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The Role of Risk and Trust Attitudes in Explaining Residential Energy Demand: Evidence from the United Kingdom

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Abstract

Recent research into the determinants of household energy consumption has aimed to incorporate findings from economics, sociology and psychology in order to obtain a more comprehensive understanding of the factors determining energy demand. The current paper contributes to this nascent stream of literature by studying the relationship between risk attitudes, trust propensity and energy consumption at the household level. Drawing on the British Household Panel Survey, a well-known data set in the context of energy studies, I show that trust is negatively correlated with household energy demand, while higher risk tolerance leads to increases in residential energy use. Potential explanations for these findings are investigated, suggesting that risk preferences may be related with overall appliance stock and the size of the rebound effect.

Keywords: Risk attitudes; Trust; Energy expenditures; BHPS; UK Households.
Journal of Economic Literature Classification: Q40; Q50

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1 Introduction

In their role as consumers of energy products and services, households account for a substantial share of energy consumption in many societies. In the United Kingdom, for instance, about 30% of all energy consumption and CO_2 emissions can be attributed directly to household behaviour (DECC, 2014a,b). Therefore, improving energy efficiency and reducing energy demand by private households are among the primary targets of public policies and campaigns aiming at energy conservation (DECC, 2013; OECD, 2002). Similarly, a growing number of private initiatives and environmental groups have launched popular campaigns in an effort to raise awareness on the environmental consequences of energy use and to offer strategies for its reduction at the level of the individual.[1] All these programs maintain that behavioural change is a crucial component to any long-term strategy for curbing energy demand and greenhouse gas emission in the domestic sector. This claim is supported by recent findings reporting that changes in U.S. household behaviour could lead to up to 20% reductions in greenhouse gas emissions without necessitating new regulatory measures or compromising the welfare of households (Stern, 2014; Dietz et al., 2009).

Clearly, a thorough understanding of antecedents and determinants of household energy demand is an important pre-requisite for any such programme. For this reason, research into correlates and causes of household energy consumption (synonymously called: “residential energy use” in this paper) has gained momentum in recent years and has attracted attention from scholars in economics, psychology and sociology alike. The joint interest from various fields has led to an increasing number of studies aiming to incorporate insights from other disciplines (Lange et al., 2014; Sapci and Considine, 2014; Abrahamse and Steg, 2009; Gatersleben et al., 2002), thus gradually overcoming the disciplinary lock-in of energy studies that has repeatedly been criticized (Stern, 2014; van den Bergh, 2008; Wilson and Dowlatabadi, 2007). For example, recent economic studies have started to

[1] An example for such an initiative in the UK is the Energy Saving Trust, which consults households and businesses on energy saving possibilities and potentials (Energy Saving Trust, 2014). Most of these programmes offer hands-on advice on reducing household energy consumption, including simple behavioural adaptations such as lowering thermostat settings or unplugging electronic appliances.

investigate the relationship between pro-environmental attitudes and household energy use (Lange et al., 2014; Sapci and Considine, 2014), thereby drawing on a long debate in environmental psychology (Abrahamse and Steg, 2009; Gatersleben et al., 2002; Becker et al., 1981; Seligman et al., 1979).

The present contribution extends this nascent literature by investigating the role of risk and trust attitudes in explaining energy demand. Both characteristics are known to be important determinants for (economic) decision making and have been found to influence a broad number of outcomes, ranging from earnings and educational attainment to health and subjective well-being (Becker et al., 2012; Dohmen et al., 2011, 2008; Shaw, 1996). More importantly, there is evidence suggesting that both traits are related to environmentally relevant behaviours. For example, more trusting individuals have been found to be more likely to buy green products (Gupta and Ogden, 2009), recycle (Sonderskov, 2011), use public transportation (van Lange et al., 1998), conserve water (van Vugt and Samuelson, 1999), or support pro-environmental policies that entail welfare reductions like environmental taxes or cuts in living standards (Irwin and Berigan, 2013). These results are underscored by a host of findings from institutional and developmental economics suggesting that trust plays a key role in sustainably managing and protecting natural resources at a regional level (see, e.g., the recent collection by Ostrom and Ahn (2003), and the review by Pretty and Ward (2001)). This stream of literature has highlighted the importance of trust as a means to facilitate collective action and solve problems involving social dilemmas like environmental protection or climate change mitigation (Ostrom, 2009). At a macro level, Carattini et al. (2015) have shown that countries with a higher share of trusting citizens have lower per capita energy use and subsequently emit significantly less greenhouse gases per capita.

By the same token, risk attitudes have been argued to substantially affect investment in energy-efficient consumer durables. As the future benefits from these investments depend on a number of unknown developments - including changes in energy requirements, variations in energy prices, and the reliability and maintainability of the technology - uncertainties concerning these developments are likely to impede the adoption of these technologies (Qiu et al., 2014; Baker, 2012; Christie et al., 2011; Hassett and Metcalf, 1993; Shama, 1983). Conducting a choice experiment in Switzerland, Farsi (2010) finds that risk considerations are important determinants of consumer choice over energy-efficient home improvements, and that risk attitudes differ substantially between energy-efficient and conventional options. Qiu et al. (2014) empirically quantify this effect. In a sample of homeowners from Arizona and California they find that more risk averse individuals are less likely to have installed energy-efficient home improvements such as attic insulation or duct sealing. Risk-averse individuals are also less likely to own energy-efficient appliances such as refrigerators and tumble dryers.[2]

All in all, there is therefore good reason to believe that risk attitudes and trust are associated with household energy demand. Yet, to the best of my knowledge, this relationship has not been studied so far. In order to motivate the relevance of studying the associations between risk, trust and residential energy demand, the paper proceeds as follows: Section 2 gives an introduction to the data set used in this analysis and discusses relevant measurement issues. Regression analyses quantifying the association between risk attitudes, trust propensity and residential energy demand are presented in section 3. Finally, section 4 provides a discussion of results and implications for policies aimed at behavioural change.

2 Data and descriptives

To investigate the relationship between risk attitudes, trust and residential energy expenditures, this study uses data from the British Household Panel Survey (BHPS), a longitudinal survey of individuals and their families living in the United Kingdom (for detailed information on the study, see also Taylor et al. (2010), on whom this description relies). Its objective was to trace economic and social changes in a representative sample of roughly 5,000 British households, amounting to about 20,000 individuals. Data collection was carried out annually between 1991 and 2008 by the Economic and Social Research Council's UK Longitudinal Studies Centre (ESRC) in cooperation with the Institute of Social and Economic Research at the University of Essex. All household members aged 16 or older were interviewed

[2] The sole exception in their study is air conditioning, for which they did not identify a significant relationship between risk attitudes and ownership of an energy-efficient version.

in each round. I rely primarily on the 2008 wave (wave r) of the data set, which included a set of items constructed to evaluate the respondent's psychological profile with respect to risk-taking. The same data set has been used in previous research on household energy demand (Lange et al., 2014; Meier and Rehdanz, 2010).

2.1 Dependent measure

The main dependent variable used in this study is the natural logarithm of monthly residential energy expenditures in British Pounds Sterling in the year preceding the interview. It is constructed as the sum of household expenditures on gas, oil, electricity and solid fuels. Prior to summation, expenditures for each energy source were adjusted for price differences using the ratio of the energy source price relative to overall energy prices based on the consumer price indices for 2008. The variable therefore measures direct rather than embodied or indirect energy use. After adjustment, monthly energy expenditures average at £94.4, which is somewhat higher than the value of £75.6 reported in the Family Spending Survey from the same year (ONS, 2009). This is likely due to the fact that individuals from Scotland, Northern Ireland, and Wales, i.e. the coldest regions in the United Kingdom, were over-sampled in the BHPS.

INSERT FIGURE 1 ABOUT HERE

Figure 1 presents the energy expenditure composition of an average household in the BHPS. More than half of this household's energy expenditures is devoted to electricity, while gas expenditures still make up over one third. Subsequently, expenditures on oil and solid fuel make up a small share of total energy expenditures. They account for 10.7% and 2.1%, respectively. Standard errors are comparatively large, reflecting the substantial heterogeneity with respect to energy composition.

A vast majority of households in the sample report non-zero expenditures on one or more sources of energy. Thus, using total direct energy expenditure as a dependent, I can focus the analysis on continuous energy demand conditional on energy use, rather than having to parametrize households' choices over single sources of energy (as done e.g. by Nesbakken, 2001). Only households providing full information on their energy expenditures - that is, expenditures of at least zero Pounds Sterling for each energy category and more than zero on their sum - are considered in this analysis. Additionally, I excluded households the energy bill of which was covered by rent (2.02%) since reliable imputations for this group were unfeasible. For more accurate results, outliers were further removed by trimming observations the energy expenditures of which are further than three standard deviations from the mean (0.7%).[3] Results including all these households are almost identical to the ones presented below.[4] Figure 2 provides an overview over the distribution of residential energy expenditures after adjustments.

INSERT FIGURE 2 ABOUT HERE

2.2 Measures of risk and trust attitudes

One of the more problematic decisions when matching psychological characteristics like risk and trust attitudes to energy demand arises from the fact that they are observed for different units of analysis. While psychological variables characterize an individual, energy demand is measured at the household level, and is therefore, more often than not, given for a group of people rather than a single person. Previous literature has dealt with this issue in two ways. A common - but usually implicit - assumption, prevalent predominantly in the psychological literature, is that information on psychological characteristics of one household member is sufficient to characterize the distribution of these traits within the household (Sapci and Considine, 2014; Abrahamse and Steg, 2009; Gatersleben et al., 2002; Brandon and Lewis, 1999). Therefore these studies have used the psychological profile of one 'representative' household member. However, research into family decision processes with respect to environmentally relevant behaviours has questioned this operationalization arguing that observable household behaviours are

[3] Additionally, I have excluded 3 households who reported annual income values below the minimum social security benefit level in 2008, since these values are likely to indicate misreporting (0.06%).

