Energy poverty and retirement income sources in Australia[1]

by

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ABSTRACT

In many countries population ageing will increase the share of retirees in the coming years. Energy poverty is a particular problem for older people (due to fixed and often relatively low incomes and the need for additional energy due to underlying health conditions). This can have cost implications for the healthcare sector if the health of older people deteriorates due to energy poverty. The burden of population ageing and the increasing dependency ratio, has meant the government is moving towards individuals funding their own retirement via compulsory superannuation schemes. Our study is based in Australia where there is a difference in retirement income sources between publicly funded Age Pensioners, Part-pensioners and Self-Funded Retirees leading to differences in energy poverty beyond income effects. Using 15 annual waves of the HILDA survey from 2005–2019, this study investigates drivers of energy poverty inequalities among retirees. Our main finding is that Age Pensioners are the worst off and Self-Funded Retirees the best off on a Low Income–High Cost measure of energy poverty and on a subjective indicator of inability to heat the home. Therefore, not all retirees have the same probability of experiencing energy poverty. However, wealth, assets, social connections and good health are significant mediators that soften the impact of subjective concerns regarding energy bills for retirees. Government-funded pensions are a safety net and need to be sufficient in times of energy price inflation. Moreover, we need to reduce the gap between state-funded pensions and self-funding arrangements to ensure equity in elderly populations.

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Author statement

Jane M. Fry: Conceptualisation, Methodology, Econometrics, Writing – Original Draft, Writing – Review & Editing.

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1. Introduction

Mirroring the experience of many high-income countries, Australia's population is ageing; by 2041, approximately 1 in 5 Australians are projected to be aged 65 or over (Wilson et al., 2021). An ageing population can change income inequalities within a country and income inequality has been shown to be a causal factor in energy poverty (Nguyen and Nasir, 2021). There is no single definition of energy poverty but it is generally defined as a "...situation in which a household lacks a socially and materially necessitated level of energy services in the home" (Bouzarovski, 2014). Energy poverty is a particular problem for retired people as many have fixed and often relatively low incomes based on superannuation or government pensions. Additional financial pressure can arise if retirees have underlying health conditions that increase energy requirements (Büchs et al., 2018). Beyond household budgets, this can have cost implications for the healthcare sector if health deteriorates due to energy poverty (Oliveras et al., 2020). Given that energy poverty has severe consequences for the elderly it is important to understand the incidence and drivers of energy poverty within this group. In this paper we investigate retirees according to their retirement income source as a potential driver of energy poverty.

Population ageing has meant the Australian government has moved towards individuals contributing to their retirement via compulsory superannuation schemes for employees. In 1992 the compulsory employer contribution scheme became part of a package of reforms aimed at solving Australia's retirement income dilemma that was predicted from the demographic shift. To reduce reliance on the government funded Age Pension, Australia introduced a three pillar approach to retirement income (Australian Productivity Commission, 2018). Pillar 1 is a means tested Age Pension, pillar 2 is compulsory employer superannuation contributions and pillar 3 is voluntary superannuation contributions by employees. Therefore, according to their income source, retirees can be categorised as: i) Age Pensioners (fully funded by public transfers), ii) Part-pensioners (whose Age Pension rates are reduced due to a means test) or iii) fully Self-funded Retirees (SFRs), usually through superannuation.[2] Income sources may affect energy poverty through differences in income levels and other less direct channels. For example, even with the same income, Age Pensioners could fare better than SFRs as the former are entitled to additional (government funded) benefits such as energy supplements (which are automatically included with Age Pension payments). Part-pensioners are likely to be in the middle as they have some private income and receive some concessions. We contribute to the literature on the determinants of energy poverty by considering inequalities in energy poverty outcomes among retirees according to their income source.

We use 15 waves of the *Household, Income and Labour Dynamics in Australia* (HILDA) survey to investigate energy poverty among the three retiree types: Age Pensioners, Part-pensioners and SFRs using two commonly employed measures of energy poverty (one objective and one subjective). We then conduct several robustness checks of our findings including testing the causal identification of our results through instrumental variables analysis. We investigate several channels by which retirement income sources might drive energy poverty beyond the obvious channel of income effects. This work is important as Australia has a unique retirement income environment with significant variation in retiree income sources and amounts of income. As Australia's population is ageing, it is important to understand energy poverty to help manage household energy costs and health and wellbeing for this vulnerable population.

We explore factors that might drive energy poverty inequalities among retirees as they are more prone to energy poverty than other population groups (Azpitarte et al., 2015; Wilkins et al., 2020). It is important to consider within group inequalities as the three pillars retirement system is designed "to deliver adequate standards of living in retirement in an equitable, sustainable and cohesive way" (Commonwealth Treasury, 2020, p. 3). Energy poverty is a rising source in inequity for many countries and so lessons from Australia will be useful for other countries facing population ageing.

2. Background and literature review

Given our Australian context, we begin by detailing Australian retirees' financial circumstances before looking at energy poverty within this group.

[2]Around retirement age, self-employed individuals have about half the level of superannuation of employees (Craston, 2018). These self-employed individuals may therefore find other ways to fund their retirement (such as income streams from property investments).

2.1 Retiree income in Australia

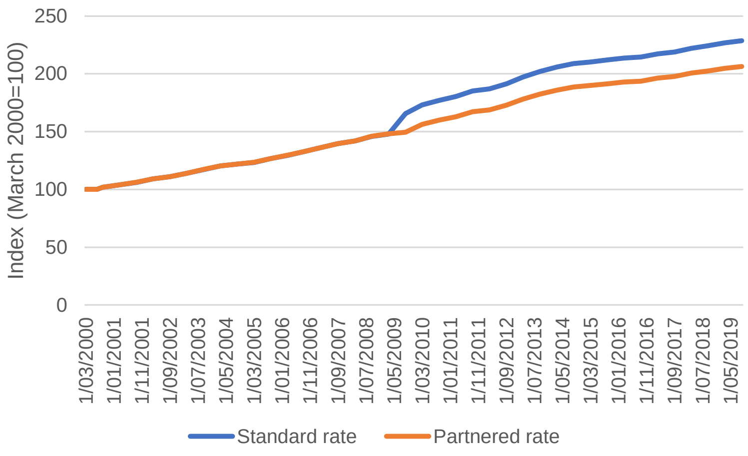
Australia provides a perfect setting to examine energy poverty among retirees as there are distinct retiree types defined by their income sources. The Age Pension should provide a basic standard of living, and in addition to the income component there are various concessions and assistance available for health, pharmaceuticals, rent and other living expenses. The Age Pension is subject to two means tests: income and assets (excluding the primary residence), which taper pension rates. In 2013-14, about 70% of people aged 65 or over received the Age Pension, of which 60% received the full rate (Commonwealth Treasury 2015).

Superannuation is designed to supplement and remove reliance on the Age Pension. Employers make payments on employees' behalf and payments are currently at least 9.5% of salary, although individuals can also make voluntary contributions. Superannuation cannot be accessed until retirement. Compulsory superannuation was introduced in Australia in 1992, so many but not all retirees have at least some superannuation and average amounts should grow as younger individuals who have always had superannuation (and at relatively high contribution rates) age. Therefore, the proportion of individuals with part-pensions will increase although the proportion of SFRs is not expected to increase (Commonwealth Treasury 2015).

