Old Age Savings and House Price Shocks

Rory McGee*

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Abstract

Retirees maintain large wealth holdings, hold the majority in housing, and often leave bequests. How do house price fluctuations affect retirees saving? Informed by evidence from a natural experiment, I estimate a model of savings decisions including housing and bequest preference heterogeneity. I disentangle precautionary savings, bequest motives, and the desire to remain in one's home utilizing variation in housing and bequest taxation. 1/4 of house price increases are passed on to future generations, despite 50% of retirees having zero estimated bequest motive. I evaluate means-tested Long Term Care programs finding providing marginal liquidity delivers large benefits per pound spent.

Keywords: Savings, Housing, Long Term Care, Aging
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1 Introduction

In the last quarter century, the OECD's over-65 population has grown by more than 40% and is projected to increase further. There is considerable interest in the consumption and savings choices of retirees given their importance for the design of social security and pensions, health and Long Term Care policy, and the bequests they leave to future generations. These older households hold lots of wealth, even at advanced ages, mostly in the form of housing; however, housing's role is not well understood. It is complicated by the consumption it provides as a home and its illiquidity.

This paper aims to understand how this illiquidity affects the composition of retirees' portfolios, their expenditures, the bequests they leave, and the value of social insurance in old age. To estimate the sensitivity of retiree responses to the financial incentives for liquidating housing, I examine behaviour around thresholds in the tax system. In particular, I exploit discontinuous increases in the Average Tax Rate (ATR) levied on housing transactions in the UK using data from the English Longitudinal Study of Aging. I examine how retirees adjust the housing component of their portfolio when the financial incentives differ on either side of this discontinuity. I argue that small increases in the ATR generate large disincentives to extract home equity by downsizing and show that retirees halve their probability of selling within two years (an almost 3 percentage point reduction) after a £5,000 increase in the tax burden on their property. Additional analysis shows a minority of retirees move to renting and a majority remain homeowners after selling.

The considerable sensitivity of housing decisions to financial incentives suggests that understanding issues related to housing may be critical for understanding the portfolio decisions of older individuals more generally. This has not been a focus of the previous literature, which tends to model consumption and savings in general terms. To provide a comprehensive view of the role of housing, I estimate a dynamic structural model which makes explicit the multiple channels through which housing affects the incentives for retires to choose between investing in housing, risk-free liquid wealth, or consuming today. I make three broad contributions to understanding saving and expenditure decisions over the life cycle. First, I exploit longitudinal variation in estate and housing transaction taxes, distinct from the natural experiment, to disentangle illiquidity in portfolios from precautionary motives and bequest preference heterogeneity. Second, I quantify the stark impact of heterogeneity in financial incentives on the intergenerational transmission of wealth. Third, I show how features of social insurance implicitly target households with low liquidity and demonstrate that both retiree valuations of social insurance and the distortions it induces depend on this targeting.

To correctly determine households' desire for liquidity, consumption, and savings for bequests over different horizons (and consequently their demand for different assets) I incorporate both idiosyncratic and aggregate risks, as well as heterogeneity in household preferences for leaving a bequest. Separately identifying precautionary savings motives, the desire to remain in one's home, and a bequest motive presents a considerable empirical challenge. Several studies estimate precautionary motives using idiosyncratic mortality and medical spending risk in old age (Hurd, 1989; Palumbo, 1999; De Nardi et al., 2010, 2021), however, they do not distinguish housing wealth from other forms of wealth. To identify preferences for housing and its illiquidity separately from other savings motives, I exploit longitudinal variation in housing transaction and estate taxes, as well as variation from UK house prices. I match moments on wealth composition, moving, and a measure of subjective expectations across multiple policy regimes using the method of simulated moments.

Recent advances exploit data on insurance under-utilization (Inkmann and Michaelides, 2012; De Nardi et al., 2016a; Lockwood, 2018), bespoke strategic survey questions on bequests and long term care (Ameriks et al., 2020), adversarial estimators (Kaji et al., 2020), and variation in social security entitlements (Lee and Tan, 2019) to separate *homogenous* bequest motives from precautionary motives.[1] My novel approach utilizes survey measures of subjective expectations of leaving a large bequest as noisy measures of stated preference (van der Klaauw, 2012) to separately identify *heterogeneous* preferences for bequests. Combining retirees' expectations of future bequests with reforms to estate taxation is uniquely advantageous — beliefs before and after the reform provide information on choices retirees would have made in futures that are no longer or not yet realized. This builds on recent work incorporating longitudinal policy variation as a source of identification in structural models (Voena, 2015; Blundell et al., 2016).

In estimation I intentionally exclude moments capturing the effect of the natural experiment (a discontinuous increase in the transaction tax ATR) and use this to validate the estimated model. The model matches the magnitude of retirees' responses

[1] De Nardi et al. (2016b) survey this literature and discuss cross-country comparisons.

to changes in the financial incentive for moving as well as their wealth holdings during old age. Estimated parameters reveal that retirees value the independence associated with remaining a homeowner, and they incur considerable costs when moving. In addition, there is important dispersion in the desire to leave a bequest, which is correlated with savings before retirement. I separate this preference heterogeneity from variation in observed savings rates attributable to differences in household portfolios and allow for differences in both the importance of bequests and the extent to which they are luxuries. Hurd (1989) models binary heterogeneity by assuming no bequest motive for the childless, whereas my approach is closer to the finite-mixture estimation in Kopczuk and Lupton (2007), relying on a classification procedure to reduce the dimensionality and retain tractability. Ameriks et al. (2018) allow for idiosyncratic bequest motives, estimated using strategic survey questions, but consider only on the financial component of household portfolios.

I use the estimated model to investigate two fundamental issues faced by retirees. First, how are retirees affected by large increases in their home values as house prices rise? Understanding these windfall responses is an important step in understanding housing's role in financing retirement and the adequacy of individual's nest eggs for retirement (Scholz et al., 2006; Gomes et al., 2020). Second, how does the structure of social insurance covering LTC expenses impact retirees valuations of these programs?

Previous studies show that inheritances shape both inter- and intra-generational consumption and wealth inequality (Kotlikoff and Summers, 1981; Gale and Scholz, 1994; Boserup et al., 2016, 2017; Nekoei and Seim, 2021). This paper shows how rising asset prices are transmitted to future generations as bequests, highlighting important heterogeneity by retirees' liquidity and the distinct response to changes in housing compared with other wealth.

UK house prices more than doubled in the last 30 years. To what extent are these windfalls for homeowning retirees shared with younger generations? I quantify the effect of exogenous increases in house prices on both consumption[2] and bequests, comparing it with the effect of pension windfalls. On average, I find that only a quarter of house price shocks experienced at age 70 are passed on to future generations as bequests. In contrast, 40% of liquid wealth shocks are passed on. The key reason

[2] An inexhaustive list of recent contributions estimating the housing wealth effect on consumption, focusing on those using micro data, includes Mian et al. (2013); Kaplan et al. (2020); Aladangady (2017); Berger et al. (2018); and Guren et al. (2021).

for this disparity is the differential effects on liquidity constraints from increases in house prices and liquid wealth. For retirees with little liquid wealth, house price increases make downsizing more attractive, since it provides more cash to spend after the sale. By contrast, increasing the money in their bank account lowers the probability of downsizing, because they have more resources to spend without needing to sell their house. This generates large differences in aggregate downsizing behaviour and realized bequests.

Determining eligibility for homeowners differently to those with only financial assets is a feature of LTC transfers in the UK, as well as Medicaid in the US and numerous tax and transfer systems. A key contribution of this work is an analysis of how differential means-testing across asset classes can be used as a method of targeting transfers in social insurance programs towards illiquid households.

Specifically, I examine the design of means-tested LTC benefits for retirees' well-being. The UK government acts as payer of last resort for LTC expenditures, requiring retirees that first spend down their private resources.[3] When only one spouse has LTC needs this requires the government takes a stance on assigning assets to each spouse. In practice, this exempts the entire housing wealth of couples and half of their remaining resources from the spend down requirement. Skinner (1996) emphasises that economizing on housing services is an alternative way to self-insure, potentially lowering the value of providing insurance.

Taking the current eligibility rules as given, I simulate retirees through a set of counterfactual reforms eliminating differences across asset classes. For each pound the UK government spends, I find that providing exemptions on only liquid wealth delivers 85% of the welfare benefits from exempting combined housing and liquid wealth. The difference in welfare benefits arises because exempting only housing wealth does not provide enough liquidity to keep healthy retirees in their homes when faced with large LTC expenses incurred by their spouse. Additional exemptions on liquid wealth provide important marginal liquidity, and when retirees value housing, the welfare benefits are high compared to their cost. Achou (2021) and Chang and Ko (2021) study the effect of Medicaid's homestead exemption on the extensive margin of homeownership for single and married US retirees respectively.[4] Both find the

[3]As with Medicaid coverage in the US, eligibility is determined by both income and wealth. This imposes a 100% marginal tax on both savings and income above eligibility thresholds.

[4]Nakajima and Telyukova (2020) and Cocco and Lopes (2020) also model retirees' decisions to remain in their own home and quantify how this dampens the use of reverse mortgage loans among

welfare benefits of the homestead exemption exceed the costs it imposes on the US government. Similarly, I find that the welfare benefits of housing exemptions exceed their cost when allowing for realistic downsizing choices. However, I also study exemptions that apply to other types of assets, highlighting the effect of these policies on welfare and the, potentially large, distortions they induce.

2 Data & Key Facts

The English Longitudinal Study of Aging (ELSA) began in 2002/03, it is a biennial survey modeled on the US Health and Retirement Study (HRS) containing a representative sample of the non-institutionalized English population aged 50+. It collects detailed panel data on demographics, earnings, health, wealth and portfolios using face to face interviews and supplementary questionnaires.

I use data from the first 7 waves and present statistics for within group means for each five year birth cohort and, as discussed below, stratified by additional data. To abstract from labour decisions around retirement, I keep a subsample of households where the head is above the age of 65 (the state pension age for men) and who do not participate in the labour market.[5] Consistent with the model, I drop households when either a new individual enters or leaves the household before death - this drops all households who either divorce or remarry during the sample period, but includes the newly widowed. I top-code wealth moments at the within group 95th percentile and drop cells with fewer than 15 observations to mitigate the impact of outliers.

As a cohort ages, it is increasingly comprised of rich people due to mortality differences between the rich and poor. To mitigate composition effects, I present wealth trajectories grouped by Permanent Income (PI) quantiles.[6] This controls for the lifetime income levels of the households. To calculate PI I follow the approach in De Nardi et al. (2021) and exploit the approximately monotonic relationship between lifetime resources and pension income in the UK. I sum all sources of annuity income in retirement and regress this measure on a polynomial in age interacted with family

the elderly while Yogo (2016) models portfolio choice at older ages.

[5] I define non-participation as households with labour income below pension credit levels, a means-tested benefit which tops up household income for those out of work and eligible for state pensions.

[6] Attanasio and Emmerson (2003) document this composition bias in the UK. Results using a balanced panel for those surviving from the first wave until the final wave are similar, but impose much stricter selection requirements while ignoring the important role of mortality risk at older ages.

composition and a fixed effect. I take the percentile rank of the fixed effect as an estimate of each household's PI — a measure invariant to household demographics. Appendix A provides more details. For clarity, I present results for three birth cohorts in the main text: those born between 1915 and 1919, 1925 and 1929, and 1935 and 1939. Results for remaining cohorts are shown in Appendix B.

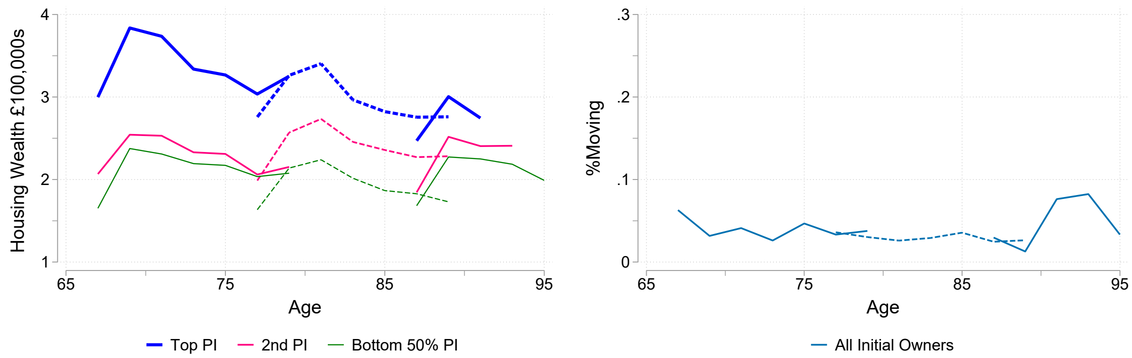
I generate three PI groups: the top 25% of households, the second quartile, and the bottom 50% of households. I separate households by PI, cohort, and by their initial homeownership status to additionally control for housing tenure. I define initial homeownership in the first wave a household enters the sample and this definition keeps the composition of each group constant in the analysis. Although there are differences in initial homeownership rates, I group the bottom two PI quartiles as conditional wealth holdings are extremely similar. For renters, I do not stratify by PI as they are largely drawn from the bottom 50% of the PI distribution.

To explore savings in different forms of wealth I present results for housing and non-housing wealth. Housing wealth is the value of their primary residence. Mortgage debt and other property is included in liquid wealth — for retirees these balances are small. Liquid (or non-housing) wealth also includes savings and current accounts, bonds/gilts, premium bonds, shares, trusts, and other physical assets less credit card debt, private debt and any other outstanding loans or debts.[7]

2.1 Housing Wealth

Savings in retirement differ by PI and a large share of this heterogeneity is driven by differences in housing wealth. The left panel of Figure 1 shows the mean housing wealth of households and the right panel shows the frequency with which initial homeowners move properties over a two year period (the frequency of the ELSA data). There is a strong PI gradient for housing wealth even after conditioning on initial home ownership status. Focussing on the 1925-1929 birth cohort (dashed lines), owners in the top quartile hold on average £275,000 in housing wealth at age 77. Those in the second quartile hold only £200,000 and those initial owners in the bottom half of the PI distribution have an average of £165,000 in housing wealth at age 77. Both absolute and relative differences increase with PI. While these differences vary across cohorts and as cohorts age there remain large differences between PI groups.

[7]Savings accounts include TESSA, all forms of ISA, PEPs, National Savings Accounts and life insurance savings. I drop retirees who directly own businesses.



(a) Mean Housing Wealth by Cohort (b) Frequency of moves in the last 2 years

Figure 1: Saving in Housing Wealth by Cohort (Initial Owners, ELSA data)

Panel (a): Each line shows a cohort-PI cell over the period 2002-14, plotted against average cohort ages. Thicker lines denote higher PI groups. Panel (b): cohort cells for the same period.

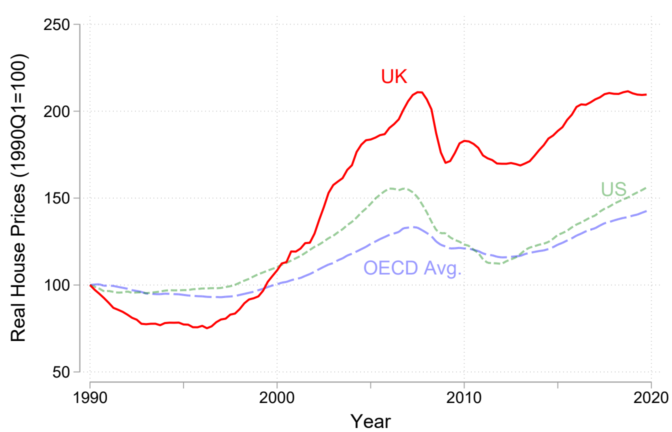


Figure 2: Relative House Prices

Quarterly real house prices over time, relative to 1990 Quarter 1. The red line plots data for the UK and the green dashed line plots data for the US. The dashed blue line plots within quarter averages for OECD member countries. Source: OECD Housing Prices Indicator (2021)

One striking feature of the UK data is the presence of time effects, which have been little studied in the context of the US or other countries.[8] For all cohorts and PI groups, housing wealth displays evidence of an aggregate trend. The x-axis plots the average age within birth cohort — thus, within cohort aging is equivalent to plotting a time dimension. Figure 2 plots the evolution of house prices over the previous 30 years. While broadly increasing, there is a clear correlation between their trend and the housing wealth of retirees. In Figure 1a mean housing wealth increases by £75,000 between ages 77 and 81 for retirees in the second PI quartile and the 1925-29 birth cohort. Between 81 and 83 these same households see almost 40% of this gain reversed and gradual declines through the rest of the sample as house prices fall in the wake of the great recession. Across cohorts, similar patterns are clear at different PI levels and ages, but at the same points in calendar time.

The rise and subsequent fall in housing wealth differs across PI and birth cohort in part due to differences in moving or cashing out behaviour. However, in the aggregate, evidence of deaccumulation is limited. Average housing wealth increases between the start and the end of the sample for all cohort and PI combinations as prices appreciate, masking downsizing behaviour.

To understand the economic importance of household mobility and to distinguish passive saving from active portfolio rebalancing of older households, I focus on the frequency and size of decisions to adjust housing wealth. Figure 1b shows limited age and cohort variation with an average of 4.4% of households selling their house and moving each wave. These adjustments are infrequent with those over 65 moving only once on average. Nevertheless, almost 50% of households move by age 90.

Moving is one of the largest financial decisions during retirement. Adjustments are large and households can realise gains from changes in house prices. Table 1 provides statistics on the mean level and relative change in housing wealth for three different categories: all downsizers, those who downsize and remain owner occupiers, and those who upsize. Within downsizers, who are over 75% of movers, I separate out transitions to renting to control for changes in the extensive margin of ownership. Conditional on downsizing, the average household releases 52% of the current value of their house or over £135,000. This is not driven by only the extensive margin

[8] As noted in Schulhofer-Wohl (2018) many studies attempt to cleanse time effects from estimation moments in the data. As housing wealth is almost 70% of retirees' aggregate wealth, total wealth displays similar time effects inheriting this trend over the sample (see Appendix B).

	Change in Housing Wealth[a]	Relative Change[b]	Proportion of Movers (%)
Downsizers (All)	-136	0.48	76.8
Downsizers Remaining Owners	-104	0.72	50.9
Upsizers (All)	55.4	1.34	23.2

Source: Author's own calculation from ELSA using a sample of 430 movers. All columns report means. [a] £1000s in 2014 prices, [b] Relative change is defined as the ratio of the new price to the old price at time of sale.

Table 1: Average Housing Wealth Change by Move Type

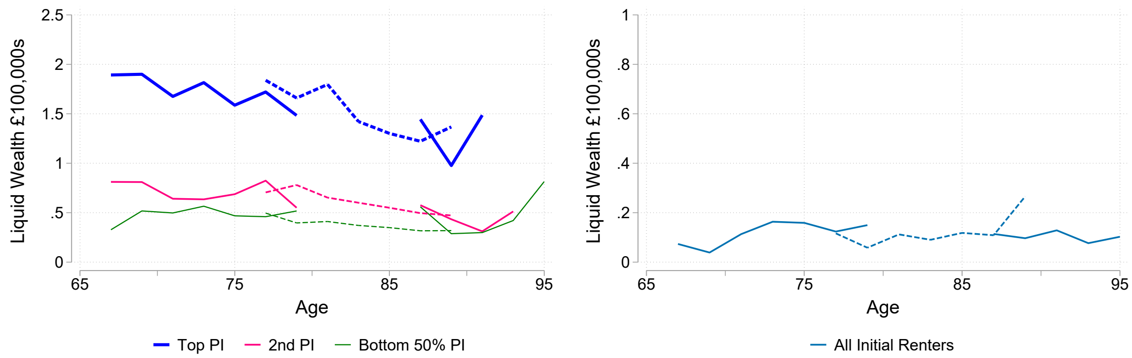
as downsizers who remain owner occupiers release over £100,000 of equity. This is approximately 40% of the average total wealth level or 30% of their previous housing wealth. The majority of retirees climb only a few rungs back down the housing ladder, remaining homeowners even at advanced ages. Upsizers are the smallest group, but they make large adjustments — increasing their housing wealth by a third.

