HOUSING TENURE, ENERGY EXPENDITURE AND THE PRINCIPAL-AGENT PROBLEM IN AUSTRALIA

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ABSTRACT:

The Australian Government is currently committed to delivering a cut in carbon emissions in response to climate change concerns. In this context, much research and policy attention has been given in recent times to the energy efficiency of new housing, much less to the existing housing stock. It is generally acknowledged that the energy efficiency of existing homes can be greatly improved with the use of existing technologies, but there are significant barriers to its uptake. This paper focuses attention on one such barrier – the principle-agent problem present in the private rental market. While landlords are generally responsible for the purchase of many energy consuming household appliances, tenants are responsible for the purchase of energy. These split incentives lead to an energy efficiency gap. Applying a hedonic regression model to the 2006 wave of the Household Income and Labour Dynamics in Australia survey (HILDA) we attempt to estimate the magnitude of the principle-agent problem by modelling energy expenditure as a function of housing tenure, dwelling type, location and other socio-demographic variables. We fail to find evidence in support of the split incentives hypothesis in Australia and offer some reasons for why this may be the case.

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1. INTRODUCTION

In this paper, we report the findings from an empirical inquiry that aims to measure the significance of split incentive issues for tenants' energy bills. More specifically, does market failure due to principal-agent problems contribute to higher energy bills for private renters and leave them more vulnerable to the adverse consequences of increased energy prices than other housing consumers?

The Garnaut draft report (GCCR, 2008) draws on economic analysis of market failure to point out that this is an example of the more general principal-agent phenomenon. An asset is owned by one party, the principal, but used by another party, the agent. If the objectives of principal and agent differ, and it is costly for each party to police observance of contractual terms, the asset's net income stream may be sub-optimal as principal and agent lack the incentives to invest in the asset so that returns are maximised. In the present context the principal is the landlord; while the landlord is responsible for purchasing the energy-using facilities, the tenant is responsible for the payment of recurrent energy bills (GCCR, 2008). Since the landlord does not reap the immediate benefits of investment in alternative energy-saving equipment, the financial incentive motivating such investment is weaker than for homeowners. On the other hand, tenants do not have the right to adapt their homes without landlord acquiescence, and any gains in asset value that accrue from energy-efficient investments are captured by the landlord.

We conduct our analysis using hedonic modelling techniques that have been widely used in the economic analysis of housing policy (Green and Malpezzi, 2003). The approach treats the total expenditures on products or services as a function of product characteristics, as well as conventional variables that affect ability to pay. Our aim is to uncover the strength of split incentives, by modelling energy consumption as a function of housing characteristics, including the tenure and type of dwelling. The size and the statistical significance of the housing tenure variable will be used to judge to what extent tenants consume more energy as a result of the blunt incentives associated with split incentives.

The paper proceeds as follows, section 2 provides a literature review, section 3 discuses our method, section 4 presents our findings and section 5 concludes.

2. LITERATURE REVIEW

The existing literature is dominated by overseas studies, USA and Canada being the most influential sources. The typical data source is surveys specifically conducted for the purposes of analysing energy consumption. This has advantages as it typically means that the survey has been designed to collect information on variables expected to drive the demand for energy. Some of the studies also include energy price variables, though this is less common in those papers exploring the role of urban form. Relative energy prices are influential determinants of the type of space and water heating systems, and conditional on this choice, the level of energy prices should shape the amount of energy consumption. Though prices are emphasised in the papers published in economics journals, it often turns out that price elasticity estimates are low, as is expected when the focus is on short-run use.

Dubin and McFadden’s (1984) seminal paper sets the benchmark for modelling approaches by taking into account the joint nature of decisions with respect to space and water heating systems, and those taken with respect to power use. Nesbakken (2001), using a Norwegian Energy Survey, and Bernard et al’s (1996) Canadian study, have been strongly influenced by the Dubin and McFadden paper. Model parameters are estimated using a two-stage approach. At the first stage, decisions regarding space and water heating systems are modelled, typically within a multinomial probit framework. Then, at the second stage, the demand for energy conditional on the chosen heating system is estimated using ordinary least squares (OLS), and a correction is applied in order to eliminate the potential estimation bias from the joint nature of the decisions.

Most studies include four types of 'right hand side' variables in their models;

- Personal characteristics e.g. income and household size;
- Property characteristics e.g. size, type and location, from which inferences about urban form are commonly deduced;
- Climate variables that can be expected to influence energy consumption for heating and cooling purposes; and
- Energy prices.

