2010), with the domestic sector being a major contributor to the total UK energy consumption, but also having potential for significant reductions (DCLG, 2007; DECC, 2009; DECC, 2011a).

This study estimated econometric models for the domestic energy expenditure in the UK, producing interesting and policy relevant results by exploiting gaps in the literature. We also consider the significant events in the recent years that have directly and indirectly affected domestic energy use, such as the soaring oil and energy prices, the subsequent economic crisis and the Russia–Ukraine gas dispute.

All the models had very good overall goodness of fit. We derive estimates for key socioeconomic effects on energy expenditure, but also focus on how dwelling attributes affect on energy spending. Nonetheless, due to data limitations, we cannot examine any energy price or temperature variation, beyond the use of dummy variables for the region and the year of data collection.

Socioeconomic characteristics, such as occupation, number of children and elderly in the household, number of families in a dwelling and length of residence in dwelling, have a statistically significant effect in our pooled model and are in line with the literature (Meier and Rehdanz 2010; Baker et al. 1989; Liao and Chang, 2002). We also find evidence of incentive asymmetry between tenants and landlords that is theoretically consistent, with private renters paying more than owner occupiers.

An income elasticity of 0.021 is estimated, which is in line with the literature (Albertini et al, 2011; Bernard, 2010; Meier and Rehdanz, 2010; Rehdanz, 2007; Narayan and Smyth, 2005; Nesbakken, 1999). This low income elasticity denotes very limited adjustments in energy expenditure spending from changes in household income levels. However, we show here that there is a 50% increase in income elasticity, following the soaring energy prices and a background of world economic crisis.

Highlighting some of the housing characteristics' effects, energy expenditure is significantly affected by the type of dwelling. Furthermore, detached houses seem to have more capacity for reducing energy expenditure than other house types, when households are faced with soaring energy prices and an economic downturn. A major factor in determining energy expenditure is the fuel and heating equipment type and age of the heating equipment. Insulation has also a significant effect on energy expenditure.

As expected, older buildings in our models increase considerably the annual energy expenditure. The important finding here concerns the periods when households are faced with energy price increases and economic downturn. During those periods in our data, the decline of energy expenditure in buildings of older construction is much steeper than newer dwellings. For example, energy expenditure reduction reaches 11% in older buildings compared to the newer. Notwithstanding this energy expenditure decline in older buildings, there is still considerable capacity for improvement.

Another key finding in this study is that the payment method of energy bills can amount to a significant additional cost over the annual energy expenditure. This is expected to affect households in the lower income groups and can contribute to fuel poverty.

A number of policy recommendations and priorities come out of this study, highlighting a few in order of importance:

- Heating fuel and equipment is a major issue, with electric portable or fixed room heaters having the by far highest impact on energy expenditure from any other attribute. There ought to be a policy strategy specifically against the use of such equipment as the main heating system. A related issue is the age of the heating system that is also shown to have a considerable effect on energy expenditure.

- A corollary is the significant capacity for energy expenditure reductions in old buildings. Adapting older buildings closer to modern standards can have huge benefits, given that the majority of the housing stock in the UK was constructed before 1980.

- An obvious policy priority is insulation (either double glazing or loft insulation) that has a significant effect on energy expenditure.

- Socially orientate policies can target the issue of the additional cost of different payment methods. This can amount to a considerable additional cost over the annual energy expenditure and is expected to affect household in the lower income groups that are prone to fuel poverty, exacerbating these effects.

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APPENDIX 1: DATA DESCRIPTION

