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How large is the Owner-Renter Divide? Evidence from an OECD cross-section*

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Abstract

When the agent making an investment decision is different from the one bearing the costs of the usage decision, the outcome (energy usage, in this case) is socially sub-optimal, a scenario known in the energy efficient technology case as "split incentive" effect. Using a sample of individual households from 11 OECD countries, this paper investigates the magnitude of the "split incentives" effect between home occupants who are owners and those who are renters. A wide variety of energy-related 'technologies' are considered: appliances, insulation, heat thermostat, solar panels, ground source heat pumps and wind turbines. The raw data provide a clear indication of difference in patterns of access to these technologies consistent with the "split incentives" hypothesis. Regression results suggest that, even after controlling for the sizeable differences in observed characteristics, owners are substantially more likely to have access to top-rated energy efficient appliances and to better insulation as well as to heat thermostats. For relatively immobile investments such as wind turbines and ground source heat pumps, we find a very small effect, possibly due to the differing institutional characteristics (such as availability of grants and regulations) which influence their adoption.

JEL Codes: $Q4, Q5$

Keywords: *Principal-Agent Problem; Split Incentives; Energy Efficiency*

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*The data used in this work come from an OECD survey on Environmental Policy and Individual Behaviour Change (EPIC) periodically conducted by the Environment Directorate. The views expressed do not necessarily reflect those of the Organisation for Economic Cooperation and Development (OECD) or its member countries.

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1 Introduction

This paper addresses the question of whether differing incentives between home owners and tenants lead to sub-optimal investment decisions on the part of the owners. Beginning with the premise that more energy efficient investments are expensive, we address whether problems related to imperfect information regarding home energy consumption characteristics (such as efficiency of insulation or of appliances already installed) on the part of the renter lead to under-investment in energy efficiency on the part of the home owner (who foresees–or has experienced–the lack of a premium for such characteristics)[1]. This issue, labelled the "split incentive" in this context, has long been viewed as being of some importance, and is viewed as part-explanation of the wider phenomenon of under-investment in energy efficiency, the so-called "energy efficiency gap" (see Allcott & Greenstone (2012) and references therein).

However, while many studies assume that certain situations invariably lead to agency problems and proceed to assess the magnitude of such problems (e.g. International Energy Agency (2007)), there have been few empirical studies rigorously quantifying the magnitude of such effects (recent studies include Davis (2011); Gillingham et al. (2012); Maruejols & Young (2011)). The current study adds to the growing weight of evidence indicating a small (yet non-negligible) magnitude of these effects. This study follows the recent ones (cited above) in using the approach (in the terminology of Allcott & Greenstone (2012), pp 19) of testing if observed market equilibria are consistent with imperfect information. In other words, the approach used is to test if the observed market equilibrium, that owners under-invest in energy efficiency in tenant-occupied homes, support the hypothesis of a principal-agent problem when conditioned on relevant observable differences between tenants and home owners. It differs from the studies cited above in using a representative sample from a large number, 11, of OECD countries, as well as a survey data set richer in other dimensions (see section 2). This wide geographic coverage should help address, to an extent, concerns of external validity of studies based on narrow geographies, noted in Allcott & Greenstone (2012).

The landlord-tenant divide in energy efficiency is a long-standing issue in the energy economics

[1]It is not possible to disentangle the above explanation for underinvestment from an alternative, which is that legal and other restrictions (mostly rent control) impede the owner from being able to charge a suitable mark-up for energy efficiency, leading to under-investment.

literature (see for instance Davis (2011); Gillingham et al. (2012); Allcott & Greenstone (2012); Jaffe & Stavins (1994)). There are essentially two variants of this issue (or two principal-agent problems), depending upon which agent makes the decision and which bears the marginal cost of usage. In the first variant, when the tenant pays the utility bills (i.e. bears the marginal costs of usage), landlords have little incentive to invest in (more costly) energy efficient devices/appliances (the technology-choice or investment-related variant). In the second, when landlords bear the marginal costs then tenants have little incentive to optimize energy use and therefore, use more energy than they would have otherwise, irrespective of both energy efficiency and of which agent makes the investment (see Gillingham et al. (2012); International Energy Agency (2007) for a taxonomy of these issues).

In this study we focus on the investment-choice-related principal-agent problem, wherein the owner ("agent") makes a appliance (e.g. Fridge) or technology (e.g. thermostat/wall insulation) choice for the tenant ("principal") who bears the cost of usage (energy costs). The agents' decision leaves the principal with potentially higher electricity costs. Empirically, this can be observed in the data in the form of fewer energy efficient devices/technologies to which the tenant has access, relative to the owner. Put another way, controlling for differences in observable characteristics and potentially, preferences (and ignoring unobserved heterogeneity), differential access to energy efficient technologies between tenants and owners, in a situation where owners provide most of the appliances/technology, is a reflection of the investment-related principal-agent problem (labelled the "split incentives" issue in this context).

The issue of "split incentives" in residential energy consumption, as indicated above, has typically been considered part of a larger context of market failures which lead to less than (socially) optimal adoption of energy efficient technologies (see for instance the surveys in Gillingham et al. (2006, 2009) and references therein). A typically advocated solution (with its own drawbacks, see Allcott & Greenstone (2012)) is the second-best one of energy efficiency standards, now adopted in most developed economies.

Prior studies can be categorized into essentially two types. The first type of studies assumed that certain types of situations invariably lead to "split incentives" issues and turn to quantifying their impact (upon energy usage or carbon emissions, typically). Examples include the analyses in Murtishaw & Sathaye (2006), which quantifies the impact–in terms of energy savings–of both investment and usage inefficiencies, presuming that all scenarios with potential for inefficiency actually are affected from it; and in International Energy Agency (2007), wherein empirical studies for the US and the Netherlands make assumptions similar to those in Murtishaw & Sathaye (2006).

The second type of studies attempt to quantify the magnitude of the "split incentive" effects, and typically provides an idea of the counterfactual scenario, with the inefficiency removed. An early study in this strand is that in Levinson & Niemann (2004), which attempts to quantify the impact of the usage inefficiency for the US, using the Department of Energy's RECS (Residential Energy Consumption Survey). This study reports modest usage-related "split incentive" effects, and therefore, low impact on total energy consumption of this effect. Gillingham et al. (2012) is a study which quantifies, using a representative sample from the RASS (Residential Appliance Saturation Survey) from California, both types of inefficiencies. This study finds only modest evidence for higher heating settings when users (tenants) do not pay for heating, and a substantial effect on investment, of upto 20% reduction in probability of being insulated. Another important study is that in Davis (2011), which attempts to quantify the investment-related "split incentive" magnitude for appliances. This study reports moderate effects for different appliances, of at most 10% reduction in probability of a tenant having access to an energy efficient ("energy-star rated") appliance. Finally, in Maruejols & Young (2011), which investigates both types of "split incentives" effects for apartments ("multi-unit dwellings") in Canada, only moderate usage effects and a small investment effect is reported.