Recent estimates put Age Pension's net present value well above superannuation balances: $419,000 for a single male, $482,000 for a single female and $816,000 for a couple versus most older superannuants who have a balance of $100,000 or less (Ralston and Feng 2017). Factoring in the self-employed for whom superannuation is not compulsory, low balances for many and the gap between preservation age and pension eligibility, it is estimated that 40% of retirees will be totally reliant on the Age Pension (Ralston and Feng 2017). Over the past 20 years, partnered Age Pension rates have doubled and, owing to an upward revision in 2009, single rates have increased even more (figure 1).[3]

[3] At December 2020, there were 1.38m partnered and 1.20m unpartnered Age Pensioners (Department of Social Security 2021).

Figure 1: Growth in Australian Age Pension rates

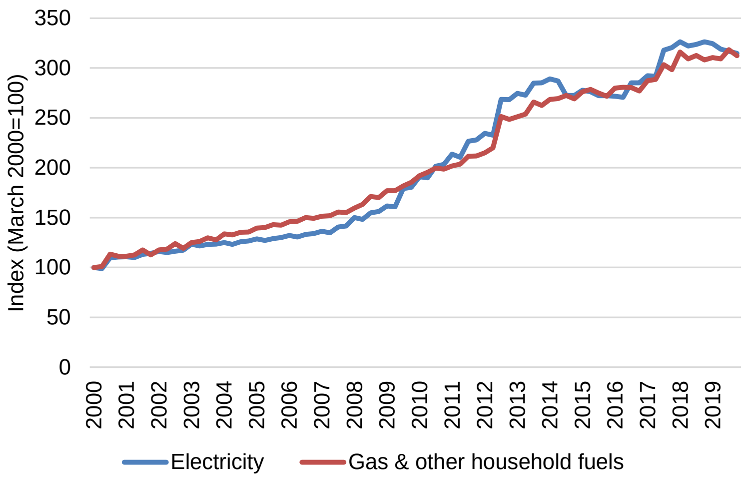


Source: https://guides.dss.gov.au/guide-social-security-law/5/2/2/10#NoteA.

2.2 Energy poverty

Access to energy supports individual wellbeing, as heating, cooling, lighting, cooking and refrigeration are necessary for life. Energy poverty is directly impacted by energy prices which have been rising steadily in Australia since 2000 (figure 2). Both electricity and gas prices have more than trebled, with strong growth around 2012 and 2016, outstripping Age Pension growth over the same period (figure 1), increasing pressure on household budgets and increasing energy poverty. More recently, energy poverty among older people in Australia has been exacerbated by COVID lockdowns — qualitative research showed some Age Pensioners had up to 50% higher energy bills than in 2019 due to increased household energy use as individuals spent more time at home (Wilkinson et al., 2021).

Figure 2: Australian energy prices



Source: ABS (2021).

Consequences of energy poverty for the elderly include vulnerability to health problems exacerbated by cold and heat and more time spent at home.[4] For example, high blood pressure and coagulation are an increased risk for older people, are exacerbated by cold and can lead to cardiovascular and respiratory conditions (Chard and Walker, 2016) which increase the risk of heart attack and stroke (Jessel et al., 2019). Increased likelihood of influenza and asthma also have more severe effects on older people (Thomson and Snell, 2013). Mental health also plays a role, as 'Alzheimer's patients have a higher rate of mortality from a combination of physiological and behavioural factors as a result of cold' (Jessel et al., 2019). Heat stroke and dehydration are associated with extreme heat, particularly for older people due to social isolation, increased physiological vulnerability and lack of access to/use of air conditioning (Bi et al., 2011; Jessel et al., 2019). Energy poverty also reduces self-assessed health (Awaworyi Churchill and Smyth, 2021). In addition to direct effects on health, there are indirect effects as individuals may substitute spending on food for energy and there may be stress associated with being unable to pay energy bills (de Vries and Blane, 2012; Hills, 2011).

Literature has also focused on adaptive behaviours in this sub-population. Some people use energy with a subjective awareness of how much it might cost (Chard and Walker, 2016), and 'older fuel poor households show a particular fear or aversion to debt, often showing a certain pride in an ability to live frugally' (Chard and Walker, 2016, p. 65). There are other adaptations to cold — wearing extra clothes, using blankets and hot water bottles or going to bed early rather than using energy to keep warm (see, for example, Anderson et al., 2012; NSW Council of Social Services, 2017). There are also adaptations in warmer climates. For example, a 2021 survey of 682 people in Sydney, Australia, found 75% of the sample had air conditioning at home, but, of those, 78% worried about the cost of using air conditioning and 54% did not use their air conditioning due to cost concerns (Bacon, 2021). Confounding subjective measures of energy poverty, older people do not 'problematise' these adaptations (Chard and Walker, 2016). Despite these behaviours, older people use more energy due to a less active lifestyle (at home more, needing more lights and heating) and the loss of economies of scale with smaller household size (Bardazzi and Pazienza, 2017). All of these factors will have an impact on the measurement of energy poverty.

[4] A small-scale study of energy use and thermal comfort in social housing in New South Wales found individuals aged 60 or over spent an average of 20 hours per day at home, and during summer 57% felt warm or very hot (Haddad et al. 2019).

Given negative consequences of energy poverty for elderly people, it is important to understand the drivers of energy poverty within this group. Beyond studies of socio-demographic and housing-related determinants of energy poverty (e.g., Drescher and Janzen, 2021; Legendre and Ricci, 2015) many factors have been considered and the literature is wide ranging: for example, Awaworyi Churchill and Smyth (2020) look at ethnic diversity and Farrell and Fry (2021) investigate gambling. We focus on literature that investigates the mechanisms through which a retiree's income source might impact their likelihood of experiencing energy poverty.

Firstly, we consider economic factors that might connect retirement income sources to energy poverty (beyond income effects). Retiree type might be a proxy for wealth, as for example, Age Pensioners must satisfy an assets test to receive the full pension and superannuation balances for middle income earners (who tend to become Part-pensioners) are modest (Ralston and Feng, 2017). We therefore consider studies that link non liquid assets and energy poverty. Best and Burke (2019) show that those in the lower quartile of the Australian wealth distribution are more likely to experience energy poverty. Investigating the broader aspects of financial capabilities, Koomson and Danquah (2021) found financial inclusion reduces energy poverty, likely through increased income (Koomson et al., 2020).

Next, we consider psychological factors. Social isolation is also related to poverty (Atkinson et al., 2002) and may be a mediator between retiree type and energy poverty if, for example, some retirees do not encourage visitors because their home is too cold (Porto Valente et al., 2021). Different types of retirees might experience different levels of social isolation due to access to social support (for example, lower socioeconomic status can lead to lower social engagement (Sabbath et al., 2015)) and this may drive energy demand according to time spent at home.