Variable	Variable Description	Mean	S.D.	Min	Max
expd_cpi	total annual energy cost adjusted to 2006 price levels	1281	549	376	13747
floorx	useable floor area of the dwelling in square meters	86.22	46.52	8.5	1160.5
expd_cpisq	expd_cpi per square meter	16.15	5.77	3.31	83.98
ln_expdcpisq	natural logarithm of expd_cpisq	2.726	0.332	1.20	4.43
fpfullinc	full household annual income adjusted to 2006 prices	25050	20355	15	551585
ln_fpfullinc	natural logarithm of full annual income	9.905	0.673	2.71	13.22
fulltime_work	1 for HRP^ in full time occupation, 0 otherwise	0.450	0.498	0	1
parttime_work	1 for HRP^ in part time occupation, 0 otherwise	0.085	0.279	0	1
retired	1 for a retired HRP^, 0 otherwise	0.293	0.455	0	1
unemployed	1 for a unemployed HRP^, 0 otherwise	0.039	0.194	0	1
fulltime_edu	1 for an HRP^ in full time education, 0 otherwise	0.013	0.115	0	1
other_occup	1 for all other occupations^^, 0 otherwise	0.119	0.324	0	1
famnumx	Number of families living in a dwelling	1.084	0.386	1	8
ln_fam_num	natural logarithm of famnumx	0.051	0.208	0	2.08
depchild	number of dependent children in the household	0.588	1.009	0	9.00
ln_dep_child	natural logarithm of depchild	0.318	0.495	0	2.30
olderx	number of people over 60 living in the household	0.506	0.725	0	2.00
ln_older60	natural logarithm of olderx	0.311	0.424	0	1.10
lenres	length of residence of HRP^ in the dwelling	13.44	13.67	0	94
ln_len_res	natural logarithm of lenres	2.123	1.121	0	4.55
nbedsx	number of bedrooms	2.675	1.477	0	10
ln_n_beds	natural logarithm of nbedsx	1.260	0.288	0	4.61
owner occu	1 for owner occupied dwellings, 0 otherwise	0.513	0.394	0	1
rented	1 for private rented dwellings, 0 otherwise	0.150	0.357	0	1
LA_owned	1 for Local Authority owned dwellings, 0 otherwise	0.181	0.385	0	1
RSL	1 for Registered Social Landlord dwellings	0.156	0.363	0	1
SouthEast	1 for a dwelling in the South East, 0 otherwise	0.155	0.362	0	1
NorthEast	1 for a dwelling in the North East, 0 otherwise	0.058	0.235	0	1
Yorkshire	1 for a dwelling in Yorkshire, 0 otherwise	0.120	0.325	0	1
NorthWest	1 for a dwelling in the North West, 0 otherwise	0.143	0.350	0	1
EastMidlands	1 for a dwelling in East Midlands, 0 otherwise	0.089	0.285	0	1
WestMidlands	1 for a dwelling in West Midlands, 0 otherwise	0.098	0.297	0	1
SouthWest	1 for a dwelling in the South West, 0 otherwise	0.102	0.303	0	1
EastofEngland	1 for a dwelling in the East of England, 0 otherwise	0.105	0.307	0	1
London	1 for a dwelling in London, 0 otherwise	0.129	0.336	0	1
Urban_CC	1 for a dwelling in Urban/City Centre area	0.223	0.416	0	1
Suburban	1 for a dwelling in Suburban/residential area	0.604	0.489	0	1
Rural	1 for a dwelling in a rural area, 0 otherwise	0.174	0.379	0	1
semidetached	1 for a semidetached house, 0 otherwise	0.257	0.437	0	1
terraced	1 for a terraced house, 0 otherwise	0.294	0.455	0	1
detached	1 for a detached house, 0 otherwise	0.238	0.426	0	1
flat	1 for a flat, 0 otherwise	0.211	0.408	0	1
prey1919	1 for a dwelling built before 1919, 0 otherwise	0.183	0.386	0	1
y1919_44	1 for a dwelling built 1919-1944 , 0 otherwise	0.165	0.371	0	1

Variable	Variable Description	Mean	S.D.	Min	Max
y1945_64	1 for a dwelling built 1945-1964, 0 otherwise	0.233	0.423	0	1
y1965_81	1 for a dwelling built 1965-1981, 0 otherwise	0.230	0.421	0	1
y1981_90	1 for a dwelling built 1981-1990, 0 otherwise	0.086	0.280	0	1
posty1990	1 for a dwelling built after 1990, 0 otherwise	0.103	0.303	0	1
nodblglaz	1 for a dwelling with no double glazing, 0 otherwise	0.108	0.310	0	1
dblglazL50	1 for under 50% double glazing, 0 otherwise	0.059	0.236	0	1
dblglazM50	1 for 50-99% double glazing, 0 otherwise	0.118	0.323	0	1
dblglazALL	1 for a dwelling with full double glazing, 0 otherwise	0.715	0.451	0	1
attic	1 for a dwelling with atic, 0 otherwise	0.079	0.269	0	1
basement	1 for a dwelling with basement, 0 otherwise	0.013	0.113	0	1
CentralH_gas	1 for a dwelling with gas central heating, 0 otherwise	0.825	0.380	0	1
Stor_el	1 for a dwelling with electric storage heating	0.074	0.262	0	1
el_other	1 for portable or fixed room electric heater	0.015	0.123	0	1
OF_other	1 for a dwelling with all other types of heating	0.072	0.258	0	1
less3years	1 for boiler/eating system newer than 3 years	0.253	0.435	0	1
y3to12years	1 for boiler/eating system 3-12 year old, 0 otherwise	0.402	0.490	0	1
more12years	1 for boiler/eating system older than 12 years	0.345	0.475	0	1
Loftinsul	1 for a dwelling with insulated loft , 0 otherwise	0.842	0.383	0	1
LoftNOinsul	1 for a dwelling with un-insulated loft , 0 otherwise	0.028	0.166	0	1
Noloft	1 for a dwelling with no loft , 0 otherwise	0.130	0.336	0	1
EMOPdirectd	1 for direct debit electricity payment method	0.511	0.500	0	1
EMOPstandard	1 for standard credit electricity payment method	0.282	0.450	0	1
EMOPprepaid	1 for electricity pre-payment method, 0 otherwise	0.208	0.406	0	1
GMOPdirectd	1 for direct debit gas payment method, 0 otherwise	0.461	0.498	0	1
GMOPstandard	1 for standard credit gas payment method, 0	0.246	0.430	0	1
GMOPprepaid	1 for gas pre-payment method, 0 otherwise	0.161	0.367	0	1
nogas	1 for no gas, 0 otherwise	0.133	0.348	0	1
CTB_A	1 for council tax band A, 0 otherwise	0.318	0.466	0	1
CTB_B	1 for council tax band B, 0 otherwise	0.201	0.400	0	1
CTB_C	1 for council tax band C, 0 otherwise	0.204	0.403	0	1
CTB_D	1 for council tax band D, 0 otherwise	0.131	0.338	0	1
CTB_E	1 for council tax band E, 0 otherwise	0.080	0.271	0	1
CTB_F	1 for council tax band F, 0 otherwise	0.040	0.196	0	1
CTB_G	1 for council tax band G, 0 otherwise	0.025	0.156	0	1
CTB_H	1 for council tax band H, 0 otherwise	0.002	0.048	0	1
y06_07	1 for data collected 04/2006-03/2007, 0 otherwise	0.243	0.429	0	1
y07_08	1 for data collected 04/2007-03/2008, 0 otherwise	0.254	0.435	0	1
y08_09	1 for data collected 04/2008-03/2009, 0 otherwise	0.244	0.430	0	1
y09_10	1 for data collected 04/2009-03/2010, 0 otherwise	0.253	0.435	0	1