It is important to note that the practical implications from these studies, in terms of either CO_2 emissions or energy savings, are always relatively small, either since the effects are quite small (Gillingham et al. (2012)) or since the appliances investigated are a small part of the total energy consumption (Davis (2011)).

The current study is similar to those in Davis (2011), Gillingham et al. (2012) and Maruejols & Young (2011), in that the framework used for analysis (using observed market equilibria to rationalize and quantify the effect of interest) and interpretation are both very similar to that used there. However, the analysis here moves beyond these in two important dimensions: first, geographic coverage is much broader and second, it addresses virtually all energy consuming technologies, both appliances and heating/cooling. Finally, the somewhat unique nature of the survey allows a disentangling of the issue of a tenant "having access to" a certain energy efficient technology: we can identify if the energy efficient technology in question, in tenant-occupied homes, exists as a result of the owners' investment or the tenant's.

The main drawback of the study is the lack of significant sample sizes for energy consumption (as well as missing price data) and the difficulty of dealing with unobserved heterogeneity (an issue whose importance is highlighted in Gillingham et al. (2012); Allcott & Greenstone (2012), among others), given that only a single cross-section is available for use. Further, we are unable to identify which appliances are "top-rated" for energy efficiency and can only provide an overall figure for the presence of at least one top-rated energy efficient appliance.

We find strong evidence for the existence of "split incentives", quantified here in terms of "ownership effects" on the probability of having access to the relevant energy efficiency technology. For appliances (excluding ACs, which are typically not provided by owners), this effect is very large, about 45%, which is at least four times as large as the largest effect in Davis (2011), for energy efficient bulbs it is an even larger 50%, although the practical implications of this are rather uncertain, given its extremely portable nature. For technologies such as ground source heat pumps, wind turbines and solar panels, we find either no effect at all or only minimal effects (solar panels, at 2.5%), which is consistent with the empirical observation that these tend to be very location specific and are likely drive by both increasing returns (at the level of the country) and local regulations/incentive structures (heat pumps and solar panels).

For heat thermostat, a relatively mobile yet moderately expensive investment, we find lower yet sizeable effects, at 10%. Finally, for different types of insulation (roof/walls, windows), we find sizeable effects, of 9.5 and 12%, which are well within the ranges for insulation of different types reported in Gillingham et al. (2012).

The rest of the paper is structured as follows: section 2 provides an outline and basic summaries of the survey data used for the analysis, section 3, the heart of the paper, lays out the empirical framework, discusses the main results and robustness to a variety of plausible alternative explanations of the observed effects and section 4 concludes.

2 Survey Details and Summaries

2.1 Survey and Data

Data for the analysis were drawn from the OECD's project on *Greening Household Behaviour*, as part of which a periodic survey on Environmental Policy and Individual Behaviour Change (EPIC), covering a number of countries and areas, is carried out. The second survey was conducted in 2011, and included 11 countries[2]: Australia, Canada, Chile, France, Israel, Korea, Japan, the Netherlands, Spain, Sweden and Switzerland. We provide a brief description of the survey, and refer to OECD (2013, Annex B) for survey details and to Kriström (2013) for a brief overview of the energy efficiency attributes analyzed here.

About 1000 individuals in each country were surveyed using an internet-based questionnaire, for a total sample size of 12,200 households. The questionnaire collected information regarding household behaviours in five distinct areas (apart from household characteristics and environmental attitudes): residential energy use, waste generation and recycling, food consumption, personal transport, and water consumption. The present analysis uses data from the energy section. Sample selection followed a strategy of stratification based on income, age-group, region and gender. In order to account for sampling-related issues, ex-post probability weights were provided, which may be used to render estimation results using this sample comparable to those using random samples from country-level population distributions.

The key question– and the basis for our analysis– is the following: "did you install/invest in the following energy efficient appliances/technologies?". The possible responses are one of the following: "Yes/No, already existing, installation not feasible". The energy efficient technologies the respondents were asked about are: "top-rated" energy efficient appliance [3], energy efficient bulbs, ground source heat pumps, solar panels, roof/wall insulation (labelled "Thermal Insulation" in table 2), heat thermostats, wind turbines and insulated windows. Unfortunately, the question does not allow us to distinguish which of these appliances (and how many, since a substantial fraction of

[2] The first round of the survey, conducted in 2008, did not have comparable questions allowing an assessment of the issues addressed here.

[3] This question was worded in the respondent's national language and the rating symbols also were country-specific. Nonetheless, all of these countries have an "energy star" label, and so, for the appliances in question at least, we can assume that the question was "Do you have an energy star rated appliance?".

the individuals report owning more than one of these appliances) were "top rated energy efficient"[4]. As a result, our discussion pertaining to appliances will stand for any of these appliances (excluding ACs, since this is the major appliance which is not typically owner provided).

It is important, at this point, to note that we have finer data on hand than in the analysis in Davis (2011) and Gillingham et al. (2012) (as well as the studies in International Energy Agency (2007)), which only have the response to a question asking if the respondent "had the appliance in question in their residence". This wording does provide enough information to evaluate whether the appliance in question *already existed* when the home was bought/rented or was acquired subsequently, an especially important issue for tenants who live in a rented home. This is an important point since the split incentives issue refers to homeowners *differentially investing* in energy efficiency depending upon whether they live in the (owned) home.

Therefore, the relevant category of rented and owned homes for comparison are those homes where owners invested in energy efficiency *after* they bought the home (thus excluding those owners who inherited efficiency) and those where renters *already had access* to the relevant energy efficiency when they rented their home (thus excluding those renters who invested in energy efficiency). In prior studies, tenants who purchased the appliances/technologies they report having access to are also included [5]; including these tenants is likely to lead to a lower estimate of the effect of ownership (see section 3.2 for a discussion of this issue). In our case, a substantial number of tenants report investing in energy efficiency, including making potentially large fixed investments in certain cases (see table 5).