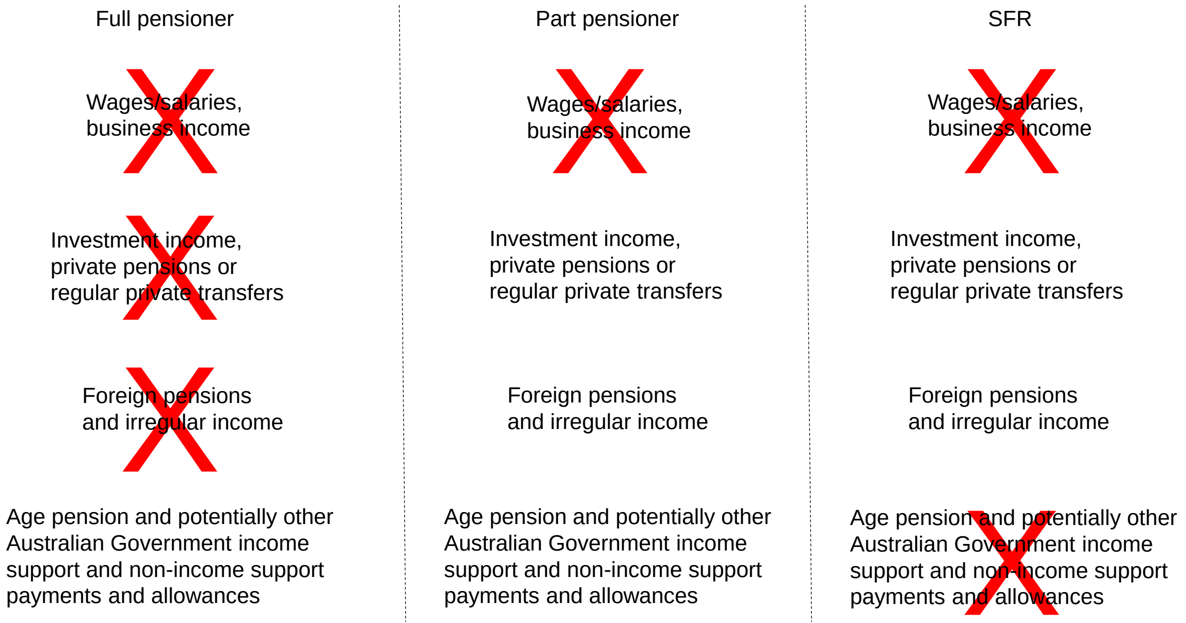
Australia's distinct retirement funding arrangements offer a unique opportunity to consider the impact of these arrangements on energy poverty. Negative outcomes associated with retiree energy poverty suggest we should investigate the prevalence of energy poverty within this vulnerable group and the determinants of any inequality.

3. Data and methods

We use 15 waves of the *Household, Income and Labour Dynamics in Australia* (HILDA) data from 2005–2019. HILDA is a large, nationally representative, long running annual household survey focusing on the dynamics of families and households, income, wealth and welfare, the labour market (including unemployment and joblessness) and life satisfaction/wellbeing. Its longitudinal nature makes HILDA ideally suited to analysing energy poverty at the individual level over time. Watson and Wooden (2012) provide initial details on the survey, with an overview of recent findings in Wilkins et al. (2020).

We examine energy poverty of retired Australians (aged 65 or over and not in the labour force) according to their income source (figure 3). Retirees are categorised into three groups: Age Pensioners, Part-Pensioners and SFRs. Key distinctions are that Age Pensioners and Part-pensioners receive the Age Pension (in whole or in part), whereas SFR do not. In addition, Part-pensioners have other non-wage sources of income.

Figure 3: Income sources of retirees



Note: crosses indicate income sources not included.

In terms of energy poverty, following Awaworyi Churchill et al. (2020), Farrell and Fry (2021), Healy and Clinch (2002) and Llorca et al. (2020), we contribute to literature that explores objective and subjective measures, as the former may provide an 'accurate' measure of energy poverty (although it may be an underestimate if low income individuals find ways to restrict energy expenditure)[5] but the latter captures the 'feeling' of energy poverty and the two may not coincide. Indeed, Azpitarte et al. (2015) show of those Australian households considered to be in energy poverty under any of the five common measures used, 61% are only identified

[5] Wilkins and Sun (2010) show energy expenditure in HILDA is 12–20% below corresponding figures from the ABS Household Expenditure Survey (HES), although some of the difference may be attributed to the expenditure measure (average or general expenditure in HILDA versus actual (diarised) expenditure over a two-week reference period in HES).

as energy poor on one out of five objective and subjective measures (Legendre and Ricci, 2015 also find differences for France depending on the measure used).

We consider two primary energy poverty measures which are the preferred measures in the literature (one objective and one subjective) and several additional measures (objective and subjective) as robustness checks. The primary objective measure (EP1) is the low income–high cost (LIHC) indicator of energy poverty originally proposed by Hills (2011) and takes account of income and energy cost circumstances leading to difficulties affording energy[6]. This measure allows thresholds to change over time as energy costs and income levels change. Our primary subjective measure (EP2) indicates an inability to heat the home due to a shortage of money. This measure is comparable with the literature in cold climate countries which focuses on heating homes. However, importantly, this measure misses cooling of homes which is an important aspect of energy use in Australia.

As extensions, we also investigate the traditional (objective) budget share (EP3), which measures annual expenditure on energy (electricity, gas and other heating fuel) as a proportion of annual household disposable income. Another (objective) measure (EP4) is an indicator of whether the budget share exceeded 10% — a traditional measure of energy poverty (see, for example, Walker et al., 2014). Although objective, this measure has been criticised for the subjectivity of the 10% threshold. Our last measure (EP5) captures inability to pay electricity, gas or phone bills on time due to a shortage of money. This is a broader subjective measure of energy poverty and will include energy use for cooling as well as heating homes and so is an especially relevant measure in the context of a warm climate country. Although this measure includes telecommunication costs, which are not generally thought of as energy costs, it has been used in the literature (Farrell and Fry, 2021).

As Age Pensioners and Part-pensioners receive an energy supplement to help pay their bills, there may be a difference between the objective and subjective measures for the three retiree groups. Some Age Pensioners or Part-pensioners may have high energy expenditure in line with SFR but will have a lower incidence of subjective energy poverty due to the supplement.

[6] Low income is defined as equivalised residual income (household disposable income less energy expenditure and housing costs, all equivalised) below the poverty line (defined for the population as 60% of median equivalised household disposable income excluding housing costs) and the equivalence factor is 1/(1+0.5*number of individuals aged 15 or over excluding household head+0.3*number of children aged 14 or under in the household). High costs are defined as equivalised energy expenditure above the population median.

Our energy poverty model is:

$$EP_{it} = \beta_0 + \beta_1 type_{it} + \sum_{j=2}^{n} \beta_j X_{jit} + \alpha_i + \gamma_s + \lambda_t + \varepsilon_{it} \quad (1)$$

where EP is our measure of energy poverty (EP1–5), type is an indicator of retiree type, X is a set of socio-demographic control variables (age, sex, marital status, household size, number of dependants, highest education level, income, home owner, disability, Australian, urban/rural location), α_i is an individual effect, γ_s is a state effect, λ_t is a year effect and ε_{it} is the error term. State and year effects control for energy price variations over time and space. Our sample comprises retirees from 2005–19, although subjective measures of energy poverty were unavailable for 2010.