On aggregate retirees retain capital gains in housing and house price changes affect different birth cohorts at different ages. However, those moving make large adjustments to their portfolio and many retirees move during their retirement. Housing is a store of wealth that may appreciate or decline in value, provides a consumption flow and is subject to potentially large adjustment costs. Explicitly modeling these assets is important for understanding saving during retirement, demand for self-insurance, and the extent to which price changes improve financial security.

2.2 Liquid Wealth

Figure 3 displays average liquid wealth for the same groupings of initial owners on the left. While differences between the bottom half of the PI distribution and the second quartile are of similar magnitude to the absolute gap in housing wealth they are larger in relative terms. The gap between the liquid wealth of the top quartile and the second PI quartile is slightly larger than in housing wealth at almost £100,000 for each age and cohort pair. This is because, on average, housing wealth is a smaller proportion of the portfolio of richer households.

Unlike housing wealth, there is no strong evidence of cyclicality in liquid wealth. Furthermore, within each cohort-PI group there is some evidence of deaccumulation.



(a) Initial Owners

(b) Initial Renters

Figure 3: Mean Liquid Wealth by Cohort (ELSA data)

Panel (a): Each line shows a cohort-PI cell over the period 2002-2014, plotted against average cohort ages. Thicker lines denote higher PI groups. Panel (b): cohort cells for the same period.

For the youngest two cohorts, liquid wealth in the top PI quartile falls by over £45,000 (from £189,000 at age 67 to £148,000 by 79 and £184,000 at age 77 to £137,000 by 89) and by over £20,000 (from £81,000 at age 67 to £55,000 and £70,000 at age 77 to £47,000) for the second PI quartile. For the lowest PI group, the youngest cohort show modest accumulation between ages 67 and 79, but deaccumulation of a similar magnitude to the second PI quartile for the 1925-29 birth cohort.[9]

Finally, I turn to the liquid wealth of initial renters. In retirement, initial renters tend to belong to lower PI percentiles. Thus, I pool all renters together. On average, initial renters hold less than half the liquid wealth of their counterparts in the bottom PI homeowners. They are both cash and income poor. While their wealth varies between £5,000 to £20,000 for different age and cohort combinations it is approximately stable. In contrast, the savings of US retirees transitioning from owning to renting decline (Nakajima and Telyukova, 2020).

For owners, increasing housing wealth offsets modest deaccumulation of liquid wealth. Blundell et al. (2016) document price-driven housing wealth increases in the UK in contrast to US evidence from the HRS. While US evidence typically finds more deaccumulation among elderly singles, Poterba et al. (2018) document a high degree of persistence between early retirement wealth and wealth at death. In the US, medical costs, longevity risk, bequests, and homeownership are important for explaining

[9] While there are some increases at the oldest ages, these cells tend to have fewer observations and are, thus, noisier measurements.

this departure from the life cycle hypothesis. The results above highlight saving in different assets and the interaction with asset price movements is an important part of retirees' financial behaviour and, consequently, the 'retirement savings puzzle'.

3 Variation in Tax Incentives

When households cross thresholds in tax schedules their incentives to save, spend, and hold different assets can change substantially. To help identify the structural model described in the next section, I exploit variation in tax policy over time in addition to cross-sectional differences. Changes to estate taxation and residential property transaction taxes provide a source of quasi-experimental variation. This varies the returns to leaving a bequest, to holding different assets, and the cost of transforming housing wealth into liquid wealth. Furthermore, large fluctuations in house prices lead to 'bracket creep' when price appreciation pushes households into higher tax brackets. This section summarizes important changes to the tax environment over the sample. Appendix C contains a full list of reforms and discuses anticipation.

I then show how the moving decisions of older households responds to changes in financial incentives. This exploits thresholds in the transaction tax schedule using a regression discontinuity research design. The results highlights the quantitative importance of the financial incentive and housing windfall mechanism. Furthermore, it demonstrates why tax policy variation is a useful source of empirical identification.[10]

3.1 Inheritance Tax in the Sample Period

Contrary to its name, UK Inheritance Tax is levied on the estate of an individual who dies and not on the recipient of a bequest. When an individual leaves the entirety of their estate to a spouse or civil partner there is no inheritance tax levied.

Inheritance Tax is a constant rate of 40% of the estate above an exemption thresh-

[10] A recent literature has shed light on the effect of housing transaction taxes and their impact on transaction volumes (Best and Kleven, 2018), sale prices (Besley et al., 2014; Kopczuk and Munroe, 2015; Slemrod et al., 2017) and mobility decisions (Hilber and Lyytikäinen, 2017). A concern is these findings are driven by younger households who have a higher baseline mobility rate — if this were true there would be no additional identifying power from these reforms when studying older households. How strongly older households respond to changes in financial incentives is an empirical question. My approach draws on Hilber and Lyytikäinen (2017) who study the moving decisions of working age UK households and find effects on a similar order of magnitude to older households.

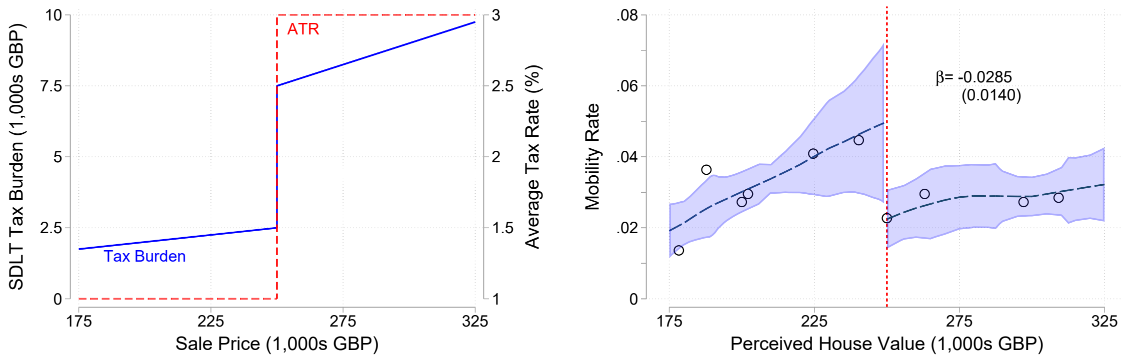
old indexed to RPI. In 2010, this threshold was £325,000. A major reform implemented on October 9th 2007 increased the exemption threshold by any unused proportion of a deceased spouse or civil partner's nil-rate band. To illustrate, suppose the husband died in 2003 and left £50,000 to other heirs and the wife died in 2010. The exemption threshold for the wife would be £600,000 because she is entitled to the full amount of her own exemption threshold (£325,000) and the unused proportion of her husband's nil-rate band (£325,000 less the £50,000 already bequeathed).

3.2 Housing Transaction Taxes in the Sample Period

The Stamp Duty Land Tax (SDLT) replaced the pre-existing Stamp Duty in 2003, and is a transaction tax levied on all residential properties in the UK. During the sample period, the tax takes the form of a percentage rate charged on the whole purchase price if the price is above a particular threshold. The SDLT varies the average tax rate creating discontinuous changes, or *notches*, in the choice set of retirees. There are numerous changes over the sample period. In 2005 the threshold for the lowest rate, charged at 1%, doubled and increased again in 2006. In 2011, new higher rates charged at 5% and 7% for all properties above £1 million and £2 million were introduced. In addition to these changes, in 2008 the UK government introduced the 'Stamp Duty Holiday' a temporary (15 month) increase to the lower threshold from £125,000 to £175,000 expiring on December 31st 2009. Table A.1 summarizes the different tax regimes over the duration of my sample.

How do transaction taxes affect retired households? Those with large amounts of wealth tied up in their home face these costs when moving. Relative to a world with no transaction tax this creates large disincentives. For downsizers, transaction taxes function as an implicit tax on their home equity extraction. For example, downsizing by £100,000 from a £400,000 house yields an effective 10.2% tax rate.[11]

[11] Under the SDLT policy the transaction tax levied on the new purchase is £9,000 while £12,000 on the sale gives the 10.2% implicit tax rate on equity withdrawal (40% of £12,000 and 60% of £9,000). For a a household with a house worth £250,000 downsizing to a house worth £200,000, releasing 20% of the equity in their home, the effective tax rate on the equity released is 13.2% (40% of £7,500 and 60% of £6,000 divided by the £50,000 base). A substantial body of evidence suggests effective incidence often falls on sellers irrespective of the statutory incidence. Besley et al. (2014) estimate 40% of the incidence falls on sellers using variation from the UK 'Stamp Duty Holiday'. I use this estimate in the calculation above. Kopczuk and Munroe (2015) present alternative estimates of transaction tax incidence using New Jersey Mansion taxes and find it is entirely incident on the seller. In contrast, Slemrod et al. (2017) estimate equal incidence using notches in Washington, DC.



(a) Transaction Taxes (b) Mobility (ELSA data)

Figure 4: Transaction Taxes, House Values and Mobility

Panel (a): Blue line indicates the tax burden if sold and the red dashed line indicates the Average Tax Rate around the £250,000 threshold. Panel (b): Circles are mobility rates for deciles of the house value distribution. The blue dashed shows the predicted fit of a regression of moving on a treatment indicator and approximating the conditional expectation function (Equation 1) non-parametrically for the optimal window around the threshold. Further details are provided in Table 2.

3.3 The Impact of Financial Incentives on Moving

Identifying the effect of housing wealth windfalls in the expenditure and savings decision of retirees is difficult. Cross-sectional comparisons of high and low housing wealth households are biased as those with different portfolios may have different preferences or expectations about the future. Instead, I rely on quasi-experimental variation in the financial returns to moving generated by the tax code.

I exploit a discontinuous increase in the housing transaction tax burden using a regression discontinuity research design to show there is an economic and statistically significant reduction in home mobility when the financial incentives for moving decline. This a reduction in the extensive margin of home equity adjustment or portfolio rebalancing in response to an exogenous increase in illiquidity.

I focus on a *notch* at the £250,000 threshold because it remains constant throughout the sample period. Sale values exceeding this threshold experience an increase in the *average* tax rate paid on the transaction from 1 to 3%. This is a discontinuous increase in the SDLT burden of £5,000 (Figure 4a). Shocks to aggregate house prices throughout the sample create variation in underlying self assessed house values leading to random assignment across this threshold. The outcome variable of interest, $Move_{i,t}$, is a dummy variable denoting a household's mobility between waves t and

$t + 1$ with treatment defined as a house value greater than or equal to £250,000:

$$Move_{i,t} = \beta_0 + \beta_1 Treat_{i,t} + f(HouseValue_{i,t}) + \delta X_{i,t} + u_{i,t} \tag{1}$$

The vector of control variables, $X_{i,t}$, includes a polynomial in household age, a polynomial in PI, household demographics, and wave and region indicators. I present results approximating the flexible function of house value $f(\cdot)$ in the conditional expectation function using a non-parametric local linear estimator and quadratic polynomial with common slope. Additionally, I drop all households more than 30% below the threshold to avoid contamination from the 'Stamp Duty Holiday'.

The key identifying assumption is that, conditional on the covariates, $u_{i,t}$ is uncorrelated with the treatment indicator $Treat_{i,t}$. In regression discontinuity frameworks, this is satisfied if other covariates vary smoothly and the forcing variable ($HouseValue_{i,t}$) cannot be manipulated. Two features of the data reduce the concern of manipulation: first, moving is measured in the following wave so the reported home value is predetermined and, second, self assessed home valuation is not the actual sale price used to calculate the SDLT burden. Manipulation of sale prices and the implied disincentive to sell is part of the estimated effect. Following Kolesár and Rothe (2018) standard errors are clustered at the household level and I provide alternative confidence intervals with guaranteed coverage properties in appendix D.[12]

Figure 4b plots the results graphically showing a sharp decrease in mobility for those households who exceed the £250,000 threshold. Table 2 presents results from the regression analysis using both non-parametric and parametric estimators and varying the window around the stamp duty threshold included in the regression.

The first row shows the results for the preferred specification using a local linear estimator. For all windows around the discontinuity the non-parametric method yields similar point estimates. However, for small bands around the cut-off these results are imprecisely estimated where the sample size is small. For larger bands around the discontinuity in the SDLT schedule the results are precisely estimated and the negative effect of an increase in the transaction tax burden is statistically significant. The parametric specification in the second row has a similar pattern and point estimates. The treatment effect of exposure to higher transaction taxes is negative in all specifications and the magnitude of the effect is robust to alternative estimation

[12] Appendix D also provides results for different order polynomials and additional robustness tests.

CEF	Band around cut-off					
Approximation	10%	15%	20%	25%	30%	Optimal (47%)
Non-parametric						
Local Linear	-0.0278	-0.0341	-0.0356*	-0.0303**	-0.0287**	-0.0285**
	(0.0334)	(0.0247)	(0.0189)	(0.0155)	(0.0141)	(0.0140)
Parametric						
Quadratic	-0.0365	-0.0450**	-0.0270**	-0.0218*	-0.0265**	
	(0.0241)	(0.0193)	(0.0133)	(0.0130)	(0.0112)	
	-727.9	*-877.5*	*-2118*	*-2110*	*-2873*	
N	1224	1559	3023	3233	3979	4348

All regressions additionally control for wave fixed effects, a polynomial in age, household demographics, a polynomial in permanent income and region dummies (Equation 1). Following Kolesár and Rothe (2018), Standard Errors are clustered by household and optimal bandwidth selection follows Imbens and Kalyanaraman (2012) . The Akike Information Criterion is shown in italics for the parametric specification. * $p < 0.10$, ** $p < 0.5$, *** $p < 0.01$

Table 2: The Effect of Transaction Taxes on Household Mobility

windows and methods for approximating the conditional expectation function.

The estimates of exposure to higher transaction taxes, a 2.85 percentage point reduction in mobility for the optimal bandwidth, show increases in transaction taxes for retirees are both economically and statistically significant. The fraction of retirees moving falls by 50% in response to a reduction in the financial returns to moving — highlighting the empirical relevance of retiree responses to financial incentives.

4 A Model of Savings After Retirement

The previous sections highlights both extensive and intensive margin adjustments to retirees' portfolios. To better understand their responses to changing financial incentives over the whole retirement period, this section introduces a model of their savings decisions. The model generates key empirical results in Section 2 and sheds light on how this mechanism interacts with the design of social insurance. It includes a rich model of housing decisions incorporating institutional features from the UK.

Households face idiosyncratic and exogenous risk in health status, mortality, LTC expenditures, and, for couples, the structure of their household. In addition, households are exposed to aggregate risk in the form of a common stochastic process for house prices. Retirees are partially insured by the tax and transfer system including means-tested transfers for LTC expenses.

Retirees begin retirement single or in a couple. For couples, the survivor continues as single if their spouse dies and I assume singles cannot remarry. Family structure and gender affect utility, health transitions, mortality, LTC costs and income.

Each period, a household chooses their expenditure on non-housing consumption, the size of the house they wish to live in, and the stock of financial assets for the next period. Financial assets are perfectly liquid and yield risk free return r. There is no borrowing.[13] Housing assets require maintenance to offset depreciation at rate δ and have a price p_h which households take as given. Renters, with zero housing wealth, rent housing services at a fraction of the sale price r^h or can purchase a house.

At the beginning of each period, households observes their age, PI, who is alive in the household, liquid wealth, housing wealth, health, LTC expense shock and the level of aggregate house prices. Decisions are made after shocks are observed and new shocks arrive at the end of the period after decisions have been made.

To capture a key source of non-stationarity in the policy environment of retirees and to leverage it as an additional source of identifying variation, I allow estate and transaction tax rules to change over time. This creates additional variation in the financial incentives retirees face over time. For simplicity, I describe the model for a single policy regime. When solving and simulating the model during estimation, I assume policy changes are unanticipated[14], solving it under each policy regime.

4.1 Demographics

A household is either a single man, single woman, or a couple. The state variable f is the family structure describing their demographics.

$$f \in \{\text{Single Man}, \text{Single Woman}, \text{Couple}\} \tag{2}$$

[13] I discussion the empirical support for this assumption in Appendix E.

[14] The exception is the "Stamp Duty Holiday". In this case, I treat the reversal of the policy as perfectly anticipated in line with the institutional context of the temporary cut.

4.2 Preferences

Preferences are time separable, with a constant discount factor β. Households maximize expected utility and the per-period utility function is given by:

$$u(f, c, s) = \frac{n_f(\frac{1}{\alpha_n} c^{\sigma} s^{1-\sigma})^{1-\gamma} - 1}{1-\gamma}, \tag{3}$$

where c is non-housing consumption and s denotes housing services. The number of adults, n, is a deterministic function of family status, f, with α_n the consumption equivalence scale for total consumption. In this specification, γ is the coefficient of relative risk aversion and σ is the weight of non-housing consumption relative to housing services. Owner occupied housing yields housing services at the rate $1 + \omega$.[15]

I assume bequests are only possible when the final surviving member of the household has died. Bequests, b, are the net of tax consolidated value of the estate and utility from bequests, takes the form of a warm glow bequest motive (Andreoni, 1989; De Nardi, 2004). The functional form for $\phi^i(b)$ is given by:

$$\phi^i(b) = \frac{\phi_1^i(\phi_2^i + b)^{(1-\gamma)} - 1}{1-\gamma}, \tag{4}$$

where ϕ_1^i controls the weight on bequests relative to lifetime consumption, while ϕ_2^i controls the curvature and the extent to which bequests are a luxury good.[16] This simple specification is consistent with altruism (as in Abel and Warshawsky, 1988) or other interpretations of the bequest motive (e.g.the strategic motive in Bernheim et al., 1985, or egoism). Allowing these parameters to vary across households is a parsimonious and tractable way of incorporating heterogeneity in families without taking a stance on the form of the bequest motive or modelling multiple generations. Additionally, durable goods providing consumption flows, such as housing, lower the cost of leaving an inheritance. Consequently, this heterogeneity allows for greater

[15] ω affects the relative price of renting housing services and captures benefits from ageing in place as a homeowner. For retirees, the ability to make modifications to their home may be more valuable as their health and mobility decline. Additionally, many retirees who rent are either in public housing or LTC facilities and may experience lower quality housing. Alternatively, they may directly value the additional commitment benefit offered by homeownership when interacting with their children (Barczyk et al., 2019). I impose a within period Cobb-Douglas aggregator for total consumption as many studies, such as Davis and Ortalo-Magné (2011), find constant housing expenditure shares.

[16] For positive ϕ_2^i marginal utility of small bequests is bounded, while the marginal utility of large bequests declines more slowly than consumption.

flexibility in both inter- and intra-temporal patterns of substitution at older ages.