^HRP: household reference person. ^^All others, including permanently sick or disabled, those looking after the family or home.

APPENDIX 2: THE POOLED EXPENDITURE MODEL

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	Coef (β)	S.E. ^	t	P>t	95% Conf. Interval		exp(β)-1*
ln_fpfullinc	0.0211	0.0027	7.95	0	0.016	0.026	N/A
parttime_work	-0.0102	0.0046	-2.23	0.026	-0.019	-0.001	-0.0102
retired	-0.0257	0.0053	-4.90	0	-0.036	-0.015	-0.0254
unemployed	0.0172	0.0064	2.68	0.007	0.005	0.030	0.0174
fulltime_edu	0.0150	0.0124	1.21	0.228	-0.009	0.039	0.0151
other_occup	-0.0025	0.0042	-0.60	0.547	-0.011	0.006	-0.0025
ln_fam_num	0.1006	0.0065	15.45	0	0.088	0.113	N/A
ln_dep_child	0.1273	0.0031	41.72	0	0.121	0.133	N/A
ln_older60	0.0266	0.0053	5.06	0	0.016	0.037	N/A
ln_len_res	0.0041	0.0015	2.79	0.005	0.001	0.007	N/A
ln_n_beds	-0.4137	0.0120	-34.37	0	-0.437	-0.390	N/A
rented	0.0232	0.0044	5.30	0	0.015	0.032	0.0235
LA_owned	-0.0458	0.0043	-10.54	0	-0.054	-0.037	-0.0448
RSL	-0.0476	0.0043	-11.17	0	-0.056	-0.039	-0.0465
NorthEast	0.0155	0.0063	2.48	0.013	0.003	0.028	0.0157
Yorkshire	0.0172	0.0052	3.31	0.001	0.007	0.027	0.0173
NorthWest	0.0067	0.0049	1.38	0.168	-0.003	0.016	0.0068
EastMidlands	0.0071	0.0055	1.29	0.196	-0.004	0.018	0.0072
WestMidlands	0.0458	0.0050	9.12	0	0.036	0.056	0.0468
SouthWest	-0.0422	0.0051	-8.20	0	-0.052	-0.032	-0.0413
EastofEngland	0.0111	0.0050	2.23	0.026	0.001	0.021	0.0111
London	0.0590	0.0052	11.45	0	0.049	0.069	0.0608
Suburban	0.0069	0.0033	2.10	0.036	0.000	0.013	0.0069
Rural	0.0013	0.0048	0.26	0.795	-0.008	0.011	0.0013
terraced	-0.0737	0.0034	-21.90	0	-0.080	-0.067	-0.0711
detached	0.0401	0.0043	9.35	0	0.032	0.049	0.0410
flat	-0.1426	0.0063	-22.54	0	-0.155	-0.130	-0.1329
prey1919	0.3041	0.0055	55.76	0	0.293	0.315	0.3554
y1919_44	0.2855	0.0051	55.75	0	0.275	0.296	0.3304
y1945_64	0.2170	0.0048	45.28	0	0.208	0.226	0.2424
y1965_81	0.1453	0.0046	31.45	0	0.136	0.154	0.1564
y1981_90	0.0890	0.0055	16.25	0	0.078	0.100	0.0930
dblglazL50	-0.0219	0.0067	-3.29	0.001	-0.035	-0.009	-0.0217
dblglazM50	-0.0800	0.0056	-14.34	0	-0.091	-0.069	-0.0768
dblglazALL	-0.0989	0.0045	-22.15	0	-0.108	-0.090	-0.0942
attic	-0.1090	0.0055	-19.69	0	-0.120	-0.098	-0.1033
basement	-0.1256	0.0137	-9.18	0	-0.152	-0.099	-0.1181
Stor_el	0.1388	0.0095	14.65	0	0.120	0.157	0.1489
el_other	0.5194	0.0135	38.41	0	0.493	0.546	0.6811
OF_other	0.0666	0.0100	6.68	0	0.047	0.086	0.0688
y3to12years	0.0403	0.0030	13.46	0	0.034	0.046	0.0411