A fixed effects model accounts for unobserved individual characteristics associated with energy poverty, such as the ability to manage energy use or pay bills on time. However, our data show individuals appear on average in about 5 of the 14 waves.[7] Thus in addition to estimating equation (1) using fixed effects, we also estimate using random effects. Finally, all models use robust standard errors (White, 1980).

To identify causal effects, it is important to rule out endogeneity of retirement income sources. Reverse causality could arise for several reasons. Energy costs while in the labour force may have affected superannuation contributions. While the employer contribution is mandatory in Australia, employee contributions are not but very few Australians make voluntary contributions. In a 2019–20 survey, 17% of respondents were unaware that they could make voluntary contributions, 25% had never made voluntary contributions, only 20% made regular contributions and the rest were past/occasional contributors. Also, voluntary contributions only make up around 25% of the total contributions to superannuation funds in Australia[8]. Given that voluntary superannuation contributions are not the norm it seems unlikely that they were significantly impacted by energy prices. Employer contributions are a fixed percentage of a person's salary and therefore are mostly influenced by occupation choices. It seems unlikely that occupation choices are determined by energy prices, as most of these decisions occur at a life stage where the individual is often not responsible for paying energy bills. Energy costs could also impact the timing of retirement, although Australian data suggests the primary

[7] Age Pensioners appear in 3.6 waves on average, Part-pensioners in 5.2 waves and SFR in 3.2 waves, which may make the model less precise. Comparing with individuals of any age outside our sample who appear on average in 7.3 waves, it might appear that we have a problem with attrition. However, some of our individuals return to the labour force and become out of scope for our study but remain in HILDA.

[8] https://www.finder.com.au/superannuation-statistics

reason for retirement is reaching the age for eligibility to access private or state funds (36% for men and 22% for women).[9] This suggests that individuals are not sensitive to energy costs when timing their retirement. Nevertheless, we employ the instrumental variables approach to empirically test for reverse causality in our model. Here we focus on EP1 and EP2 and investigate using two instruments i) the State wage index (which determines the relative trade-off between remaining in the workforce and retiring) and ii) the State level variation in the population aged 65+ (the size of this cohort will impact labour force opportunities). Our IV approach uses external and internal instruments (with fixed effects) via the Lewbel (2012) methodology. This methodology relies on heteroscedasticity in first stage error terms to identify causal effects using internally generated instruments, is well accepted and has been applied to energy poverty (see, for example, Awaworyi Churchill et al., 2020; Farrell and Fry, 2021; Zhang and Awaworyi Churchill, 2020).

The variable Disability refers to a long term health condition, impairment or disability that restricts everyday activities. As reverse causality would bias the estimated coefficient, we investigate the robustness of our results using the Lewbel (2012) approach. In this instance we utilise only internally generated instruments based on heteroscedastic covariance restrictions as there is no obvious instrument for disability that is independent of energy poverty.

Any effect of retiree type is additional to income effects as our model controls for income. We therefore consider several other possible mechanisms through which retirement income sources might causally drive energy poverty, namely wealth, assets, social isolation, and general health. Controlled for income, there may be monetary effects through wealth and assets. Retiree types may have different levels of wealth and/or assets and this may impact energy poverty if they use wealth and assets to support energy costs. Social isolation is a similar mechanism. Retiree types associated with social isolation (through income effects) might spend more time at home, generating higher energy costs. They may also have less support to help pay bills in difficult times. Finally, we investigate general health as a mechanism as retiree types could have different health outcomes due to health care costs, leading to different energy needs.

9 https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6238.0Main+Features1July%202016%20to%20June%202017?OpenDocument=

For a channel to be viable it must be statistically related to retiree types so we can include it in the model. Coefficients on retiree types should become smaller if some of the mechanism by which retiree types impact energy poverty is picked up by the channel's variable.

Our last robustness test considers the importance of omitted variables. While the mechanisms above suggest possible channels there are other mechanisms that we cannot capture in our data, such as a person's rate of time preference, that could lead to omitted variables bias. We therefore conduct Oster's (2019) bounds analysis to address any endogeneity due to omitted variables bias. This technique is becoming more common in the assessment of omitted variables bias in energy poverty estimates (see, for example, Awaworyi Churchill and Smyth, 2021; Burlinson et al., 2021; Dogan et al., 2021; Pan et al., 2021). It relies on changes in coefficients and R^2 to determine bias based on the relative degree of selection on observed and unobserved variables. The technique identifies the effect of retiree type on energy poverty by placing consistent bounds on the 'true' estimates that would have been obtained if we had information on unobserved variables affecting energy poverty, such as rates of time preference. Identifying the bounds requires an assumption about the relative degree of selection on the observed and unobserved variables (δ). Following Oster's (2019) suggestion, we assume $\delta = 1$. This implies observed and unobserved variables are of equal importance. The bounds are

$$\left[\hat{\beta}, \beta^*\left(Min\{1, 1.3\hat{R}^2\}, \delta = 1\right)\right]^{10} \quad (2)$$

where $\hat{\beta}$ is the sample estimate of β from the model including control variables and β^* is estimated as

$$\beta^* \approx \hat{\beta} - \left(\dot{\beta} - \hat{\beta}\right) \frac{R^2_{MAX} - \hat{R}^2}{\hat{R}^2 - \dot{R}^2} \quad (3)$$

where $\dot{\beta}$ is the sample estimate of β and $\dot{R}^2$ is the coefficient of determination from the model without controls. R^2_{MAX} is a theoretical maximum from a hypothetical model containing both observed and unobserved controls and is set at $min\{1, 1.3\hat{R}^2\}$. $\hat{R}^2$ is the coefficient of determination from the model with controls.

Our sample comprises 24% Age Pensioners, 62% Part-pensioners and 14% SFR (Table 1).[11] For our objective LIHC measure (EP1), on average 19.9% of retirees face energy poverty, while for our subjective measure (EP2) 2.9% of retirees were unable to heat their homes due

[10] The bounds are $\left[\beta^*\left(Min\{1, 1.3\hat{R}^2\}, \delta = 1, \hat{\beta}\right)\right]$ if $\hat{\beta} > \beta^*$.

[11] Population-weighted proportions: 23% Age Pensioners, 63% Part-pensioners and 14% SFR.

to a shortage of money. The higher rate of energy poverty under the LIHC measure is an artifact of the low incomes of retirees and their high energy costs relative to the Australian population.[12] As noted, retirees spend more time at home than other demographic groups and so have higher energy demands. The lower subjective measure may under record energy poverty for Australia as it only considers heating. Further, behavioural factors may increase ability to pay heating bills at the expense of other items such as skipping meals. Considering the extended set of energy poverty measures we find: on average 4.1% of retiree household income is spent on energy bills; 5.8% of retirees spend more than 10% of their income on energy bills, and 5.3% could not pay energy bills.