The EPIC survey provides a large collection of self-reported variables pertaining to distinct environment-related behaviors/attributes. Of these, we choose the following two as being most relevant to our purpose: self-reported membership in an environmental organization (following Kotchen & Moore (2008)) and an index derived from self-reported measures taken to save energy (scaled to the interval $[0, 10]$, with higher values indicating greater responsibility); a similar index composed of more general behaviours was used in Maruejols & Young (2011) in a context similar to

[4]The precise wording of the question was (for the appliances option): "Top rated energy efficient appliances (e.g. top-rated washing machines, refrigerators)". Since the wording is rather vague, we presume that consumers assume that the larger durable goods are being considered (excluding for instance televisions and computers).

[5]it includes as well as a few owners who inherited the energy efficiency–when they purchased the home–and made no particular investment in it. However, it is likely that some of this investment in energy efficiency is reflected in the purchase price. In any case, this is likely a relatively minor issue in the population.

ours. In addition, the survey provides self-reported data on income (in euro), electricity consumption (in euro and in Kwh, from which an average price was derived[6]), home details (size of home in sqr. mtr, number of residents, apartment or other type of housing, location details etc) and socio-economic characteristics of the respondent (age, gender and employment status), some of which are used in the regressions (see section 2.2 and section 3.2 for details of variables used). As regards the energy consuming technology data, individuals are also asked how many of refrigerators, freezers, clothes dryers (and televisions/computers, which we ignore) they own.

2.2 Summary Statistics

Table 1 presents the summary statistics for the regression sample. A few features of the data are worth noting: it is evident that owners as a group are sampled more than tenants, a typical issue with most surveys of this sort (see also the remarks in Davis (2008); Maruejols & Young (2011)) and further, that while "green tastes" (see next) are identical for both groups, incomes are substantially different. In more detail, tenants are just as likely as owners to be member of an environmental organisation (at about 8%), are just as "responsible" in their attitude towards energy saving (i.e. have very similar "energy saving behavior" scores, at about 7.5) and have very similar (almost identical) wtp for a fully green energy system. Taken together, these clearly imply that there is no distinction between them in terms of "green taste". Owners and tenants however differ in the size (in sq. mtr) of residences, and in annual electricity spending (in euro), conforming largely with differences in income (i.e. owners tend to inhabit larger houses).

Owners as a group are also more likely to report "Married or Living together", compared to renters, and are also substantially older. These help understand the slightly larger household sizes on average, at 3.16, for owner-occupied dwellings in comparison to renter-occupied ones, at 2.6. Both factors indicate that owners, as a group, tend to have a very different social profile, one not reflected in the "Employment" category, since they are also much more likely to be pensioners (not reported). In summary, therefore, a picture emerges of renters as being younger, less well off, less likely to be married and/or having children, spending less on electricity and yet, exhibiting

[6]A large part of the sample, about 60%, did not report data on electricity consumption–either kwh or euro. Using these data therefore result is substantial loss of sample size. Nonetheless, we report results using average price derived from the self-reported consumption data in section 3.3.

Variable	Owner	Renter	N(Owner)	N(Renter)	N(Total)	pvalues
wtp (%age of elect. Bill)	11.678	11.688	6166	3501	9667	0.113
Income (Euro)	42000	34000	6503	3824	10000	0
Individual and household Characteristics						
Years of post-high school	3.379	3.224	7695	4507	12000	0
Household Size	3.164	2.589	7695	4507	12000	0
Home size (sqr. Mtr)	117.927	79.398	7166	3970	11000	0
Energy Behaviour index	7.508	7.556	7689	4500	12000	0
Electricity spending (Euro)	1048.703	741.952	3920	2118	6038	0
Live in Apt. (1=Yes)	0.333	0.608	7695	4507	12000	0
Marital status (1=Married)	0.675	0.493	7695	4507	12000	0
Vote in Local Elections (1=Yes)	0.788	0.634	7695	4507	12000	0
Vote in National Elections (1=Yes)	0.843	0.721	7695	4507	12000	0
Employed (1=Yes)	0.616	0.626	7695	4507	12000	0
Env. Org. Member (1=Yes)	0.079	0.076	7695	4507	12000	0.174
Age of respondent	45.204	38.907	7695	4507	12000	0
Energy cost consideration (1=Yes)	0.29	0.243	6964	4117	11000	0
Appliance Saturation						
Air Conditioner	0.590	0.509	7695	4507	12000	0.000
Refrigerator	0.991	0.982	7695	4507	12000	0.001
Freezer	0.368	0.242	7695	4507	12000	0.000
Clothes Dryer	0.478	0.343	7695	4507	12000	0.000
Computer	0.994	0.987	7695	4507	12000	0.000

Notes: Means are based on the relevant sub-sample, with (sub-)sample sizes shown in the table. For binary variables, the "means" are simply proportion of the sample with category 1. "p-values" refer to the p-value of a two-sided, unpaired t-test for mean difference (assuming unequal variances) between the two sub-groups, Owner and Renter. The summary statistics use probability weights to account for survey sampling (including adjustments to test statistics and the mean itself). This implies, in particular, that the means reported above are not simply the raw means of the sample.

Table 1: Summary statistics for Socio-economic variables and Appliance saturation.

Variable	Owner	Renter	N(Owner)	N(Renter)	N(Total)	pvalues
Our Definition						
Energy Efficient Appliances	0.58	0.081	3274	2100	5374	0
Energy Efficient Bulbs	0.879	0.061	6658	4506	11000	0
Ground Source Heat Pumps	0.064	0.012	3388	4506	7894	0
Solar Panels	0.151	0.019	3892	4506	8398	0
Thermal Insulation	0.521	0.101	4511	4506	9017	0
Heat ThermoStats	0.536	0.099	4385	4506	8891	0
Wind Turbines	0.032	0.01	3345	4506	7851	0
Energy Efficient Windows	0.608	0.122	4605	4506	9111	0
Extant Definition						
Energy Efficient Appliances	0.685	0.494	3274	2100	5374	0
Energy Efficient Bulbs	0.916	0.63	6951	4506	11000	0
Ground Source Heat Pumps	0.099	0.024	3434	4506	7940	0
Solar Panels	0.199	0.042	4157	4506	8663	0
Thermal Insulation	0.713	0.186	5265	4506	9771	0
Heat ThermoStats	0.696	0.22	4886	4506	9392	0
Wind Turbines	0.061	0.016	3383	4506	7889	0
Energy Efficient Windows	0.764	0.251	5225	4506	9731	0

Notes: Definition of mean and computation of test statistics are as reported in table 1. Individuals "having access to" the energy efficient technologies, in the rows under "Our Definition", correspond to owners who invested in, and tenants who gained access by renting a unit already equipped with, the relevant technology. Under the "Extant Definition", owners who gained access to the relevant technology by purchasing a home already equipped with it and tenants who invested in the relevant technology are also counted as "having access to" that technology.