4.3 Income, Health, Mortality and LTC Spending

Income Households earn a return, r, on their financial assets, a. Non-asset pension income, y, is deterministic and depends on age, j, current family structure, f, (which captures size and gender) and PI, I:

$$y = y(j, f, I) \tag{5}$$

In addition to an Estate Tax, τ_b, and Stamp Duty levied on housing transactions, τ_h, income taxes, τ_y, are due on income from pensions and financial assets.

Health Status Health status takes one of three values for living household members

$$m \in \{Good, Bad, ADL, \textbf{Dead}\}, \tag{6}$$

and transitions according to a flexible age, family structure and PI dependent Markov process. Allowing the process to vary with PI and family composition captures differences in health investment that are not modelled directly. The direct effects of aging, health status, and gender on health production or deterioration are also captured by the Markov process. Following Ameriks et al. (2020) I use difficulties with Activities of Daily Living (ADLs) to define the worst health state. ADL measures capture a range of needs associated with institutional LTC use and community care. For couples, m denotes a pair with a health status for each member — for notational convenience I continue to use m to denote the nine valued health status for the couple.

Mortality Individuals face exogenous mortality risk depending on age, family structure, health status and PI. $\eta(j, I, m, f)$ denotes household survival probabilities.

LTC Spending For US retirees, out-of-pocket medical expenditure risk is an important driver of precautionary savings. In the UK, comprehensive coverage for acute and chronic medical expenses is free at the point of use. However, LTC risks pose considerable out-of-pocket risk with lifetime costs exceeding £100,000 for 10% of individuals (Dilnot et al., 2011). The National Health Service (NHS) provides coverage for acute and chronic expenses for the entire UK population.

I define mx_j as the flow of all LTC expenses incurred between j and $j-1$. Consistent with evidence of limited income elasticity for LTC needs (e.g. Ameriks et al., 2020), they are exogenous and depend on current and previous period health status and family structure, PI, age, and a standard normal idiosyncratic shock, $\epsilon_{mx,j}$:

$$\ln mx_j(\cdot) = \mu_{mx}(m_{j-1}, m_j, I, f_{j-1}, f_j, j) + \sigma_{mx}(m_{j-1}, m_j, I, f_{j-1}, f_j, j) \times \epsilon_{mx,j} \tag{7}$$

The government acts as a payer of last resort for LTC expenses when individuals have insufficient resources or when resources are exhausted paying LTC expenses. This imposes a 100% marginal tax rate on private resources by requiring retirees first spend down their wealth. Following Hubbard et al. (1994, 1995), I model this means-tested benefit as a health state dependent consumption floor, c_{min}. Couples are subject to different means-testing rules that cap their spending at 50% of their joint financial assets when only one spouse has LTC needs. In other words, 100% of their house and 50% of their remaining wealth are not subject to the spend down requirement. I allow the floor to depend on family structure capturing additional insurance and incentives to hold wealth in housing for couples.

4.4 Housing Market and House Prices

Moving is costly. I model two types of cost: the statutory transaction tax and additional financial costs. The total value of a house, h, is $p_h h$ and if a household adjusts their housing stock they must pay the following adjustment cost:

$$Q(h_{t+1}, h_t, p_{h,t}) = \mathbb{1}[h_{t+1} \neq h_t] \times \begin{pmatrix} p_{h,t}h_{t+1} - p_{h,t}h_t(1-\pi) + F \\ +(1-\kappa) \cdot \tau_h(p_{h,t}h_{t+1}) + \kappa \cdot \tau_h(p_{h,t}h_t) \end{pmatrix} \tag{8}$$

The total cost consists of three parts. First, the change in housing evaluated at today's price net of a proportional cost π. The proportional component of the transaction cost allows the costs to vary between houses of different values or sizes.[17] Second, a fixed cost, F, capturing the invariant component. Third, the transaction tax, $\tau_h(\cdot)$, with incidence on the seller $\kappa \in [0, 1]$. Allowing for the effective incidence to differ

[17] The financial value of hassle costs vary with size because larger houses require moving, or disposing of, more possessions or take longer to sell in thinner markets. Real costs may be proportional because the intricacy of legal agreements or surveying varies with the property value or size.

from the statutory incidence incorporates incentives to manipulate sale prices without modelling the bargaining protocol or other features of the real estate market.

Homeowners must pay a proportional maintenance cost, δ, each period. Current renters, who may choose to purchase, rent housing services at a fraction r^h of the sale price. Consequently, rental prices include housing market volatility.

House prices are stochastic and their log evolves as a standard AR(1) process:

$$\ln(p_{h,t+1}) = \mu_h + \rho_h \ln(p_{h,t}) + \epsilon_{h,t+1}, \quad \epsilon_{h,t+1} \sim N(0, \sigma_h^2) \tag{9}$$

Drift μ_h reflects trend growth in house prices. This formulation is common and fits the data at both individual and aggregate levels well (see Nagaraja et al., 2011; Berger et al., 2018, respectively). I model aggregate house price movements, thus, the price level is common to all households in time period t.

4.5 Recursive Formulation and Household Problem

I describe the recursive formulation for a current homeowner (renters differ only in terms of rental expenditures). Letting a_t denote the liquid wealth of retirees in time period t and r denote their return, total post tax income is $\tau_y(r\,a_t + y_t(\cdot), \tau, f_t)$ with vector τ summarizing the tax system. To economize on state variables, I follow Deaton (1991) and redefine the problem in terms of cash-on-hand

$$x_t = a_t - \delta h_t + \tau_y\big(r\,a_t + y_t, \tau, f_t\big) + tr_t - mx_t, \tag{10}$$

which has the following law of motion

$$x_{t+1} = x_t - c_t - Q(h_{t+1}, h_t, p_{h,t}) - \delta h_{t+1} - mx_{t+1} + \tau_y\big(r\,a_{t+1} + y_{t+1}, \tau\big) + tr_{t+1} \tag{11}$$

where savings, which are constrained to be non-negative, are given by

$$a_{t+1} = x_t - c_t - Q(h_{t+1}, h_t, p_{h,t}) \geq 0, \quad \forall t. \tag{12}$$

Cash-on-hand is net of housing maintenance costs and LTC expenses, but includes income after taxes and transfers. The tax function accounts for means-tested transfers excluding those covering LTC expenses. Means-tested transfers, $tr_t(\cdot)$, bridge the gap between a minimum consumption floor and a household's resources and provide a ceiling for couples' LTC expenses. Define the resources available next period after tax, but *before* government transfers with

$$\widetilde{x_{t+1}} = a_{t+1} - \delta h_{t+1} - mx_{t+1} + \tau_y\big(r\, a_{t+1} + y_{t+1}, \tau, f_t\big). \tag{13}$$

Consistent with assistance for LTC expenses which depends on total resources, housing, health, and family structure, government transfers are defined as

$$tr_t(\widetilde{x}_t, f_t, h_t, m_t, p_{h,t}) = \max\big\{0, c_{min}(f_t, h_t, m_t) - (\widetilde{x}_t - x_{D,t} - h_{D,t})\big\} \tag{14}$$

where $x_{D,t}$ and $h_{D,t}$ are exemptions (or disregards) on combined liquid assets and income and housing assets respectively.[18] The law of motion for cash-on-hand next period can thus be rewritten as

$$x_{t+1} = \widetilde{x}_{t+1} + tr_{t+1}(\widetilde{x}_{t+1}, f_{t+1}, h_{t+1}, m_{t+1}, p_{h,t+1}). \tag{17}$$

Finally, bequests are exposed to LTC costs and constrained to be non-negative, thus, the after tax value of their consolidated wealth is given by:

$$b_t = \tau_b(max\{Q(0, h_{t+1}, p_{h,t}) + a_{t+1} - mx_{t+1}, 0\}). \tag{18}$$

The recursive formulation depends on i due to idiosyncratic preferences for bequests. The state variables of a household are given by $\Omega = (j, f, I, m, h, x, p_h)$ with next period values denoted by a prime. These variables are: age (j), family structure (f), PI (I), health status (m), housing stock (h), cash-on-hand (x), and the aggregate

[18] Households who cannot afford the minimum level of consumption after liquidating their assets must sell their house and spend all wealth. They begin next period as renters and receive transfers to meet the consumption floor. Disregards are functions of state variables following the rules summarized in Section 4.3, let m_t^1 and m_t^2 denote health for arbitrary individuals within the household:

$$x_{D,t} = X_D(f_t, \widetilde{x}_t, m_t) = \mathbb{1}[m_t^1 = ADL \cap m_t^2 \neq ADL \cap f_t = couple] \times \widetilde{x}_t/2 \tag{15}$$
$$h_{D,t} = H_D(f_t, h_t p_{h,t}, m_t) = \mathbb{1}[m_t^1 = ADL \cap m_t^2 \neq ADL \cap f_t = couple] \times h_t p_{h,t} \tag{16}$$

house price level (p_h). The recursive problem for homeowner i is:

$$V_j^i(\Omega) = max_{\{c,h',a'\}}\Big\{u(f,c,s) + +\beta \cdot \eta(j,I,m,f)E[V_{j+1}^i(\Omega')\,\Big|\,\Omega, h', a'] \\ + \beta(1-\eta(j,I,m,f))E[\phi^i(b)\,\Big|\,\Omega, h', a']\Big\}, \tag{19}$$

subject to equations (2)-(9) and(12)-(17) and bequests are constrained by (18). Households choose non-housing consumption, c, savings in financial assets (before LTC costs), a', and the new housing stock, h'.[19] They form expectations over individual mortality, family structure tomorrow, f', household health, m', the transitory component of LTC expenses, ϵ_{mx}, and the level of house prices, p'_h. LTC expense risk implies households form expectations over realized cash-on-hand tomorrow, x', and the possibility they are compelled to sell their house to finance LTC costs.

5 Estimation

I adopt a two-stage estimation strategy. In the first stage I estimate (or calibrate using existing evidence) parameters that can be cleanly identified outside of the model. I fix the consumption floor and household equivalence scales based on pre-existing evidence. Additionally, I discretize latent preference heterogeneity into K groups using a k-means algorithm to reduce dimensionality (Bonhomme et al., 2021).

In the second stage I estimate the remaining model parameters, the discount factor, risk aversion, weight on housing, homeownership premium, transaction costs and heterogeneous bequest parameters,

$$\theta = (\beta, \gamma, \sigma, \omega, F, \pi, \{\phi_1^k, \phi_2^k\}_{k=1}^K), \tag{20}$$

using the method of simulated moments (MSM) and taking the first stage parameters and groups as given. The value of these parameters minimises the weighted distance between simulated moment conditions and the data using a GMM criterion function

$$\hat{\theta} \arg\min_{\theta\in\Theta} G(\theta)'WG(\theta), \tag{21}$$

with W the inverse-diagonal weighting matrix. The target moment conditions are:

[19]This delivers housing services $s = (1+\omega)h'$.

1. For initial homeowners, I match mean liquid and housing wealth by age, PI, and cohort. For renters, I match mean liquid wealth by age and cohort.

2. I match mean subjective bequest probabilities by age, PI, and cohort for initial homeowners and by age and cohort for initial renters. I use the self-reported probability of leaving a bequest greater than £150,000.

3. Moving is costly, but liberates liquidity from housing. Thus, I match the fraction of initial homeowners moving and homeownership rates by age and cohort.

The MSM approach is standard. Appendix G provides a detailed description. Due to the frequency of tax reforms, I do not explicitly target pre and post periods or the level and treatment effect using indirect inference. Instead, target moments embed behavioural responses to longitudinal variation in tax policy. In addition, I use estimates of the effect of transaction taxes from the regression discontinuity design to validate the model so do not target this explicitly in estimation.

5.1 Identification

Separately identifying precautionary and bequest motives is a long standing challenge (De Nardi et al., 2016b; Lockwood, 2018). I combine data on wealth composition and subjective bequest probabilities with exogenous policy reforms (discussed in detail in Section 3), and variation in house prices over time.

Policy reforms shift the returns and risks associated with holding different assets and moving. Along with house price changes, this creates longitudinal variation in incentives which provides an additional source of identification as it requires the model to match changes in behaviour when incentives change. Additionally, how decisions vary with age and across the PI distribution uses differences in health, mortality and LTC expense risks to identify the model.[20] In complex non-linear models, all moments

[20]Even when panel data is available, many MSM approaches match repeated cross sections or pool time periods. Instead, this paper's approach accounts for, and exploits, multiple sources of non-stationarity over time. This uses cross cohort comparisons where the fully specified model controls for differences across households in a given calendar year. I assume preference parameters in the structural model are unaffected by policy or house price changes — an exclusion restriction. How these comparisons vary with age and PI provides additional identifying variation due to differences in income, expected longevity and future LTC expenses. Those with low PI face lower longevity (Table 3) and higher LTC costs while alive. In contrast, those with higher PI survive for longer and experience lower LTC costs. These differences help pin down the demand for self-insurance.

potentially influence all parameters, however, I provide intuition for why particular moments are more informative about certain parts of the model.

Parameters in the period utility function Households vary in their ability to self-insure LTC costs by their level of wealth and the risks they face vary with age and PI. Their liquid wealth determines their ability to self-insure in the short run. Matching liquid wealth identifies risk aversion γ. The total level of wealth captures their ability to self-insure over longer horizons and the extent of life cycle saving identifying β the intertemporal discount factor.

Renters' savings and expenditure strongly respond to the consumption share of housing, σ, because it determines their expenditure share on rent. House prices changes create variation in renters' spending, saving and demand for liquid buffers identifying σ. In contrast, I identify the benefits of homeownership, ω, by matching the behaviour of initial owners: the fraction remaining homeowners by age and cohort.

The Cost of Moving Retirees move house when the benefits exceed the costs. Variation in the size of transaction taxes lead to differences in these costs. Household responses to these changes is informative about the size of the estimated costs of moving, π and F, relative to the observed tax costs.

Bequest Motives The reform to estate taxation shifts the return to saving for a bequest without changing the utility of future lifetime consumption. The extent to which households adjust their savings decisions in response to this tax reform helps identify the bequest utility parameters. As bequests are slow to adjust and only realised at death, I match information on expected future bequests. This survey measure provides information on the savings of each household under both estate tax regimes — allowing the econometrician to fully exploit the reform without the infeasible requirement that the same household's bequest is observed under both tax regimes. Information on each household's future bequests allows me to identify the average strength of bequest motives, but also heterogeneity in the population.[21]

[21] I provide supporting evidence illustrating the potential additional identifying variation encoded in these survey measures in Appendix I.

5.2 Econometric Concerns

Non-stationarity introduced by cohort and time effects could lead to biased estimates of model parameters. Wealth holdings at the same age may differ due to differences in income growth, asset prices, asset growth or public policy over the life cycle. Cross sectional moments may attribute differences between cohorts to differences in savings rates by age resulting in biased parameter estimates.

By sampling household initial conditions, controlling flexibly for household PI, and simulating the sequence of observed aggregate shocks[22] and policy reforms faced in their retirement I replicate differences across cohorts and time periods. I construct moment conditions by cohort and calendar year to eliminate this source of potential bias. Formally, this paper makes two important assumptions: first, cohort effects are summarized by cohort's composition and initial characteristics and, second, relevant time effects are captured by policy reforms and changing house prices. This is a structural approach to the age-time-cohort problem which explicitly accounts for differences across households and leverages policy reforms for identification.

Individual mortality is negatively correlated with lifetime income, thus surviving members of a cohort are wealthier on average. To address "mortality bias" (and sample attrition) in the simulations each household is given an observed sequence of mortality, health, and attrition shocks. This is the observed sequence for the data household who provide their initial conditions; therefore any sample selection in the unbalanced ELSA panel is exactly replicated in the simulated panel.

6 Estimation Results

Section 2 reports some of the key facts about housing and liquid wealth I require the estimated model to match. In this section I report a subset of the most relevant features of the first stage model estimates, and discuss second stage estimates.

6.1 First Stage Estimates

The risks and financial incentives facing retirees are key drivers of their saving behaviour and the benefits of different assets, I report the most important results from first stage estimates here and provide complete details in Appendix H.

[22] Fagereng et al. (2019) argue asset price growth can substantially overstate active saving rates.

PI Percentile	Men in Good Health		Men in Bad Health		Women Good Health		Women in Bad Health	
	Life Expectancy	ADL Years	Life Expectancy	ADL Years	Life Expectancy	ADL Years	Life Expectancy	ADL Years
Singles								
10^{th}	13.65	2.02	11.23	2.85	18.21	2.57	16.38	3.82
50^{th}	16.91	2.32	14.91	2.92	20.02	2.65	19.14	3.82
90^{th}	19.57	1.58	17.83	1.87	20.93	1.91	20.03	2.66
Couples								
10^{th}	13.31	2.15	10.95	3.02	19.18	3.92	17.99	5.60
50^{th}	16.79	2.36	15.10	3.21	21.19	4.07	20.65	5.48
90^{th}	19.29	1.57	17.40	2.19	21.89	2.65	20.88	3.56

Conditional on surviving to age 66. ADL years defined by spell with 2 or more difficulties. For couples the calculation assumes both spouses have the same health at age 66

Table 3: Life Expectancy & Expected Duration of ADL difficulties

Mortality and Health Transitions I estimate survival and health status transition probabilities in ELSA using a multinomial logit approach allowing transitions to depend on age, family size, health status and PI. I define the ADL state as individuals with two or more limitations and describe ELSA's measures in Appendix H. Table 3 summarizes simulated health and mortality trajectories using these estimates, revealing an important PI gradient to life expectancy for both men and women. Men at the 90th percentile of the PI distribution live 6 years longer than those at the 10th percentile. For women, the difference is halved. Those with lower PI ranks spend longer living with ADL limitations when alive and women both live longer and spend a greater proportion of retirement with ADL limitations irrespective of initial health.

Long Term Care Costs Micro-data on the LTC expenses of UK retirees is scarce. However, Banks et al. (2019) document costs reported by US households in the HRS line up closely with available measures in ELSA. Motivated by this, I estimate the LTC expense process described in equation (7) using the HRS. Effectively this imputes LTC costs across countries. To capture NHS coverage of other medical expenses, health costs are 0 unless a household member has ADL needs.

Consumption Floor The consumption floor, which replicates the effective value of receiving public assistance including any stigma or disutility from receiving state care rather than a statutory value, is taken from Ameriks et al. (2011). For couples

Group	Homeowner	Wealth	PI	Bequest Index	N	Share
Type I	5.5%	24,200	29.4	-17.6	1,296	24.59%
Type II	98.0%	184,600	47.1	-25.21	1,487	28.22%
Type III	98.5%	323,400	34.6	35.0	1,169	22.18%
Type IV	98.6%	640,500	83.7	10.9	1,318	25.01%

Table 4: Distribution of Latent Household Types

this value is equivalized. I calibrate this parameter using US evidence because there is limited information on who pays for LTC expenses or the deaccumulation of wealth by those entering nursing homes in the ELSA data.

Latent Types Equation 4 specifies idiosyncratic preference heterogeneity parametrically. I approximate latent heterogeneity with $K = 4$ groups, then estimate group specific parameters treating bequest preferences as non-linear group fixed effects.

Classification flexibly partitions households into K groups, $\mathscr{K} = \{k(i)\}_{i=1}^{n}$, as an unrestricted function of household level observations, z_i, to minimise within cluster sum of squared errors. The vector z_i uniquely recovers the underlying latent heterogeneity as panel length grows: the *injecitvity* assumption (Bonhomme et al., 2021).