[12] Using HILDA, Awaworyi Churchill et al. (2020) find the incidence of energy poverty under the LIHC measure is 5.4% for the Australian population.

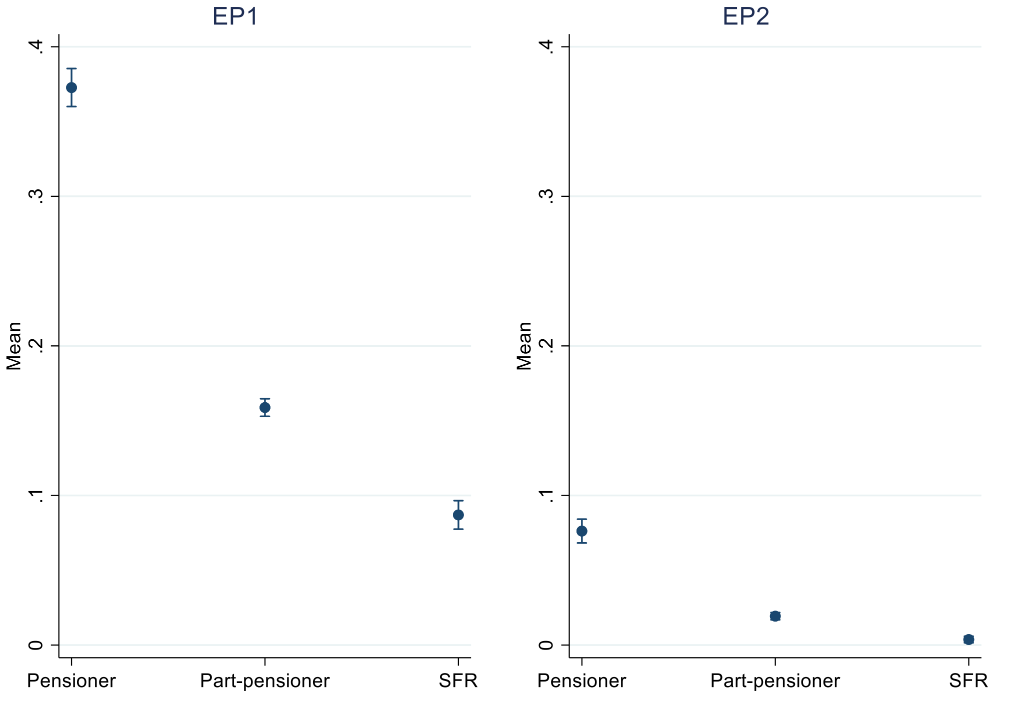
Table 1: Descriptive statistics for the sample

Variable	Obs	Mean	Std. Dev.	Min	Max
EP1	23,596	0.199	0.399	0	1
EP2	19,679	0.029	0.169	0	1
EP3	23,596	0.041	0.056	0	1
EP4	23,596	0.058	0.233	0	1
EP5	19,780	0.053	0.223	0	1
Age Pensioner	23,596	0.235	0.424	0	1
Part-pensioner	23,596	0.624	0.484	0	1
SFR	23,596	0.141	0.348	0	1
Age	23,596	75.428	6.842	65	101
Age squared	23,596	5736.209	1057.492	4225	10201
Female	23,596	0.574	0.495	0	1
Married/De facto	23,596	0.585	0.493	0	1
Separated/widowed/divorced	23,596	0.370	0.483	0	1
Single	23,596	0.045	0.207	0	1
Household size	23,596	1.634	0.564	1	8
Dependants	23,596	0.005	0.110	0	5
Higher education	23,596	0.118	0.323	0	1
Further education	23,596	0.264	0.441	0	1
School education	23,596	0.618	0.486	0	1
Log income	23,596	10.387	0.689	5.318	14.342
Homeowner	23,596	0.804	0.397	0	1
Disability	23,596	0.602	0.489	0	1
Australian	23,596	0.706	0.456	0	1
Urban	23,596	0.850	0.357	0	1
Wage index (2000=100)	23,596	156.348	19.157	118.748	187.813
Population 65+/100,000	23,596	50.864	22.024	2.091	80.874
Log net wealth	6,178	12.774	1.889	0	16.057
Log assets	6,227	12.741	1.957	0	16.241
Social isolation	20,910	3.453	1.498	1	7
General health	21,052	59.703	22.185	0	100
State	23,596	2.593	1.584	1	8
Wave	23,596	12.802	4.253	5	19

Note: EP1 indicates LIHC. EP2 indicates unable to heat the home. EP3 is the budget share for energy. EP4 indicates energy budget share >10%. EP5 indicates unable to pay energy bills on time. Age pensioner, Part-pensioner and SFR are defined in fig. 3. Disability indicates having a health condition. Higher education is bachelor's degree or above. Further education is education between school level and University level, comprising Certificate III/IV, Diplomas and Advanced Diplomas. School education is year 12 or below (and includes Certificate I/II). Homeowner distinguishes owners/mortgagees from renters. Australian indicates born in Australia. Urban denotes residence in an urban area. Social isolation is a scale indicating (decreasing) frequency of getting together socially with friends/relatives.

Figure 4 explores our main energy poverty measures by retiree type. For the objective LIHC measure, we see energy poverty inequality among retiree types with Age Pensioners most likely to experience energy poverty and SFR least likely. The same pattern emerges for the main subjective measure of energy poverty: ability to heat the home.

Figure 4: Energy poverty measures by retiree type



Note: EP1 indicates LIHC. EP2 indicates unable to heat the home. 95% confidence intervals shown.

4. Results

4.1 Main energy poverty measures

For EP1 (LIHC) we find significantly higher probability of energy poverty for Age Pensioners relative to Part-pensioners, but we cannot distinguish Part-pensioners from SFRs. We find similar results for fixed and random effects, suggesting consistency in our main energy poverty findings across the different model specifications. We find similar results for the main subjective measure (EP2) although the result is only significant in the random effects specification. These results support the descriptive analysis that showed Age Pensioners to be most at risk of energy poverty and suggests there are inequalities among retiree types. As our model controls for income, these are not simply income effects, but are picking up something additional, such as a lack of family support for pensioners in hard times (related to social isolation (see Stephens et al., 2010). Increased income reduces energy poverty (as we might expect — energy being a necessity) for EP1. For EP2 we see a positive marginally significant effect in the fixed effects model and a negative but insignificant effect in the random effects model, suggesting adequate income does not fully compensate a perceived deficit in energy use (if, for example, retirees engage in adaptive behaviours mentioned earlier).