The vector of property characteristics commonly includes a variable distinguishing between dwellings that are owner-occupied or rented. Rehdanz (2007) and Bernard et al (1996) find that residents of owner-occupied dwellings consume significantly lower energy than their tenant counterparts.

3. METHOD[1]

3.1 Data and sample design

We conduct our analysis using the 2006 Household, Income and Labour Dynamics in Australia (HILDA) Survey. There are several unique characteristics of this dataset which make it helpful for measuring the relative influence of the determinants of energy consumption. The HILDA Survey is a nationally representative dataset that contains a wide range of variables representing the demographic, socio-economic and housing characteristics of Australian households. The survey also contains information on energy expenditure. Specifically, households are asked about their annual expenditure on electricity, gas and other heating fuel.

Our sample comprises all households in private dwellings. We exclude households in non-private dwellings as it is unclear whether their energy expenditures are captured in their board payments, residents of mobile dwellings such as caravans, and households who report annual energy expenditure of less than $100 as it is likely that these households have not lived long in their dwelling. Finally, households that own property apart from their primary home are excluded, as these households may have reported the energy expenditure on both their primary home and other properties. The final sample comprises 3,650 households, of which 2,560 are homeowners and 1,090 are renters. The units of analysis and measurement are on a household basis.

[1] Additional details can be obtained from Gabriel et al (forthcoming).

3.2 Variable measurement and modelling approach

Actual energy consumption is not reported in the HILDA Survey; we utilise a variable that represents annual household energy *expenditure*. Expenditure is not as precise as quantity measures of energy consumption, so the use of controls for dwelling characteristics and location in hedonic models is relied on to address measurement error concerns[2].

Housing tenure is represented by a series of binary variables that identify owners, private renters, public renters and rent-free households. Our primary interest lies in whether owners spend more or less on energy than private renters after controlling for other factors.

There are three groups of location variables. One comprises binary variables representing the state or territory of residence. Energy prices vary by location because diverse energy sources are relied on in different parts of the nation, and these sources will have different costs of production and hence prices. Unfortunately a price variable is unavailable. State and territory location serves as a crude proxy for energy price variations. To further account for price differences a second sequence of binary variables are added representing location in major cities, inner regional areas, outer regional areas and remote or very remote areas. The third is a neighbourhood variable that represents the socio-economic profile of the neighbourhood of residence - the 2001 Socio-economic Indexes for Areas (SEIFA) of advantage/disadvantage. Collection districts are grouped in ten separate deciles, which reflect a continuum of disadvantage to advantage (ABS, 2003).

The state variables could pick up climate differences as well as energy price variations. Overseas studies have used alternative climate measures; annual heating degree-days (HDDs) and annual cooling degree-days (CDDs). These are quantitative indices indicating demand for energy to heat or cool houses. They are based on how far the daily average temperature varies from a human comfort level. The Australian Bureau of Meteorology (BoM) (2010) calculates HDDs and CDDs using two alternative temperature thresholds that reflect human comfort levels. We use the 18^{o}C and 24^{o}C set of temperatures to calculate HDDs and CDDs.

For each capital city, the average temperature for each day is calculated as the midpoint between the maximum and minimum temperature reached on each day in 2006 as sourced from the BoM. Heating degrees (HDs) and cooling degrees (CDs) are calculated as 18 minus the average temperature for that day if less than 18^{o}C, or the average temperature minus 24 if greater than 24^{o}C, respectively. The HDDs (CDDs) for each capital city was derived by summing up the HDs (CDs) for that city over the entire year. It is not possible to calculate the HDDs and CDDs of regional areas as the HILDA Survey location variables are not disaggregated enough for identification of regional centres. Hence, the two climate variables are included in a separate model that estimates capital city residents' energy expenditures.

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[2] Other studies sharing the same limitation include Rehdanz (2007).

The third vector of variables includes dwelling characteristics. We expect dwelling size to have a positive association with energy expenditure. In the absence of actual dwelling floor size we rely on the number of bedrooms to indicate dwelling size. Different dwelling types are also expected to have differential impacts on energy expenditure – a separate house would expend more on energy than an equivalently sized flat, for example. A series of binary variables representing residence in separate houses, semi-detached houses and flats, units or apartments are entered into the model.