Table 2: Proportion of (sub-) sample having the relevant energy efficient technology.

identically “green” behaviours/attitudes.

Consider next mean differences in access to specific energy efficiency/generating technologies, the effect of interest. In keeping with our discussion in section 1, we report mean differences for two measures of “having access to”: in the first, labelled “Our Definition” in table 2, only owners who invested and tenants who “inherited” the technology by renting a unit with which it was equipped are counted while in the second, labelled “Extant Definition”, in addition to those in the first, owners who “inherited” the relevant technology by purchasing a home equipped with it and tenants who invested in it are counted.

It is evident from table 2 that irrespective of which measure is used, the differences in access to technologies between owners and renters is sizeable. For instance, for the definition we work with, these range from a very high 81% for bulbs to a rather low 5.2% for heat pumps. There is also an apparent pattern in these differences, the highest (between 50 and 81%) are associated with appliances and bulbs, lower but rather sizeable (between 42% and 48%) for insulation-related technologies (insulation, windows and thermostats) and lowest (between 5 and 15%) for difficult-to-port technologies with large investment and low access levels (heat pumps[7], wind turbines [8] and solar panels). While the highest and second-highest categories are inter-changed when the second definition is used (see section 3 for a discussion of these differences), the overall mean differences in access are still quite high.

To summarize, there are clearly significant differences in mean outcomes between owners and renters across many dimensions, providing a basis for, and impetus to, further investigation. Yet, given the independent nature of such comparisons (e.g. differential access to specific technologies do not control for differing attributes between owners and renters, such as education and income levels or for age) it is not clear if observed mean differences are a reflection of the underlying owner-renter dichotomy–which is the effect of interest–or are being driven by common, unobserved factors (or combinations of observed factors). In order to address this issue, we turn next to a regression framework.

[7]Substantial ownership of heat pumps is restricted to the 4 colder countries in the sample, France, Canada, Sweden and Switzerland. Full country-specific tables are available upon request.

[8] The sample sizes for wind turbines, a very capital intensive good, are rather small, with only 158 individuals in the sample owning them, of who 115 are home owners. See table 5.

3 Quantifying Agency Effects

3.1 Empirical Framework

Recall that the main objective of the paper is to quantify the agency effect i.e. the size of the principal-agent problem in the rental market. Similar to prior analyses (Davis (2011); Gillingham et al. (2012); Maruejols & Young (2011), we use a binary choice framework to quantify the relevant effect for each of the eight energy efficient technologies/appliances. In more detail, we estimate below the following generic model:

$$\mathbb{P}(Y_i = 1|X_i, ownership) = F(X_i\beta + \alpha\mathbb{I}\{owner\}) \quad (1)$$

where $F(.)$ is a generic conditional distribution, usually the normal or the logistic, X_i is a set of conditioning variables described next, and $\mathbb{I}\{owner\}$ is an indicator of ownership. Interest in this case centers around the average marginal effect (AME) of the impact of ownership i.e. upon $\mathbb{E}_X[\mathbb{P}(Y_i = 1|X_i, owner) - \mathbb{P}(Y_i = 1|X_i, tenant)]$, corresponding to the change in the probability of having access to the energy efficient technology in question between owners and renters. This is the effect of interest reported in table 3.

The estimation takes into account the non-random nature of sampling (i.e. uses sampling probabilities) and the resulting likelihood function is known as the "pseudo-likelihood". Standard error for the AME is, in all cases here, computed as a linearized version–instead of the more common delta-method version–accounting for sampling variability of the conditioning variables. In addition, the standard errors are robust to arbitrary correlation within countries (i.e. are clustered at the country-level).

We emphasize that the main benefit of estimation of agency effects for a wide cross-section of countries, using a common data set and methodology, is the resulting comparability of estimates. So far as we are aware, this is the first study to undertake such an analysis. We capture country-specific unobserved common factors by using a country-fixed-effect in the estimation (written implicitly as a part of the X_i in eq. (1)). We note that, unlike in the case of the linear model, this is not as restrictive an approach as appears at a first glance, in that despite not explicitly allowing for country-specific coefficients (e.g. α_i), the marginal effects–being a function of the country-fixed-effects–vary by country. We do not allow explicitly for country-specific coefficients in the interests of both interpretation and parsimonious estimation (the country-specific sample sizes vary and, for many countries, are rather small) and report the marginal effect averaged over all countries (and covariate values) [9], labelled AME and referred to subsequently as the more concise "effects".

A *positive* AME implies that owners are more likely to own the device in question, relative to tenants; in other words, a positive AME implies an agency effect. The magnitude of the AME on the coefficient on ownership provides a *quantitative* measure of the agency effect for that particular energy efficient technology. Sample sizes vary between technologies due to the number of non-responses, which are much higher in case of technologies with high fixed costs (such as wind turbines and heat pumps, for instance). As indicated earlier, for the main specifications, we use probit (and logit) models, and in these models, the marginal effects have the same sign as the coefficient in the main regression. An ancillary benefit of the probit (or any binary regression) framework is that information from households who *do not have access to* the device in question can be beneficially used, unlike in the Linear Probability Model (LPM)–used in Davis (2011)–, wherein the "0s" must necessarily be omitted from the regression framework. This is an important reason for the choice of a relatively difficult to interpret categorical regression framework, in comparison to the simpler LPM.

The regression results are reported in table 3.The controls, X_i in eq. (1), used in each regression include: age, gender and employment status (employed or not) of the respondent, number of individuals in the household, size (in sq. mtr of the home), an indicator for whether the home is in an apartment building, defined here as part of a multi-unit complex with more than 12 units and, finally, cubic splines for income and country-fixed effects. We also include for all technologies–except for appliances (see below)–an indicator for whether the primary source of space heating/cooling is electricity. We do not use, in this set of regressions, either the quantity of electricity used or the electricity price due to a variety of reasons (see footnote 6).