Table 2: Main measures

Variable	EP1 FE	EP1 RE	EP2 FE	EP2 RE
Age Pensioner	0.0697***	0.1050***	0.0059	0.0236***
	(0.0125)	(0.0099)	(0.0057)	(0.0048)
SFR	-0.0212	0.0043	-0.0034	-0.0135***
	(0.0180)	(0.0097)	(0.0046)	(0.0028)
Age	-0.0022	-0.0093	0.0100**	0.0102***
	(0.0111)	(0.0087)	(0.0048)	(0.0039)
Age squared	0.0001	0.0000	-0.0001*	-0.0001***
	(0.0001)	(0.0001)	(0.0000)	(0.0000)
Female		0.0127		0.0060
		(0.0082)		(0.0041)
Separated/widowed/divorced	0.0291	-0.0041	0.0240**	0.0286***
	(0.0265)	(0.0121)	(0.0117)	(0.0081)
Single	0.1253	-0.0545**	-0.3101**	0.0264*
	(0.2427)	(0.0217)	(0.1578)	(0.0137)
Household size	-0.0370	-0.0279***	0.0049	0.0058
	(0.0229)	(0.0101)	(0.0095)	(0.0070)
Dependants	0.0692	0.0769**	0.0057	-0.0170**
	(0.0698)	(0.0312)	(0.0060)	(0.0070)
Higher education		0.0024		0.0012
		(0.0114)		(0.0056)
Further education		-0.0042		0.0047
		(0.0093)		(0.0049)
Log income	-0.1896***	-0.1883***	0.0051**	-0.0001
	(0.0087)	(0.0077)	(0.0025)	(0.0020)
Homeowner	0.0065	0.0181*	0.0063	-0.0201***
	(0.0184)	(0.0109)	(0.0073)	(0.0060)
Disability	0.0059	0.0147***	0.0006	0.0090***
	(0.0065)	(0.0055)	(0.0025)	(0.0023)
Australian		-0.0111		-0.0143***
		(0.0088)		(0.0050)
Urban	0.0103	-0.0073	-0.0118	-0.0006
	(0.0206)	(0.0102)	(0.0093)	(0.0047)
States	Yes	Yes	Yes	Yes
Waves	Yes	Yes	Yes	Yes
Constant	1.9445***	2.5053***	-0.4426**	-0.3440**
	(0.4320)	(0.3409)	(0.1875)	(0.1529)
Observations	23,596	23,596	19,679	19,679
R-squared	0.0748		0.0077	
Number of individuals	3,884	3,884	3,636	3,636

Note: Reference categories are: Part-pensioner, married, school education. EP1 indicates LIHC. EP2 indicates unable to heat the home. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

5. Robustness tests

Our main finding is that Age Pensioners are more likely to experience energy poverty than Part-pensioners or SFRs and to ensure this effect is clearly identified we conduct several robustness checks. Firstly, we test the robustness of the results to the measures of energy poverty by estimating the models on an alternative set of energy poverty measures employed in the literature. Secondly, we consider the possibility of endogeneity in our models. Thirdly, we investigate potential mechanisms whereby retiree income sources might indirectly cause energy poverty. Finally, we present a bounds analysis to control for possible omitted variables.

5.1 Alternative energy poverty measures

For our extended set of measures the results add depth to the main findings. EP3 is the energy expenditure share and EP4 indicates expenditure exceeding 10% of income. For both measures we find similar results for both fixed and random effects. Compared to Part-pensioners, SFR are *more* likely and Age Pensioners less likely to be energy poor according to both measures. This result likely includes the effects of energy supplements available to Age Pensioners and Part-pensioners but not all SFRs[13], reducing actual expenditure for those on the Age Pension (although it is not clear from the data whether reported expenditure is net of supplements and some SFRs are eligible for concessions if they hold a Seniors Health Card[14]). Our results are consistent with Age Pensioners adopting more frugal attitudes to energy use, making do with less (see Chard and Walker, 2016), and SFRs choosing to spend more. This highlights why the LIHC measure of energy poverty is preferred over budget share measures (EP3 and EP4) which might hide poverty if those on low income reduce usage and 'go without' to manage energy costs (see Anderson et al., 2012).

The results for EP5, our broader subjective measure that also includes telecommunication costs, reflect those of EP2 (ability to heat the home), with Age Pensioners more likely to experience energy poverty and SFR less likely. These findings support the budget share findings that Age Pensioners are the most disadvantaged retiree type in terms of managing the costs of heating and having to restrict expenditure to manage competing demands on limited incomes.

Again, we see negative effects of income (although not significant in the EP5 fixed effects specification), so as income increases energy poverty decreases. Hence the coefficients on the income source variables are separately and independently identified.

[13] Subsidies are available under the Commonwealth Seniors Health Card, which is held by older people not on the Age Pension. Examples of State subsidies are available at: https://selectra.com.au/energy/guides/rebate/senior-rebate.

[14] See, for example: https://www.servicesaustralia.gov.au/individuals/services/centrelink/commonwealth-seniors-health-card/who-can-get-it)

Table 3: Alternative EP measures

Variable	EP3 FE	EP3 RE	EP4 FE	EP4 RE	EP5 FE	EP5 RE
Age Pensioner	-0.0054***	-0.0077***	-0.0119*	-0.0149***	0.0046	0.0359***
	(0.0014)	(0.0012)	(0.0067)	(0.0051)	(0.0077)	(0.0063)
SFR	0.0252***	0.0331***	0.0678***	0.1089***	0.0054	-0.0134**
	(0.0049)	(0.0030)	(0.0132)	(0.0067)	(0.0108)	(0.0055)
Age	-0.0025*	-0.0037***	-0.0126*	-0.0124**	-0.0168**	-0.0107*
	(0.0013)	(0.0011)	(0.0065)	(0.0048)	(0.0069)	(0.0056)
Age squared	0.0000***	0.0000***	0.0001***	0.0001**	0.0001**	0.0001*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Female		0.0003		0.0059		-0.0056
		(0.0011)		(0.0041)		(0.0057)
Separated/widowed/ divorced	-0.0006	-0.0026*	0.0103	0.0071	0.0241*	0.0501***
	(0.0027)	(0.0015)	(0.0134)	(0.0061)	(0.0135)	(0.0101)
Single	-0.0156	-0.0098***	-0.0547	-0.0176	-0.2540*	0.0444**
	(0.0195)	(0.0027)	(0.1550)	(0.0108)	(0.1360)	(0.0173)
Household size	0.0135***	0.0143***	0.0347***	0.0440***	0.0058	0.0287***
	(0.0023)	(0.0016)	(0.0102)	(0.0052)	(0.0115)	(0.0095)
Dependants	0.0005	-0.0033	-0.0296	-0.0147	0.0016	-0.0305
	(0.0053)	(0.0028)	(0.0362)	(0.0102)	(0.0837)	(0.0227)
Higher education		0.0076***		0.0331***		-0.0153**
		(0.0018)		(0.0073)		(0.0068)
Further education		0.0017		0.0087*		-0.0083
		(0.0013)		(0.0048)		(0.0063)
Log income	-0.0673***	-0.0645***	-0.1936***	-0.1768***	-0.0013	-0.0073***
	(0.0029)	(0.0026)	(0.0064)	(0.0053)	(0.0031)	(0.0026)
Homeowner	0.0093***	0.0136***	0.0124	0.0347***	0.0146	-0.0237***
	(0.0022)	(0.0014)	(0.0096)	(0.0053)	(0.0097)	(0.0071)
Disability	-0.0001	0.0005	-0.0030	-0.0001	-0.0024	0.0076**
	(0.0008)	(0.0007)	(0.0039)	(0.0032)	(0.0043)	(0.0037)
Australian		0.0020*		-0.0015		-0.0071
		(0.0012)		(0.0047)		(0.0058)
Urban	-0.0013	-0.0012	-0.0327***	-0.0085	0.0110	0.0031
	(0.0026)	(0.0015)	(0.0110)	(0.0058)	(0.0138)	(0.0068)
States	Yes	Yes	Yes	Yes	Yes	Yes
Waves	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.7263***	0.8017***	2.2432***	2.1985***	0.7352***	0.5378**
	(0.0586)	(0.0524)	(0.2561)	(0.1947)	(0.2767)	(0.2220)
Observations	23,596	23,596	23,596	23,596	19,780	19,780
R-squared	0.3445		0.1535		0.0034	
Number of individuals	3,884	3,884	3,884	3,884	3,650	3,650