I select z_i motivated by existing empirical evidence and economic theory and use: initial homeownership status, initial wealth, PI and a bequest preference index constructed from beliefs over future bequests. The first three elements parsimoniously capture life cycle savings and income incorporating correlation between preferences and initial conditions. These are exogenous, but are the outcomes of working life choices. Houses lower the opportunity cost of bequests because they provide a consumption flow. Retirement wealth is determined by early life choices (Venti and Wise, 1998) and stronger bequest motives lead to more wealth accumulation. Combining retirement wealth with PI exploits heterogeneity in lifetime saving rates[23], distinguishing lifetime spenders (high income, low retirement wealth) from savers (vice versa). Finally, the bequest preference index is a measure of systematic differences in future bequests unexplained by current state variables. I construct a household fixed effect by regressing subjective bequest probabilities on flexible controls for observable state variables. Full details are provided in Appendix H.

[23] Moser and Olea de Souza e Silva (2019) similarly identify preference heterogeneity using variation in lifetime saving rates.

Parameter	Description	Type I	Type II	Type III	Type IV
β	Annual Discount Factor		0.957		
			(0.00326)		
γ	CRRA		3.98		
			(0.0291)		
σ	Consumption Weight		0.567		
			(0.00298)		
ω	Ownership Premium		1.15		
			(0.0379)		
F	Fixed Transaction Cost		13,288		
			(96.2)		
π	Proportional Transaction Cost		14.2%		
			(0.313%)		
ϕ_0	Bequest Weight	69.2	5.34×10^{-4}	97.9	21.1
		(96.45)	(2.276×10^{-3})	(4.89)	(3.05)
ϕ_1	Bequest Shifter (1,000s)	602.9	66.6	70.2	46.9
		(1587.583)	(29.9)	(6.49)	(26.4)

Standard Errors correct for simulation error and are calculated using the asymptotic variance of the GMM estimator (see Appendix G for details). I report annual values where appropriate.

Table 5: Estimated Parameters

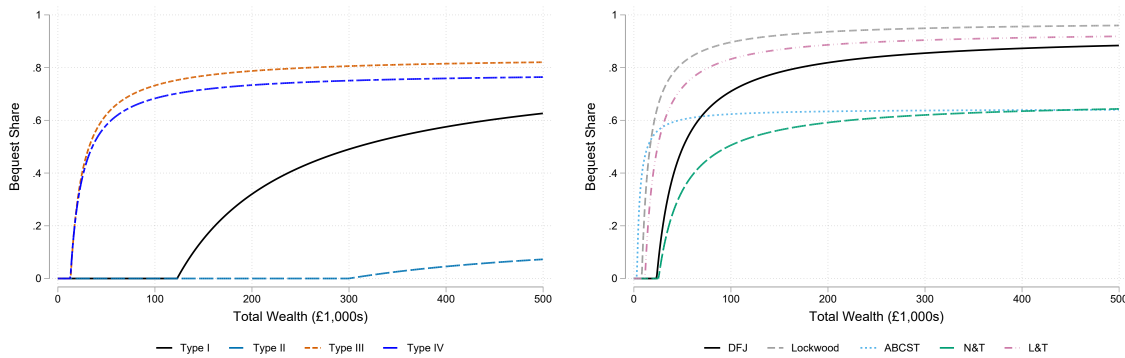
Table 4 reports the distribution over types[24] and group means for elements of z_i. Type I are low wealth and PI initial renters who are systematically less likely to leave a bequest. Type IV are the highest wealth and PI homeowners. Types II and III divide remaining homeowners into 'spenders' with higher PI, but lower wealth and low probability of leaving a bequest and 'savers' who are their opposites.

6.2 Second Stage Estimates

Table 5 reports the second stage estimates beginning with parameters common across households. The discount factor, β, and the coefficient of relative risk aversion, γ, are in line with typical life cycle estimates. Together with the estimated weight on non-housing consumption, σ, an intertemporal elasticity of substitution for consumption is 0.37 which is standard (see Havránek, 2015, for a meta-analysis).

Taken together, estimated transaction costs imply housing assets have substantial adjustment costs. These are larger than values estimated for younger households.

[24] While any labelling is ad hoc, I order types by the average value of initial wealth.



(a) Bequest Allocation (Estimates)

(b) Bequest Allocation (Literature)

Figure 5: Bequest Allocation

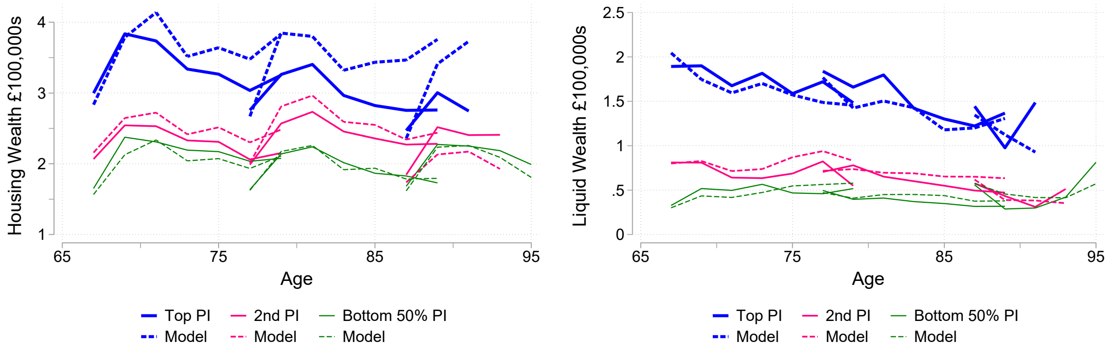
Panel (a): expenditure share allocated to bequests for estimated types facing certain death. Panel (b): expenditure shares using estimates in De Nardi et al. (2010) (DFJ), Lockwood (2018), Ameriks et al. (2020) (ABCST), Nakajima and Telyukova (2020) (N&T), and Lee and Tan (2019) (L&T).

Cocco (2005) argues financial costs often reach 8-10% of the seller's home value excluding the effect of disruption. For older households, disruptions are likely to be large as even geographically small moves can isolate them from their community and support networks. Furthermore, these estimates include the cost of delay (or 'fire sale') as health deteriorates and immediate care needs rise. The utility premium of homeownership shows retirees value the benefits of aging in place. Rental options are typically either (lower quality) social housing or assisted living facilities restricting the independence of retirees or their ability to modify their home. This estimate is smaller than similar models (e.g. Nakajima and Telyukova, 2020) as the ability to downsize on the intensive margin makes homeownership more attractive.

Estimates for the weight and curvature of the bequest function are difficult to interpret. To aid comparison, Figure 5 reports the share of resources a single retiree facing certain death at the end of the period allocates to bequests.[25]

The left panel shows bequest allocations for each of the estimated types. There is a large amount of heterogeneity in the strength of the estimated bequest motives with Types I and II having effectively no bequest motives (Kopczuk and Lupton, 2007, find a similar binary distinction). Extrapolating Type I estimates imply motives operative at higher levels of wealth, however, behaviour at this level is not identified as it lies outside the range of observed wealth holdings for Type I. Turning to those with posi-

[25] Full details of this calculation for all studies are given in appendix J



(a) Mean Housing Wealth

(b) Mean Liquid Wealth

Figure 6: Model Fit - Wealth Profiles (Initial Owners, ELSA Data & Simulations)

Solid lines: cohorts aged 64-68, 74-78 and 84-88 in 2002. Dashed lines: model simulations.

tive bequest motives, estimates for Types III and IV imply similar allocations among those making positive bequests. Estimates for those with positive motives lie within the range of estimates in the literature shown in the right panel. They are stronger than Nakajima and Telyukova (2020), who model a homeownership decision, and Ameriks et al. (2020) who model the financial wealth of a wealthier population and match strategic survey responses, but weaker than estimates assuming all wealth is liquid. This suggests modeling illiquidity and the demand for housing is key. Furthermore, estimated parameters correlate with lifetime spenders and savers, suggesting a simple model of luxury bequests may be consistent with behaviour *after* retirement, but not necessarily with accumulation *before*.

6.3 Model Fit

I require the model to match observed heterogeneity in portfolios, expected bequests, and housing choices by age, cohort, and PI levels. Specifically I target average housing wealth, liquid wealth and the probability of leaving an inheritance conditional on PI group, by cohort and age, for initial owners and these moments unconditional on PI for initial renters. I also target average homeownership and mobility rates for initial owners by age and cohort. These moments identify retirees' demand for housing, precautionary savings, and heterogeneity in bequest motives. I present a subset of the targets here, for birth cohorts shown in Section 2, with the rest in Appendix K.

Figure 6 highlights important features of retiree portfolios over the sample. The

	Band around cuttoff					
	10%	15%	20%	25%	30%	Optimal
Simulations	-0.0263	-0.0239	-0.0190	-0.0184	-0.0174	-0.0181
ELSA	-0.0278	-0.0341	-0.0356*	-0.0303**	-0.0287**	-0.0285**
	(0.0334)	(0.0247)	(0.0189)	(0.0155)	(0.0141)	(0.0140)
N	1224	1559	3023	3233	3979	4348

Regressions using simulated and ELSA data using identical estimating equation in Equation 1. ELSA results are reproduced from Table 2 in Section 3. * $p < 0.10$, ** $p < 0.5$, *** $p < 0.01$

Table 6: Transaction Taxes and Household Mobility: Model vs Data

left panel shows housing wealth sharply increases and gradually declines throughout the sample for all cohorts. While there is large variation in the level of housing assets by PI, this trend is common to all PI groups. In contrast, the liquid wealth of initial owners declines with age and lower PI retirees dissave more slowly from their liquid wealth. The estimated model matches all of these aspects of the data.

6.4 Validation against Quasi-Experimental Evidence

I use moments of the data not targeted in estimation to test the model's goodness of fit, a notch in the transaction tax schedule and its effect on moving estimated using a regression discontinuity design in Section 3. This a strict test of the model's validity as it is required to generate local responses to variation in tax incentives as well as global responses from longitudinal variation in tax incentives embedded in target moments. Importantly, this requires the magnitude of a key mechanism in the model matches the data: how households respond to changes in the financial incentive to transform housing wealth into liquid assets. This is important for predicting behaviour in counterfactual exercises and showing the model reproduces quasi-experimental evidence improves the credibility of these exercises. I estimate an identical equation in simulated data and the ELSA data reported in Table 6.

For all bandwidths, point estimates in the simulated data are a similar order of magnitude and lie within one standard error of the ELSA point estimates. Model estimates are slightly smaller than their data counterparts, but point estimates in the simulated data are economically and statistically comparable to the responses in the data. This suggests the model is able to reproduce both population level responses to tax variation (embedded in the moments) while also producing local responses to variation. This lends considerable support for the magnitude of the liquidity demand and housing windfall channels in the following counterfactual exercises.

7 Responses to Unanticipated Shocks

To understand the joint role of portfolios and retirement windfalls, I use the estimated model as a laboratory simulating consumption and saving responses to *ceteris paribus* increases in housing wealth or cash-on-hand, a proxy for lump sum pension payouts.

I simulate changes for a single cohort, those born between 1930 and 1934, take the joint distribution of their initial state variable as given, and assign each member of the cohort the age of 68 in the first wave of ELSA. Housing wealth windfalls occur at age 70 due to an increase in the level of house prices by 5%. After age 70 the future house prices continue to follow the AR(1) process described in Equation 9 and thus the effect of the unanticipated shock is persistent, but not necessarily permanent. The cash-on-hand windfall is parametrized as an one-time tax rebate (See e.g. Parker et al., 2013; Kaplan and Violante, 2014; Misra and Surico, 2014) at age 70 delivering the same 5% increase in after tax income. Neither windfall is anticipated.

To understand how households respond to changes in their portfolio and total wealth, I report two measures in Table 7: the aggregate Marginal Propensity to Consume (MPC) for annual non-housing consumption and the aggregate Marginal Propensity to Bequeath (MPB).[26] The MPC is measured when the shock arrives and captures contemporaneous non-housing consumption responses. The MPB is measured at death, summarizing how wealth is used over the remaining life cycle.

Turning first to the MPCs. At the arrival of the shock, the contemporaneous MPC out of a transitory income shock is larger than the housing wealth shock and both estimates are within the range of estimates in the respective literatures.[27] They imply that for an additional £1 of wealth at age 70, a household consumes an additional 15 pence when they experience an income shock and 3 pence when they experience an

[26] I compute household level measure and explicitly aggregate households in the model. Thus, the results I present here depend on the distribution of initial state variables in this cohort. MPBs are net all expenditures including adjustment costs and LTC expenses. Average MPBs reported below use the PDV of bequests and integrate over all uncertainty in their remaining lifetime including mortality and health risk, house price changes and medical expense risk.

[27] For example, Aladangady (2017) finds an MPC out of housing wealth of 0.047 on the dollar.

	Marginal Propensity to	
Shock	Consume	Bequeath
Income	0.11	0.39
House Price	0.032	0.26

Simulated responses for a single birth cohort to a one-time 5% increase in income and a one-time 5% increase in house prices. Annual MPC is measured at age 70 when shocks arrive and reported.

Table 7: Household Responses to Unanticipated Shocks

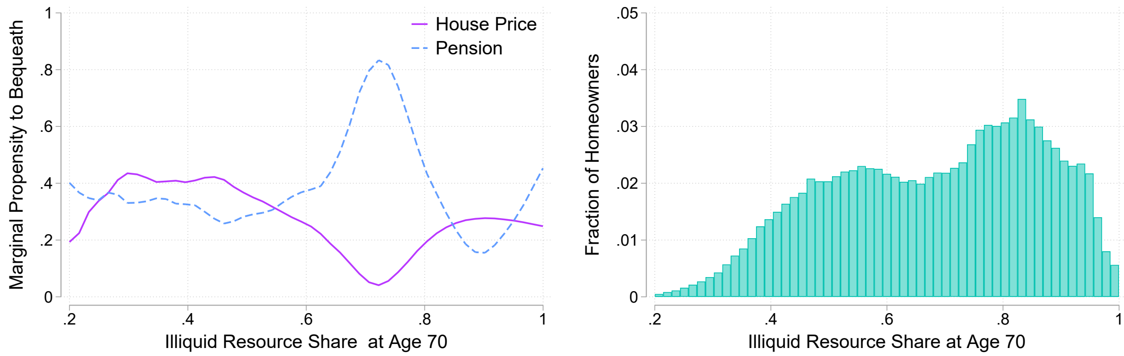
increase in house prices. Retirees use housing wealth windfalls to finance retirement spending, but the consumption increase is smaller than from pension windfalls.

In both experiments, a large, economically significant fraction of one generation's good luck is shared with the next: 1/4 of the house price shock's PDV is transmitted to bequests. However, the transmission of the income shock is 1.5 times larger.[28]

Households respond differently to the two shocks over time — especially those who are liquidity constrained or likely to be during their remaining lifetime. In response to an income shock, low wealth households with larger housing portfolio shares are less likely to downsize. Marginal downsizers in the baseline have more cash available to spend today and find downsizing less attractive. These households no longer liquidate housing wealth, no longer pay adjustment costs and retain additional housing returns because the income shock alleviates liquidity constraints in some states of the world. This effectively increases their lifetime saving.

In contrast, an unanticipated increase in the value of housing wealth actually reduces the savings of these same households over their remaining lifespan. Marginal households increase the frequency with which they move house to access otherwise trapped home equity because the financial return to downsizing has grown. Households increase their cash-on-hand by similar amounts to the liquid wealth windfall, but this is now driven by changes in the intensive and extensive margins of downsizing. Thus, retirees who face liquidity constraints, either today or in some future states of the world, behave differently when they experience the two windfalls. When house prices increase, they use this additional wealth to relax liquidity constraints, but do so by economizing on housing consumption and bequests. They pay large adjustment

[28] The order of magnitude is consistent with the estimated MPB out of social security income in Lee and Tan (2019), but substantially larger than the MPB in Altonji and Villanueva (2007).



(a) Response by Liquidity

(b) Household Liquidity Distribution

Figure 7: Marginal Propensity to Bequeath by Liquidity

Panel (a): the Average MPB along the distribution of illiqiud wealth. Solid line is the response to a house price windfall and dashed line is the response to a pension windfall (tax rebate) both received at age 70. See Table 7. Panel (b): The distribution of households' illiquid wealth shares at age 70

	MPC by Type				MPB by Type			
Shock	I	II	III	IV	I	II	III	IV
Income	0.15	0.16	0.06	0.11	0.32	0.32	0.46	0.40
House Price	0.031	0.031	0.032	0.032	0.24	0.25	0.23	0.24

Simulated responses for a single birth cohort to a one-time 5% increase in income and a one-time 5% increase in house prices. Annual MPC is measured at age 70 when shocks arrive and reported. To isolate the effect of preferences, the correlation with initial conditions is set to 0.

Table 8: Household Responses to Unanticipated Shocks by Latent Type

costs in the process. Constrained households and how they trade off housing for liquidity is the key driver of differences in the MPB.[29] Figure 7 displays this heterogeneity along the distribution of the illiquid wealth share, the ratio of illiquid wealth to total resources. In line with standard intuition, those with high liquidity have larger MPBs out of housing wealth. However, the population of households at the margin of lifetime adjustment drives the aggregate reversal.

While liquidity constraints are important, there is considerable heterogeneity across retirees. Table 8 highlights another key dimension: Types I and II who have weaker bequest motives have larger consumption responses to pension windfalls and

[29] House prices are *persistent* not *permanent*: the mechanical effect of the house price shock at age 70 declines. Even if they do not adjust their behaviour after a house price shock, its transmission to bequests will be smaller. However, estimated parameters imply this effect is negligible

smaller MPBs.[30] In contrast, there are smaller differences in the response to house price shocks. Declining health has a similar effect, increasing MPCs and lowering MPBs, as households face lower survival probabilities and an increase in the probability of catastrophic LTC expenses — reducing effective planning horizons.

8 Differential Means-Testing of LTC Benefits

Means-tested benefits for households who have large LTC expenditures, but limited private resources are common (OECD, 2011). In the UK, means-testing is applied at the individual level and a single retiree must spend down their private assets (housing and liquid wealth) before qualifying for public assistance.

Applying individual means-testing to couples requires allocating joint resources to each spouse. The UK government assigns 50% of the joint financial wealth to the spouse with LTC needs and 50% to their partner. In contrast, they assign 100% of the house to the healthy partner.[31] Consequently, couples no longer face an implicit spend down tax rate of 100%. This insures spouses against their partner's risks, but creates asymmetries in social insurance's generosity for couples and singles.

I simulate changes to the generosity and design of this means-testing, to quantify the value of this additional insurance. I first eliminate both exemptions ($h_{D,t} = x_{D,t} = 0$) that apply to couples with LTC expenditures and, second, eliminate the financial asset exemption ($x_{D,t} = 0$). I compare the resulting changes in government spending to the changes in retiree welfare for these inframarginal reductions in social insurance. I then show how the value of these policies vary with the amount of marginal liquidity they provide to retirees. To measure the costs associated with these reforms I compute the present discounted value (PDV) of changes to the government budget constraint including implicit changes covered by disregarded assets and differences in taxes paid. Welfare changes are measured by compensating variation (CV) defined as an immediate cash-on-hand payment leaving retirees indifferent to the reform.