[4] They, together with a set of robustness checks, are given in Table A3 in the Appendix.

usually the result of complex interactions between household members (Grønhøj and Ölander, 2007; Grønhøj, 2006). Moreover, research into assortative mating and intra-generational transmission of risk attitudes and trust has found that intra-household correlations in both traits are about 0.3 (Bacon et al., 2014; Dohmen et al., 2012). These values indicate that household members may share less than 10% of the variance in these traits and suggest that an operationalization of household characteristics using information from a single household member may be problematic for the present purpose.[5]

In order to deal with this within-household heterogeneity in attitudes, I adopt a strategy applied by Lange et al. (2014) and aggregate risk and trust attitudes across household respondents aged 16 or older.[6] In particular, risk and trust attitudes for each household are approximated by the median value. Results using values from the household reference person are statistically indistinguishable from the ones presented below. As expected, parameter estimates are slightly smaller in the latter case.[7]

Measures for risk attitudes and trust propensity are provided in the 2008 wave of the BHPS. They are based on the following questions:

- Risk attitudes: *Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?*
- Trust propensity: *Are you generally a person who is fully prepared to take risks in trusting strangers or do you try to avoid taking such risks?*

[5] More precisely, using the values from a ‘representative’ individual will introduce additional noise into the measurement of psychological characteristics if these traits differ across household members. Parameter estimates based on such measures are thus likely to be biased towards the origin.

[6] A similar operationalization strategy has also been used by Clark et al. (2003) and Kotchen and Moore (2007) in studying psychological determinants of household participation in green-electricity programmes.

[7] Estimates are given in Table A3 in the Appendix. Note that taking some kind of aggregate value is preferable to including values from all family members because the latter by definition would necessitate the exclusion of households with less than a certain number of household members. For example, including the attitudes of the reference person and his or her spouse will exclude single and lone parent households, while additionally accounting for the attitude expressed by, say, the oldest child would lead to an additional exclusion of couples without children.

Both items track the respondent's answer on a 10 point scale, where higher values imply higher willingness to take risk or higher willingness to trust in strangers.[8] Dohmen et al. (2011) have validated this survey measure for risk using German data. They demonstrated that an almost identically phrased question reliably predicts risky behaviour in both experimental and real-world settings including lottery choices, smoking, stock holdings or self-employment. To ensure the validity of the measure for the currently used data set, I have replicated their results using BHPS data (not reported but available upon request). While not all behaviours studied by Dohmen et al. (2011) are available in the BHPS, results of these exercises nevertheless suggest that one can be fairly confident about the validity of the general risk measure applied in this contribution.

The item measuring trust propensity corresponds to a measure of generalized trust proposed by Miller and Mitamura (2003). It is a refinement of the well-known dichotomous generalized trust item developed by Rosenberg (1956), which is used extensively in empirical macro-economic research (e.g. by Carattini et al., 2015). A stream of previous literature in psychology and behavioural economics has documented that items eliciting a general propensity to trust in strangers are reliable predictors of trusting behaviour in wide range of experimental and non-experimental settings (Colquitt et al., 2007; Gächter et al., 2004; Glaeser et al., 2000).

INSERT TABLE 1 ABOUT HERE

Table 1 presents basic descriptives for both items. The median in household risk attitudes reached 5.5, while half of the households report values of 4 or less concerning their trust towards strangers. Obviously, households are substantially more willing to take general risks than they are willing to put their trust in strangers. This is particularly evident in the tails of both distributions. 10.38% of all households report very low levels of trust towards strangers, compared to only 4.06% who claim to be highly averse to general risk. On the other end of the distribution

[8] Concrete answers range from "won't take risks" (1) to "ready to take risks" (10) for the risk item and from "don't trust strangers" (1) to "will trust strangers" (10) for the item measuring trust.

9.69% of the households report levels of general risk attitudes of 8 or higher, while only 3.17% of households report identical trust taking values. This result ties in nicely with recent findings showing that valuations of risk differ depending on whether the agent of uncertainty is nature or another human being (Bohnet and Zeckhauser, 2004; Bohnet et al., 2008).[9]

2.3 Socio-economic controls

The BHPS data set contains rich information on individual and household level characteristics. In determining relevant controls I follow the previous economic literature on household energy demand (Lange et al., 2014; Leth-Petersen and Togeby, 2001; Meier and Rehdanz, 2010; Rehdanz, 2007; Schuler et al., 2000). In accordance with these studies, socio-demographic controls include the average age of respondents in the household, as well as its squared term. The share of males, the share of whites and the share of household respondents born in the UK are also part of this control set. Further variables account for median level of educational attainment in the household and median levels of self-rated health.

The measure of household income applied in this analysis is the natural logarithm of annual net household income standardized by the income of the median household. A quadratic specification was chosen in order to allow for changes in income elasticities along the income distribution. Preliminary experiments substituting this specification by linear variants or higher-order polynomials yielded results that are highly similar to the ones presented below. Moreover, an analysis of standard goodness-of-fit measures suggested that the quadratic specification fits the data better than any alternative. Further household controls encompass the natural

[9] The risk attitude distribution found in this sample is very similar to the one identified by Dohmen et al. (2011) using German data. Moreover, it corresponds well with risk attitude distributions identified in experimental research (e.g. by Holt and Laury, 2002). However, using the survey measure of risk, both Dohmen et al. (2011) and I find somewhat higher average values of risk tolerance than commonly identified in experimental studies (Harrison and Rutström, 2008; Holt and Laury, 2002). While a number of reasons, like the dependency of risk perceptions on the elicitation method (cf. Harrison and Rutström, 2008), may explain these differences, results by Dohmen et al. (2011) demonstrate that answers to the general risk question significantly and substantially predict the value of the safe option at the switching point in common lottery experiments. That is, despite certain differences in central tendency, experimental and survey measures seem to be closely related.

log of the household size as measured by the number of individuals living in the household, the share of household members not being employed, the number of children in 5 age categories, the number of household members aged 75 or older, and the number of cars owned by the household. An additional dummy set controls for the type of household as specified in the data.

Previous analyses have demonstrated that type of dwelling, housing conditions and housing tenure explain a non-negligible part of residential heating expenditures (Leth-Petersen and Togeby, 2001; Meier and Rehdanz, 2010; Rehdanz, 2007; Schuler et al., 2000). Consequently, measures of each are included into the estimations. Assuming that households residing in buildings containing several units enjoy scale efficiencies in space heating, I distinguish between following types of dwellings: detached house/bungalow, semi-detached house, end-terraced house, terraced house, purpose-built or converted flat < 10 units, purpose-built or converted flat > 10 units, other type. Additionally, I include the number of rooms in the dwelling (logged) in order to control for its size, as well as the type of ownership (owned, rented, or non-owned but rent-free). Estimations further use dummy sets to control for whether the dwelling possesses central heating, the type of fuel used for heating and the dichotomous answers to a number of questions describing problematic conditions of the dwelling (condensation, rot in windows or floors, damp walls, and leaky roof). Finally, since direct energy expenditures contain electricity as well, I additionally include a set of dummies controlling for the household's possession of 13 electronic devices ranging from mobile phones to tumble dryers. Controls for the household's stock in electronic durables are commonly applied in primary studies on residential electricity demand (cf. van den Bergh, 2008). Moreover, two variables capture the extent of green technology adoption by the household. A dummy measures whether the household obtains electricity on a green tariff, and another variable codes how many of the following green technologies a household has installed: solar water heating, wind turbine, and photovoltaic panels.

Final dummy sets control for the geographic location of the household within the UK and the month in which the household was interviewed. These account for unobservable regional and temporal differences (e.g. in heating degree days and prices), which I cannot control for directly due to the cross-sectional nature of the data. Descriptive statistics of the all the variables used in this analysis are given in Table A1 in the Appendix to this paper.

3 Empirical findings

In order to identify the relationship between risk attitudes, trust propensity, and household energy expenditures, demand is modelled using the following cross-sectional regression equation:

$$ln(E_i) = \alpha + \beta R_i + \delta T_i + \sum_{s=1}^{m} \gamma_s Z_{is} + \varepsilon_i \tag{1}$$

where the dependent variable E_i corresponds to monthly energy expenditures of household i. R_i measures this household's median risk attitude, while T_i describes its median trust propensity. Z_{is} gives a corresponding vector of controls. α, β, δ and γ_s are the $3+m$ coefficients to be estimated, while ε_i is the usual error term. For more accurate inference, standard errors are clustered on the regional level. Regions, as defined in the data set, correspond to 16 metropolitan areas within England, plus Northern Ireland, Wales and Scotland. A complete list can be found in Table A1 in the Appendix. In choosing regions as units of clustering, I follow the common consensus in applied econometrics and opt for the most conservative among a number of estimations based on similarly probable choices of clustering units, like household or dwelling type (cf. Cameron and Miller, 2015).

3.1 Risk, Trust and Energy expenditures

Table 2 presents the results of a set of cross-sectional OLS estimations. Each column presents a different regression model for the same dependent. Column (1) gives the results for a model including only risk and trust attitudes. The ensuing columns then track the changes in these parameters as the number of additional controls m increases. In order to economize on space only parameter estimates for risk and trust attitudes as well as the most common determinants of energy demand in the literature are given in Table 2. A complete presentation of results can be found in Table A2 in the Appendix. Standard measures of goodness-of-fit are provided at the bottom of the table. They suggest that including each set of co-variates increases the explanatory power of the model, albeit marginal increases are small for sets controlling for appliance holdings and problematic conditions of the dwelling.