Note: Reference categories are: Part-pensioner, married, school education. EP3 is the energy budget share. EP4 indicates energy budget share >10%. EP5 indicates unable to pay energy bills on time. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

5.2 Endogeneity investigations

The results for the investigation of retiree type endogeneity suggest the external instruments are weak (Table 4 Panel A: F-stats <10). Panel B shows the internal instruments are weak for the instrumentation for Age Pensioners but not for SFRs. Age Pensioners are more likely to experience energy poverty measured by LIHC and SFR are now significantly less likely to suffer energy poverty. The same signs are found for EP2 but the results are not significant. Panel C includes both external and internal instruments and reports the Breusch-Pagan test for heteroscedasticity which is significant, indicating our use of internal instruments is statistically valid. Due to weak external instruments, the results match those in panel B when we only use internal instruments. It is important to note that in Panels B and C we see no statistical significance on the endogeneity test indicating retiree type is not endogenous as might be expected given the discussion above, suggesting (by extension) the results are capturing the causal effect of retiree type on energy poverty.

Table 4: Retiree type instrumental variables and endogeneity test results

	EP1	EP2
Panel A - 2SLS with external instruments		
Pensioner	0.6518	-0.0563
	(0.8104)	(0.1989)
SFR	-2.6869	-0.2950
	(1.8040)	(0.5344)
Controls	Yes	Yes
Observations	23,596	19,679
First stage Age Pensioner		
State wage index	-0.0046**	-0.0077***
	(0.0021)	(0.0021)
State population aged 65+	-0.0028*	-0.0030*
	(0.0016)	(0.0017)
F-stat for excluded instruments	3.63**	7.65***
First stage SFR		
State wage index	0.0022*	0.0028**
	(0.0011)	(0.0012)
State population aged 65+	-0.0009	-0.0008
	(0.0009)	(0.0010)
F-stat for excluded instruments	2.53*	3.09**
Endogeneity test (Durbin-Wu-Hausman)	11.1960***	0.3370
Panel B – Lewbel 2SLS with internal instruments		
Pensioner	0.1182*	0.0071
	(0.0638)	(0.0281)
SFR	-0.0928*	-0.0052
	(0.0499)	(0.0141)
Controls	Yes	Yes
Observations	23,596	19,679
First stage Age Pensioner		
F-stat for excluded instruments	5.22***	4.03***
First stage SFR		
F-stat for excluded instruments	12.98***	11.50***
Hansen J	60.4910	31.8770
Endogeneity test (Durbin-Wu-Hausman)	0.8690	0.0300
Panel C Lewbel 2SLS with external and internal instruments		
Pensioner	0.1276**	0.0073
	(0.0630)	(0.0277)
SFR	-0.0946*	-0.0057
	(0.0498)	(0.0141)
Controls	Yes	Yes
Observations	23,596	19,679
First stage – Age Pensioner		
F-stat for excluded instruments	5.18***	4.18***
First stage - SFR		
F-stat for excluded instruments	12.72***	11.31***
Hansen J	72.7780*	32.4260
Endogeneity test (Durbin-Wu-Hausman)	2.6890	0.0270
Breusch-Pagan test	5372.23***	12147.16***

EP1 indicates LIHC. EP2 indicates unable to heat the home. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Disability may be endogenous. This could be due to reverse causality if individuals have debilitating health conditions that increase reliance on energy for heating or cooling. There may be omitted variables that drive both energy poverty and disabilities (although they should be captured by the fixed effects). There may also be measurement error if individuals do not report their disabilities. To investigate the robustness of our results, in table 5 we report key results for Instrumental Variables models using internally generated instruments for disability status (Lewbel, 2012). We see evidence of heteroscedasticity in the Breusch-Pagan test, so our use of internal instruments is statistically valid. The Durbin-Wu-Hausman test is barely significant, suggesting disability may not be endogenous. The coefficients on Age Pensioners and SFR are again very similar to those estimated without instruments in the comparable models in table 2.

Table 5: Disability instrumental variables results

	EP1	EP2
Disability	0.0246	0.0378
SE	(0.0760)	(0.0331)
Pensioner	0.0698***	0.0064
SE	(0.0118)	(0.0056)
SFR	-0.0207	-0.0021
SE	(0.0169)	(0.0047)
Controls	Yes	Yes
Observations	23,596	19,679
First stage		
F-stat for excluded instruments	1.69**	6.88***
Hansen J	29.333	26.695
Endogeneity test (Durbin-Wu-Hausman)	0.0250	2.8850*
Breusch-Pagan test	5372.23***	12147.16***

EP1 indicates LIHC. EP2 indicates unable to heat the home. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

5.3 Channels

Table 6 shows the relationships between retiree type and each of the proposed channels is statistically significant and they have the expected signs. Consistent with the literature, Age Pensioners have less wealth, lower assets, have higher levels of social isolation and lower health. We therefore include each of these variables in equation (1) as additional covariates and present the results in table 7.

Table 6: Effects of retiree type on mediators

	Net wealth	Assets	Social isolation	General health
Pensioner	-0.7355***	-0.7328***	0.1424***	-1.5061***
	(0.0484)	(0.0489)	(0.0331)	(0.3738)
SFR	0.7764***	0.7763***	-0.1259***	2.5898***
	(0.0378)	(0.0384)	(0.0405)	(0.5251)
Observations	6,178	6,227	20,910	21,052

Each model includes control variables. Net wealth and assets only available for 4 waves. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Each panel of table 7 presents results for retiree type and the channel variable. The baseline model presents retiree type coefficients without the channel variable, and these vary slightly due to differences in sample size according to the measure of energy poverty and the channel being considered. Panels A and B show that neither wealth nor assets impact EP1 but both impact EP2 as the inclusion of these variables reduces the retiree type coefficients. This is not surprising as EP1 is an income (not a wealth or assets) based measure of energy poverty. Liquidity matters for objectively measured energy poverty. However, it appears that wealth and assets form a psychological buffer against perceived inability to afford heating (Smith et al., 2005). We see a similar pattern for social isolation in panel C. As isolation increases EP2 increases, and the main effects are smaller. However, there is no effect on EP1 the objective measure. Isolation impacts perceptions about heating affordability probably due to having no support networks and perhaps reflects an unwillingness to heat when in isolation rather than an inability to afford to heat (Porto Valente et al., 2021; Liddell and Guiney, 2005). Panel D shows the impact of general health has the same pattern: the channel variable influences EP2 but not EP1.