We speculate that household personal characteristics such as age and ethnicity are important and include the characteristics of the eldest person in the household. The educational qualification variable used in the regression is that of the most highly qualified member in the household. Household size is an obvious determinant of expenditure. It is also potentially important to identify whether someone is normally at home during the day as this will increase energy use. We attempt to capture this effect through a variable set equal to the number of non-employed adults (excluding full-time students).

Capacity to pay for energy use is captured by financial variables including gross household equivalised income using the modified OECD scale. Net worth is collateral that can be drawn on to finance investment in home retrofitting designed to lower energy consumption. The potential impact of liquidity constraints is explored by exploiting a variable that records a respondent's difficulty in raising $2,000 in an emergency.

The regression model is estimated by OLS, with the dependent variable and continuous 'right hand side' variables expressed in natural logarithmic form[34]. Two models are estimated. Model 1 includes all households that meet the criteria listed under the sample design section but excluding HDD and CDD measures that cannot be computed for regional centres. Model 2 incorporates HDD and CDD measures; however, the model is estimated on a smaller sample of households in capital cities (Sydney, Melbourne, Brisbane, Adelaide and Perth). These climate measures replace the state and remoteness area variables.

4. DESCRIPTIVES

It turns out that the typical homeowner spends 34% more on energy than the typical renter in our sample. The average annual 2006 expenditure by owners was $1287, but that of renters was only $961. Assuming no differences in the price per unit of energy paid by these two groups, it seems that contrary to expectations, homeowners consume more energy despite split incentives that are expected

[3] Where a continuous variable is equal to zero, the log of the variable is set equal to zero. A drawback is that, because the log of negative values cannot be measured, households with negative income or net worth are excluded from the sample. 248 households (6.4%) are excluded as a consequence.

[4] In this case the estimated coefficient on a variable such as income represents its elasticity measure. In the case of income elasticity, values exceeding (less than) one indicate an elastic (inelastic) demand because a 10% increase in income results in an increase in energy consumption that is greater than (less than) 10%.[4]

to deter landlord investment in energy-saving amenities, insulation, draught-proofing and energy-efficient building materials. But these reflect differences in property type and size that could obscure tenure-related differences in energy consumption.

Table 1 presents comparisons of average expenditures on energy by property type, size and tenure type. We can see from these figures how important it is to control for property attributes. Average annual expenditures by occupants of detached housing is $1273, 41% higher than the average outlays incurred by residents in semi-detached/terraced, and an even larger 46% higher than the outlays incurred by residents of flats. Only 21% of detached housing is occupied by renters, so this feature of the housing stock will boost homeowner energy consumption; but even when we control for property type and compare expenditures by renter-occupied and owner-occupied detached housing, the latter have significantly higher energy expenditures - $1316 or 18% higher than the $1112 annual expenditures in renter-occupied detached housing. We obtain the same higher expenditures by owners when comparing outlays in the two other types of housing – in fact the spending differentials are even wider with owners outspending renters by 50% in semidetached//terraced, and 30% in flats[5].

Table 1: Mean annual energy expenditure, by housing tenure and dwelling type, 2006, dollars

Dwelling type	Renter	Owner	Total
Separate house	1112	1316	1273
Semi-detached/ row/ terrace house	729	1090	904
Flat	794	1036	869

Source: 2006 HILDA Survey

There are personal characteristics that distinguish owners and renters and that correlate with energy consumption. Owner-occupier household incomes are typically higher; couples with dependents are more likely to be homeowners and so on. A comparison of Australian homeowners and renters highlight the following key points:

- The location and climate features of owners and renters residences are similar.

[5] Size also matters. For example, occupants of detached housing with four or more bedrooms spend $1459 per annum. This is 55% more than the outlays ($943) typical among occupants of detached housing with two or less bedrooms. Due to space limitations, statistics by number of bedrooms are not reported here but are available from the authors upon request.

- Homeowners are much more likely to occupy energy 'guzzling' detached housing and larger housing, as is to be expected given a larger household size.
- The financial and demographic profile of owner-occupiers and renter-occupiers is very different. The former have higher incomes, even after adjustment for household size, and higher net worth. Their experience of liquidity constraints is then less common.
- Private renters are younger and their financial characteristics tend to lie at some point between those of homeowners and public renters. Their outlays on electrical appliances are around 40% less than that of homeowners, and this will correlate with energy consumption.

This brief description highlights the importance of taking confounding influences into account. Split incentive effects could be masked by the higher incomes of owner-occupiers, particularly if energy consumption is income elastic. Their larger homes will be more expensive to heat and cool and the type of housing most commonly occupied by owners appear to be more energy-intensive. The modelling exercise in section 4 controls for some of the more important confounding factors.