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E. ^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
more12years	0.1063	0.0032	32.86	0	0.100	0.113	0.1122
LoftNOinsul	0.0958	0.0085	11.31	0	0.079	0.112	0.1005
Noloft	-0.0534	0.0055	-9.77	0	-0.064	-0.043	-0.0520
EMOPstandard	0.0466	0.0058	7.99	0	0.035	0.058	0.0477
EMOPprepaid	0.0670	0.0060	11.14	0	0.055	0.079	0.0693
GMOPstandard	0.0439	0.0059	7.38	0	0.032	0.056	0.0449
GMOPprepaid	0.0714	0.0062	11.58	0	0.059	0.083	0.0740
nogas	0.0816	0.0100	8.16	0	0.062	0.101	0.0850
CTB_B	-0.0233	0.0040	-5.86	0	-0.031	-0.016	-0.0231
CTB_C	-0.0512	0.0048	-10.72	0	-0.061	-0.042	-0.0499
CTB_D	-0.1209	0.0063	-19.31	0	-0.133	-0.109	-0.1139
CTB_E	-0.2018	0.0081	-25.00	0	-0.218	-0.186	-0.1827
CTB_F	-0.3175	0.0102	-31.01	0	-0.338	-0.297	-0.2720
CTB_G	-0.4205	0.0124	-33.82	0	-0.445	-0.396	-0.3433
CTB_H	-0.5942	0.0340	-17.46	0	-0.661	-0.528	-0.4480
y07_08	0.0243	0.0034	7.09	0	0.018	0.031	0.0246
y08_09	0.2080	0.0035	59.76	0	0.201	0.215	0.2312
y09_10	0.2900	0.0034	84.52	0	0.283	0.297	0.3365
_cons	2.7270	0.0295	92.33	0	2.669	2.785	N/A
R^2: 0.5987, F(59, 30866): 706.61, Prob > F: 0, Nobs: 30926							

^ White's (1980) robust standard errors correcting for heteroskedasticity.

* Halvorsen and Palmquist (1980) correction for the relative effect of a dummy variable in a semi-logarithmic functional from, which is not its coefficient β, as with continuous variables, but (e^{β} – 1).

APPENDIX 3: THE EXPENDITURE MODEL OF 2006/07

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E.^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
ln_fpfullinc	0.01576	0.00529	2.98	0.003	0.005	0.026	N/A
parttime_work	-0.01980	0.00967	-2.05	0.041	-0.039	-0.001	-0.0196
retired	-0.02187	0.01092	-2	0.045	-0.043	0.000	-0.0216
unemployed	0.02842	0.01377	2.06	0.039	0.001	0.055	0.0288
fulltime_edu	0.00141	0.02608	0.05	0.957	-0.050	0.053	0.0014
other_occup	-0.00214	0.00851	-0.25	0.802	-0.019	0.015	-0.0021
ln_fam_num	0.11998	0.01308	9.17	0	0.094	0.146	N/A
ln_dep_child	0.12273	0.00585	20.99	0	0.111	0.134	N/A
ln_older60	0.01885	0.01094	1.72	0.085	-0.003	0.040	N/A
ln_len_res	0.00410	0.00287	1.43	0.153	-0.002	0.010	N/A
ln_n_beds	-0.41819	0.01538	-27.19	0	-0.448	-0.388	N/A
rented	0.01953	0.00909	2.15	0.032	0.002	0.037	0.0197
LA_owned	-0.04647	0.00848	-5.48	0	-0.063	-0.030	-0.0454
RSL	-0.05802	0.00890	-6.52	0	-0.075	-0.041	-0.0564
NorthEast	0.01498	0.01302	1.15	0.25	-0.011	0.040	0.0151
Yorkshire	0.01935	0.01104	1.75	0.08	-0.002	0.041	0.0195
NorthWest	0.02689	0.01043	2.58	0.01	0.006	0.047	0.0273
EastMidlands	0.00532	0.01152	0.46	0.644	-0.017	0.028	0.0053
WestMidlands	0.04889	0.01052	4.65	0	0.028	0.070	0.0501
SouthWest	-0.05353	0.01028	-5.21	0	-0.074	-0.033	-0.0521
EastofEngland	0.01702	0.01000	1.7	0.089	-0.003	0.037	0.0172
London	0.08353	0.01080	7.73	0	0.062	0.105	0.0871
Suburban	0.01187	0.00672	1.76	0.078	-0.001	0.025	0.0119
Rural	0.01063	0.01000	1.06	0.288	-0.009	0.030	0.0107
terraced	-0.09016	0.00681	-13.24	0	-0.104	-0.077	-0.0862
detached	0.05434	0.00894	6.08	0	0.037	0.072	0.0558
flat	-0.14462	0.01224	-11.81	0	-0.169	-0.121	-0.1346
prey1919	0.35549	0.01220	29.13	0	0.332	0.379	0.4269
y1919_44	0.32108	0.01181	27.19	0	0.298	0.344	0.3786
y1945_64	0.25383	0.01140	22.27	0	0.231	0.276	0.2889
y1965_81	0.17813	0.01104	16.13	0	0.156	0.200	0.1950
y1981_90	0.10549	0.01266	8.33	0	0.081	0.130	0.1113
dblglazL50	-0.01465	0.01164	-1.26	0.208	-0.037	0.008	-0.0145
dblglazM50	-0.06612	0.01032	-6.41	0	-0.086	-0.046	-0.0640
dblglazALL	-0.09801	0.00794	-12.34	0	-0.114	-0.082	-0.0934
attic	-0.11055	0.01153	-9.59	0	-0.133	-0.088	-0.1047
basement	-0.10195	0.02543	-4.01	0	-0.152	-0.052	-0.0969
Stor_el	0.11301	0.02023	5.59	0	0.073	0.153	0.1196
el_other	0.52356	0.03203	16.35	0	0.461	0.586	0.6880
OF_other	0.06255	0.01862	3.36	0.001	0.026	0.099	0.0646
y3to12years	0.03365	0.00664	5.07	0	0.021	0.047	0.0342