INSERT TABLE 2 ABOUT HERE

With respect to socio-demographic characteristics, results are largely congruent with previous economic findings on the determinants of residential energy consumption (Lange et al., 2014; Meier and Rehdanz, 2010; van den Bergh, 2008; Rehdanz, 2007). The association with age takes an inverse U-form, with expenditures peaking at an age of 56 when measured as the average over specifications. No robust relationship can be established between energy expenditures and variables assessing the composition of the household in terms of sex, race and birth place. Similarly, median education seems to be unrelated to energy expenditures. On the other hand, median health is significantly and negatively related with energy expenditures, suggesting that individuals with better health require less energy. Two reasons may explain this finding. For one, thermal comfort has been found to be one of the key drivers of energy use (Becker et al., 1981), making it likely that health impaired individuals simply prefer higher temperature settings. Additionally, a compromised state of health may limit the mobility of an individual, thus forcing her to spend more time at home. As a consequence, average daily heating periods become longer and the use of electronic devices like TV sets may be more extensive. This latter interpretation is corroborated by the finding that the share of non-employed individuals, who also can be conjectured to spend more time at home, also increases household energy expenditures.[10]

[10] Note that I cannot exclude the possibility that the causal relationship between health and energy use also runs the other way. For instance, it is conceivable that spending more time in front of the TV increases energy demand and leads to worse health outcomes, due to decreasing levels of physical activity. However, additional estimations (not reported but available upon request) excluding households who have access to satellite or cable television, that is those with high revealed preferences for entertainment, yield point estimates on health that are indistinguishable from the ones presented in Table 2. Hence, while clearly more research is required on the causal relationship(s) between energy use and health, I find no indication that energy use for entertainment purposes affects health.

For both measures of household size parameter estimates suggest substantial and significant positive relationships. Thus, household energy expenditures increase in the number of people living in the household as well as in the number of rooms in the dwelling. Yet, as both variables are measured in logarithms and estimated coefficients are well below unity, energy expenditures increases under-proportionally in both variables. For instance, doubling the number of rooms is associated with increases in energy expenditures of about 30%, while doubling the number of individuals living in the household increases energy expenditures between 25% and 36%. These findings underscore a host of previous research suggesting that co-habitation creates substantial scale economies (Ferrer-i Carbonell and van den Bergh, 2004; Schröder et al., 2015).

Finally, results also underline the common finding that long-term, energy-related investment decisions have important consequences for household energy expenditures (Stern, 2014; Meier and Rehdanz, 2010; Rehdanz, 2007; Schuler et al., 2000). Parameter estimates on type of central heating, for example, suggest that energy expenditures were highest for households heating with solid fuels, followed by oil, electricity and finally gas. Furthermore, it becomes obvious that the type and condition of the dwelling are significantly and substantially associated with the household's total energy expenditures. For example, households living in a building consisting of 10 or more purpose-built or converted flats spend almost 20% less on total energy than households living in a detached house or a bungalow. Similarly, damp floors and walls, or rot in windows and doors increase monthly energy expenditures by about 6% each. Finally, households owning more electronic devices also have higher energy expenditures. Owning a tumble dryer or a dish washer, for instance, increases monthly energy bills by 4.5% and 7%, respectively.

More surprisingly, I find clear evidence for a non-linear relationship between income and energy expenditures at the household level, with coefficients on both income and its squared term presented in Table 2 being positive and significant. Figure 3 plots the evolution of income elasticities with increasing income decile. It shows that income elasticities are below 0.1 across all deciles, suggesting that energy is a staple good over the entire observable income range. At median values of income, income elasticity is about 0.04 and thus comparable to estimates presented in earlier research using the BHPS (Meier and Rehdanz, 2010) and other data sources (Dubin and McFadden, 1984; Nesbakken, 1999). Figure 3 also shows that income elasticities are strongly increasing in income with households at the 90% income decile reacting more than twice as sensitively to changes in the budget constraint as the median household, while households at the lower end of the income distribution do not seem to react at all to changes in the budget constraint. Notably these findings remain unaffected when increasing the order of the polynomial or when using non-standardized household income. This strongly suggests that despite being a staple good, there are certain "luxury" components to energy. One possible explanation for this result may be that high income households are more likely to invest additional income in running energy-intensive durables like in-house saunas or heated swimming pools. Since, the dependent variable is energy expenditures rather than energy use, an alternative explanation is that wealthier households tend to pay higher prices for energy. While a definitive conclusion is beyond the scope of this paper, an interesting avenue of future research would be to investigate whether increases in income elasticities can also be identified in other data sets, and whether they can be traced to differences in prices or differences in consumption. From a conservation perspective the latter case would suggest that substantial energy savings could be achieved by simple re-distributional policy measures.

INSERT FIGURE 3 ABOUT HERE

With respect to the main variables of interest, results presented in Table 2 show that risk and trust are both related to energy expenditures. Results from the model excluding all co-variates (column (1)) indicate that a one-step increase in general risk tolerance is associated with 2.5% higher energy expenditures, while the same change in the trust propensity measure yields about 1% lower energy expenditures. Gradually increasing the number of co-variates reduces the parameter size on risk attitudes by almost two-thirds, with the biggest impact stemming from socio-economic characteristics of the household. Thus, parts of the effect of risk attitudes on energy expenditures are mediated by socio-economic characteristics, like income and education. This may not be entirely surprising, as research in labour economics has found that an individual's risk attitudes are strongly associated with her educational attainment, occupational choice and earnings (Dohmen et al., 2012; Shaw, 1996). However, despite these reductions in size, parameter estimates for risk attitudes remain significant, indicating that *ceteris-paribus* a one-step increase in median household risk tolerance is associated with increases in energy expenditures of about 1%.

The coefficient estimate on trust remains unaltered by specification changes. The finding that trust attitudes are negatively related to residential energy use is congruent with results in psychology and sociology, reporting a significant relationship between trust and a variety of energy conserving behaviours (Gupta and Ogden, 2009; Sonderskov, 2011; van Lange et al., 1998; van Vugt and Samuelson, 1999). Moreover, results provide a micro-econometric base for the findings by Carattini et al. (2015), who demonstrate that countries with higher shares of trusting individuals show lower per capita energy consumption and greenhouse gas emissions.

With interquartile ranges of 2 and 2.5 steps for risk and trust attitudes, respectively, effect sizes from both determinants may seem modest at first sight. Results on these variables are, thus, comparable to the effects of pro-environmental attitudes on household energy demand, which have likewise been found to be small (Lange et al., 2014; Abrahamse and Steg, 2009; Gatersleben et al., 2002; Brandon and Lewis, 1999). However, although these results unmistakably demonstrate that risk and trust attitudes are not the unique key to understanding residential energy use, they also suggest that energy consumption is not independent of these traits. To get a sense for the magnitude of the point estimates it is important to compare them to the parameters of other relevant predictors. For example, coefficients on income, reported above, suggest that at median levels of income a change of 1% in annual household income corresponds to a change in energy expenditures of about 0.037%, all else being equal. This implies that at median income levels a one-step change in risk or trust attitudes yields the same adjustments in energy expenditures as an income change of about 29% or £8'100. Hence, clearly risk and trust attitudes are not negligible in determining residential energy expenditures.

3.2 Exploring the positive association between risk attitudes and energy demand

At least with respect to risk attitudes, results from the preceding section are surprising. Previous research indicated that more risk-tolerant households are more likely to invest in energy-efficient technologies (Qiu et al., 2014), which initially would lead to the expectation that these households have lower rather than higher energy expenditures. Estimates from Table 2, however, provide evidence for the opposite effect.

An important question is therefore, whether the results presented by Qiu et al. (2014) generalize to the BHPS sample. To investigate this issue, I make use of the fact that the BHPS records the installation of renewable energy-producing technologies like solar water heating, wind turbines and photovoltaic panels, as well as the intention thereof. While clearly, these items differ from the measures of energy-efficient appliance holding and retrofitting used by Qiu et al. (2014), the theoretical argument linking risk attitudes and ownership of energy-related technologies is very similar in both cases. If (perceived) risks concerning future energy cost savings affect investment into energy-efficient household appliances (Christie et al., 2011; Shama, 1983), they can likewise be expected to influence decisions on the purchase of renewable energy production units as their expected value also depends on future energy prices.

Corresponding to the very early stage in the diffusion of these technologies in the UK in 2008, the number of households in the sample that has installed any of these technologies is extremely limited.[11] Of all the households used in the preceding analyses only 40 (i.e. 0.79% of the sample) have installed any of the aforementioned technologies. I therefore create a variable which takes a value of one if the household has installed or seriously considers installing one or more of the following technologies: solar water heating, wind turbine, photovoltaic panels. If none, the variable takes a value of zero.

Comparable to Qiu et al. (2014) this variable is then regressed on socio-demographic, household and housing characteristics similar to the ones used in the

[11] For instance, installed capacities from solar photovoltaics in the UK in 2008 amounted to only 22.5 MW (DECC, 2011).

preceding section, but additionally including household energy expenditures. The estimation sample is restricted to owner-occupied households, where the dwelling is a detached, semi-detached, terraced or end-terraced house. The reason for this restriction is that renters and owners of flats in apartment blocks are likely to face considerably higher barriers in the installation of energy producing technologies than homeowners of single family houses. Indeed, about 90% of the households that have installed such a technology or that express their intent to install one are living in owner-occupied family homes.[12] 8.2% of all owner-occupied households report that they are seriously considering the installation of any renewable energy production unit or have done so already.

INSERT TABLE 3 ABOUT HERE

Table 3 presents mean marginal effects from a set of regressions on household ownership of renewable energy production technologies using probit estimators. Columns (1) and (2) give the result from models focusing separately on risk attitudes and trust propensity, while column (3) presents the results when controlling simultaneously for both determinants. Marginal effects shown in this table lend support to the findings of Qiu et al. (2014). They indicate that the propensity to invest in green technologies - or at least the intention to do so - increases in risk and trust attitudes. The latter effect, however, is not robust to the simultaneous inclusion of both measures, suggesting that risk attitudes are likely to be the dominating trait in determining investments in green technologies. Variance inflation factors of accompanying linear probability models are well below 2, indicating that limited information is an unlikely explanation for the null-finding on trust propensity. Hence, results suggest that more risk-tolerant households have higher energy expenditures despite higher probabilities to invest in energy-saving technologies.

One reason for this finding might be that risk-averse individuals are more concerned about the long-term environmental consequences of their behaviour and therefore invest more effort into energy conservation actions, like wearing extra

[12] Exercises repeating the estimations from the preceding section with this sub-sample yield results which are similar to the ones presented in Table 2. Yet, point estimates on risk and trust attitudes are slightly bigger. These results are given in Table A3 in the Appendix.

layers instead of turning up the heat or regularly unplugging unused electronic devices. Lange et al. (2014) find that such energy-conserving actions indeed reduce residential energy expenditures. Thus, if risk attitudes had an effect on energy-conserving behaviours, it would suggest that risk-averse households can off-set their lower investments in energy-efficient appliances by performing more energy-conserving behaviours. Likewise, risk and trust attitudes have been found to be linked with social preferences such as altruism and kindness (Fehr, 2009; Ashraf et al., 2006), which are known to affect pro-environmental attitudes and behaviours (Torgler et al., 2009).