5. MODEL FINDINGS

Table 2 reports OLS regressions coefficient estimates, their standard errors and significance. In table 2, Model 1 presents findings Australia-wide; location categories are used to distinguish residents that might face different climatic conditions (and price regimes). Under model 2, the sample is restricted to state capitals where we have HDD and CDD climate measures.

Consider the Australia-wide estimates under model 1, and the property variables in particular. With the exception of the critical split incentive test variable, property characteristics have expected impacts on energy expenditure. Using a sample of all households, detached housing is found to be energy intensive (bills are 20% higher than in semi-detached, row and terraced housing); large housing units are more expensive to heat and cool. But even after controlling for these and other factors, the bills of homeowners are estimated to be 13% higher than those of private renters.

HILDA elicits actual expenditures that will be net of energy rebates where the household is eligible, and will not include energy consumption in communal areas that can be included in strata fees or rents. Households are billed for their energy consumption by retailers who deduct rebates from the amounts due. When asked to provide annual energy expenditures, eligible consumers will respond with estimates of the amounts due in energy bills and these will understate consumption. If private renters are more likely to be eligible for rent rebates these coefficient estimates could be 'contaminated'. We address this measurement error by repeating our empirical exercises using a restricted sample of households that are identified as ineligible for rebates. On restricting the sample to ineligible households we arrive at an even higher owner energy bill premium of 16%. In fact the proportions of owner–occupiers and private renters that are eligible for rebates are similar; 35.3% of owner-occupiers are eligible for rebates, and 37.2% of private renters. It would seem that rebates are not masking split incentive effects.

The other variables reveal some interesting patterns. Residents in the southern states have higher energy bills, with those living in Victoria spending 18% more that their New South Wales counterparts. Household size very important; each additional child under 15 (adult 15 years and over) adds 18% (27%) to household energy expenditure. We estimate a positive income elasticity, but it is low at 0.06. According to Rehdanz (2007) the majority of studies estimate income elasticities between 0.08 and 0.17. Outlays on electrical appliances are found to have a positive elasticity of 0.03. These low estimates reflect a short-run response that is variation in annual expenditures. Other variables Including liquidity constraints, age and net worth turn out to be generally unimportant[6].

Under model 2, the sample is limited to capital city residents and we have an opportunity to more rigorously investigate the role of climate. It turns out that the number of HDDs is both statistically significant and quantitatively important. A 10% increase in the number of HDDs raises energy outlays by 4.3%. It is then unsurprising to note that the model 1 specification finds that residents in the southern states typically have higher energy bills. On the other hand the number of CDDs has no impact, with a coefficient estimate that is not significantly different from zero[7]. Importantly we have further confirmation that split incentive problems are absent. Homeowners in capital cities are discovered to be spending 15% more than private renters, 'all else equal'. On excluding those eligible for energy rebates the premium once again increases to 16%. Findings with respect to other variables are very similar.

[6] Conclusions are generally unaffected when the same model is estimated using only those households ineligible for energy rebates.

[7] There is multicollinearity here that makes it difficult to disentangle effects. Based on the sample of all households in capital cities, the correlation coefficient between the log of HDD and log of CDD is -0.828 and is significant at the 1% level.

Table 2: Energy expenditure model results, all Households, 2006 [a]

Explanatory variables	Model 1		Model 2	
	Coef.	Std. error	Coef.	Std. error
Constant	5.394**	0.234		
Victoria	0.178**	0.030		
Queensland	-0.180**	0.031		
South Australia	0.157**	0.039		
Western Australia	-0.073	0.039		
Tasmania	0.112	0.061		
Northern Territory	0.291*	0.137		
Australian Capital Territory	0.253**	0.084		
Inner regional	0.019	0.028		
Outer regional	0.067	0.037		
Remote, very remote or migratory	0.057	0.086		
Log of HDD			0.430**	0.072
Log of CDD			0.046	0.052
Log of number of bedrooms	0.172**	0.040	0.143**	0.052
Separate house	0.203**	0.052	0.218**	0.063
Log of SEIFA index of advantage/disadvantage	0.063**	0.018	0.035	0.024
Homeowner	**0.132****	**0.031**	**0.152****	**0.040**
Public renter	0.065	0.059	0.074	0.077
Rent-free	0.166	0.072	0.256*	0.110
Log of number of children aged under 15 years	0.178**	0.034	0.219**	0.046
Log of number of adults aged 15+ yrs	0.270**	0.032	0.231**	0.042
At least one household member unemployed	-0.055	0.050	-0.255*	0.127
Log of gross household equivalised income	0.055**	0.016	0.072**	0.025
Log of non-housing net worth	0.024**	0.008	0.033**	0.011
Log of number of adults usually at home	-0.132**	0.049	-0.048	0.067
Age of oldest responding household member	-0.064	0.039	-0.030	0.053
Log of expenditure on electrical appliances	0.026**	0.003	0.032**	0.004
Flat/unit/apartment, two-storey semi-detached house, ability to raise $2000, ethnicity: not significant at the 5% level.				
Sample	3594		1995	
Adjusted R^2	0.225		0.235	
F-stat	24.732**		18.055**	