Table 7: Effects of mediators on energy poverty

	EP1	EP2
Panel A (direct effects)		
Pensioner	0.1245***	0.0158**
	(0.0175)	(0.0075)
SFR	0.0405***	0.0026
	(0.0154)	(0.0065)
Net wealth	0.0057	-0.0092***
	(0.0057)	(0.0036)
Observations	6,178	4,312
Baseline (total effect)		
Pensioner	0.1188***	0.0243***
	(0.0163)	(0.0076)
SFR	0.0457***	-0.0056
	(0.0146)	(0.0058)
Panel B (direct effects)		
Pensioner	0.1248***	0.0152**
	(0.0174)	(0.0075)
SFR	0.0396**	0.0044
	(0.0154)	(0.0068)
Assets	0.0063	-0.0105***
	(0.0056)	(0.0038)
Observations	6,227	4,350
Baseline (total effect)		
Pensioner	0.1185***	0.0251***
	(0.0161)	(0.0076)
SFR	0.0454***	-0.0050
	(0.0146)	(0.0059)
Panel C (direct effects)		
Pensioner	0.1135***	0.0231***
	(0.0104)	(0.0049)
SFR	0.0041	-0.0124***
	(0.0101)	(0.0028)
Social isolation	-0.0008	0.0034***
	(0.0020)	(0.0010)
Observations	20,910	19,004
Baseline (total effect)		
Pensioner	0.1133***	0.0236***
	(0.0104)	(0.0049)
SFR	0.0042	-0.0130***
	(0.0101)	(0.0028)

Table 7 (continued)

	EP1	EP2
Panel D (direct effects)		
Pensioner	0.1121***	0.0217***
	(0.0106)	(0.0049)
SFR	0.0052	-0.0126***
	(0.0099)	(0.0027)
General health	-0.0001	-0.0005***
	(0.0002)	(0.0001)
Observations	21,052	19,088
Baseline (total effect)		
Pensioner	0.1125***	0.0229***
	(0.0106)	(0.0049)
SFR	0.0048	-0.0141***
	(0.0099)	(0.0028)

EP1 indicates LIHC. EP2 indicates unable to heat the home. Each model includes control variables. Baseline (total effect) uses the same sample as main (direct effect) analysis. Net wealth and assets only available for 4 waves. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

5.4 Bounds analysis

To investigate concerns about omitted variable bias, the first step is to consider coefficient stability with and without covariates, comparing baseline and controlled effects (Table 8). If the coefficients are stable, omitted variables are of limited influence in the model (Altonji et al., 2005). Comparing the fixed effects estimates with and without controls, in our models for EP1 and EP2 the 95% confidence intervals on the Age Pensioner and SFR coefficients are overlapping suggesting coefficient stability. However, we also need to examine the effect of unobservables considering different R^2 in the models with and without covariates, as coefficients may be stable if the controls are uninformative (Oster, 2019). As the bounds contain the true β, the causal effect of a retiree type on energy poverty is significant since our bounds do not include zero. Given R^2_{MAX}, we can also estimate the δ that would be required for the causal effect to be zero. For EP1, $|\delta|$ exceeds 4.8 for Age Pensioners, suggesting the effects of unobservables would have to be more than 4.8 times greater than the effects of observables, which is unlikely. However, $|\delta|$ is less than one (0.9) for SFR. This suggests there are important omitted variables affecting SFR that we cannot capture, such as rates of time preference or energy efficiency. However, the effects we capture are still important and robust, given the bounds on the estimate exclude zero. For EP2, $|\delta|$ is greater than two and for Age Pensioners exceeds 92. This indicates a very limited role for unobservables and is potentially due to the inclusion of individual fixed effects that account for individual unobserved heterogeneity. The bounds and δ estimates suggest our results are robust to omitted variable bias and, compared to Part-pensioners, Age Pensioners are more susceptible to energy poverty and SFR less so. These results are consistent with those in Table 2.

Table 8: Bounds analysis

Treatment variable	Baseline effect $\dot{\beta}$ (SE) $[\dot{R}]$	Controlled effect $\hat{\beta}$ (SE) $[\hat{R}]$	Bounds $[\hat{\beta}, \beta^*(Min\{1, 1.3\hat{R}^2\}, \delta = 1)]$	Exclude zero?	$\lvert\delta\rvert$ for $\beta = 0$ given R^2_{MAX}
Panel A: EP1					
Pensioner	0.1084*** (0.0128) [0.0070]	0.0697*** (0.0013) [0.0748]	[0.0569,0.0697]	Yes	4.8675
SFR	0.0587*** (0.0182) [0.0006]	-0.0212 (0.0180) [0.0748]	[-0.0454,-0.0212]	Yes	0.8583
Observations	23,596	23,596			
Panel B: EP2					
Pensioner	0.0056 (0.0057) [0.0001]	0.0059 (0.0057) [0.0077]	[0.0059,0.0061]	Yes	92.9090
SFR	-0.0084* (0.0045) [0.0001]	-0.0034 (0.0046) [0.0077]	[0.0057,0.0100]	Yes	2.0894
Observations	19,679	19,679			

EP1 indicates LIHC. EP2 indicates unable to heat the home. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

6. Conclusion

We have investigated energy poverty for three types of retiree in Australia (Age Pensioners, Part-pensioners and SFRs) using two main measures of energy poverty. Compared to Part-pensioners, our objective measure (the LIHC measure) Age Pensioners have a higher prevalence of energy poverty and SFRs have lower. Our subjective measure of one's ability to heat the home also shows Age Pensioners are the worst off and SFRs best off. The analysis shows that not all retirees have the same probability of experiencing energy poverty and that the means of funding of retirement is critical to energy poverty outcomes. A fair and equitable society should allow all citizens adequate energy for healthy living and it is important that retirees' health and wellbeing is not impacted by an inability to heat and cool their homes.

Our robustness tests confirm these general findings, but results are sensitive to the measures of energy poverty employed consistent with the literature. Our analysis also suggests several pathways through which retirement types can influence the distribution of energy poverty across retirees. We find that wealth, assets, social connections and good health are significant mediators that soften the impact of subjective concerns regarding energy bills for retirees. However, we find no effects of these mechanisms for our objective energy poverty measure.

In summary we find that energy poverty is being experienced within the group of retirees and it is not randomly distributed. Age pensioners are the most likely to be at risk of experiencing energy poverty and targeted policy could be used to address this issue. This finding is not surprising given that the growth in energy prices has been greater than the growth in the Age Pension in Australia. Tackling energy poverty can involve concessions to energy bills or funding for targeted energy efficiency upgrades (such as the Warm Front Program in England — see Sovacool (2015)).

There are important lessons here for countries looking to tackle the retirement income in ageing populations. While government funded pensions are supposed to act as a safety net, they need to remain sufficient in times of increasing energy prices. Further attention needs to be paid to the gap between state funded and SFRs in order to ensure equity in elderly populations.

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