To test whether this is a likely explanation, I repeat exercises from Table 2 including measures of environmental attitudes and energy-conserving behaviours, as well as for social preferences. Measures of environmental attitudes and pro-environmental behaviour largely correspond to ones employed by Lange et al. (2014). For environmental attitude items, higher values reflect a higher degree of agreement to the proposition. For behaviour items, higher values reflect higher environmental responsibility. To measure social preferences, I follow Fehr (2009) and include a set of co-variates assessing household median reciprocity preferences, altruism and sociability. As a measure for altruism, I use two variables assessing the respondent's frequency of volunteering by (a) attending meetings of local groups or voluntary organizations, and (b) doing voluntary work. Higher values imply higher frequencies. For sociability, four controls are constructed. The first two measure the frequency of meeting people and talking to neighbours, respectively. The third assesses the respondent's importance attached to having good friends, as measured on a ten-point ordinal scale, with higher values implying higher importance. The fourth measure is constructed from a set of eight questions measuring the respondent's sense of belonging to her local community. Construction of this measure using principal component analysis is discussed more thoroughly in Appendix B. Finally, preferences over reciprocity were assessed using degree of consent to the proposition "Adult children should care for their parents". Again, higher values imply a higher degree of consent. Consistent with Fehr (2009), I find that these variables significantly predict risk attitudes and trust propensity at the individual level in a number of preliminary exercises (not reported but available upon request).

Finding substantial changes in either size or statistical significance of the coefficient on risk attitudes, would suggest a close relationship between this variable and attitudes, concerns or behaviour and thus would support the hypothesis explicated above. Results from this exercise are given in Table 4. Little surprisingly, results on attitudes, behaviours and concern about climate change mirror the ones presented by Lange et al. (2014). In particular, they suggest that attitudes affect residential energy use (column (1)), but that these relationships are largely mediated by energy conserving behaviours (column (5)). This finding is in line with a majority of psychological theories of behaviour (see e.g. the review by Darnton, 2008). Results also show that higher levels of sociability and altruism are associated with lower energy expenditures (columns (5) and (6)), suggesting that other-regarding preferences may indeed play a role in decisions over energy consumption. These results are also congruent with research in environmental psychology demonstrating that higher levels of "place attachment", understood as an affective identification with a geographical area, correspond to higher levels of environmentally responsible behaviours (cf. Gifford, 2014).

More importantly, I find that including controls for social preferences, pro-environmental attitudes, concerns and behaviours has no effect on either size or significance of the parameter estimate of risk attitudes. Thus, I find no evidence that the positive association between risk attitudes and residential energy expenditures can be explained by an effect of risk aversion on these variables.

INSERT TABLE 4 ABOUT HERE

An alternative explanation would be that more risk-tolerant individuals are not only more willing to invest in energy-efficient durables, but generally show a higher willingness to obtain household appliances. Households with more risk-tolerant members may, for instance, own on average more television sets or a broader variety of electronic devices. While no information on the number of any specific electronic durable in a household is available in the BHPS, one possibility is to test whether risk attitudes affects the variety of electronic durables in a household. Therefore the number of different appliances is summed at the household level, to obtain a measure for the variety of consumer durables. Column (1) of Table 5 presents the mean marginal effects from a negative binomial estimation regressing this dependent on socio-demographic characteristics of the household. As an alternative measure for household appliance possession, I use the number of cars owned by the household. Results for these exercises are given in column (2) of Table 5. Findings from both models indeed suggest that risk attitudes are positively related to the number of different household appliances and the number of cars owned by the household. They therefore indicate that more risk-tolerant households might actually off-set potential reductions in energy expenditures attained through the investment into energy-efficient durables by acquiring additional energy consuming items. Alternatively, more risk-tolerant households may have a higher incentive to obtain energy-efficient versions due to higher initial energy expenditures. It is important to note that due to the absence of appropriate data I cannot control for the full stock of electronic durables in a household. Therefore, conclusions drawn on the potential off-setting effect of risk attitudes must be treated with caution. However, results clearly demonstrate that median risk attitudes in a household are positively associated with the variety of electronic appliances and the number of cars owned by the household, and thus suggest one possible reason why risk attitudes are positively associated with residential energy use.

INSERT TABLE 5 ABOUT HERE

A final aspect that has to be taken into account when trying to understand the apparently paradoxical relationship between risk attitudes and energy demand is that risk attitudes may affect households' reactions to changes in relative prices and income induced by the adoption of energy-efficient appliances. It is a common concern in energy policy and analysis that savings resulting from these kinds of investments may lead to changes in energy-related behaviours or consumption patterns, which partially (or completely) off-set the originally induced savings (Alcott, 2005; Binswanger, 2001). Economic theory suggests two basic channels by which this rebound effect is likely to feedback on household energy consumption (cf. Borenstein, 2014). Higher energy efficiency of a certain good may lead to decreases in the relative price of energy and thus to an increase in use of this energy-consuming good (substitution effect). At the same time, decreasing relative prices yield an increase in purchasing power, thus increasing expenditures for all normal goods, including energy (income effect). Due to the absence of suitable data, no test of the rebound effect or any of its channels can be presented here. However, an important pre-requisite for the income effect to coherently explain the baseline results of this contribution, the findings of Table 3 and the results presented by Qiu et al. (2014) is that risk-tolerant households react more sensitively to changes in income. Under the assumption that the source of the income expansion is irrelevant for determining the distribution of this additional income over expenditure categories, systematic increases of income elasticity along the risk preference distribution would indicate that this channel of the rebound effect is stronger among more risk-tolerant households.[13]

To assess whether risk attitudes and trust affect households' sensitivity to income changes, I expand model (1) by four interaction terms capturing these effects.[14] The extended regression model is then given by:

$$\begin{aligned} ln(E_i) = \alpha + \beta R_i + \delta T_i + \gamma_1 Y_i + \gamma_2 Y_i^2 + \theta_1 (R_i \times Y_i) + \theta_2 (R_i \times Y_i^2) \\ + \eta_1 (T_i \times Y_i) + \eta_2 (T_i \times Y_i^2) + \sum_{s=3}^{m} \gamma_s Z_{is} + \varepsilon_i \end{aligned} \quad (2)$$

where Y_i gives the log of households income. R_i and T_i are centred at their median in order to retain interpretable base effects. Thus, holding T_i constant, $\gamma_1 + 2\gamma_2 Y_i + R_i(\theta_1 + 2\theta_2 Y_i)$ describes the marginal effect of income on energy expenditure at different levels of risk attitudes and household income, with γ_1 denoting this marginal effect at the median value of risk and income.

INSERT TABLE 6 ABOUT HERE

[13] Previous studies have already identified heterogeneity of direct and indirect rebound effects with respect to socio-economic status in the UK (Chitnis et al., 2014).

[14] Results from a simplified model dropping income squared as well as its interactions with risk and trust yield almost identical results (available upon request).

Results from these estimations are given in Table 6. Controls correspond to the ones used in column (6) of Table 2. Columns (1) and (2) give the result from models focusing on the interaction between risk and income, and trust and income, while results for the more comprehensive model (2) are presented in column (3). Parameter estimates provide evidence for the fact that marginal effects of income increase systematically in risk but not in trust. The parameter estimate of the interaction between income and risk is robust to the inclusion of trust interactions. Moreover it is sizeable compared to the marginal effect of income at median levels of risk, suggesting that a household at the 90th percentile of the risk preference distribution (implying a value of 7.5) reacts almost twice as strongly to changes in its budget constraint as the median household.

The positive interaction term also suggests that for highly risk-averse households, energy may be an inferior good, as the coefficient on income will become negative at small values of median household risk. However, it remains unclear whether marginal effects are different from zero at low levels of the risk scale. To get a more comprehensive impression, Figure 4 plots the marginal effect of income over the entire distribution of risk values using information from the full model (2).

INSERT FIGURE 4 ABOUT HERE

It shows that while marginal effects of income are increasing in risk, they are not significantly different from zero at low levels of risk. Thus, I find no evidence that energy is an inferior good for highly risk-averse households. Energy expenditures of highly risk-tolerant households react significantly more elastic to income changes than those of households with low risk tolerance, making risk-related differences in the size of rebound effects another potential candidate for explaining the apparent conflict between the findings from section 3.1 and the results presented in Table 3.

4 Conclusions

Recent research into the determinants of household energy consumption has aimed to incorporate findings from economics, sociology and psychology and thus to overcome the oft-criticized disciplinary lock-in of energy studies (Stern, 2014; van den Bergh, 2008; Wilson and Dowlatabadi, 2007). These approaches allow for a more comprehensive understanding of the variety of factors that drive energy demand. More importantly, by studying the interaction between determinants of different provenance they shed some light on the "blind spots" of approaches relying on a single discipline (Stern, 2014; van den Bergh, 2008). The current paper contributes to this nascent stream of literature by studying the relationship between risk attitudes, trust attitudes and household energy consumption. Drawing on the British Household Panel Survey, a well-known data set in the context of energy studies, I show that both traits are correlated with household energy demand.

Congruent with previous macro-economic findings (Carattini et al., 2015), I find that more trusting households have lower energy expenditures as compared to their less trusting counterparts. Given the intensity of the public discussion on climate change and its consequences in recent years, it seems plausible to assume that this observed relationship stems from households' voluntary efforts to reduce their environmental impact. This result thus underpins the importance of trust and reciprocity in solving collective action problems, identified in institutional economics (Ostrom, 2009; Ostrom and Ahn, 2003). It lends additional support to the claim that policies aiming to improve levels of collective action in order to overcome social dilemmas must decrease free-riding incentives by enhancing the level of trust among participants (Ostrom, 2009). Fehr (2009) shows that, at least in experimental settings, trust can easily be increased by providing means to build a reputation or to observe the compliance of others. Thus, raising public awareness of average policy compliance on regional or national levels may help improving trust levels. For example, providing regular information on average energy use, energy savings or waste reduction by private households in a community may help to achieve conservation goals.