We turn briefly to discussing the rationale for inclusion, as well as direction of effect, for various controls. It is likely, a priori, that certain technologies (e.g. heat pumps) are likely to be more diffi-

[9] It is important to note that, with many indicator variables—as in the case here—reporting the grand average of marginal effects ensures that the (marginal) effects correspond to an "average individual", not to any particular category (for instance, male, employed and owner). It is also possible to compute category-specific marginal effects.

cult to install in apartments, especially for an individual apartment. In addition, apartment-dwellers, owners and tenants both, are likely to face other restrictions on installation which either makes it infeasible to use certain technologies (e.g. solar panels) or increase the cost. In addition, in countries where electric space heating is used, it is likely more expensive than alternatives (such as district heating, in Sweden) and we account for these factors by including an indicator for households which use electricity as a primary source of space heating/cooling[10].

In most countries, the dynamics of space cooling and heating are rather different: for instance, it is likely that owners do not provide air-conditioners, an important space cooling equipment in many countries. Since these are not directly subject to the split incentives issue, we exclude them from the remit of our appliance access decision and therefore consider only households which do not report owning an air conditioner, for the appliance access decision (row I in table 3).

A final issue is related to a priori expectations regarding the magnitude of effects for different technologies. To illustrate the considerations involved, we compare two types of energy efficient technologies, bulbs and solar panels. The former is very portable but is liable to damage and frequent failure (as well as to theft) and has a lower return period; the latter is difficult-to-port and has a much larger return period. A priori, therefore, one anticipates that landlords are less likely to risk investing in energy efficient bulbs; however, this is counteracted by the much smaller investment in bulbs. Overall, therefore, it is unclear which of these effects dominate, without more knowledge of a few specifics, such as average (expected) tenure length, building codes etc. This is also seen in the empirical results in Davis (2011), wherein lighting is seen to have a smaller magnitude of the agency effect than many other categories with higher fixed costs and return periods (e.g. dishwashers).

[10]It is difficult to disentangle whether space heating or cooling is the primary goal for all countries; for certain countries e.g. Sweden, Switzerland and Canada, heating is most likely the major goal. For certain other countries e.g. Spain, France and Chile, it is likely to be a combination of both heating and cooling. It is important to note that there are far fewer options for space cooling other than using electricity, strengthening the case for controlling for electric heating/cooling as a driver for technology choice.

3.2 Results

	Our Definition		N	Conventional Definition		N
	Probit	Logit		Probit	Logit	
Energy Star Appliances (excl. AC)	0.452***	0.459***	4997	0.122***	0.120***	4997
	(16.52)	(18.64)		(5.00)	(4.97)	
Energy Efficient Bulbs	0.509***	0.511***	9432	0.0504***	0.0507***	9432
	(30.90)	(16.23)		(2.83)	(2.86)	
Ground Source Heat Pump	0.00353	0.00458	7348	0.000636	-0.000124	7348
	(0.39)	(0.40)		(0.07)	(-0.01)	
Solar Panels	0.0295**	0.0328*	7582	0.0161**	0.0163*	7582
	(1.99)	(1.94)		(2.19)	(1.88)	
Roof/wall insulation	0.0941***	0.0957***	8012	0.198***	0.197***	8012
	(3.05)	(2.85)		(6.60)	(6.34)	
Heat Thermostat	0.0983***	0.0976***	8226	0.0511***	0.0524***	8226
	(3.45)	(3.18)		(4.29)	(4.30)	
Wind Turbine	-0.000403	-0.000643	7360	-0.00436	-0.00539	7360
	(-0.05)	(-0.06)		(-0.58)	(-0.57)	
Insulated Windows	0.124***	0.126***	8374	0.116***	0.116***	8374
	(4.20)	(4.09)		(4.82)	(4.64)	
Average Marginal effects; t statistics in parentheses						
***p<0.01 **p<0.05 *p<0.1						

Notes: Average Marginal Effects for the indicator variable on home ownership from probit and logit regressions. Standard error computations take into account the nature of sampling, account for sampling variation in the conditioning variables and are robust to arbitrary correlations within country. The dependent variable in each regression is an indicator variable for 'having access to' the energy efficient technology in question. The definition of 'having access to' differs between the columns under 'Our Definition' and 'Conventional definition' (see the definitions in table 2). All regressions include country-fixed effects (not reported). All regressions are "significant" in that the Wald test for joint significance of the included covariates (excluding the country-fixed-effects) are significant (not reported).

Table 3: Quantifying agency effects in energy efficient technology.

As indicated earlier, our data set allows us to explicitly identify whether tenants access to a given technology is due to their investment or to owner investment (i.e. tenants inherit the technology along with the rental unit). Prior studies (Davis (2008); Gillingham et al. (2012)) are unable to make this distinction, as a result of which, under their measure (described also in table 2), a larger share of tenants (and owners) have access to energy efficiency (every row in the table 2 under "Our definition" is smaller than that under "Extant definition"). Note however, that the direction of the impact of this definition upon the agency effect depends upon the following factors: the number of home owners who "inherit" energy efficiency during home purchase, and the number of renters who invest in them. If the latter category is larger (smaller) in size than the former, then it is unlikely that the inclusion of these cases in the "having access to" category will lead to an increase (decrease) in the magnitude of the split incentive effect [11].

To illustrate a practical case, consider the case of energy efficient bulbs, from table 5: the "correct" definition of the agency problem yields 5946 owners who have access, compared with 360 renters. The conventional definition, however, would add the 3045 renters who invested in bulbs to the 360 renters who did not; since the number of owners who "inherited" such bulbs is far smaller (at 545) than the number of renters who invested, one anticipates, a priori, that a *smaller* agency effect should be detected in the latter case than the former. This situation is reversed in the case of the ground source heat pumps.

We turn now to understanding the agency effects in different energy efficient technologies, from table 3. Note that we will discuss the results in terms of "having access to" the relevant energy efficient technology, with the two definitions of "having access to" outlined above. Consider first the case of energy efficient appliances[12]: the positive significant coefficient of 0.45 indicates that owners are 45% more likely than renters to have access to top-rated energy efficient appliances. To understand the magnitude of the effect, observe that the raw differences in means are about 50% (table 2, Row I). Thus, controlling for income and other relevant covariates barely reduces the magnitude of the impact. The effect is much smaller (about a quarter), at 12%, with the definition of "having access to" used in Davis (2011); Gillingham et al. (2012). These differences are evident from an inspection of the mean differences (under the "conventional definition" column in table 2), which are only 18% in this case, the reason being the significantly greater renters investing in a top-rated energy efficient appliance in comparison to owners "inheriting" the same category of appliance (792 versus 357, from table 5). Essentially, we report a very high agency effect on energy efficient appliances, which is much larger than the largest effect for appliances reported in Davis (2011)–the study closest to ours–, at 9.5% for dishwashers (Table 2).