This approach makes three assumption. First, I assume it costs the government

[30] To isolate the effect of preferences from heterogeneity in initial conditions Table 8 additionally eliminates the correlation between preferences and initial conditions

[31] In Medicaid, a US program with many similarities, houses are deemed countable assets while *homes* are excluded. A house qualifies as a home if a community spouse or dependent relative resides there or a nursing home stay is deemed temporary with intent to return. In practice, the homestead exemption applies to many singles — a third of single Medicaid recipients own homes (Achou, 2021).

	Δ PDV of payments			Compensating	Ratio:
	Total	Transfers	Disregard	Variation	-CV/ΔPDV
All Initial Owners	-8439	49	-5244	49407	5.85
Top PI quartile	-8663	-82	-3626	48150	5.56
2nd PI quartile	-8551	78	-5651	52158	6.10
Bottom 50% PI	-8098	147	-6417	47725	5.89

Note: Columns (1)-(3): £increase in the PDV of government costs as of age 68. Column (4): £transfer needed to compensate retirees for the reform. Column (5): Ratio column 4/column 1

Table 9: The Costs and Benefits of Eliminating All Exemptions for Couples

£1 to provide £1 of payments[32] and compare the compensating variation with the actuarial value of the alternative policy. Second, reforms are not revenue neutral. The cost of providing both exemptions exceeds the cost of providing only one. For comparison, I compute the value per £1 of government spending as the ratio of costs to compensating variation. A ratio above 1 implies that eliminating the program and lump sum redistributing proceeds to retirees would be welfare decreasing. Third, I assume reforms are unanticipated, ruling out changes to portfolio composition, saving or marriage markets over the working life and measures the effect of a reform on current retirees. I simulate changes for the same cohort as in Section 7 selecting a subsample who are in couples and who own their own home at 68.

Specifically, compensating variation is computed at age 68 (the initial age in simulation) and defined as $\chi_{68} = \chi^i_{68}(f_{68}, I, m_{68}, h_{68}, x_{68}, p_h)$ solving

$$V^i_{68}(f_{68}, I, m_{68}, h_{68}, x_{68}, p_h) = V^i_{68}(f_{68}, I, m_{68}, h_{68}, x_{68} + \chi_{68}, p_h | Reform), \tag{22}$$

with $V^i_{68}(\cdot)$ the age 68 value function computed for a given set of state variables. This forward looking ex-ante measure incorporates both mechanical effects and the behavioural responses to the reform and I report results for group averages.

Table 9 presents results from eliminating both exemptions for couples. The PDV of total payments is reported in the first column. Columns 2 and 3 separate this into direct transfers and implicit payments through disregarded assets.[33] Column 1 shows that on average there is a large reduction in the cost born by the government.

[32]This rules out other methods to make transfers more or less attractive to potential claimants.

[33]Columns 2 and 3 do not sum to the value in Column 1 because of changes in revenue collected from housing transaction taxes, income taxes and estate tax.

Pooling together all married homeowners in the first row, the average reduction is almost £8,500. While the reduction in payments comes from a decrease in disregards, this is partly offset by a small increase in transfers because retirees now deplete their private resources and qualify for direct transfers (columns 2 and 3). Splitting results for initial owners along the PI dimension reveals heterogeneity in the size of the implicit transfer from exempting assets and that the likelihood of receiving direct transfers by exhausting financial resources after the exemption is decreasing in PI.

Column 4 presents the compensating variation and column 5 presents the ratio of this to the change in payments. This form of implicit insurance has an income effect and also targets insurance at states of the world with high marginal utility. Those with the highest consumption experience the largest drops when exposed to potentially catastrophic LTC expenses. This reform increases their exposure to the risk of high LTC expenses associated with their spouse and increases the probability they rely on their housing wealth to finance future consumption or, even worse, see their whole portfolio spent on a spouse's care. Consequently, the baseline policy offers substantially more insurance for their total wealth and households require large compensation to be indifferent to the reform. Compared to results for Medicaid expansion (e.g. De Nardi et al., 2016a; Achou, 2021), the per £1 valuation is larger. These studies, however, show a strong gradient in lifetime resources and the sample of married homeowners studied here have much larger wealth holdings on average than samples of single US retirees. Furthermore, as highlighted by De Nardi et al. (2021), saving to insure surviving spouses are responsible for almost 30% of all retiree wealth holdings — consistent with the large valuation of this policy. Finally, valuations of this social insurance are large because it almost fully indemnifies couples.[34]

Table 10 eliminates only the exemption on couples' financial assets. The out-of-pocket share for LTC expenditures is smaller than in the previous experiment, as households are partially insured against potentially catastrophic costs. On average, the government expenditure declines by less than 40% of the full policy, but household valuations, column 4, fall by more than the change in expenses per initial owner and the per £1 valuation falls.

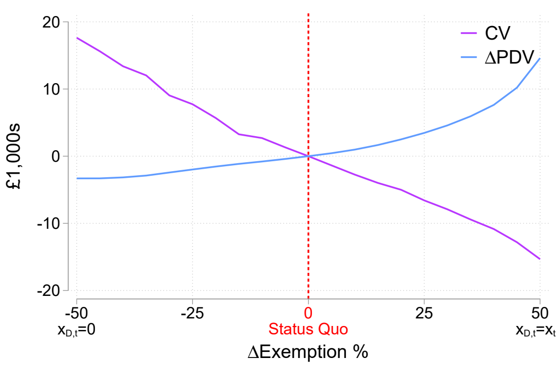
Both of these reforms consider inframarginal reductions in household insurance. Figure 8 shows how valuations for exemptions to household financial wealth vary

[34] LTC expenditures are exogenous, consistent with evidence on their income elasticities. This may lead to quantitatively larger welfare effects, but is unlikely to affect the qualitative findings.

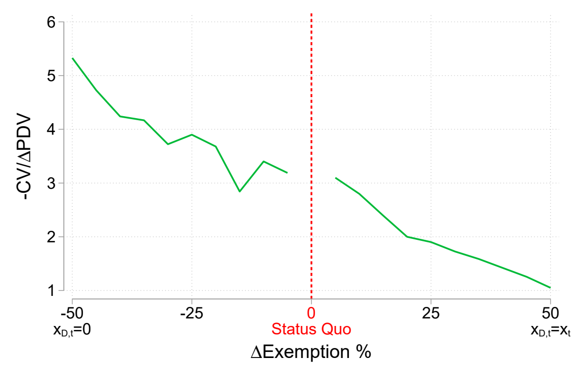
	Δ PDV of payments			Compensating	Ratio:
	Total	Transfers	Disregard	Variation	-CV/ΔPDV
All Initial Owners	-3308	186	-2784	16682	5.04
Top PI quartile	-3645	54	-2319	20182	5.54
2nd PI quartile	-3366	227	-3053	14024	4.17
Bottom 50% PI	-2913	274	-2958	16040	5.51

Note: Columns (1)-(3): £increase in the PDV of government costs as of age 68. Column (4): £transfer needed to compensate retirees for the reform. Column (5): Ratio column 4/column 1

Table 10: The Costs and Benefits of Eliminating Financial Asset Exemptions



(a) WTP and Costs by Exemption Size



(b) Per £1 Value by Exemption Size

Figure 8: Effect of Liquid Wealth Exemption by Exemption Size

Panel (a): the CV and change in PDV of government expenditures (analogous to columns 1 and 4 in Table 10). Panel (b): The ratio (analogous to column (5) in Table 10). Both panels vary the percentage exemption applied to Couples when one member of the household has LTC needs.

non-linearly with the generosity of the exemption and sign of the policy change. Per £1 valuations are decreasing in the size of the exemption offered with the additional value of offering some insurance at the extensive margin outweighing the limited cost this imposes on the government. Yet increasing insurance from the already generous status quo is less valuable and as it approaches full indemnity the asymmetric moral hazard effect substantially increases government costs. Eliminating risk completely reduces liquid wealth holdings for self insurance — distorting portfolios.

Why are the valuations for marginal liquidity so large? Consider married retirees Kate and Will. They own a home, have liquid resources of £50,000, and must finance his LTC expenditures. The existing policy caps Will's LTC costs at £25,000. Kate has £25,000, the house, and a reduced pension income after Will dies.

Without any exemptions on financial assets, Will's LTC costs eliminate all liquid resources. Kate can keep their home and absorb the LTC expenses into non-housing consumption, but reduces future consumption and enjoys a severe decline in consumption today. Alternatively, she can sell her home, pay large adjustment costs, economize on housing services and bequests, but release liquid wealth for consumption. As discussed by Chetty and Szeidl (2007) and Kaplan and Violante (2014), households may not find it optimal to adjust their housing stock in response to 'small' shocks. Non-adjusters exhibit excess sensitivity in their non-housing consumption, magnifying the welfare costs of shocks. Providing exemptions for liquid wealth creates a buffer which helps Kate avoid this dilemma and the large costs associated with it. Crucially, insuring only her housing wealth is not enough to allow her to remain in the house. Complementarity between housing and precautionary motives amplifies retirees' valuation of liquidity because selling homes is costly. Increasing the generosity of the policy leaves Kate better off as it provides additional liquidity, but, importantly, is no longer providing the marginal liquidity to stay in their home.

9 Conclusion

This paper leverages features of the UK institutional context to identify and quantify savings motives. The results offer important lessons for the well being of retirees and the design of public programs around the world. With rising house prices and aging populations it is essential to understand housing's role in old age.

I estimate a dynamic microeconomic model of consumption and housing choices during old age in the presence of health, LTC expense, mortality and house price risk. Combining data on wealth composition with tax policy changes in the UK facilitates separately identifying different motives for holding wealth. Disentangling the strength of these various motives is necessary to evaluate the welfare effects of reforming social insurance and the longer term impacts of rising house prices on intergenerational transfers of wealth. Estimation disciplined by data on future bequests reveals large differences in retirees' preference for leaving bequests which is correlated with lifetime income and wealth.

Understanding the portfolio composition of retirees and how they trade-off liquidity and housing is key to understanding intergenerational impacts and the value they place on social insurance. To lend credibility to its quantitative predictions of counterfactual policies, I validate the estimated model by reproducing causal evidence from notches in the housing transaction tax schedule — showing that the magnitude of responses in the face of the liquidity trade-off is in line with the data. This demand for liquidity drives differences in the response to windfalls in retirement wealth. When house prices increase, downsizing becomes more attractive, whereas pension windfalls lower the attractiveness of downsizing. This leads to differences among marginal downsizers; generating an aggregate marginal propensity to bequeath from house price shocks of 25%. This is only 2/3 of the size of the marginal propensity to bequeath out of a pension windfall. Nevertheless, in both cases older generations share their good fortune with future generations.

Finally, I address how means-testing in the provision of LTC benefits treats different asset classes. For couples, exempting their joint housing assets from means-testing criteria when one spouse has LTC expenses provides substantial additional insurance — outweighing the large costs it imposes on the government. However, insuring only housing assets is often insufficient to allow a healthy spouse to remain in the home when their remaining liquid buffers are diminished. This leads to high valuations of policies insuring marginal liquid wealth (which have only modest costs to the government) and smaller benefits from expanding insurance to fully indemnify households (which create larger costs for the government). These findings suggest that the asset-testing criteria for social insurance can be a tool to provide liquidity and insurance in high marginal utility states of the world. Designing differential means-testing across asset classes to both screen and insure households when they hold complex portfolios is a fruitful avenue for future work.

References

Abel, A. B. and M. Warshawsky (1988). Specification of the Joy of Giving: Insights from Altruism. *The Review of Economics and Statistics 70*(1), 145–149.

Achou, B. (2021). Housing in Medicaid: Should it Really Change? *American Economic Journal: Economic Policy* (Forthcoming).

Aladangady, A. (2017). Housing Wealth and Consumption: Evidence from Geographically-Linked Microdata. *American Economic Review 107*(11), 3415–3446.

Altonji, J. G. and E. V. Villanueva (2007). The Marginal Propensity to Spend on Adult Children. *The B.E. Journal of Economic Analysis & Policy 7*(1).

Ameriks, J., J. Briggs, A. Caplin, M. Shapiro, and C. Tonetti (2018). The Long-Term-Care Insurance Puzzle: Modeling and Measurement. NBER WP 22726.

Ameriks, J., J. Briggs, A. Caplin, M. D. Shapiro, and C. Tonetti (2020). Long-Term-Care Utility and Late-in-Life Saving. *Journal of Political Economy 128*(6), 2375–2451.

Ameriks, J., A. Caplin, S. Laufer, and S. V. Nieuwerburgh (2011). The Joy of Giving or Assisted Living? Using Strategic Surveys to Separate Public Care Aversion from Bequest Motives. *The Journal of Finance 66*(2), 519–561.

Andreoni, J. (1989). Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence. *Journal of Political Economy 97*(6), 1447–1458.

Attanasio, O. P. and C. Emmerson (2003). Mortality, Health Status, and Wealth. *Journal of the European Economic Association 1*(4), 821–850.

Banks, J., R. Blundell, P. Levell, and J. P. Smith (2019). Life-Cycle Consumption Patterns at Older Ages in the United States and the United Kingdom: Can Medical Expenditures Explain the Difference? *American Economic Journal: Economic Policy 11*(3), 27–54.

Barczyk, D., S. Fahle, and M. Kredler (2019). Save, Spend or Give? A Model of Housing, Family Insurance, and Savings in Old Age. Working Paper.

Berger, D., V. Guerrieri, G. Lorenzoni, and J. Vavra (2018). House Prices and Consumer Spending. *The Review of Economic Studies*.

Bernheim, B. D., A. Shleifer, and L. H. Summers (1985). The Strategic Bequest Motive. *Journal of Political Economy 93*(6), 1045–1076.

Besley, T., N. Meads, and P. Surico (2014). The incidence of transaction taxes: Evidence from a stamp duty holiday. *Journal of Public Economics 119*, 61–70.

Best, M. C. and H. J. Kleven (2018). Housing Market Responses to Transaction Taxes: Evidence From Notches and Stimulus in the U.K. *The Review of Economic Studies 85*(1), 157–193.

Blundell, R., M. Costa Dias, C. Meghir, and J. Shaw (2016). Female Labor Supply, Human Capital, and Welfare Reform. *Econometrica 84*(5), 1705–1753.

Blundell, R., R. Crawford, E. French, and G. Tetlow (2016). Comparing Retirement Wealth Trajectories on Both Sides of the Pond. *Fiscal Studies 37*(1), 105–130.

Bonhomme, S., T. Lamadon, and E. Manresa (2021). Discretizing unobserved heterogeneity. *Econometrica* (Forthcoming).

Boserup, S. H., W. Kopczuk, and C. T. Kreiner (2016). The Role of Bequests in Shaping Wealth Inequality: Evidence from Danish Wealth Records. *American Economic Review 106*(5), 656–661.

Boserup, S. H., W. Kopczuk, and C. T. Kreiner (2017). Intergenerational Wealth Formation over the Life Cycle: Evidence from Danish Wealth Records 1984-2013. Working Paper.

Chang, M. and A. Ko (2021). Marital Transitions, Housing, and Long-Term Care in Old Age. Mimeo.

Chetty, R. and A. Szeidl (2007). Consumption Commitments and Risk Preferences. *The Quarterly Journal of Economics 122*(2), 831–877.

Cocco, J. F. (2005). Portfolio Choice in the Presence of Housing. *The Review of Financial Studies 18*(2), 535–567.

Cocco, J. F. and P. Lopes (2020). Aging in Place, Housing Maintenance, and Reverse Mortgages. *The Review of Economic Studies 87*(4), 1799–1836.

Davis, M. A. and F. Ortalo-Magné (2011). Household expenditures, wages, rents. *Review of Economic Dynamics 14*(2), 248–261.

De Nardi, M. (2004). Wealth Inequality and Intergenerational Links. *The Review of Economic Studies 71*(3), 743–768.

De Nardi, M., E. French, and J. B. Jones (2010). Why Do the Elderly Save? The Role of Medical Expenses. *Journal of Political Economy 118*(1), 39–75.

De Nardi, M., E. French, and J. B. Jones (2016a). Medicaid Insurance in Old Age. *American Economic Review 106*(11), 3480–3520.

De Nardi, M., E. French, and J. B. Jones (2016b). Savings After Retirement: A Survey. *Annual Review of Economics 8*(1), 177–204.

De Nardi, M., E. French, J. B. Jones, and R. McGee (2021). Why Do Couples and Singles Save During Retirement? NBER WP 28828.

Deaton, A. (1991). Saving and Liquidity Constraints. *Econometrica 59*(5), 1221–1248.

Dilnot, A., N. Warner, and J. Williams (2011). Fairer Care Funding: The Report of the Commission on Funding of Care and Support. Technical report.

Fagereng, A., B. Moll, M. B. Holm, and G. Natvik (2019). Saving Behavior Across the Wealth Distribution: The Importance of Capital Gains. Technical report.

Gale, W. G. and J. K. Scholz (1994). Intergenerational Transfers and the Accumulation of Wealth. *The Journal of Economic Perspectives 8*(4), 145–160.

Gomes, F., K. Hoyem, W.-Y. Hu, and E. Ravina (2020). Retirement Savings Adequacy in U.S. Defined Contribution Plans. SSRN Scholarly Paper 3294422.

Guren, A. M., A. McKay, E. Nakamura, and J. Steinsson (2021). Housing Wealth Effects: The Long View. *The Review of Economic Studies 88*(2), 669–707.

Havránek, T. (2015). Measuring Intertemporal Substitution: The Importance of Method Choices and Selective Reporting. *Journal of the European Economic Association 13*(6), 1180–1204.

Hilber, C. A. L. and T. Lyytikäinen (2017). Transfer taxes and household mobility: Distortion on the housing or labor market? *Journal of Urban Economics 101*, 57–73.

Hubbard, R. G., J. Skinner, and S. P. Zeldes (1994). Expanding the Life-Cycle Model: Precautionary Saving and Public Policy. *The American Economic Review 84*(2), 174–179.

Hubbard, R. G., J. Skinner, and S. P. Zeldes (1995). Precautionary Saving and Social Insurance. *Journal of Political Economy 103*(2), 360–399.

Hurd, M. D. (1989). Mortality Risk and Bequests. *Econometrica 57*(4), 779–813.

Imbens, G. and K. Kalyanaraman (2012). Optimal Bandwidth Choice for the Regression Discontinuity Estimator. *The Review of Economic Studies 79*(3), 933–959.

Inkmann, J. and A. Michaelides (2012). Can the Life Insurance Market Provide Evidence for a Bequest Motive? *Journal of Risk and Insurance 79*(3), 671–695.

Kaji, T., E. Manresa, and G. Pouliot (2020). An Adversarial Approach to Structural Estimation. *arXiv:2007.06169 [cs, econ, math, stat]*. arXiv: 2007.06169.

Kaplan, G., K. Mitman, and G. L. Violante (2020). Non-durable consumption and housing net worth in the Great Recession: Evidence from easily accessible data. *Journal of Public Economics 189*, 104176.

Kaplan, G. and G. L. Violante (2014). A Model of the Consumption Response to Fiscal Stimulus Payments. *Econometrica 82*(4), 1199–1239.

Kolesár, M. and C. Rothe (2018). Inference in Regression Discontinuity Designs with a Discrete Running Variable. *American Economic Review 108*(8), 2277–2304.

Kopczuk, W. and J. P. Lupton (2007). To Leave or Not to Leave: The Distribution of Bequest Motives. *The Review of Economic Studies 74*(1), 207–235.

Kopczuk, W. and D. Munroe (2015). Mansion Tax: The Effect of Transfer Taxes on the Residential Real Estate Market. *American Economic Journal: Economic Policy 7*(2), 214–257.