My results also suggest that more risk-tolerant households have higher energy expenditures. This is a rather surprising result, given that previous literature had identified risk tolerance as a key barrier to the adoption of energy-efficient technologies (Qiu et al., 2014; Christie et al., 2011; Farsi, 2010). Notably, I find similar results in the currently used sample, showing that risk-tolerant households are more likely to invest in technologies for renewable energy production such as photovoltaic panels or solar water heating. Further results suggest that these contradicting findings may arise from two different channels. One, more risk tolerant households in general tend to own more energy consuming appliances (and cars). Thus, the incentive for adopting energy-efficient versions may be particularly strong among these households, as otherwise their energy expenditures would be even higher. This interpretation would also explain why neither Qiu et al. (2014) nor I find a relationship between the household energy bill and the adoption of energy-efficient home-improvements or devices, which one would initially expect to be negative. A second channel for explaining higher energy expenditures among more risk-tolerant households despite a higher probability of investment into energy-efficient devices is that these households react more sensitively to changes in income. This indicates that for these households savings accrued from the adoption of energy-efficient technologies may feedback more strongly into energy expenditures than for risk-averse households. In order words, results suggest that more risk-tolerant households tend to "rebound" stronger. From a policy perspective, results on risk attitudes indicate the need to more comprehensively address risks associated with individual energy consumption. Particularly, they suggest that some guidance on environmentally beneficial ways of dealing with conservation-induced savings are likely to improve conservation pay-offs from programs fostering the adoption of energy-efficient technologies.

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Appendix

Table 1: Descriptive statistics for risk attitudes and trust propensity

VARIABLES	Risk attitudes	Trust propensity
Mean (standard deviation)	5.40 (1.84)	4.12 (1.83)
Median	5.5	4
Share of households with median response, m:		
$m < 2$	4.06%	10.38%
$2 \leq m < 3$	4.00%	11.41%
$3 \leq m < 4$	8.44%	19.02%
$4 \leq m < 5$	12.93%	20.57%
$5 \leq m < 6$	24.29%	18.79%
$6 \leq m < 7$	20.98%	10.89%
$7 \leq m < 8$	15.62%	5.79%
$8 \leq m < 9$	6.88%	2.22%
$m \geq 9$	2.81%	0.95%

$N = 5'058$

Table 2: Risk, trust and energy expenditures

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES						
Risk attitude	0.0255***	0.0146***	0.0134**	0.0112**	0.0110**	0.0108**
	(0.0049)	(0.0039)	(0.0047)	(0.0040)	(0.0044)	(0.0043)
Trust propensity	-0.0103***	-0.0134***	-0.0103***	-0.0105***	-0.0106***	-0.0109***
	(0.0033)	(0.0035)	(0.0032)	(0.0035)	(0.0034)	(0.0032)
Income (log)		0.2188***	0.0836***	0.0458***	0.0362***	0.0368***
		(0.0104)	(0.0116)	(0.0104)	(0.0102)	(0.0101)
Income squared (log)		0.0498***	0.0479***	0.0305**	0.0300**	0.0300**
		(0.0117)	(0.0127)	(0.0124)	(0.0134)	(0.0134)
Share of males		-0.0397*	-0.0073	0.0089	0.0132	0.0150
		(0.0228)	(0.0196)	(0.0204)	(0.0204)	(0.0212)
Age (mean)		0.0120***	0.0134***	0.0063**	0.0056**	0.0053**
		(0.0031)	(0.0024)	(0.0024)	(0.0025)	(0.0024)
Age (mean) squared		–0.0001***	-0.0001***	-0.0001***	-0.0000**	-0.0000**
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Median health		-0.0191***	-0.0276***	-0.0383***	-0.0353***	-0.0333***
		(0.0061)	(0.0047)	(0.0053)	(0.0051)	(0.0050)
Median education		-0.0265***	0.0171*	-0.0066	-0.0059	-0.0064
		(0.0082)	(0.0094)	(0.0080)	(0.0087)	(0.0089)
Household size (log)			0.3637***	0.2701***	0.2619***	0.2586***
			(0.0394)	(0.0324)	(0.0290)	(0.0295)
Number of rooms (log)				0.3105***	0.2846***	0.2844***
				(0.0262)	(0.0243)	(0.0258)
ADDITIONAL CONTROLS						
Socio-demographic	No	Yes	Yes	Yes	Yes	Yes
Household	No	No	Yes	Yes	Yes	Yes
Dwelling	No	No	No	Yes	Yes	Yes
Appliances	No	No	No	No	Yes	Yes
Problems	No	No	No	No	No	Yes
Month and Region	No	Yes	Yes	Yes	Yes	Yes
Observations	5,058	5,050	5,050	5,050	5,050	5,043
Adjusted R^2	0.007	0.180	0.310	0.379	0.390	0.392
Log Lik	-3222	-2719	-2275	-2002	-1948	-1936
AIC	6450	5472	4585	4041	3932	3908

Notes: The dependent is the log of household energy expenditures. Complete results are given in Table A3 in the Appendix. All estimations contain a constant. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses) *** p<0.01, ** p<0.05, * p<0.1

Table 3: Risk, trust and investment in green energy production (Mean Marginal Effects)

	(1)	(2)	(3)
VARIABLES			
Risk attitudes	0.0102***		0.0082**
	(0.0030)		(0.0041)
Trust propensity		0.0076***	0.0042
		(0.0019)	(0.0030)
Observations	3,484	3,484	3,481
Pseudo R^2	0.112	0.111	0.113
Log Lik	-888	-890	-887
AIC	1811	1815	1808

Notes: The dependent is an indicator of (planned) household ownership of green technologies. All estimations control for socio-demographic and housing characteristics. Controls correspond to the ones used in column (6) of Table 2, but additionally include household energy expenditures. All estimations contain a constant. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses) *** p<0.01, ** p<0.05, * p<0.1

Table 4: Risk, trust, and environmental and social attitudes

VARIABLES	(1)	(2)	(3)	(4)	(5)
Risk attitudes	0.0105**	0.0107**	0.0110**	0.0101**	0.0103**
	(0.0045)	(0.0040)	(0.0042)	(0.0043)	(0.0042)
Trust propensity	-0.0099**	-0.0110***	-0.0111***	-0.0103**	-0.0104***
	(0.0035)	(0.0034)	(0.0029)	(0.0036)	(0.0033)
Too much time to be environmental	-0.0257***			-0.0200***	-0.0204***
	(0.0064)			(0.0060)	(0.0061)
Science will solve environmental problems	-0.0039			-0.0077	-0.0082
	(0.0085)			(0.0072)	(0.0070)
Environment low priority	0.0095			0.0049	0.0038
	(0.0055)			(0.0054)	(0.0052)
Environmentally friendly life	-0.0205**			-0.0024	-0.0035
	(0.0072)			(0.0074)	(0.0074)
Leaves TV on standby		-0.0159***		-0.0145***	-0.0141***
		(0.0042)		(0.0041)	(0.0041)
Switches off lights		-0.0275***		-0.0257***	-0.0257***
		(0.0060)		(0.0066)	(0.0064)
Lets tab water run		-0.0103**		-0.0091**	-0.0092**
		(0.0041)		(0.0040)	(0.0039)
Wears extra clothes (or layers)		-0.0226***		-0.0212***	-0.0216***
		(0.0047)		(0.0047)	(0.0048)
Talks to neighbours (freq.)			-0.0152		-0.0121
			(0.0089)		(0.0092)
Meets people (freq.)			0.0115		0.0100
			(0.0102)		(0.0108)
Belongs to community			-0.0045		-0.0049
			(0.0037)		(0.0032)
Importance of friends			0.0013		0.0019
			(0.0055)		(0.0058)
Attends meetings (freq.)			-0.0079***		-0.0073***
			(0.0024)		(0.0020)
Works voluntarily (freq.)			0.0005		0.0006
			(0.0042)		(0.0045)
Reciprocity preferences			-0.0042		-0.0057
			(0.0049)		(0.0045)
Observations	5,031	4,999	5,034	4,987	4,978
Adjusted R^2	0.395	0.401	0.392	0.402	0.401
Log Lik	-1908	-1866	-1928	-1850	-1843
AIC	3852	3768	3892	3736	3721

Notes: The dependent is the natural logarithm of household energy expenditures. All estimations control for socio-demographic and housing characteristics. Controls correspond to the ones used in column (6) of Table 2. All estimations contain a constant. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses) *** p<0.01, ** p<0.05, * p<0.1

Table 5: Risk, trust and household stock of energy consuming durables (Mean Marginal Effects)

	(1)	(2)
	Number of electronic appliances	Number of cars
Risk attitudes	0.0389**	0.0212***
	(0.0185)	(0.0041)
Trust propensity	-0.0129	-0.0123**
	(0.0158)	(0.0053)
Observations	6,684	6,684
Pseudo R^2	0.0429	0.129
Log Lik	-14723	-7597

Notes: Additional controls correspond to the ones used in column (4) of Table 2. The number of cars in the household was removed from the controls in both estimations. All estimations contain a constant. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses) *** p<0.01, ** p<0.05, * p<0.1

Table 6: The interaction between Risk and Income, and Trust and Income

VARIABLES	(1)	(2)	(3)
Risk attitudes (centered)	0.0145***	0.0109**	0.0155***
	(0.0033)	(0.0044)	(0.0032)
Trust propensity (centered)	-0.0109***	-0.0105*	-0.0128***
	(0.0033)	(0.0052)	(0.0041)
Risk attitude × Income	0.0083**		0.0086**
	(0.0039)		(0.0037)
Risk attitude × Income squared	-0.0024		-0.0040
	(0.0050)		(0.0050)
Trust propensity × Income		0.0032	-0.0006
		(0.0038)	(0.0036)
Trust propensity × Income squared		0.0004	0.0029
		(0.0046)	(0.00042
Income (centered)	0.0356***	0.0352***	0.0356***
	(0.0102)	(0.0109)	(0.0107)
Income (centered) squared	0.0269**	0.0290**	0.0261**
	(0.0124)	(0.0132)	(0.0123)
Observations	5,043	5,043	5,043
Adjusted R^2	0.393	0.392	0.392
Log Lik	-1933	-1936	-1933
AIC	3902	3907	3901

Notes: The dependent is the natural logarithm of household energy expenditures. Remaining controls correspond to the ones used in column (6) of Table 2. All estimations contain a constant. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses) *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Energy expenditure shares of an average household, BHPS 2008 (Standard errors in parentheses).