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E.^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
more12years	0.08821	0.00669	13.18	0	0.075	0.101	0.0922
LoftNOinsul	0.10002	0.01480	6.76	0	0.071	0.129	0.1052
Noloft	-0.05854	0.01130	-5.18	0	-0.081	-0.036	-0.0569
EMOPstandard	0.04503	0.01108	4.06	0	0.023	0.067	0.0461
EMOPprepaid	0.06973	0.01191	5.85	0	0.046	0.093	0.0722
GMOPstandard	0.05359	0.01126	4.76	0	0.032	0.076	0.0550
GMOPprepaid	0.07822	0.01212	6.45	0	0.054	0.102	0.0814
nogas	0.08951	0.01984	4.51	0	0.051	0.128	0.0936
CTB_B	-0.02221	0.00832	-2.67	0.008	-0.039	-0.006	-0.0220
CTB_C	-0.05217	0.00975	-5.35	0	-0.071	-0.033	-0.0508
CTB_D	-0.11106	0.01240	-8.96	0	-0.135	-0.087	-0.1051
CTB_E	-0.19826	0.01564	-12.68	0	-0.229	-0.168	-0.1798
CTB_F	-0.29138	0.01907	-15.28	0	-0.329	-0.254	-0.2528
CTB_G	-0.41910	0.02492	-16.82	0	-0.468	-0.370	-0.3424
CTB_H	-0.61392	0.05932	-10.35	0	-0.730	-0.498	-0.4588
_cons	2.74823	0.05729	47.97	0	2.636	2.861	N/A
R^2: 0.5345, F(56, 7651): 149.96, Prob > F: 0, Nobs: 7708							

^ White's (1980) robust standard errors correcting for heteroskedasticity.

* Halvorsen and Palmquist (1980) correction for the relative effect of a dummy variable in a semi-logarithmic functional from, which is not its coefficient β, as with continuous variables, but (e^{β} – 1).

APPENDIX 4: THE EXPENDITURE MODEL OF 2007/08

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E.^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
ln_fpfullinc	0.0241	0.0052	4.61	0	0.014	0.034	N/A
parttime_work	-0.0102	0.0093	-1.1	0.27	-0.028	0.008	-0.0102
retired	-0.0241	0.0101	-2.38	0.017	-0.044	-0.004	-0.0238
unemployed	0.0114	0.0134	0.85	0.396	-0.015	0.038	0.0115
fulltime_edu	0.0403	0.0233	1.73	0.084	-0.005	0.086	0.0411
other_occup	-0.0110	0.0081	-1.35	0.176	-0.027	0.005	-0.0110
ln_fam_num	0.0770	0.0134	5.73	0	0.051	0.103	N/A
ln_dep_child	0.1223	0.0066	18.51	0	0.109	0.135	N/A
ln_older60	0.0224	0.0102	2.2	0.028	0.002	0.042	N/A
ln_len_res	0.0005	0.0032	0.16	0.87	-0.006	0.007	N/A
ln_n_beds	-0.3735	0.0329	-11.36	0	-0.438	-0.309	N/A
rented	0.0277	0.0093	2.96	0.003	0.009	0.046	0.0281
LA_owned	-0.0361	0.0086	-4.19	0	-0.053	-0.019	-0.0354
RSL	-0.0367	0.0087	-4.22	0	-0.054	-0.020	-0.0360
NorthEast	0.0433	0.0123	3.53	0	0.019	0.067	0.0443
Yorkshire	0.0346	0.0100	3.45	0.001	0.015	0.054	0.0352
NorthWest	0.0051	0.0101	0.5	0.616	-0.015	0.025	0.0051
EastMidlands	0.0123	0.0107	1.15	0.25	-0.009	0.033	0.0124
WestMidlands	0.0622	0.0099	6.27	0	0.043	0.082	0.0641
SouthWest	-0.0312	0.0105	-2.97	0.003	-0.052	-0.011	-0.0307
EastofEngland	0.0264	0.0096	2.75	0.006	0.008	0.045	0.0267
London	0.0699	0.0103	6.76	0	0.050	0.090	0.0724
Suburban	0.0098	0.0064	1.53	0.125	-0.003	0.022	0.0099
Rural	-0.0154	0.0094	-1.64	0.102	-0.034	0.003	-0.0153
terraced	-0.0623	0.0068	-9.21	0	-0.076	-0.049	-0.0604
detached	0.0587	0.0088	6.66	0	0.041	0.076	0.0605
flat	-0.1211	0.0143	-8.49	0	-0.149	-0.093	-0.1140
prey1919	0.3225	0.0105	30.6	0	0.302	0.343	0.3805
y1919_44	0.2914	0.0098	29.83	0	0.272	0.311	0.3383
y1945_64	0.2194	0.0091	24.15	0	0.202	0.237	0.2454
y1965_81	0.1505	0.0087	17.31	0	0.133	0.167	0.1624
y1981_90	0.0954	0.0110	8.7	0	0.074	0.117	0.1001
dblglazL50	-0.0297	0.0137	-2.18	0.029	-0.057	-0.003	-0.0293
dblglazM50	-0.0886	0.0107	-8.25	0	-0.110	-0.068	-0.0848
dblglazALL	-0.0955	0.0086	-11.07	0	-0.112	-0.079	-0.0911
attic	-0.1067	0.0113	-9.43	0	-0.129	-0.085	-0.1012
basement	-0.0858	0.0293	-2.93	0.003	-0.143	-0.028	-0.0822
Stor_el	0.1949	0.0182	10.73	0	0.159	0.231	0.2152
el_other	0.5286	0.0301	17.55	0	0.470	0.588	0.6966
OF_other	0.1104	0.0199	5.54	0	0.071	0.149	0.1167
y3to12years	0.0316	0.0060	5.27	0	0.020	0.043	0.0321