Kotlikoff, L. J. and L. H. Summers (1981). The Role of Intergenerational Transfers in Aggregate Capital Accumulation. *Journal of Political Economy 89*(4), 706–732.

Lee, S. and K. T. K. Tan (2019). Bequest Motives and the Social Security Notch. HCEO Working Paper 2019-061.

Lockwood, L. M. (2018). Incidental Bequests and the Choice to Self-Insure Late-Life Risks. *American Economic Review 108*(9), 2513–2550.

Mian, A., K. Rao, and A. Sufi (2013). Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics 128*(4), 1687–1726.

Misra, K. and P. Surico (2014). Consumption, Income Changes, and Heterogeneity: Evidence from Two Fiscal Stimulus Programs. *American Economic Journal: Macroeconomics 6*(4), 84–106.

Moser, C. and P. Olea de Souza e Silva (2019). Optimal Paternalistic Savings Policies. SSRN Scholarly Paper 2959844.

Nagaraja, C. H., L. D. Brown, and L. H. Zhao (2011). An autoregressive approach to house price modeling. *The Annals of Applied Statistics 5*(1), 124–149.

Nakajima, M. and I. A. Telyukova (2020). Home Equity in Retirement. *International Economic Review 61*(2), 573–616.

Nekoei, A. and D. Seim (2021). How Do Inheritances Shape Wealth Inequality? Theory and Evidence from Sweden. *Review of Economic Studies* (Forthcoming).

OECD (2011). Public Long-term Care Financing Arrangements in OECD Countries. In *Help Wanted?*, OECD Health Policy Studies, pp. 231–245.

Palumbo, M. G. (1999). Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle. *The Review of Economic Studies 66*(2), 395–421.

Parker, J. A., N. S. Souleles, D. S. Johnson, and R. McClelland (2013). Consumer Spending and the Economic Stimulus Payments of 2008. *American Economic Review 103*(6), 2530–2553.

Poterba, J., S. Venti, and D. A. Wise (2018). Longitudinal determinants of end-of-life wealth inequality. *Journal of Public Economics 162*, 78–88.

Scholz, J., A. Seshadri, and S. Khitatrakun (2006). Are Americans Saving "Optimally" for Retirement? *Journal of Political Economy 114*(4), 607–643.

Schulhofer-Wohl, S. (2018). The age-time-cohort problem and the identification of structural parameters in life-cycle models. *Quantitative Economics 9*(2), 643–658.

Skinner, J. S. (1996). Is Housing Wealth a Sideshow? In D. A. Wise (Ed.), *Advances in the Economics of Aging*, pp. 241–272.

Slemrod, J., C. Weber, and H. Shan (2017). The behavioral response to housing transfer taxes: Evidence from a notched change in D.C. policy. *Journal of Urban Economics 100*, 137–153.

van der Klaauw, W. (2012). On the Use of Expectations Data in Estimating Structural Dynamic Choice Models. *Journal of Labor Economics 30*(3), 521–554.

Venti, S. F. and D. A. Wise (1998). The Cause of Wealth Dispersion at Retirement: Choice or Chance? *The American Economic Review 88*(2), 185–191.

Voena, A. (2015). Yours, Mine, and Ours: Do Divorce Laws Affect the Intertemporal Behavior of Married Couples? *The American Economic Review 105*(8), 2295–2332.

Yogo, M. (2016). Portfolio choice in retirement: Health risk and the demand for annuities, housing, and risky assets. *Journal of Monetary Economics 80*, 17–34.

Appendix

A Inferring Permanent Income

I infer household level measures of permanent income that is invariant to the household structure so that it is fixed across demographic transitions. Individual non-labour income is the sum of state pension income, private pension income, annuity income, war pensions, widows pensions and any other declared non-labour income. It excludes employment, self-employment income and asset returns. Other than state pensions it does not include benefit income (which are part of the tax function in the model). For singles income is the same as individual income and for couples it is the sum across husband and wife. Following De Nardi et al. (2021), I assume log household income for household i at age j follows:

$$\ln y_{i,j} = f(j, f_{it}) + h(I_i) + e_{i,j} \tag{A.1}$$

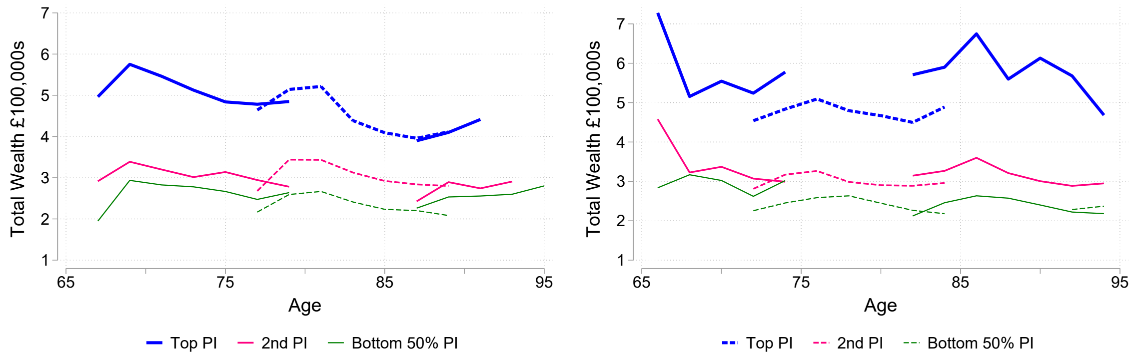
where $f(\cdot)$ is a flexible function of age and family structure and I_i is their time invariant permanent income (PI). In practice I estimate the following fixed effect regression to obtain consistent estimates of $f(\cdot)$:

$$\ln y_{i,j} = f(j, f_{it}) + \gamma_i + e_{i,j} \tag{A.2}$$

For each household the estimated vector of coefficients is used to compute the mean residual (or the estimate of their fixed effect) $\hat{\gamma}_i$ which is consistent as the number of periods a household is observed becomes large. $\hat{I}_i$ is computed as the percentile rank of $\hat{\gamma}_i$. The final step is to estimate:

$$\ln y_{i,j} - f(j, f_{it}) = h(I_i) + e_{i,j}, \tag{A.3}$$

which recovers the mapping from the PI index to the log of household income. In practice, I use a third order polynomial in age j, dummies for family structure and interactions with a linear trend in age to estimate $f(\cdot)$. $h(\cdot)$ is a fifth order polynomial in estimated PI $\hat{I}_i$.



(a) Mean Total Wealth (Main Text Cohorts) (b) Mean Total Wealth (Additional Cohorts)

Figure A.1: Total Wealth by Cohort (Initial Owners)

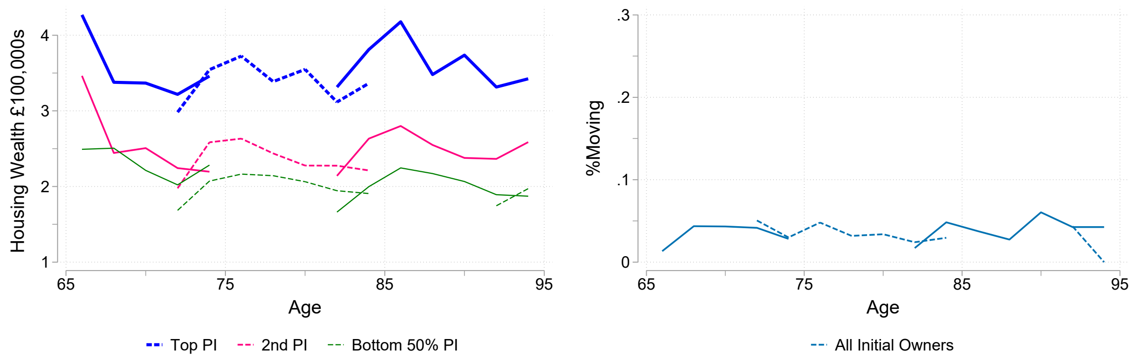
Each line shows a cohort-PI cell over the period 2002-2014, plotted against average cohort ages. Thicker lines denote higher PI groups.

B Additional Key Facts

Figure A.1 displays average total wealth for the cohorts presented in the main text (Panel a) and the remaining birth cohorts (Panel b). As with the discussion of housing wealth in the main text and below, there is evidence of a common aggregate trend. This leads to increasing wealth in the early waves and slowly declining wealth thereafter for all PI groups. As discussed elsewhere, this is driven by the cyclicality of housing wealth. Liquid wealth does not display the same cyclicality. As gaps in both types of wealth accumulate, total wealth shows the largest PI gradient with substantial heterogeneity along PI dimensions. This PI heterogeneity is larger than the effect of within cohort ageing (with the exception of the youngest cohort in panel b which are discussed below).

B.1 Housing Wealth

Figure A.2 reproduces Figure A.2 in the main text for the remaining birth cohorts. Although the key facts remain when considering alternative cohorts, housing wealth in panel (a) shows two apparent differences. First, the housing wealth of the highest PI households appears more volatile. Second, the youngest cohort do not at first glance appear to follow the same aggregate trend. However, this cohort ages into the sample fours years later at the peak of UK house prices.



(a) Mean Housing Wealth by Cohort (b) Frequency of moves in the last 2 years

Figure A.2: Saving in Housing Wealth by Cohort (Initial Owners, Additional Cohorts)

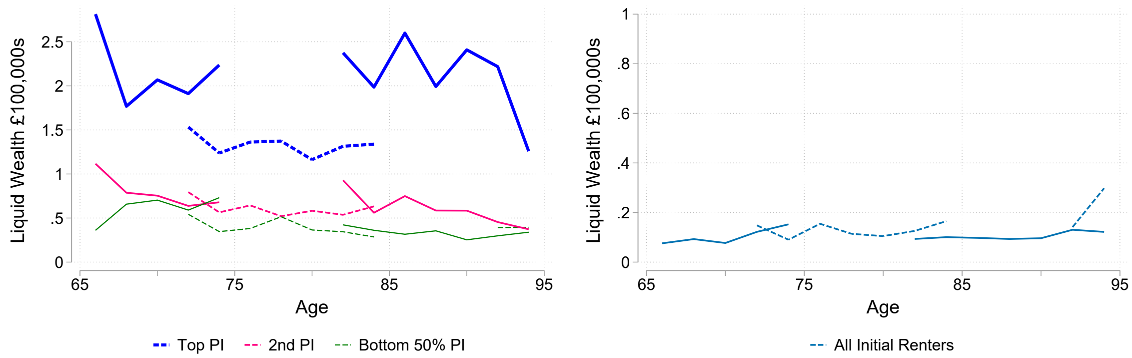
Panel (a): Each line shows a cohort-PI cell over the period 2002-2014, plotted against average cohort ages. Thicker lines denote higher PI groups. Panel (b): cohort cells for the same period.

B.2 Liquid Wealth

Figure A.3 displays average liquid wealth for the alternative cohorts. As with the cohorts in the main text, there is some evidence of deaccumulation among initial owners and differences between the top PI quartile and the 2nd group exceed differences between the 2nd quartile and bottom 50% of the PI distribution. There are signs of accumulation by initial owners, but this is small in absolute terms.

C Policy details

Table A.1 documents the thresholds and rates for SDLT throughout the sample period. The final column indicates how different tax policies are implemented in the model. Due to the two year time period in the model (to match the ELSA data), and to keep estimation computationally feasible, I pool the March 2005 reform with the March 2006 reform. The "Stamp Duty Holiday" was originally scheduled to end in September 2009 before being extended in April of that year. I treat this April extension and eventual reversal as known ex-ante. One important feature of the variation in SDLT over the time period is that it effects households across the wealth distribution with reforms at both the upper and lower ends of the housing wealth distribution. Households elsewhere in the distribution also interact with this tax system as price fluctuations move them across thresholds.



(a) Initial Owners

(b) Initial Renters

Figure A.3: Mean Liquid Wealth by Cohort (Additional Cohorts)

Panel (a): Each line shows a cohort-PI cell over the period 2002-2014, plotted against average cohort ages. Thicker lines denote higher PI groups. Panel (b): cohort cells for the same period.

	Threshold (£1,000s) by Rate					
Effective from	1%	3%	4%	5%	7%	Regime
28 March 2000	£60	£250	£500	*N/a*	*N/a*	I
17 March 2005	£120	£250	£500	*N/a*	*N/a*	II
23 March 2006	£125	£250	£500	*N/a*	*N/a*	II
03 September 2008[a]	£175	£250	£500	*N/a*	*N/a*	III
01 January 2010	£125	£250	£500	*N/a*	*N/a*	IV
06 April 2011	£125	£250	£500	£1,000	£2,000	V

Table A.1: Rates and Thresholds for Stamp Duty Land Tax

All thresholds and rates refer to transactions of residential property . During the time period there are additional exemptions for disadvantaged areas. [a] denotes the "Stamp Duty Holiday" where the 0% rate threshold was temporarily extended.

The reform to Estate Taxation, which was backdated indefinitely, described in Section 3 came with little warning.[1] Consequently, I assume no anticipation. Model regimes I-II use the original tax treatment while III-V use the new threshold. Strictly, the reform depends on bequests disbursed at death of the first partner. However, to avoid introducing additional state variables (and consistent with the model) I assume this doubles the effective threshold at death of the final spouse. This in line with the effective change to the policy for the majority of older households in ELSA. Crawford and Mei (2018) report that nearly all wealth is left to a surviving partner, if one exists, alleviating the impact of incomplete histories. Typically, the never-married or divorced retirees have lower savings and the original threshold is non-binding. Thus, this simplification introduces minimal error in tax incentives. Figure A.1, shows the mean wealth holdings in the top 50% of the PI distribution are near or above the original exemption rate, suggesting the reform is empirically relevant.

D Additional RDD results

A key concern in RDD estimation is the manipulation of the forcing variable. Conventional tests for manipulation (McCrary, 2008) over-reject when the forcing variable is discrete. Figure A.4a plots the distribution of self assessed house values and shows that their support has a number of mass points. Mass points are not themselves evidence of manipulation and there is no evidence of missing mass to the right of the threshold — missing mass here would be consistent with manipulating self assessed house values reported to ELSA.[2] Furthermore, the distribution around the transaction tax threshold is similar to other windows.

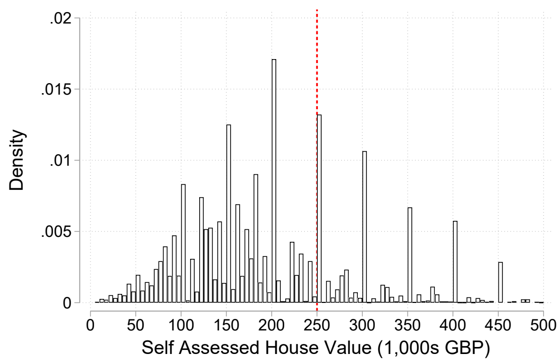
Nevertheless, a concern is that the sparsity of the underlying distribution may lead to bias in statistical inference. Figure A.4b shows the results from placebo tests applying the same estimation to artificial thresholds evenly spaced at £10,000

[1] The BBC described events as:

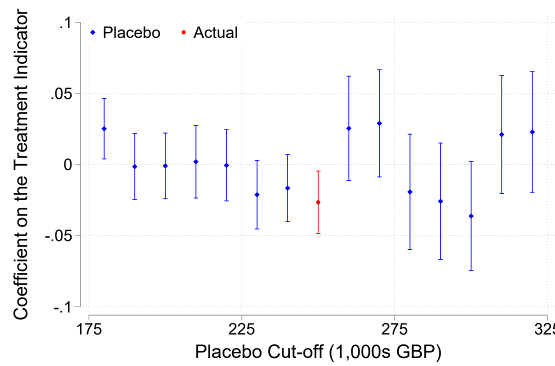
> Chancellor Alistair Darling has doubled the inheritance tax threshold for married...But he was accused by the Tories - who unveiled policies in all these areas last week - of being in a "panic" after their recent opinion poll surge.

Source: http://news.bbc.co.uk/2/hi/uk_news/politics/7034399.stm

[2] The distribution suggests households have a tendency to report round numbers — a form of non-classical measurement error. Battistin et al. (2009) show that as long as non-classical measurement error is orthogonal to the process of interest then the regression discontinuity design still identifies the parameter of interest.



(a) Self Assessed House Values



(b) Placebo Tests

Figure A.4: Transaction Taxes, House Values and Mobility - Additional Details

Panel (a): The distribution of self assessed house values for the sample population.The vertical dashed red line indicates the transaction tax threshold. Panel (b): Placebo tests for alternative artificial transaction tax thresholds using the quadratic specification described in the main text.

intervals. Only the coefficient using the true transaction tax threshold is significant and sparsity does not generate false significance at placebo thresholds. Additional results for confidence intervals with guaranteed coverage properties are below.

In addition to checking for manipulation, I directly test for the smooth distribution of additional covariates by estimating the main specification with alternative covariates as the outcome variable. Table A.2 reports the treatment effect for four variables that economic theory predicts affects household moving decisions. The first two columns show there is no statistically significant discontinuity in total (or liquid) resources around this threshold. Likewise column 3 shows age varies smoothly across the transaction tax threshold. The final column shows there is a small, statistically

Total Wealth (100,000s GBP)	Liquid Wealth (100,000s GBP)	Age (Years)	Permanent Income (0 to 1)
-0.0568	-0.0568	0.0382	-0.0411**
(0.0868)	(0.0868)	(0.458)	(0.0191)

All regressions use a second order polynomial in housing wealth and additionally control for wave fixed effects, household demographics, and region dummies. Standard Errors are clustered by household. N=3979 throughout. * $p < 0.10$, ** $p < 0.5$, *** $p < 0.01$

Table A.2: Covariate Balance around Transaction Tax Thresholds significant reduction in household PI which falls by 4 percentage points. Those to the left of the threshold have an average PI rank at the 60th percentile. While it is unlikely that such a small decline generates the behaviour of interest (the sign of the effect predicted by economic theory is ambiguous), I condition on PI throughout to avoid this potential confounder.[3]

Table A.3 presents alternative specifications from the regression discontinuity estimation of the effect of transaction taxes on the mobility of older household described in Section 3 as well alternative inference.