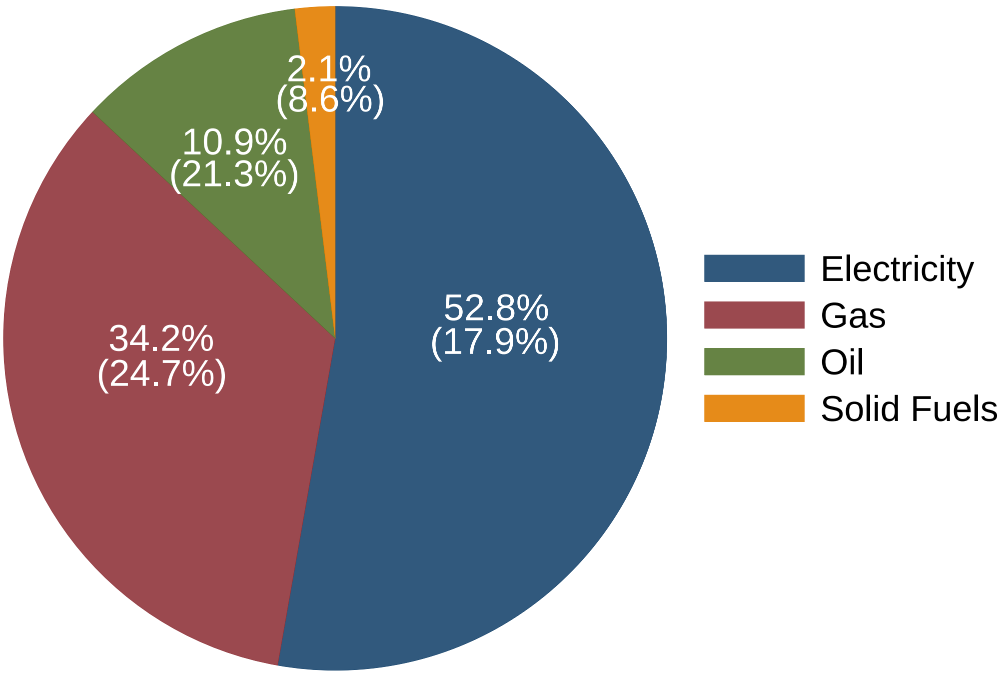


Figure 2: Histogram for household energy expenditures, overlaid with best-fit Gaussian density (fitted to empirical mean and standard deviation).

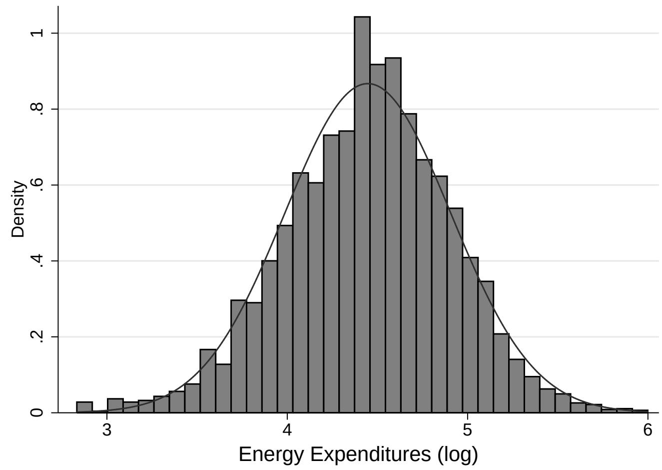


Figure 3: Marginal effects of household income on energy expenditures at different deciles of household income (shaded area gives the 95% confidence bounds).

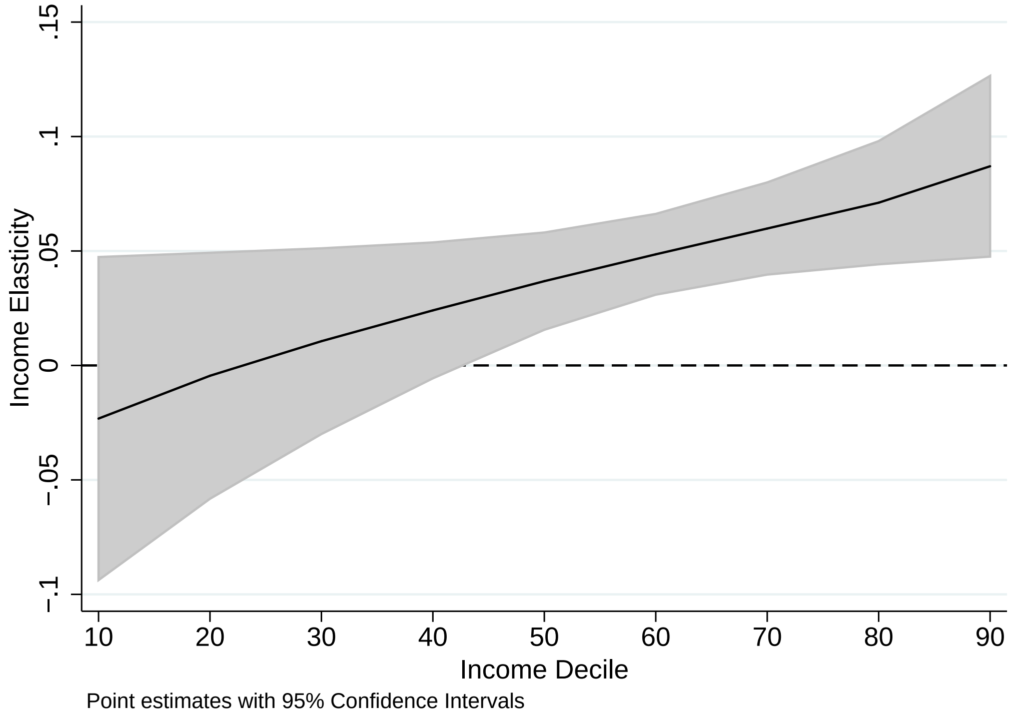
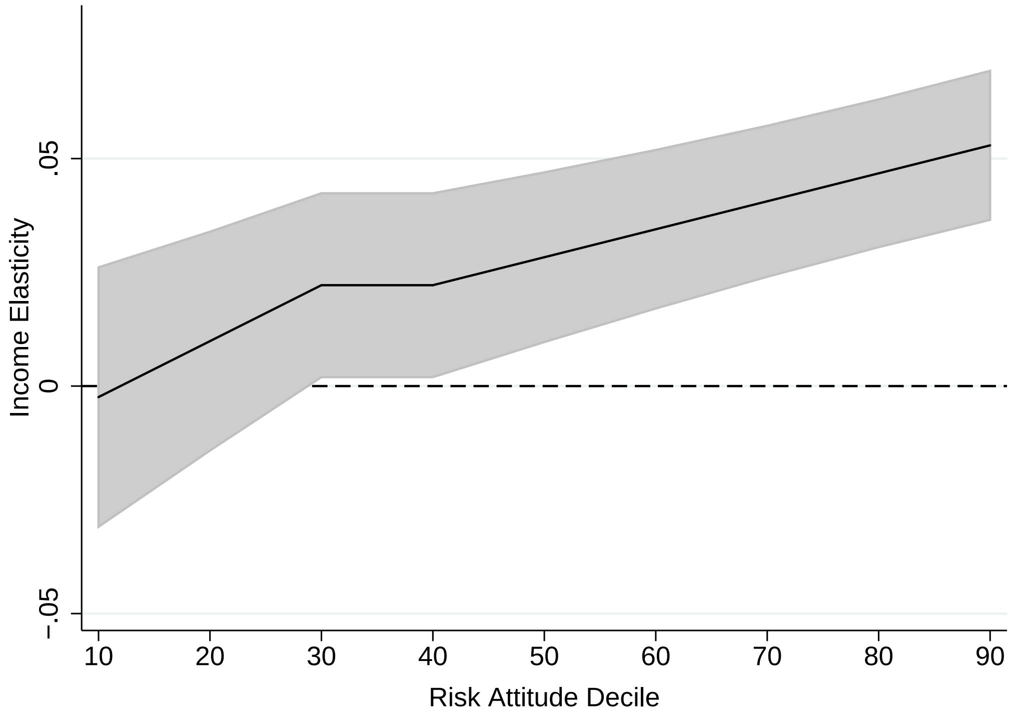


Figure 4: Marginal effects of household income on energy expenditures at different levels of risk attitudes (shaded area represents the 90% confidence bounds).



A Appendix A

Table A1: Summary Statistics.