Turning now to the case of energy efficient light bulbs, our a priori anticipation is of a large effect, mainly due to the insecurity already alluded to. In accordance with intuition, we see a very

[11] Providing, of course, that sample sizes do not alter substantially as a result, which is mostly the case in our data. See table 5.

[12] Given that the probit and logit specifications are almost indistinguishable for all cases, we focus on the results of the probit specification. We also note that the close agreement between probit and logit–but not for other specifications–is a well known empirical fact. Attempts were made to estimate specifications other than these, such as the skewed logit or heteroscedastic probit, but were unsuccessful (likelihoods did not converge) due to the inclusion of fixed effects and sampling weights. Heteroscedasticity, in particular, is an important issue in this setting (since ignoring heteroscedasticity can lead to not just inefficient but *inconsistent* parameter estimates) but one which we are unable to deal with here.

large effect, at about 50%. This is also evident from an inspection of the mean differences between owners and renters, which are substantial–and substantially higher than the estimated effect– at 82%. The magnitude of this effect also illustrates the importance of controlling for observable differences between owners and renters; the conditional difference is about 60% of the unconditional. From the same table (table 2), we see that mean differences, at 28%, are a third as large when renter investment is included; correspondingly, the estimated effect, at 5.4%, is barely a fifth of the mean difference and only a bit over 10% of the "correct" definition of the agency effects. Indeed, this estimate is very close to the estimate for lighting in Davis (2011), at 4.9% (mean differences are also close, at 39%). Maruejols & Young (2011) also report an agency effect in energy efficient lighting, although they do not quantify the magnitude. In sum, there is a much higher "agency effect" in the case of energy efficient bulbs, although it is not clear how practically relevant the agency issue here is, given the very portable nature of these devices.

We turn next to ground source heat pumps and wind turbines, which are relatively rare (in terms of access), at 6.4% and 1.2%, respectively, for owners and renters (heat pumps) and 3.2 and 1% (wind turbines) while heat pumps are also relatively country-specific (see table 2). The mean differences between owners and renters (rows III and VII, table 2) are rather small; this, allied with the rather low number of individual who have access to it, indicates an a priori expectation of moderate or no effect. This is confirmed by the regression results, where for both these technologies, the effects are less than 1% and insignificant (same rows, table 3).

Turning next to solar panels, the agency effects are estimated at about 3% using the more precise definition ("Our Definition") and roughly half as large, at 1.6%, using the more common definition. The magnitude of the agency effect is less than a third of the mean difference (at 13%), while in the case of the common definition, conditioning reduces the effect even further (the mean differences are slightly larger, at 15%). It is important to highlight that cost savings with relatively expensive and difficult-to-port technology such as solar panels are accrued only after a substantial time period. In this context, it is not clear if these smaller-than-anticipated differences are a result of unusually high renter access or to the overall low penetration of this technology in the population, in combination with country-specific factors such as subsidies (it is interesting that this is the technology for which the highest proportion of participants reported having received a govt. grant/subsidy–figures not reported).

We next consider issues which are specifically related to home insulation: roof/ wall insulation and use of a heat thermostat[13]. Roof/Wall insulation is evidently more expensive than a thermostat; from our discussion of these factors (in section 3), we note that it is difficult to make a specific prediction regarding the direction of the effects in these cases. From the regression results (rows V and VI, table 3) we find, surprisingly, identical coefficients for both insulation-related technologies, of around 10%, which is about a quarter of the mean difference of 42%. We observe a curious reversal for thermostats: despite an increased mean difference for the conventional definition (of 47%), the agency effect actually is only half the one with our preferred definition, at 5%. This can be attributed primarily to a change in sample size, and reiterates the necessity of controlling for other covariates, rather than relying on mean differences. The estimate for insulation, using the conventional definition, is doubled, to 20%, despite only moderately higher mean difference, at 53%.

Overall, for both roof/wall insulation and thermostats, we find sizeable agency effects whose magnitudes are very similar to those found in Gillingham et al. (2012). They report (Table 11) that owners are 20% more likely than renters to live in homes with attic/ceiling insulated and 6% more likely to live in homes with walls insulated. We cannot distinguish between wall and roof insulation, and so it is not clear which of their estimates are directly comparable; nonetheless, our estimates lie roughly between their ceiling and wall insulation estimates. Strictly speaking, their estimates are to be compared to our estimate of 20% (using the "conventional definition" of "having access to") for insulation, which is identical to their estimate for attic/ceiling insulation.

Finally, for window insulation[14], we find a sizeable agency effect, at 12% (row VIII, table 3), which is a fourth of the mean difference, at 48%. Curiously, the magnitude of this effect is virtually identical for both definitions of "having access to", while the unconditional mean difference is only

[13]These issues are somewhat more relevant for the colder countries in the sample and the raw data display a clear pattern confirming this. Australia, Israel, Japan and Spain have relatively lower penetration of roof and wall insulation, while Chile, Israel, Japan and Australia have a lower penetration of heat thermostats (tables available upon request). Nonetheless, even in these countries, the penetration of these technologies are non-trivial and generally above 5%, warranting their inclusion in the analysis.

[14]We consider the issue of insulated windows separately, mainly due to lack of comparable results elsewhere. The country-specific distribution of these technologies mirror those of the roof/wall insulation, with homes in Australia, Chile, Israel and Japan having relatively smaller proportion of access to this technology. As before, these proportions (at above 5%) are reasonable enough to be included in the regressions.

slightly larger, at 51%.

3.3 Robustness Checks

From the foregoing discussion (as well as that in section 1), it should be evident that while agency problems are a very likely cause for the effects identified above, two alternative explanations are equally plausible: first, that owners and renters are different in unobserved (to the econometrician) dimensions and second, that they differ in observed characteristics not already included. Addressing the first issue, of unobserved heterogeneity, is more challenging in our case; unlike in Gillingham et al. (2012), we do not have access to more than one observation per household and cannot use a fixed- or random-effect framework. However, unlike in the cases in Gillingham et al. (2012); Maruejols & Young (2011), who had access to a rather narrow geographic region (California and (apartments in) Canada, respectively), we have a much broader sample, covering many countries. It is arguably less plausible that, across the range of institutional and legal frameworks in our multi-country context, there are unobserved factors which systematically drive these differences[15].