Panel A: Higher Order Polynomials

	Band around cuttoff				
Order of polynomial	10%	15%	20%	25%	30%
Parametric Common Slope					
Linear	-0.0445**	-0.0475***	-0.0207*	-0.0200*	-0.0250**
	(0.0181)	(0.0160)	(0.0114)	(0.0116)	(0.0110)
	-729.5	*-879.4*	*-2118*	*-2112*	*-2873*
Cubic	-0.0548*	-0.0377	-0.0575***	-0.0533***	-0.0287**
	(0.0332)	(0.0289)	(0.0180)	(0.0176)	(0.0140)
	-730.9	*-877.8*	*-2124*	*-2118*	*-2871*
Quartic	-0.0383	-0.0305	-0.0519**	-0.0549***	-0.0293**
	(0.0398)	(0.0294)	(0.0207)	(0.0180)	(0.0148)
	-727.7	*-882.1*	*-2127*	*-2116*	*-2869*
N	1224	1559	3023	3233	3979

Panel B: Bounded Second Derivative Inference

Smoothness (K)	0.001	0.01	0.02	0.1	0.1
Local Linear	-0.0290	-0.0290	-0.0290	-0.0290	-0.0290
BSD CI	[-0.0571,-0.000892]	[-0.0571,-0.000875]	[-0.0572,-0.000826]	[-0.0587,0.000694]	[-0.0539,-0.00405]
Implied Bandwidth	30%	30%	30%	30%	30%
Significance Level	5%	5%	5%	5%	10%
Eff. Sample Size	943	943	943	943	943

All regressions additionally control for wave fixed effects, a polynomial in age, household demographics, a polynomial in permanent income and region dummies. Following Kolesár and Rothe (2018), Standard Errors in panel A are clustered by household. The Akike Information Criterion is shown in italics. In panel B the implied bandwidth is the one that minimizes the length of the resulting CI for a given choice of K. * $p < 0.10$, ** $p < 0.5$, *** $p < 0.01$

Table A.3: The Effect of Transaction Taxes on Household Mobility

Panel A shows the robustness of the common slope estimates to alternative order polynomials. First, the linear specification is more sensitive to the size of the bandwidth chosen than the specification in the main text. For the smallest band around the cut-off value the result using a quadratic specification are of a similar magnitude to the linear specification, but estimated with less precision. Using both the cubic and quartic estimators the estimated treatment effect remains negative for

[3]The effect on estimated parameters of including this additional control is minimal.

all bandwidths and is significant for larger bandwidths around the discontinuity in the SDLT schedule. The results are consistent with the lower order polynomial and local linear estimates presented in the main text. Gelman and Imbens (2017) caution over using higher-order global polynomials due to noisy estimates, sensitivity to the degree of the polynomial and poor coverage of confidence intervals. While the results here demonstrate some of these problems, nevertheless the point estimates are similar to those obtained with lower order polynomials and non-parametric methods (particularly over the largest estimation window). This suggests estimated treatment effects are not driven by the approximation of the conditional expectation function.

House values have an underlying discrete support (Figure A.4a). In the baseline analysis, tests of statistical significance use standard errors clustered at the household level. As recommended by Kolesár and Rothe (2018) they are not clustered at values in the support of the forcing variable (Lee and Card, 2008, motivates this adjustment). When resulting model misspecification bias is large these confidence intervals undercover the true average treatment effect. This is especially concerning when large bandwidths are used or the discrete support leads to insufficient observations in a small neighbourhood of the threshold.

To assess the robustness of results to these concerns, Panel B in A.3 uses an alternative method (see Kolesár and Rothe, 2018) to construct confidence intervals with guaranteed coverage properties. Implementing this method requires that a smoothness constant K (a bound on the second derivative of the conditional expectation function with $K = 0$ indicating it is known to be linear) is chosen.

Column 1-5 report confidence intervals for $K \in \{0.001, 0.01, 0.02, 0.1\}$, representing a range of smoothness parameters ranging from 'optimistic' to 'pessimistic' choices (central values sandwich a lower bound estimate $K = 0.012$). Each column reports bias corrected point estimates using a local linear estimator with optimal bandwidth for fixed smoothness constants and classes. Resulting confidence intervals are reasonably tight and are close to those reported in Table 2. The null hypothesis of 0 effect is rejected at the 5% significance level for all but the most pessimistic value of K. Even for this extreme case a 90% confidence interval excludes 0.[4]

[4]Although this is not analogous to a one-sided test it is also the case that the null hypothesis of a weakly positive treatment effect is rejected at the 5% significance level.

E (Un)Collateralized Borrowing by the Elderly

I rule out collateralized and uncollateralized borrowing for three reasons. First, 95% of older households have paid off their mortgage or have positive liquid wealth balances. Second, many retired households fail to meet the income requirements of traditional forward mortgages and in the data very few retired households take out new mortgages to upsize. Third, although reverse mortgage products do exist the UK market is small — a common international trend. Finally, the UK market is tightly controlled on negative equity where the total value of the mortgage is still required to be paid in full which lowers the demand for equity release.

Davidoff et al. (2017) documents that limited financial literacy of potential product users contributes to the low take up of reverse mortgages in the US. Two major mortgage retailers offered home equity release products in the UK between 1996 and 1998 as shared appreciation schemes (where home owners are insured against falls in house prices, but own progressively less of the equity in their home when prices rise). These shared appreciation schemes were subject to limited financial regulation and were the subsequent target of extensive negative press coverage and a class action lawsuit. This likely persistently depresses demand for equity release products.

F Renter's Problem

The renter's problem ($h' = 0$), renting housing services $\tilde{h}$ at price $r^h p_h$, is:

$$V_j^i(\Omega) = max_{\{c,\tilde{h},a'\}}\Big\{u(f,c,\tilde{h}) + +\beta \cdot \eta(j,I,m,f)E[V_{j+1}^i(\Omega')\,\Big|\,\Omega, h'=0, a'] \\ + \beta(1-\eta(j,I,m,f))E[\phi^i(b)\,\Big|\,\Omega, h'=0, a']\Big\}, \tag{A.4}$$

subject to equations (2)-(9), (A.5)-(A.6), (14)-(17) and bequests constrained by equation (18). Renting housing services implies modified constraints:

$$x_{t+1} = x_t - c_t - r^h p_{h,t}\tilde{h}_t - Q(0,h_t,p_{h,t}) - mx_{t+1} + \tau_y\big(r\, a_{t+1} + y_{t+1}, f_{t+1}, \tau\big) + tr_{t+1} \tag{A.5}$$

$$a_{t+1} = x_t - c_t - r^h\tilde{h}_t p_{h,t} - Q(0,h_t,p_{h,t}) \geq 0, \quad \forall t. \tag{A.6}$$

G Method of Simulated Moments

The estimated parameters are defined by minimizing the weighted distance between data moments and model generated moments for a given parameter vector:

$$\hat{\theta} \arg\min_{\theta \in \Theta} G(\vartheta, \theta)' W G(\vartheta, \theta), \tag{A.7}$$

which takes the form of a standard GMM objective function. This differs from equation (20) as here moment conditions depend explicitly on both ϑ and θ the vectors of first and second stage estimates respectively. W is the inverse-diagonal weighting matrix proposed by Pischke (1995) as the asymptotically optimal weighting matrix suffers from finite sample bias (Altonji and Segal, 1996).

The dynamic programming problem described in Section 4 does not admit closed form analytic solutions and I use numerical methods described in Appendix L to compute optimal policies and simulate household decisions. This is a standard approach (see, for example, Gourinchas and Parker, 2002). Given the optimal household decisions for a given set of parameter values and household initial conditions drawn from the data, I simulate forward households through the different policy regimes drawing values of ϵ_{mx} from their distribution using Monte Carlo methods. I then construct moment conditions from this simulated data in the exact same way as in the data — this forms the basis of my estimation procedure.

To construct moment conditions, I calculate model implied 'objective' probabilities as the equivalent of subjective probabilities in ELSA provided on a 101 point (0-100) percentage scale. The question I match is

> Including property and other valuables that you [and your husband/wife/partner] might own, what are the chances that you [and your husband/wife/partner] will leave an inheritance totalling £150,000 or more?

This assumes self-reported probabilities accurately summarize optimal future behaviour given a household's current information set. This is common when expectations about future behaviour are used in combination with contemporaneous choice data (e.g. van der Klaauw and Wolpin, 2008; van der Klaauw, 2012).

Using conditional means as moment conditions requires the model matches the full distribution of wealth holdings well because a household's total wealth rank and PI are positively correlated. I winsorize wealth moments in both data and simulations at the 95th percentile. This mitigates the impact of the very wealthy and other potential sources of measurement error. I use 7 five year birth cohorts and 3 PI groups. Data versions of these moments are presented in Section 2 and I use identical operations to calculate simulation equivalents.

I simulate 150,000 sample households and draw initial state variables from the empirical joint distribution in the ELSA data. Simulated counterparts remain in the simulation sample for the duration that their ELSA donor remains in the ELSA sample and receive their donor's sequence of exogenous state variables. This defines a calendar time window including reforms to Inheritance Tax and transaction taxes (SDLT) and house price changes experienced by their ELSA donor. This procedure perfectly replicates any compositional changes in the sample as they age and die as well as the sequence of time effects through aggregate house price changes and policy reforms (including arbitrary realized correlation).

To summarize, I match mean liquid wealth, housing wealth, bequest probabilities, mobility rates, and homeownership rates by birth cohort, age and conditional on PI and initial ownership status. Matching moments by average age conditional on birth cohort is equivalent to matching the ELSA data by wave. Let $q_{i,t}$ denote a data quantity for household i at time t and $\bar{q}_{c,p,o,t}(\vartheta, \theta)$ denote the model predicted average quantity for simulated households in cohort c, PI group p, initial housing tenure o at time t t. Moment conditions can then be expressed as:

$$E([q_{i,t} - \bar{q}_{c,p,o,t}(\vartheta, \theta)] \times \mathbb{1}[c_i = c] \times \mathbb{1}[I_i \in \mathcal{P}_p] \times \mathbb{1}[o_i = o] \times \mathbb{1}[i \text{ observed at } t] | t), \quad \text{(A.8)}$$

for $c \in \{1910, 1915, 1920, 1925, 1930, 1935, 1940\}$, $o \in \{owner, renter\}$, $p \in \{1, 2, 3\}$, and $t \in \{2002, 2004, ..., 2014\}$. $\mathcal{P}_p$ defines the values contained in the pth PI group. In addition, each cohort-income-ownership-age cell must have at least 15 observations to be included in the GMM criterion. In total there are 410 target moments.

Let N denote independent households that are each observed at up to T separate calendar years. $G(\vartheta, \theta)$ denotes the J-element vector of moment conditions described immediately above, and $\hat{G}_N(\vartheta, \theta)$ denotes its sample analogue. Letting $\widehat{W}_N$ denote the $J \times J$ weighting matrix, computed as the inverse-diagonal of the sample analogue[5] to the optimal asymptotic weighting matrix, the MSM estimator $\hat{\theta}$ is implemented

[5] I use the observations in each cell, $N_{c,p,o,t}$, instead of N to calculate diagonal elements of $\widehat{W}_N$.

as:

$$\arg\min_{\theta\in\Theta} \hat{G}_N(\vartheta,\theta)'\widehat{W}_N\hat{G}_N(\vartheta,\theta). \tag{A.9}$$

In practice, ϑ is also estimated, however, computational concerns necessitate treating it as known throughout the analysis that follows. Under the regularity conditions stated in Pakes and Pollard (1989) and Duffie and Singleton (1993), the MSM estimator $\hat{\theta}$ is both consistent and asymptotically normally distributed:

$$\sqrt{N}\left(\hat{\theta}-\theta_0\right) \rightsquigarrow N(0,\mathbf{V}), \tag{A.10}$$

with the variance-covariance matrix $\mathbf{V}$ given by

$$\mathbf{V} = (1+\tau)(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}\mathbf{D}'\mathbf{W}\mathbf{S}\mathbf{W}\mathbf{D}(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}, \tag{A.11}$$

where $\mathbf{S}$ is the variance-covariance matrix of the data; τ is the ratio of the number of observations to the number of simulated observations;

$$\mathbf{D} = \frac{\partial G(\vartheta,\theta)}{\partial\theta'}\bigg|_{\theta=\theta_0} \tag{A.12}$$

is the $J\times M$ gradient matrix of the population moment vector; and $\mathbf{W} = \text{plim}_{N\to\infty}\{\widehat{\mathbf{W}}_N\}$. $\mathbf{D}$, $\mathbf{S}$, and $\mathbf{W}$ are estimated by their sample analogues. When estimating $\mathbf{S}$, I use sample statistics, replacing $\bar{q}_{c,p,o,t}(\vartheta,\theta)$ by the sample mean for group c,p,o,t.

H Additional Estimation Details

This appendix summarizes first stage parameter estimates or calibrations not in the main text as well as providing more detail on how health and mortality are estimated. Table A.4 summarizes data sources and first stage parameter values.

The Utility Function The consumption equivalence scale is set using the OECD modified scale (estimates for retirees in De Nardi et al., 2021, are almost identical).

The Housing Market Annual depreciation, δ, is set at 2% (Cocco and Lopes, 2020) and the rental cost is 3.94% of the sale price (Jordà et al., 2019). I estimate the time series process for house prices using OLS and data from the HM Land Registry

Parameter	Description	Value	Source
α_n	Consumption Equivalence Scale	1.5	OECD Modified Scale
δ	Housing Maintenance Costs	0.02	Cocco and Lopes (2020)
r_h	Rental Cost	3.94%	Jordà et al. (2019)
ρ_h	House Price AR(1) persistence	0.977	HM Land Registry
μ_h	House Price Drift	0.019	HM Land Registry
σ_h	House Price S.D. Innovations	0.095	HM Land Registry
κ	Incidence of SDLT on Seller	0.4	Besley et al. (2014)
r	Risk Free Return	3.0%	Bozio et al. (2017)
$y(\cdot)$	Deterministic Income Profile		ELSA
τ_y	Income Tax Function	Table A.5	TAXBEN
c_{min}	LTC consumption floor (Singles)	£2,679	Ameriks et al. (2011)
$\eta(\cdot)$	Survival Probabilities		ELSA
$Pr(m^g_{j+1}\|\cdot)$	Health status		ELSA
$\mu_{mx}(\cdot)$	Mean LTC Expenses		HRS
$\sigma_{mx}(\cdot)$	Conditional variance LTC Expenses		HRS

All values are annual and expressed in 2014 prices.

Table A.4: 1st Stage Parameter Estimates

UK house price index series. The estimation sample uses data from all regions in England and normalizes December 2002 house prices to 1. House prices are highly persistent, drift upwards, and innovations with a large variance. Parameter values are in table A.4. Transaction tax incidence is taken from Besley et al. (2014).

The Budget Constraint I calibrate returns on the risk free asset, r, at 3% (Bozio et al., 2017). Non-asset pension income profiles are estimated directly from ELSA using the procedure described in Appendix A. Income taxes are approximated by a modified version of a common log-linear functional form (e.g. Feldstein, 1969) with after tax income given by

$$\tilde{y} = \bar{y} + \lambda_y y^{1-\tau_y},$$

where λ_y controls the level of taxation, τ_y controls progressivity and $\bar{y}$ captures features corresponding to an income floor. I estimate this separately for couples and singles. I combine data from TAXBEN, a microsimulation model of the UK tax and benefit system (see Waters, 2017, for further details), with individual household data for my ELSA sample in order to estimate the tax function. This includes taxes and both means-tested and universal benefits, but excludes coverage of social care costs.[6]

[6]This is not included in the tax function as its means-testing is explicitly modeled.

	$\bar{y}$	λ_y	τ_y	R^2
Singles	556	99.1	0.468	0.90
	(737)	(24.8)	(.0213)	
Couples	5,083	7.62	0.213	0.927
	(819)	(2.32)	(0.0262)	

Table A.5: Tax Function Parameter Estimates

Table A.5 reports parameters estimated by non-linear least squares. Despite its parsimony, R^2 values show this accurately predicts after tax and transfer income.

Mortality and Health Transitions I define the worst health status as difficulties with two or more Activities of Daily Living (ADL) capturing both mortality and medical expenditure effects in a parsimonious manner. Each wave, household members are asked about difficulties in six different categories of activities:

1. difficulty dressing, including putting on shoes and socks
2. difficulty walking across a room
3. difficulty bathing or showering
4. difficulty eating, such as cutting up food
5. difficulty getting in and out of bed
6. difficulty using the toilet, including getting up or down

This is intended to capture the minimum range of daily activities typically performed by the adult population and proxy an individual's ability to live independently. Each individual's health status, m^g, has four possible values enumerated as follows:

$$m = \begin{cases} 0 & \text{Good Health} \\ 1 & \text{Bad Health} \\ 2 & \text{ADL Limitations} \\ 3 & \text{Dead} \end{cases}, \tag{A.13}$$

with transition probabilities depending on current health, age j, family structure f, PI I, and gender g.[7] Elements of the health transition matrix are given by

$$\pi_{i,q,p}(j, f_{it}, I_i, g) = \Pr\left(m^g_{m,j+2} = q \,\middle|\, m^g_{i,j} = p; j, f_{i,t}, I_i, g\right), \tag{A.14}$$

where transitions span the two year interval of the ELSA data. These transition probabilities are estimated by fitting a multinomial logit model to observed transitions. This gives the following expression for health and mortality transitions

$$\pi_{i,q,p}(j, f_{it}, I_i, g) = \frac{e^{x_{it}\beta_q}}{\sum_{h=0}^{3} e^{x_{it}\beta_h}} \ , \tag{A.15}$$

where β_q denotes the coefficient vector for next period outcome q. Health transitions and survival probabilities are jointly estimated at the individual level using a maximum likelihood estimator. The vector of covariates x_{it} includes age, sex, current health status, marital status, and PI. Specifically, a third order age polynomial, indicators for gender and marital status (interacted with a linear age trend), an indicator for single man interacted with PI, contemporaneous indicators for health (interacted with age, gender and PI), and a quadratic in PI (interacted with a linear age trend and marital status). In total this gives 25 parameters in each β_q coefficient vector. Table 3 summarizes simulated histories using estimated transition probabilities.

Long Term Care Costs Due to the paucity of UK data I use comparable data from the HRS to estimate the LTC expense process — effectively imputation. I construct the HRS data identically to the ELSA data to replicate sample selection.

The HRS medical spending measure is the sum of expenditures paid out-of-pocket plus those paid by Medicaid (See De Nardi et al., 2021, for details on this construction) capturing total costs incurred by private individuals and the government. This is the relevant measure as the model incorporates means-tested government payments that would be covered by Medicaid in the US. This measure is backwards looking, hence mx_j captures the flow of LTC expenses between $j-1$ and j. Equations (7) and (**??**) outline this process. I estimate $\mu_{mx}(\cdot)$ and $\sigma_{mx}(\cdot)$, by writing Equation (7) as

$$\ln mx_{it} = x_{1i}\beta_1 + x_{2it}\beta_2 + \vartheta_i + \varsigma_{it}, \tag{A.16}$$

[7] Health transitions are independent of medical spending. Empirical evidence on whether medical spending improves health at older ages is inconclusive in part due to reverse causality.

where x_{1i} denotes a vector of time-invariant variables, x_{2it} denotes a vector of time-varying variables, ϑ_i is an unobserved person-specific term, and ς_{it} captures any remaining variation. I assume $E(\varsigma_{it} \mid \vartheta_i) = 0$.

I estimate Equation (A.16) in three steps. First, regressing log medical spending on the time-varying factors in Equation (A.16), namely age, household structure, and health, and interaction terms (such as gender and PI interacted with the time varying variables) using a fixed effects estimator. Specifically, I regress log medical spending on an age quadratic (the linear trend interacted with PI), indicators for single man and single woman (interacted with an age trend), the contemporaneous and lagged values of indicators for health status, whether the man died (interacted with PI), whether the woman died (interacted with PI). Including current and lagged family structure indicators accounts for the jump in medical spending at the death of a family member and including health indicators for both periods distinguishes persistent from transitory health episodes.

As fixed effects regression cannot identify the effects of time-invariant factors, which are subsumed into the estimated fixed effects, the second step collects the residuals from the first regression, including estimated fixed effects, and regresses them on the time-invariant factors: a quadratic in PI and a set of cohort dummies.

A key feature of this spending model is that *both* the conditional variance and the conditional mean of medical spending depends on demographic and socio-economic factors, through the function $\sigma(\cdot)$. The third step uses estimates $\hat{\mu}_{mx}(\cdot)$ to back out the residual ϵ from Equation (7). To find $\widehat{\sigma^2(\cdot)}$, residuals are squared and regressed on the demographic and socio-economic variables in Equation (7).