VARIABLES	(1) Mean	(2) SD	(3) Min	(4) Max
Energy Expenditures (in £)	94.41	44.08	20.04	403.0
Risk Attitudes (median)	5.403	1.846	1	10
Trust Propensity (median)	4.119	1.836	1	10
Annual Household Income (in £)	33,396	25,184	2,050	438,732
Males (share)	0.439	0.314	0	1
Age (mean)	49.35	17.34	17	97
Born in UK (share)	0.959	0.168	0	1
White (share)	0.982	0.125	0	1
Health (median)	3.788	0.801	1	5
Education (median)	2.349	0.917	1	4
Household size (log)	0.782	0.540	0	2.773
Number of children				
aged 0 to 2	0.064	0.252	0	2
aged 3 to 4	0.064	0.255	0	3
aged 5 to 11	0.237	0.575	0	4
aged 12 to 15	0.145	0.409	0	3
aged 16 to 18	0.047	0.230	0	2
Members over 75 (number)	0.162	0.438	0	2
Unemployed (share)	0.529	0.396	0	1
Household type				
Single non-elderly	0.106	0.307	0	1
Single elderly	0.137	0.344	0	1
Couple, no children	0.292	0.455	0	1
Couple, dependent children	0.258	0.437	0	1
Couple, non-dependent children	0.082	0.274	0	1
Lone parent: dependent children	0.065	0.247	0	1
Lone parent: non-dependent children	0.040	0.195	0	1
2+ unrelated adults	0.008	0.086	0	1
Other households	0.013	0.113	0	1
Number of cars				
None	0.195	0.396	0	1
One	0.436	0.496	0	1
Two	0.295	0.456	0	1
Three or more	0.074	0.262	0	1

VARIABLES	Mean	SD	Min	Max
Number of rooms (log)	1.481	0.354	0	2.944
Type of central heating				
No central heating	0.043	0.202	0	1
Gas	0.668	0.471	0	1
Oil	0.194	0.396	0	1
Electricity	0.073	0.260	0	1
Solid fuels	0.022	0.147	0	1
House ownership				
Owner	0.766	0.423	0	1
Renter	0.219	0.414	0	1
Rent free and other	0.015	0.120	0	1
House type				
Detached house or bungalow	0.268	0.443	0	1
Semi-detached house	0.319	0.466	0	1
End terraced house	0.0854	0.280	0	1
Terraced house	0.189	0.392	0	1
Apartment block $<$ 10 units	0.097	0.296	0	1
Apartment block $>$ 10 units	0.031	0.174	0	1
Other	0.009	0.096	0	1
Household appliances				
Cable TV	0.141	0.348	0	1
Satellite dish	0.457	0.498	0	1
Landline phone	0.911	0.285	0	1
Mobile phone	0.908	0.290	0	1
Colour TV	0.989	0.103	0	1
VCR	0.943	0.232	0	1
Freezer	0.967	0.178	0	1
Washing machine	0.973	0.163	0	1
Tumble dryer	0.634	0.482	0	1
Dish washer	0.432	0.495	0	1
Microwave	0.934	0.249	0	1
Home computer	0.748	0.434	0	1
CD player	0.828	0.377	0	1
Green electricity tariff	0.0247	0.155	0	1
Green technologies	0.0113	0.137	0	3
Dwelling problems				
Condensation	0.090	0.287	0	1
Leaky roof	0.035	0.185	0	1
Damp walls or floor	0.076	0.264	0	1
Rot in windows or doors	0.040	0.196	0	1

VARIABLES	Mean	SD	Min	Max
Environmental and Social Attitudes (median household values)				
Too much time to be environmentally friendly	2.492	0.773	1	5
Science will solve environmental problems	2.332	0.773	1	5
Environment low priority in life	2.699	0.871	1	5
Leads environmentally friendly life	3.611	0.698	1	5
Leaves TV on standby	2.620	1.514	0	4
Switches off lights	3.341	0.811	0	4
Lets tap water run	1.872	1.457	0	4
Wears extra clothes (or layers)	2.437	1.058	0	4
Frequency of talking to neighbours	4.042	0.900	1	5
Frequency of meeting people	4.306	0.690	1	5
Belonging to community	-0.0654	1.773	-4.991	7.575
Importance of having good friends	9.223	1.115	1	10
Attends local groups/voluntary organizations	1.771	1.289	1	5
Does unpaid voluntary work	1.612	1.119	1	5
Reciprocity preferences	3.259	0.865	1	5
Month of interview				
January	0.013	0.112	0	1
February	0.004	0.060	0	1
March	0.005	0.067	0	1
September	0.496	0.500	0	1
October	0.319	0.466	0	1
November	0.133	0.340	0	1
December	0.030	0.170	0	1
Geographic region				
Inner London	0.011	0.106	0	1
Outer London	0.028	0.164	0	1
Rest of South East	0.111	0.314	0	1
South West	0.057	0.231	0	1
East Anglia	0.030	0.171	0	1
East Midlands	0.052	0.221	0	1
West Midlands Conurbation	0.021	0.143	0	1
Rest of West Midlands	0.029	0.169	0	1
Greater Manchester	0.022	0.147	0	1
Merseyside	0.0123	0.110	0	1
Rest of North West	0.027	0.161	0	1
South Yorkshire	0.0144	0.119	0	1
West Yorkshire	0.0162	0.126	0	1
Rest of Yorkshire and Humberside	0.020	0.141	0	1

Variables	Mean	SD	Min	Max
Tyne and Wear	0.009	0.096	0	1
Rest of North	0.016	0.124	0	1
Wales	0.174	0.379	0	1
Scotland	0.180	0.384	0	1
Northern Ireland	0.171	0.377	0	1
$N = 5,058$				

Table A2: Risk, trust and energy expenditures: Complete Results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Risk attitude	0.0255***	0.0146***	0.0134**	0.0112**	0.0110**	0.0108**
	(0.0049)	(0.0039)	(0.0047)	(0.0040)	(0.0044)	(0.0043)
Trust propensity	-0.0103***	-0.0134***	-0.0103***	-0.0105***	-0.0106***	-0.0109***
	(0.0033)	(0.0035)	(0.0032)	(0.0035)	(0.0034)	(0.0032)
Income (log)		0.2188***	0.0836***	0.0458***	0.0362***	0.0368***
		(0.0104)	(0.0116)	(0.0104)	(0.0102)	(0.0101)
Income squared (log)		0.0498***	0.0479***	0.0305**	0.0300**	0.0300**
		(0.0117)	(0.0127)	(0.0124)	(0.0134)	(0.0134)
Share of males		-0.0397*	-0.0073	0.0089	0.0132	0.0150
		(0.0228)	(0.0196)	(0.0204)	(0.0204)	(0.0212)
Age (mean)		0.0120***	0.0134***	0.0063**	0.0056**	0.0053**
		(0.0031)	(0.0024)	(0.0024)	(0.0025)	(0.0024)
Age (mean) squared		-0.0001***	-0.0001***	-0.0001***	-0.0000**	-0.0000**
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Born in UK (share)		-0.0228	0.0065	-0.0141	-0.0210	-0.0206
		(0.0435)	(0.0364)	(0.0374)	(0.0342)	(0.0353)
White (share)		-0.0719	0.0106	0.0246	0.0247	0.0223
		(0.0638)	(0.0419)	(0.0428)	(0.0451)	(0.0459)
Health (median)		-0.0191***	-0.0276***	-0.0383***	-0.0353***	-0.0333***
		(0.0061)	(0.0047)	(0.0053)	(0.0051)	(0.0050)
Education (median)		-0.0265***	0.0171*	-0.0066	-0.0059	-0.0064
		(0.0082)	(0.0094)	(0.0080)	(0.0087)	(0.0089)
Household size (log)			0.3637***	0.2701***	0.2619***	0.2586***
			(0.0394)	(0.0324)	(0.0290)	(0.0295)
Number of children						
aged 0 to 2			-0.0491*	-0.0439	-0.0438	-0.0440
			(0.0277)	(0.0268)	(0.0259)	(0.0261)
aged 3 to 4			0.0114	0.0138	0.0165	0.0118
			(0.0191)	(0.0188)	(0.0175)	(0.0184)
aged 5 to 11			-0.0100	-0.0137	-0.0155*	-0.0154*
			(0.0096)	(0.0089)	(0.0083)	(0.0083)
aged 12 to 15			-0.0076	-0.0052	-0.0064	-0.0052
			(0.0105)	(0.0091)	(0.0086)	(0.0083)
aged 16 to 18			0.1009***	0.0839***	0.0852***	0.0851***
			(0.0194)	(0.0191)	(0.0203)	(0.0204)
Unemployed (share)			0.0790***	0.0590**	0.0546*	0.0558*
			(0.0266)	(0.0259)	(0.0278)	(0.0285)
Members over 75 (number)			-0.0221	0.0001	0.0067	0.0058
			(0.0188)	(0.0197)	(0.0196)	(0.0198)
Household type (base: single non-elderly)						
Single elderly			0.0218	0.0357	0.0431	0.0411

	(1)	(2)	(3)	(4)	(5)	(6)
			(0.0213)	(0.0249)	(0.0259)	(0.0275)
Couple, no children			-0.0276	-0.0068	-0.0125	-0.0136
			(0.0308)	(0.0292)	(0.0274)	(0.0282)
Couple, dependent children			-0.0556	-0.0329	-0.0409	-0.0403
			(0.0321)	(0.0307)	(0.0269)	(0.0268)
Couple, non-dependent children			0.0138	0.0548	0.0442	0.0444
			(0.0425)	(0.0376)	(0.0368)	(0.0386)
Lone parent: dependent children			0.0377	0.0375	0.0273	0.0267
			(0.0427)	(0.0389)	(0.0384)	(0.0392)
Lone parent: non-dependent children			0.0817	0.0907**	0.0888**	0.0845**
			(0.0490)	(0.0420)	(0.0404)	(0.0393)
2+ unrelated adults			-0.1476**	-0.0990	-0.1120	-0.1145
			(0.0678)	(0.0685)	(0.0747)	(0.0762)
Other households			0.0322	0.0969	0.0999	0.1002
			(0.0765)	(0.0771)	(0.0701)	(0.0709)
Number of cars in household (base: no car)						
One car			0.0571***	0.0162	0.0022	0.0026
			(0.0140)	(0.0134)	(0.0132)	(0.0138)
Two cars			0.1378***	0.0458*	0.0207	0.0217
			(0.0190)	(0.0226)	(0.0200)	(0.0194)
Three or more cars			0.2113***	0.0754**	0.0498	0.0494
			(0.0380)	(0.0357)	(0.0327)	(0.0328)
Number of rooms (log)				0.3105***	0.2846***	0.2844***
				(0.0262)	(0.0243)	(0.0258)
Type of central heating (base: none)						
Gas				0.0452	0.0310	0.0365
				(0.0355)	(0.0379)	(0.0362)
Oil				0.1526**	0.1416**	0.1432**
				(0.0673)	(0.0664)	(0.0653)
Electricity				0.0860*	0.0805*	0.0824*
				(0.0420)	(0.0418)	(0.0403)
Solid fuels				0.1658*	0.1664*	0.1666*
				(0.0867)	(0.0871)	(0.0851)
House ownership (base: owner)						
Renter				0.0160	0.0237	0.0191
				(0.0196)	(0.0182)	(0.0185)
Rent free and other				0.0950*	0.1011**	0.0971**
				(0.0462)	(0.0440)	(0.0449)
House type (base: detached house or bungalow)						
Semi-detached house				-0.0885***	-0.0805***	-0.0790***
				(0.0122)	(0.0112)	(0.0111)
End terraced house				-0.0887***	-0.0785***	-0.0781***
				(0.0162)	(0.0163)	(0.0164)
Terraced house				-0.1190***	-0.1069***	-0.1062***
				(0.0136)	(0.0139)	(0.0143)
Apartment block < 10 units				-0.1366***	-0.1277***	-0.1330***
				(0.0217)	(0.0209)	(0.0218)
Apartment block > 10 units				-0.1907***	-0.1766***	-0.1797***
				(0.0523)	(0.0527)	(0.0536)
Other				-0.1333***	-0.1161***	-0.1216***
				(0.0283)	(0.0306)	(0.0312)
Household appliances						
Cable TV					0.0493***	0.0489***
					(0.0158)	(0.0156)
Satellite dish					0.0308***	0.0310***
					(0.0103)	(0.0100)
Landline phone					-0.0307	-0.0302
					(0.0190)	(0.0199)
Mobile phone					0.0087	0.0090
					(0.0203)	(0.0200)