Prominent in the second category is the hypotheses of "green tastes" i.e. owners are wealthier and therefore have a (unobserved, to the econometrician) preference for "green" goods. A related issue is the lack of accounting (in the results in section 3.2) for "intensity of use": the hypothesis is that owners, having greater usage, benefit more from greener goods which in turn tends to reduce the cost of usage. In order to address these, we provide in table 4 a check of the following hypothesis: the agency effects estimated in section 3.2 are driven primarily by differences in the following observable characteristics: membership in an envt. organization, living in an apartment, having electric space heating/cooling and finally, including the price of electricity[16].

In more detail, we check to see if the observed effects are either specifically driven by a particular categorization or are consistent with the "green tastes" hypothesis. Recall from section 1 that,

[15] Exploring the contribution of the differences in institutional and other frameworks across countries driving the results obtained here is an interesting avenue, one which we are unable to pursue. As a first, and simple, approach, we posit that these are fixed across countries and account for their effect by using country-specific fixed-effects.

[16] Note that simply including an indicator for some of these characteristics in the specification in eq. (1) does not address the issue. To address it, the indicator for ownership must be interacted with, say, the indicator for membership; thus, the "effect of interest"–the coefficient on the ownership variable–varies between members and non-members. For the price variable, however, the rationale is a bit different, and involves simply adding the variable itself to the regression in eq. (1), with the hypothesis that sizeable variation in prices between owners and renters drive the results. If the "effects" of interest are relatively unchanged with the addition of price, that particular hypothesis is rejected.

	Energy Star Appliances (excl. AC)	Energy Efficient Bulbs	Ground Source Heat Pump	Solar Panels	Roof/wall insulation	Heat Thermostat	Wind Turbine	Insulated Windows
Baseline	0.452***	0.509***	0.00353	0.0295**	0.0941***	0.0983***	-0.000403	0.124***
	(16.52)	(30.90)	(0.39)	(1.99)	(3.05)	(3.45)	(-0.05)	(4.20)
Apartment (Yes)	0.399***	0.464***	0.0166	0.0338*	0.0429**	0.107**	0.0129	0.141***
	(13.54)	(9.45)	(0.76)	(1.93)	(2.06)	(2.50)	(0.68)	(2.94)
Apartment No)	0.473***	0.540***	-0.00632	0.0278	0.132***	0.0841***	-0.00551	0.106***
	(7.18)	(7.90)	(-1.54)	(1.33)	(3.32)	(3.05)	(-1.09)	(3.58)
Electric heating (Yes)		0.533***	0.00207	0.0404*	0.0975***	0.0954***	-0.00141	0.138***
		(25.67)	(0.16)	(1.76)	(2.91)	(2.85)	(-0.11)	(4.48)
Electric heating (No)		0.469***	0.00793	0.0118	0.0812***	0.104***	0.00116	0.109***
		(31.84)	(0.93)	(0.88)	(3.08)	(3.59)	(0.24)	(2.79)
Envt. Membership (Yes)	0.527***	0.444***		0.148**	0.261	0.0903		-0.0457
	(5.39)	(3.68)		(2.43)	(1.58)	(0.78)		(-0.66)
Envt. Membership (No)	0.496***	0.585***	0.0236	0.127***	0.152*	0.108***	0.0280*	0.0967**
	(9.98)	(10.66)	(0.91)	(8.58)	(1.94)	(3.40)	(1.65)	(2.12)
Incl. Price	0.487***	0.571***	0.0387*	0.136***	0.185*	0.102***	0.0516*	0.0891*
	(8.25)	(14.21)	(1.90)	(5.72)	(1.95)	(3.26)	(1.75)	(1.67)

Notes: Average Marginal Effects (t-statistics in parentheses) for the indicator variable on home ownership from probit regressions, with the dependent variable an indicator for "having access to" the technology indicated in the column header. "Baseline" results are from Column II of table 3. Rows II-VII report results from probit regressions estimated separately "category"=1 and "category"=0, where "category" refers to the relevant row header. Standard error and test statistics computations as well as other details are as reported in table 3.

Table 4: Robustness checks for agency effects.

we have three measures of environmental "tastes", membership in an environmental organization, wtp for a completely green energy system and an index of responsibility in energy usage, the "energy behaviour index". As already noted in section 2.2, owners and renters are very similar in these characteristics and so, a priori, we do not anticipate that this explanation will provide an explanation for the estimated ownership effect. Finally, the data set also provides a measure of self-reported consumption, allowing a computation of the (average) price. Due to the substantial non-response in the data set, we do not (unlike in Davis (2011)) include this variable in the main regression. If prices (or consumption) do not systematically differ between owners and renters, we do not anticipate any change in the agency effect already observed.

We first make a few general observations about table 4; certain coefficients were not estimable due to lack of any samples for that particular categorization (heat pump and wind turbines for envt. org. members and electric heating/cooling for appliances) and sample sizes (not shown) varied widely for each (sub-) category[17]. We do not also provide an interpretation for each possible specification for each energy technology under consideration: we merely point out certain interesting points pertinent to our discussion and provide comments regarding the overall patterns.

We begin our discussion of the results of robustness checks (from table 4) with the impact of inclusion of the (average) price variable, in a specification otherwise identical to the baseline. We note a striking result (row VIII, table 4), that inclusion of this variable leads to *higher* estimated agency effect for most technologies (except for insulated windows, for which the effect is halved). This indicates that the effect indicated by a comparison of the unconditional mean (which indicates that homeowners face higher (avg.) price) holds true after controlling for other relevant factors. Nonetheless, the overall effects are very similar, with only a slight increase, in most cases[18].

Consider next the impact of allowing for separate effects of home ownership for apartments; except for the case of roof/wall insulation–possibly more difficult to install in an apartment–, no substantial differences are found between apartments and other types of housing. Similarly, except for solar panels, there are no qualitative (or quantitative) differences in estimates of agency

[17]The full table, including results for the alternative definition of "having access to" energy efficient technologies, is available from the corresponding author upon request.

[18]It is also important to note that the sample size falls to 721 (for appliances), when average price is included, from 4350 for the full sample. Similar loss in sample occurs for almost all energy efficient technologies. Almost identical results are obtained when electricity consumption is substituted for price.

effects between homes which are heated/cooled with electricity and those which are not. For solar panels, the substantially higher agency effect (at about 4.9% a full four times the non-electrically heated/cooled homes) can be interpreted by understanding its spatial distribution. Recall that Israel and Australia accounted for a large fraction of homes with access to solar panels, and these countries also use electric space cooling preferentially; these factors likely explain the sizeable increase in agency effects.