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E.^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
more12years	0.0901	0.0065	13.92	0	0.077	0.103	0.0943
LoftNOinsul	0.0860	0.0171	5.02	0	0.052	0.120	0.0898
Noloft	-0.0619	0.0113	-5.49	0	-0.084	-0.040	-0.0601
EMOPstandard	0.0494	0.0113	4.36	0	0.027	0.072	0.0506
EMOPprepaid	0.0818	0.0118	6.91	0	0.059	0.105	0.0852
GMOPstandard	0.0415	0.0115	3.62	0	0.019	0.064	0.0424
GMOPprepaid	0.0759	0.0120	6.35	0	0.052	0.099	0.0789
nogas	0.0532	0.0190	2.8	0.005	0.016	0.091	0.0547
CTB_B	-0.0192	0.0082	-2.35	0.019	-0.035	-0.003	-0.0190
CTB_C	-0.0548	0.0099	-5.56	0	-0.074	-0.036	-0.0534
CTB_D	-0.1350	0.0133	-10.12	0	-0.161	-0.109	-0.1263
CTB_E	-0.2173	0.0174	-12.5	0	-0.251	-0.183	-0.1953
CTB_F	-0.3503	0.0222	-15.8	0	-0.394	-0.307	-0.2955
CTB_G	-0.4530	0.0265	-17.13	0	-0.505	-0.401	-0.3643
CTB_H	-0.6121	0.0618	-9.91	0	-0.733	-0.491	-0.4578
_cons	2.6564	0.0571	46.54	0	2.544	2.768	N/A
R^2: 0.5553, F(56, 7787) 154.88, Prob > F: 0, Nobs: 7844							

^ White's (1980) robust standard errors correcting for heteroskedasticity.

* Halvorsen and Palmquist (1980) correction for the relative effect of a dummy variable in a semi-logarithmic functional from, which is not its coefficient β, as with continuous variables, but (e^{β} – 1).