	(1)	(2)	(3)	(4)	(5)	(6)
Colour TV					0.0612	0.0650
					(0.0474)	(0.0483)
VCR					0.0562**	0.0594**
					(0.0229)	(0.0235)
Freezer					0.0072	0.0023
					(0.0517)	(0.0506)
Washing machine					0.0621	0.0573
					(0.0485)	(0.0482)
Tumble dryer					0.0453***	0.0450***
					(0.0104)	(0.0110)
Dish washer					0.0703***	0.0732***
					(0.0126)	(0.0125)
Microwave					0.0304	0.0345
					(0.0255)	(0.0257)
Home computer					0.0136	0.0133
					(0.0173)	(0.0172)
CD player					-0.0162	-0.0159
					(0.0131)	(0.0129)
Green electricity tariff					-0.0234	-0.0318
					(0.0306)	(0.0317)
Green technologies					-0.0249	-0.0245
					(0.0419)	(0.0413)
Dwelling problems						
Condensation						0.0072
						(0.0174)
Leaky roof						-0.0446
						(0.0349)
Damp walls or floor						0.0742***
						(0.0188)
Rot in windows or doors						0.0631*
						(0.0332)
Month of interview (base: January)						
February		0.4001***	0.3833***	0.3557***	0.3578***	0.3624***
		(0.1184)	(0.0906)	(0.0631)	(0.0655)	(0.0665)
March		0.1645	0.1984**	0.2032**	0.1851*	0.1777*
		(0.1024)	(0.0800)	(0.0911)	(0.0918)	(0.0912)
September		-0.1699***	-0.1758***	-0.1392***	-0.1337***	-0.1367***
		(0.0494)	(0.0372)	(0.0386)	(0.0414)	(0.0381)
October		-0.1464***	-0.1435***	-0.1140***	-0.1103***	-0.1126***
		(0.0490)	(0.0347)	(0.0363)	(0.0383)	(0.0352)
November		-0.1180**	-0.1039**	-0.0666	-0.0612	-0.0638
		(0.0532)	(0.0467)	(0.0468)	(0.0478)	(0.0450)
December		-0.1534**	-0.1391**	-0.1114*	-0.1015	-0.1066*
		(0.0615)	(0.0574)	(0.0638)	(0.0667)	(0.0605)
Geographic region (base: Inner London)						
Outer London		0.0508***	-0.0276***	-0.0544***	-0.0756***	-0.0742***
		(0.0054)	(0.0080)	(0.0053)	(0.0073)	(0.0077)
Rest of South East		0.1027***	-0.0069	-0.0832***	-0.1033***	-0.1019***
		(0.0076)	(0.0120)	(0.0094)	(0.0111)	(0.0114)
South West		0.1450***	0.0065	-0.0940***	-0.1112***	-0.1123***
		(0.0099)	(0.0125)	(0.0110)	(0.0133)	(0.0136)
East Anglia		0.2323***	0.0897***	-0.0265**	-0.0410***	-0.0407***
		(0.0102)	(0.0131)	(0.0117)	(0.0129)	(0.0134)
East Midlands		0.1750***	0.0533***	-0.0461***	-0.0686***	-0.0714***
		(0.0118)	(0.0139)	(0.0090)	(0.0105)	(0.0107)
West Midlands Conurbation		0.1371***	0.0222	-0.0317***	-0.0534***	-0.0474***
		(0.0094)	(0.0141)	(0.0094)	(0.0109)	(0.0109)
Rest of West Midlands		0.2242***	0.0707***	-0.0075	-0.0311***	-0.0302***
		(0.0101)	(0.0129)	(0.0083)	(0.0095)	(0.0095)
Greater Manchester		0.1579***	0.0785***	0.0049	-0.0140	-0.0121
		(0.0085)	(0.0087)	(0.0064)	(0.0087)	(0.0084)

	(1)	(2)	(3)	(4)	(5)	(6)
Merseyside		0.2528***	0.1358***	0.0344**	0.0181	0.0167
		(0.0137)	(0.0152)	(0.0130)	(0.0146)	(0.0146)
Rest of North West		0.2618***	0.1617***	0.0607***	0.0412***	0.0401***
		(0.0098)	(0.0112)	(0.0084)	(0.0101)	(0.0098)
South Yorkshire		0.3100***	0.1834***	0.0844***	0.0589***	0.0587***
		(0.0114)	(0.0132)	(0.0099)	(0.0111)	(0.0112)
West Yorkshire		0.2392***	0.1734***	0.0821***	0.0599***	0.0643***
		(0.0091)	(0.0113)	(0.0074)	(0.0089)	(0.0095)
Rest of Yorkshire and Humberside		0.2495***	0.0999***	-0.0059	-0.0277**	-0.0277*
		(0.0117)	(0.0139)	(0.0113)	(0.0130)	(0.0137)
Tyne and Wear		0.1055***	0.0291**	-0.0110	-0.0390***	-0.0435***
		(0.0106)	(0.0107)	(0.0087)	(0.0106)	(0.0121)
Rest of North		0.2088***	0.1103***	0.0121	-0.0028	-0.0054
		(0.0127)	(0.0148)	(0.0119)	(0.0127)	(0.0127)
Wales		0.2243***	0.0857***	-0.0319***	-0.0514***	-0.0526***
		(0.0116)	(0.0136)	(0.0107)	(0.0123)	(0.0124)
Scotland		0.2669***	0.1643***	0.1241***	0.0996***	0.1048***
		(0.0101)	(0.0116)	(0.0089)	(0.0110)	(0.0113)
Northern Ireland		0.4270***	0.2780***	0.0728*	0.0520	0.0572
		(0.0129)	(0.0167)	(0.0350)	(0.0369)	(0.0382)
Constant	4.3483***	4.3111***	3.6899***	3.7914***	3.6027***	3.5965***
	(0.0553)	(0.1429)	(0.1079)	(0.1180)	(0.1412)	(0.1399)
Observations	5,058	5,050	5,050	5,050	5,050	5,043
Adjusted R-s	0.00749	0.180	0.310	0.379	0.390	0.392
Log Lik	-3222	-2719	-2275	-2002	-1948	-1936
AIC	6450	5472	4585	4041	3932	3908

Heteroskedasticity-robust standard errors clustered at regional level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3: Robustness estimations varying dependent variable, sample, and risk and trust measurement

	Change in					
	Sample		Dependent		Measurement	
	Using information from all available households	Owner-occupied, single family homes	Energy expenditures per capita	Energy expenditures per equivalent adult	Mean household risk and trust measures	Values from the household reference person
Risk attitudes	0.0110**	0.0188***	0.0107*	0.0118***	0.0118**	0.0081***
	(0.0042)	(0.0037)	(0.0051)	(0.0036)	(0.0046)	(0.0028)
Trust propensity	-0.0111***	-0.0118***	-0.0111***	-0.0100***	-0.0112***	-0.0093***
	(0.0026)	(0.0030)	(0.0028)	(0.0030)	(0.0034)	(0.0022)
Observations	5,201	3,529	5,050	4,752	5,043	4,982
Adjusted R^2	0.397	0.386	0.516	0.513	0.392	0.387
Log Lik	-2080	-1181	-2078	-1485	-1935	-1932
AIC	5626	2397	4193	3007	3907	3900

Notes: The dependent is the natural logarithm of household energy expenditures. All estimations control for socio-demographic and housing characteristics. Controls correspond to the ones used in column (6) of Table 2. All estimations contain a constant. Estimations using reference person risk and trust taking values substitute household averaged socio-demographic characteristics by the characteristics of the reference person. (Heteroskedasticity-robust standard errors clustered at regional level in parentheses)*** p<0.01, ** p<0.05, * p<0.1

B Appendix B

To construct a measure of the respondent's attachment to her local community of living, information was used from eight items assessing respondent's perception on her integration in the local community. These questions cover different areas of life and are presented in the form of proposition to which the respondent notes her level of agreement on a 5-point Likert scale, ranging from "strongly agree" (1) to "strongly disagree" (5). In detail, these propositions are:

(a) I feel like I belong to this neighbourhood.

(b) The friendships and associations I have with other people in my neighbourhood mean a lot to me.

(c) If I needed advice about something I could go to someone in my neighbourhood.

(d) I borrow things and exchange favours with my neighbours.

(e) I would be willing to work together with others on something to improve my neighbourhood.

(f) I plan to remain a resident of this neighbourhood for a number of years.

(g) I like to think of myself as similar to the people who live in this neighbourhood.

(h) I regularly stop and talk with people in my neighbourhood.

Principal component analysis yielded a single underlying item as judged by the number of principal components with eigenvalues of one or larger. The Kaiser-Meyer-Olkin measure of sampling adequacy reached 0.8843, suggesting sufficient overlap between these variables to merit the construction of this item.