Source: 2006 HILDA Survey

Note: a. The omitted binary categories are New south Wales, major cities, one-storey semi-detached house and private renter. * and ** denote statistical significance at the 5% and 1% levels respectively.

6. CONCLUSION

Our investigations fail to offer evidence in support of the split incentive hypothesis. But before dismissing split incentives we should pay careful attention to a number of important caveats, of which there are at least three. The first is the absence of a satisfactory measure of per unit energy prices. Closely related to this is a second weakness – the unobserved choice of space and water heating (or cooling) systems. The preferred approach since Dubin and McFadden (1984) is the simultaneous modelling of heating (cooling) systems and the demand for energy in a two stage estimation procedure. Finally the empirical work reported here is based on a cross section data set. Longitudinal data can generate more compelling research designs that exploit changes in key variables such as tenure, and the fixed nature of other variables that cannot or rarely change over time.

These are important deficiencies that future research needs to address. But putting these caveats to one side, and accepting for the sake of argument that the split incentive phenomenon is indeed unimportant, what explanations might we offer? One potentially important factor that we perhaps overlook is the powerful tax incentives that motivate Australian landlords to hold residential investments with high building to lot ratios (Wood, Ong and Stewart, 2010). Land taxes that exempt owner occupiers but apply to property that is held by investors, encourage the acquisition of property with small lot sizes. On the other hand depreciation allowances on amenities (that will include energy-saving appliances), building write off allowances for construction costs, the addition of retrofit capital outlays to the cost base used to compute taxable capital gains, the deduction of interest on borrowings to finance such retrofits and the lenient taxation of capital gains (relative to rental income) are all tax preferences that encourage landlord investment in the building rather than the land that rental properties 'sit on'. We might also remark on the source of empirical studies that can be cited in support of the split incentive hypothesis. They have typically been conducted in Western Europe or North America where institutional arrangements can be different. Rehdanz (2007, p18), explains that landlords in Germany have less of an incentive to improve on energy-efficiency because they have to bear the costs of improvements themselves, and adjustments in rental rates to recoup those costs are curbed by strict regulations. This observation suggests a market adjustment that we could have overlooked in our enthusiasm to investigate split incentives. Tenants will pay lower bills when energy-saving investments are made by their landlords. If there is competition between tenants for rental properties, and tenants are *well informed*, those landlords that have retrofitted will be able to capture a rent premium. Countries that have no rent regulation, such as Australia, could well find that the combination of tax preferences and rent premiums are sufficient to offset any split incentive effects. There is one additional related point. In some Western European countries (and some parts of North America), rent control is accompanied by security of tenure legislation that 'locks' landlords into their investments, and arguably deters maintenance of buildings. Critics argue that in such countries private rental housing will typically be older and dilapidated, and so lower energy consumption among owner occupiers is unsurprising. In Australia there is no such regulation and in fact there is considerable churning of properties in and out of the sector.

Research in this area is hampered by the absence of comprehensive data bases such as those generated by the USA Residential Energy Consumption Survey. The ABS has not conducted a similar survey in recent times at the national level. Three state-based surveys cover some of the same ground but are more limited in scope (Domestic use of Water and Energy, South Australia 2004; Domestic Water Use, Western Australia 2003; and Domestic Water Use, New South Wales 2002). The surveys record the energy sources used for domestic applications e.g. energy source for hot water systems and the technology used for applications, e.g. front- or top-loader washing machines. But the surveys do not contain consumption measures – either expenditure or volume. The ABS Household Expenditure Survey (HES) has an important advantage over HILDA because it contains disaggregated energy expenditure variables – expenditure on gas, electricity, wood etc. But once again price information is lacking, as well as details on the type of heating and cooling systems.

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