APPENDIX 5: THE EXPENDITURE MODEL OF 2008/09

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	Coef (β)	S.E.^	t	P>t	95% Conf. Interval		exp(β)-1*
ln_fpfullinc	0.0234	0.0052	4.47	0	0.013	0.034	N/A
parttime_work	-0.0049	0.0089	-0.55	0.584	-0.022	0.013	-0.0049
retired	-0.0227	0.0105	-2.16	0.031	-0.043	-0.002	-0.0225
unemployed	-0.0012	0.0129	-0.09	0.928	-0.026	0.024	-0.0012
fulltime_edu	0.0260	0.0279	0.93	0.351	-0.029	0.081	0.0263
other_occup	0.0037	0.0088	0.43	0.67	-0.013	0.021	0.0037
ln_fam_num	0.0879	0.0127	6.9	0	0.063	0.113	N/A
ln_dep_child	0.1401	0.0058	24.2	0	0.129	0.151	N/A
ln_older60	0.0283	0.0107	2.64	0.008	0.007	0.049	N/A
ln_len_res	0.0057	0.0028	2.03	0.042	0.000	0.011	N/A
ln_n_beds	-0.4529	0.0147	-30.83	0	-0.482	-0.424	N/A
rented	0.0285	0.0086	3.31	0.001	0.012	0.045	0.0289
LA_owned	-0.0524	0.0090	-5.79	0	-0.070	-0.035	-0.0511
RSL	-0.0538	0.0084	-6.43	0	-0.070	-0.037	-0.0524
NorthEast	0.0174	0.0125	1.39	0.166	-0.007	0.042	0.0175
Yorkshire	0.0316	0.0104	3.03	0.002	0.011	0.052	0.0321
NorthWest	0.0131	0.0092	1.42	0.156	-0.005	0.031	0.0131
EastMidlands	0.0172	0.0109	1.58	0.114	-0.004	0.039	0.0173
WestMidlands	0.0531	0.0099	5.38	0	0.034	0.072	0.0546
SouthWest	-0.0356	0.0105	-3.4	0.001	-0.056	-0.015	-0.0350
EastofEngland	0.0148	0.0103	1.44	0.15	-0.005	0.035	0.0149
London	0.0245	0.0103	2.39	0.017	0.004	0.045	0.0248
Suburban	0.0021	0.0066	0.32	0.751	-0.011	0.015	0.0021
Rural	0.0114	0.0096	1.18	0.238	-0.008	0.030	0.0114
terraced	-0.0774	0.0068	-11.4	0	-0.091	-0.064	-0.0745
detached	0.0374	0.0083	4.5	0	0.021	0.054	0.0381
flat	-0.1592	0.0116	-13.68	0	-0.182	-0.136	-0.1471
prey1919	0.2782	0.0109	25.44	0	0.257	0.300	0.3208
y1919_44	0.2625	0.0103	25.45	0	0.242	0.283	0.3002
y1945_64	0.2164	0.0095	22.68	0	0.198	0.235	0.2416
y1965_81	0.1357	0.0092	14.74	0	0.118	0.154	0.1453
y1981_90	0.0841	0.0106	7.94	0	0.063	0.105	0.0878
dblglazL50	-0.0276	0.0142	-1.95	0.052	-0.055	0.000	-0.0272
dblglazM50	-0.0804	0.0118	-6.81	0	-0.104	-0.057	-0.0772
dblglazALL	-0.1050	0.0099	-10.62	0	-0.124	-0.086	-0.0997
attic	-0.1153	0.0111	-10.39	0	-0.137	-0.094	-0.1089
basement	-0.1637	0.0310	-5.28	0	-0.224	-0.103	-0.1510
Stor_el	0.1014	0.0192	5.29	0	0.064	0.139	0.1067
el_other	0.5123	0.0254	20.19	0	0.463	0.562	0.6692
OF_other	0.0895	0.0218	4.11	0	0.047	0.132	0.0936
y3to12years	0.0403	0.0061	6.65	0	0.028	0.052	0.0411

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E.^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
more12years	0.1141	0.0065	17.68	0	0.101	0.127	0.1208
LoftNOinsul	0.1078	0.0182	5.94	0	0.072	0.143	0.1138
Noloft	-0.0523	0.0108	-4.83	0	-0.073	-0.031	-0.0509
EMOPstandard	0.0351	0.0119	2.95	0.003	0.012	0.059	0.0358
EMOPprepaid	0.0564	0.0125	4.53	0	0.032	0.081	0.0580
GMOPstandard	0.0468	0.0123	3.8	0	0.023	0.071	0.0479
GMOPprepaid	0.0712	0.0129	5.54	0	0.046	0.096	0.0738
nogas	0.1141	0.0208	5.5	0	0.073	0.155	0.1209
CTB_B	-0.0261	0.0078	-3.34	0.001	-0.041	-0.011	-0.0258
CTB_C	-0.0422	0.0092	-4.57	0	-0.060	-0.024	-0.0413
CTB_D	-0.1103	0.0121	-9.14	0	-0.134	-0.087	-0.1044
CTB_E	-0.1936	0.0151	-12.84	0	-0.223	-0.164	-0.1760
CTB_F	-0.2901	0.0194	-14.93	0	-0.328	-0.252	-0.2518
CTB_G	-0.4049	0.0235	-17.23	0	-0.451	-0.359	-0.3330
CTB_H	-0.5539	0.0760	-7.29	0	-0.703	-0.405	-0.4253
_cons	2.9697	0.0591	50.25	0	2.854	3.085	N/A
R^2: 0.5598, F(56, 7497): 154.82, Prob > F: 0, Nobs: 7554							

^ White's (1980) robust standard errors correcting for heteroskedasticity.

* Halvorsen and Palmquist (1980) correction for the relative effect of a dummy variable in a semi-logarithmic functional from, which is not its coefficient β, as with continuous variables, but (e^{β} – 1).