Finally, we turn to understanding if some form of "green tastes" can account for the large agency effects observed in our sample. Recall that this is a hypothesis which states that differences in (observed or unobserved) preferences between owners and renters explains (at least a part of) the observed differential effect i.e. at least a part of the agency effects are attributable instead to differences in preferences. In terms of the effects in table 4, we anticipate that in the sample of non-members, the estimated agency effects are *larger*[19]. As already indicated, owners and renters turn out to be especially similar along this dimension; as a result, the lack of any pattern in the effects for members versus non-members (larger coefficients for appliances and solar panels and smaller ones for the others) is not surprising. Thus, it is at least plausible that "green tastes" do not substantially impact our estimates of agency effect.

Overall, the results in this section indicate that the magnitude of the agency effects reported in section 3.2 are relatively robust to plausible alternative explanations or data configurations. Naturally, it is impossible to definitely rule out alternative explanations, particularly due to an inability to accommodate heterogeneity.

4 Summary and Conclusions

This paper set out to quantify the magnitude of the split incentive effect in investment in energy efficiency and adds to the relatively small literature on rigorous empirical analysis of this issue. In particular, the issue examined was whether owners had a higher likelihood of "having access to" a variety of energy-consuming appliances/technologies, including: appliances, bulbs, insulation of

[19]To understand this, note that the "green tastes" hypothesis states that when these "tastes" are included (i.e. when the sample is restricted to people exhibiting these tastes, which is what we do when we restrict the sample to those households where the respondent is a member of an envt. org.), there is no agency effect (i.e. a 0 effect). A weaker form of the hypothesis would hold that a part of the agency effect is attributable to this effect, and as a result, the effect for members of envt. org. (who exhibit "green tastes") is likely smaller than for non-members (who do not).

different types (roof/wall and windows), heat thermostats as well as larger equipment with substantial investments such as solar panels, ground source heat pumps and wind turbines.

Using a wide cross-section of data from 11 OECD countries, we find a substantial ownership effect, varying widely across these different technologies considered, from about 45% for appliances, to 2% for solar panels. In general, appliances (and bulbs) appear to exhibit the largest magnitude of split incentives, while insulation exhibits a smaller, yet substantial, effect. These effects are robust to controlling for plausible alternative hypothesis: those related to unobserved preference differences–such as "green tastes" (which we are directly able to account for)–, to specific types of homes (many investments are either infeasible or more expensive) and to electrically heated/cooled homes (which possibly face higher costs and so are likely more motivated). It is important to note that for appliance and bulbs in particular, the estimated agency effects are substantially larger than estimated before, by a factor of $4-6$. We believe that the main reason for the strength of the effect estimated here is an ability to distinguish between tenant investment and owner-provision. Given the substantial investment by tenants in these devices in the countries in our sample , ignoring this distinction leads to substantial under-estimation even in our case (table 3 under the columns "Conventional Definition").

While these results are promising and indicates scope for policy, there are two types of data-related drawbacks which calls for some caution in interpreting our results. First, the cross-section nature of the data do not allow an accounting of individual heterogeneity and product replacement cycles and second, while the data set is relatively rich (compared to even the RECS, say), it is not rich enough to allow more precise delineation of specific issues/effect (e.g. appliance-specific effects such as in Davis (2011) or non-electric heating costs). Collection of panel data sets which are comparable across countries for this issue would especially allow addressing both issues; in particular, addressing unobserved individual heterogeneity is an important aspect, from both estimation (e.g Gillingham et al. (2012, § 5.1.3)) and policy (Allcott & Greenstone (2012)) perspectives.

The investment-related split incentives issue is important since it represents a possible loss in social welfare, due to the externalities imposed in electricity generation. In addition, the residential sector is a key part of the solution to the climate change issue, in particular for the kyoto protocol signatories in the sample (Japan, EU countries of Italy, Spain, Sweden, France as well as for

Australia).

The direct policy implications of studies which identify/quantify the magnitude of these agency effects is unclear, however, mainly since policy makers are essentially dealing with two "market failures" (in the terminology of Allcott & Greenstone (2012)); the first due to the externality from energy consumption (e.g. climate change) and second, that related to information asymmetries and failures (exacerbated by policies, such as rent control, targeting other aspects). A typical administrative, second-best solution to the problem consists of stringent building codes (for insulation), minimum efficiency standards (for appliances) and information enhancement campaigns in general. These are already in place, to varying degrees, in most of the countries in our sample, and further increases of the stringency of these measures are likely to lead to only marginally higher social returns or even losses in welfare, as discussed in Allcott & Greenstone (2012).

Identification of the "split incentive" effects is a necessary step in understanding the costs and benefits to a variety of approaches to addressing the issue, from the first-best information disclosure to the second-best intervention (subsidies/standards etc). Analyses of the type carried out here, when coupled with country-specific computations of counterfactual scenarios, provides an important step in quantifying the social cost of the agency problem.

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Appendix A Additional Tables

Variable		Owner	Renter
Energy Efficient Appliances	Purchased	4484	1798
	pre-existing	780	398
Energy Efficient Appliances (excl. AC)	Purchased	1921	792
	pre-existing	357	199
Energy Efficient Bulbs	Purchased	5946	3045
	pre-existing	545	360
Ground Source Heat Pumps	Purchased	270	81
	pre-existing	119	64
Solar Panels	Purchased	801	221
	pre-existing	350	167
Thermal Insulation	Purchased	2242	523
	pre-existing	1473	514
Heat ThermoStats	Purchased	2253	629
	pre-existing	1101	523
Wind Turbines	Purchased	115	43
	pre-existing	85	41
Energy Efficient Windows	Purchased	2597	689
	pre-existing	1293	608

Notes: Tabulation of sample sizes, for each energy efficiency technology, by home ownership status (owner and tenant) and purchase type (purchased and pre-existing). For energy efficient appliances, two categorizations are provided: the first one including air conditioners and the second, excluding it. Sample sizes by owners and renters for all energy efficient technologies (except for the appliances excluding ACs) are: Owner 7695 and tenant 4506, for a total of 12201. For appliances excluding ACs: Owner 3274 and tenant 2100, for a total of 5374. The regression sample sizes reported in table 3 vary due to sample-size differences in included covariates.

Table 5: Ownership and Investment patterns in energy efficient technology.