APPENDIX 6: THE EXPENDITURE MODEL OF 2009/10

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	Coef (β)	S.E. ^	t	P>t	95% Conf. Interval		exp(β)-1*
ln_fpfullinc	0.0243	0.0055	4.43	0	0.014	0.035	
parttime_work	-0.0066	0.0089	-0.74	0.46	-0.024	0.011	-0.0065
retired	-0.0337	0.0104	-3.22	0.001	-0.054	-0.013	-0.0331
unemployed	0.0304	0.0120	2.54	0.011	0.007	0.054	0.0309
fulltime_edu	-0.0072	0.0237	-0.31	0.76	-0.054	0.039	-0.0072
other_occup	0.0023	0.0084	0.28	0.781	-0.014	0.019	0.0023
ln_fam_num	0.1118	0.0124	9.03	0	0.088	0.136	
ln_dep_child	0.1275	0.0055	23.18	0	0.117	0.138	
ln_older60	0.0398	0.0103	3.87	0	0.020	0.060	
ln_len_res	0.0069	0.0027	2.54	0.011	0.002	0.012	
ln_n_beds	-0.4316	0.0146	-29.58	0	-0.460	-0.403	
rented	0.0212	0.0081	2.63	0.009	0.005	0.037	0.0214
LA_owned	-0.0496	0.0086	-5.79	0	-0.066	-0.033	-0.0484
RSL	-0.0414	0.0079	-5.21	0	-0.057	-0.026	-0.0405
NorthEast	-0.0137	0.0122	-1.12	0.262	-0.038	0.010	-0.0136
Yorkshire	-0.0124	0.0101	-1.22	0.222	-0.032	0.007	-0.0123
NorthWest	-0.0140	0.0094	-1.49	0.136	-0.032	0.004	-0.0139
EastMidlands	-0.0011	0.0110	-0.1	0.923	-0.023	0.021	-0.0011
WestMidlands	0.0196	0.0098	1.99	0.046	0.000	0.039	0.0198
SouthWest	-0.0493	0.0098	-5.01	0	-0.069	-0.030	-0.0481
EastofEngland	-0.0143	0.0097	-1.48	0.138	-0.033	0.005	-0.0142
London	0.0557	0.0100	5.57	0	0.036	0.075	0.0573
Suburban	0.0071	0.0067	1.06	0.291	-0.006	0.020	0.0071
Rural	-0.0013	0.0098	-0.14	0.892	-0.021	0.018	-0.0013
terraced	-0.0632	0.0066	-9.59	0	-0.076	-0.050	-0.0612
detached	0.0139	0.0081	1.71	0.088	-0.002	0.030	0.0140
flat	-0.1463	0.0107	-13.63	0	-0.167	-0.125	-0.1361
prey1919	0.2747	0.0105	26.11	0	0.254	0.295	0.3161
y1919_44	0.2780	0.0097	28.73	0	0.259	0.297	0.3205
y1945_64	0.1912	0.0090	21.32	0	0.174	0.209	0.2107
y1965_81	0.1309	0.0087	15.02	0	0.114	0.148	0.1398
y1981_90	0.0815	0.0101	8.05	0	0.062	0.101	0.0850
dblglazL50	-0.0155	0.0149	-1.04	0.298	-0.045	0.014	-0.0154
dblglazM50	-0.0819	0.0121	-6.77	0	-0.106	-0.058	-0.0786
dblglazALL	-0.0969	0.0098	-9.89	0	-0.116	-0.078	-0.0923
attic	-0.0976	0.0103	-9.45	0	-0.118	-0.077	-0.0930
basement	-0.1420	0.0247	-5.76	0	-0.190	-0.094	-0.1324
Stor_el	0.1359	0.0182	7.46	0	0.100	0.172	0.1456
el_other	0.5176	0.0241	21.49	0	0.470	0.565	0.6781
OF_other	0.0092	0.0196	0.47	0.639	-0.029	0.048	0.0092
y3to12years	0.0612	0.0055	11.05	0	0.050	0.072	0.0631

Dependent Variable: Natural Logarithm of Annual Energy Expenditure (£) per square meter							
Variable	**Coef (β)**	**S.E. ^**	**t**	**P>t**	**95% Conf. Interval**		**exp(β)-1***
more12years	0.1394	0.0063	22.05	0	0.127	0.152	0.1496
LoftNOinsul	0.0851	0.0187	4.56	0	0.048	0.122	0.0888
Noloft	-0.0424	0.0103	-4.11	0	-0.063	-0.022	-0.0415
EMOPstandard	0.0526	0.0122	4.31	0	0.029	0.076	0.0540
EMOPprepaid	0.0572	0.0117	4.88	0	0.034	0.080	0.0589
GMOPstandard	0.0392	0.0124	3.16	0.002	0.015	0.063	0.0400
GMOPprepaid	0.0628	0.0122	5.14	0	0.039	0.087	0.0648
nogas	0.0749	0.0203	3.69	0	0.035	0.115	0.0778
CTB_B	-0.0256	0.0076	-3.34	0.001	-0.041	-0.011	-0.0252
CTB_C	-0.0548	0.0090	-6.1	0	-0.072	-0.037	-0.0533
CTB_D	-0.1251	0.0115	-10.89	0	-0.148	-0.103	-0.1176
CTB_E	-0.1953	0.0148	-13.18	0	-0.224	-0.166	-0.1774
CTB_F	-0.3279	0.0186	-17.63	0	-0.364	-0.291	-0.2795
CTB_G	-0.3911	0.0223	-17.55	0	-0.435	-0.347	-0.3237
CTB_H	-0.6179	0.0794	-7.79	0	-0.774	-0.462	-0.4609
_cons	3.0205	0.0616	49.07	0	2.900	3.141	
R^2: 0.5797, F(56, 7763): 192.73, Prob > F: 0, Nobs: 7820							

^ White's (1980) robust standard errors correcting for heteroskedasticity.

* Halvorsen and Palmquist (1980) correction for the relative effect of a dummy variable in a semi-logarithmic functional from, which is not its coefficient β, as with continuous variables, but (e^{β} – 1).