When including this estimated process in the model, I impose 0 costs unless a member of the household is in the ADL state. I do not impose this in estimation, using information about the relationship between demographic and socio-economic characteristics and medical spending in all health states of the HRS to ameliorate limited sample size across age, PI, and family structure cells in the ADL state.

Latent Types I recover the bequest preference index by estimating:

$$y_{i,t} = \beta X_{i,t} + f(W_{i,t}^{liquid}, W_{i,t}^{housing}) + \lambda_t + \gamma_i + u_{i,t} \tag{A.17}$$

where the dependent variable is their subjective bequest probability and I control for total wealth by allowing for within wave quintile specific effects. Quintile specific effects impose limited restrictions on the underlying function and I control separately for home ownership and the housing wealth share. I control for contemporaneous characteristics of the household with time t period controls for age, household income, gender, marital status, health for all household members, subjective survival probabilities, and vital statistics of their parents as well as wave fixed effects.[8] Finally, the object of interest is a household specific fixed effect γ_i. Additionally, I rezidualize on time invariant PI and birth cohort dummies.

I place no direct interpretation on the coefficients or fixed effects recovered by this regression, instead viewing it as a statistical exercise designed to capture systematic differences across households. Estimated fixed effects, $\hat{\gamma}_i$, are noisy measures, but potentially informative of future behaviour. This is similar to using heterogeneity in stated intention to save for a bequest (see Laitner and Juster, 1996) or reason for saving (Favilukis et al., 2017, use the Survey of Consumer Finances to calibrate binary bequest motive heterogeneity generating wealth inequality).

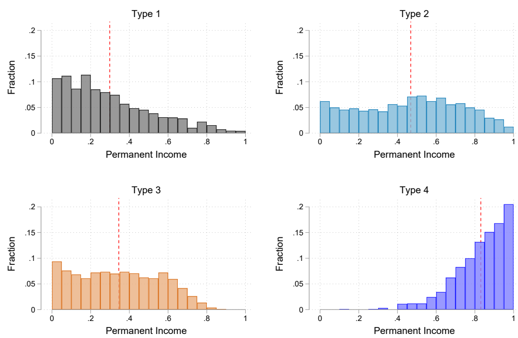
Marginal distributions of household characteristics, z_i, by household types are displayed in figures A.5a to A.5c with mean values denoted by dashed vertical line. This provides a succinct description of how the *k-means* clustering algorithm partitions household's based on their characteristics. These results offer a more complete characterisation than the summary statistics provided in Table 4. The full distributions reflect the comparisons of group means. However, as clustering uses multiple dimensions the supports in any given dimension are not exclusive.

When using the *k-means* clustering approach, the researcher is left with two degrees of freedom: a) which variables to use to cluster the households and b) the number of clusters.[9] The choice of variables to cluster on is motivated by the economic problem agents face and is discussed in more detail in Section 6 and I choose the number of clusters following heuristic methods in machine learning. Indexing the problem by a given number of clusters K:

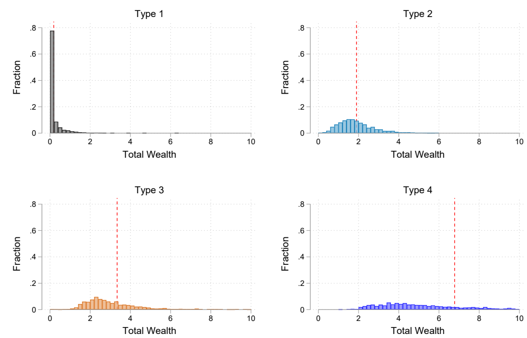
$$\min_{\mathscr{K}_K, \{\bar{z}_k\}_{k=1}^K} SSE_K \quad \text{where} \quad \bar{z}_k = \frac{1}{N_k} \sum_{k(i)=k} z_i, \quad \mathscr{K}_K = \{k(i)\}_{i=1}^n \tag{A.18}$$

[8] Wave specific effects are necessary because survey questions refer to a fixed nominal threshold.

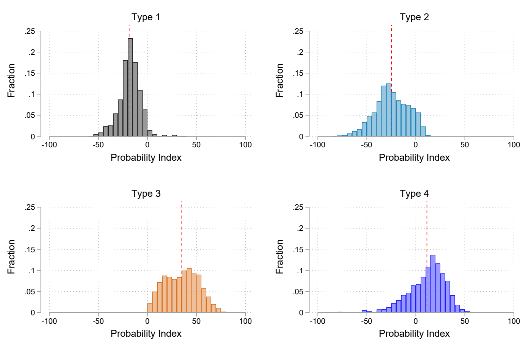
[9] It is also necessary to specify cluster initialization, however, I use a multi-start algorithm where the initial assignment of clusters across households is drawn from 10,000 random seeds.



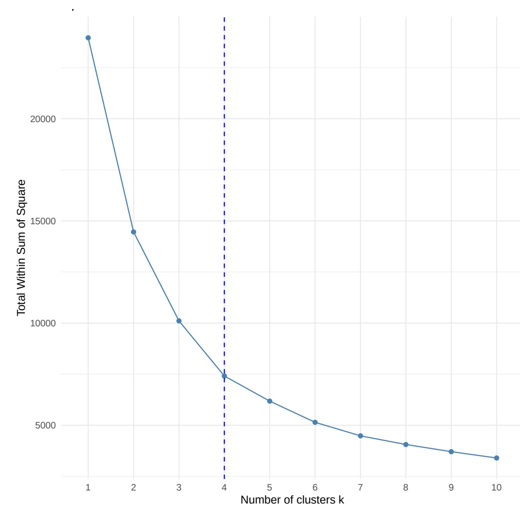
(a) PI Across Groups



(b) Total Wealth Across Groups



(c) Bequest Probability Index Across Groups



(d) Optimal Cluster Heuristic (Elbow Method)

Figure A.5: Additional Clustering details the optimal number of clusters K minimises this objective function without 'overfitting'. As within cluster dissimilarity (the Sum of Squared Errors) is decreasing in the number of clusters K, which precludes cross-validation techniques, heuristics use the following intuition: suppose there is a true number of clusters K^*. For $K < K^*$ the algorithm assigns a subset of the true groups to each cluster. Increasing the number of clusters allows the algorithm to assign groups in a subset to a new cluster. Then increasing the number of clusters if $K < K^*$ leads to a large decrease in the measure of within cluster dissimilarity. In contrast, when $K > K^*$ one of the clusters partitions a true group into two spurious clusters. Consequently, the decrease in within cluster dissimilarity must be smaller.

Figure A.5d plots the Sum of Squared Errors (SSE_K) against the number of clusters a commonly used heuristic method for identifying this kink point: the 'Elbow statistic'. Visual inspection identifies a kink at $K = 4$, which partitions the data into transparent groups while maintaining computational tractability.

I Private Information in Subjective Probabilities

Incorporating subjective bequest probabilities as a set of moments in estimation exploits the additional information they contain over and above the savings choices of households. In particular, it leverages additional information about future bequests when the policy environment changes — relaxing the need for long panels or observed bequests in both regimes. To formalize this intuition and illustrate the potential gains, I estimate a series of quantile regressions for the partial correlation of future wealth and current subjective probabilities (controlling for additional observables $X_{i,t}$). The conditional quantile function $Q(\cdot|\cdot)$, for a given quantile τ, is given by:

$$Q_{Wealth_{i,t+1}}(\tau|\cdot) = \beta(\tau) Pr(Bequest \geq \pounds 150,00)_{i,t} + \delta(\tau) X_{i,t} \tag{A.19}$$

Figure A.6 displays the results of these estimated partial correlations, $\beta(\tau)$, graphically for two alternative specifications of the conditional quantile function, in the first I additionally control for current period wealth; polynomials in age and permanent income; household demographics; the health of each individual in the household; the sample wave and homeownership status. In the second specification I control only for sample wave and current period wealth. The value of the coefficient at each point of

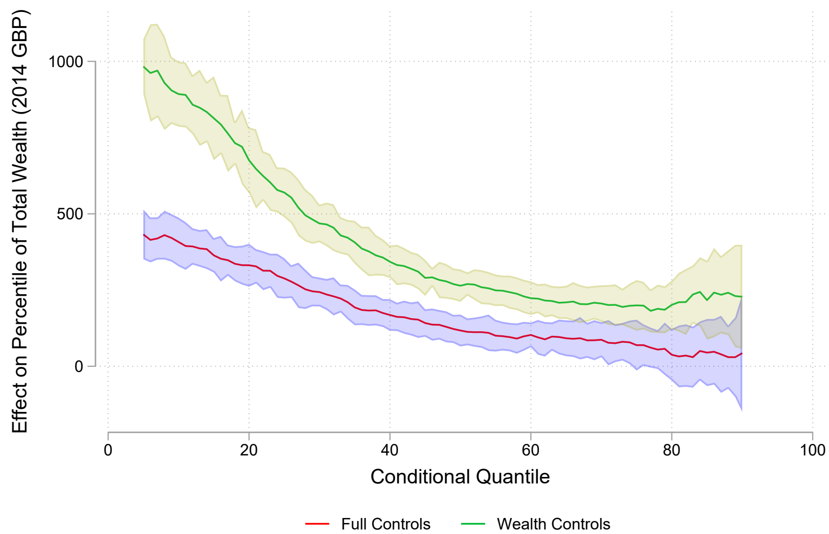


Figure A.6: Information Content of Subjective Bequest Probabilities

Estimated partial correlations using equation A.19. Full controls include: current period wealth; polynomials in age and permanent income; household demographics; the health of each individual in the household; the sample wave and homeownership status

the x-axis is the partial correlation (at a given conditional quantile of total wealth) of a 1 percentage point increase in the probability of leaving a large bequest.

The results show that individual level variation in the subjective probability of leaving a large bequest is a statistically and economically significant predictor of future wealth holdings for the majority of the wealth distribution. In the main specification, at the conditional 5th percentile of future wealth a percentage point increase in the probability is associated with a £425 increase in tomorrow's wealth, while at the median it has fallen to approximately £100. The absence of the effect for the richest households is in part an artefact of the survey design: these retirees hold assets well in excess of the £150,000 threshold and report that they are likely to leave a large bequest (reducing variation in the independent variable). Comparing the alternative specification, the estimated effect sizes approximately half when a full set of controls is included. Interpreting the systematic fall in the estimated effect across the distribution highlights that although observable characteristics (or the state variables in a household problem) explain part of the link between subjective beliefs and wealth, there is a significant proportion that is unexplained.

J Computing the Bequest Share

To simplify discussion, I present bequest allocations when a household faces certain death in the following period. To do so, I compute the solution to the following static allocation problem for a single retiree renting housing:

$$\max_{c,s} u(f,c,s) + \beta\phi(b) \quad \text{s.t.} \quad c + s + b = x \tag{A.20}$$

I solve the problem expressed in terms of expenditures, e, under unit house prices and abstract from LTC costs. The indirect utility function is given by:

$$u^e(e) = \frac{e^{1-\gamma}}{1-\gamma} \times \left[\sigma^\sigma \big(\frac{1-\sigma}{r^h}\big)^{1-\sigma}\right]^{1-\gamma} = \frac{e^{1-\gamma}}{1-\gamma} \times \bar{u}, \tag{A.21}$$

and the allocation between within period expenditures and bequests solves:

$$\max_{e \leq x} u^e(e) + \beta\phi(x-e) \tag{A.22}$$

The solution to this problem characterises the marginal propensity to bequeath and the threshold level of consumption above which bequests are operative. Interior solutions have the following expression for the marginal propensity to expend:

$$MPE = \frac{\bar{\phi}}{1+\bar{\phi}} \quad \text{where} \quad \bar{\phi} = \big(\frac{\beta\phi_1}{\bar{u}}\big)^{-\frac{1}{\gamma}}, \tag{A.23}$$

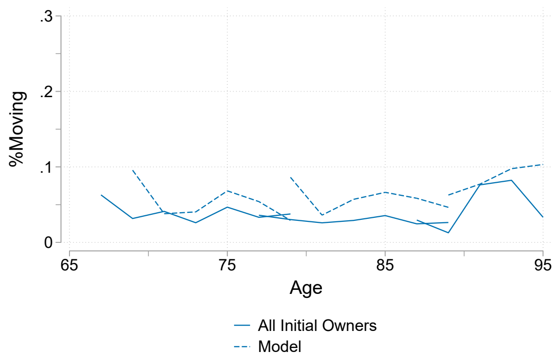
and the threshold value of final period wealth above which bequest motives become operative (or the annuity value of consumption) is given by:

$$c_{beq} = \bar{\phi} \times \phi_2. \tag{A.24}$$

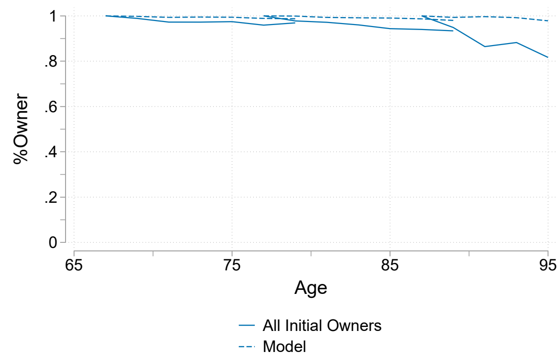
Finally, Figure 5 requires homogenizing estimates across studies. Only Nakajima and Telyukova (2020) estimate a model with housing. For the remaining studies I use this paper's estimated σ to calculate $\bar{u}$ while using their own estimate of the coefficient of relative risk aversion, γ. This generates minor differences between reported MPCs and the MPE. Lastly, I adjust for a 2014 price level.

K Additional Model Fit

Figures 6 - A.12 display the corresponding data and simulated moments for additional target moments, including the remaining four birth cohorts.



(a) Frequency of moves in the last 2 years



(b) Homeownership rates by Cohort

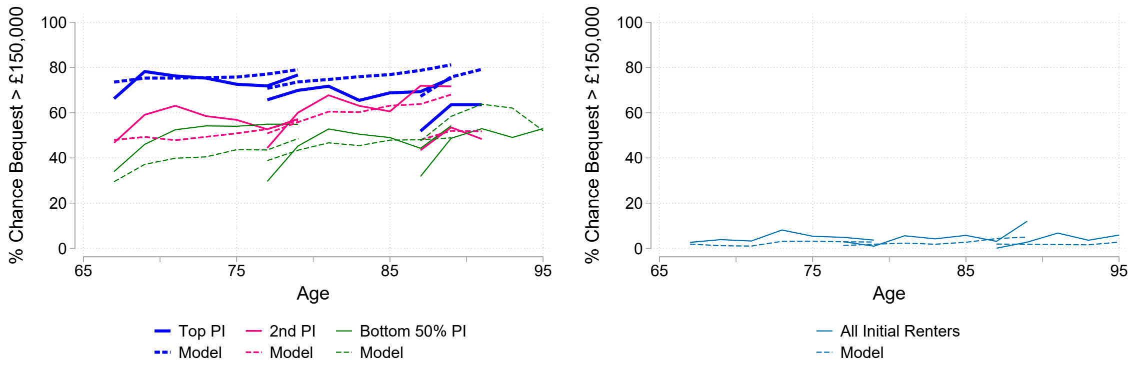
Figure A.7: Model Fit - Mobility (Initial Owners, ELSA Data & Simulations)

Solid lines: cohorts aged 64-68, 74-78 and 84-88 in 2002. Dashed lines: model simulations.

Figure A.7 highlights that the model replicates moving and tenure decisions. The left panel shows the model captures the infrequent decision to move house, endogenously generating illiquidity in housing. Similarly, the right panel shows the model is able to broadly capture the observed rates of homeownership. If anything, it slightly understates the increase in transitions to renting occurring with age.

Figure A.8 shows the model dispersion in expected bequests matches the data. The left panel shows that for initial owners it varies with age, PI and cohort — capturing salient heterogeneity in the data. Comparing to the right panel shows that the model captures large differences in expected bequests by initial housing tenure.

Figure A.9 shows the model replicates the limited liquid wealth holdings and lack of wealth accumulation for initial renters. The right panel shows the same simulated and data moments for the additional birth cohorts presented in Appendix B. Figures A.10-A.12 produce simulated and data moments for these additional cohorts, showing the model's ability to match key patterns and heterogeneity extends to these additional cohorts.

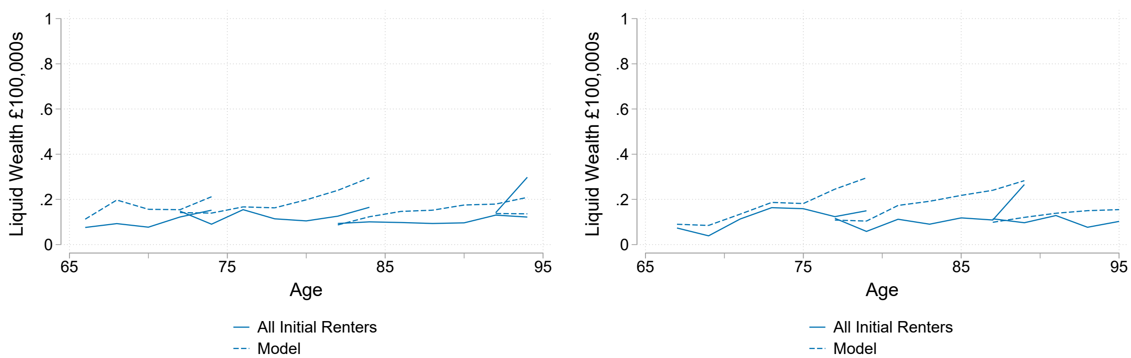


(a) Initial Owners

(b) Initial Renters

Figure A.8: Model Fit - Bequest Probabilities (ELSA Data & Simulations)

Solid lines: cohorts aged 64-68, 74-78 and 84-88 in 2002. Dashed lines: model simulations.



(a) Main Text Cohorts

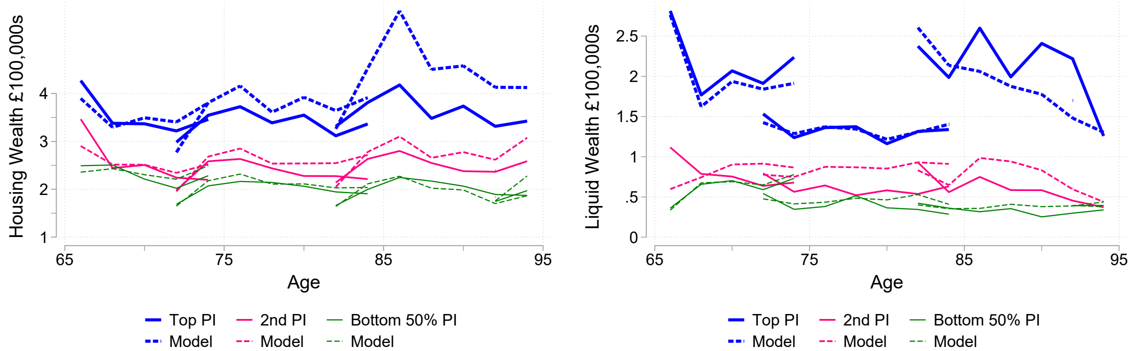
(b) Additional Cohorts

Figure A.9: Model Fit - Liquid Wealth (Initial Renters, ELSA Data & Simulations)

Panel (a): Solid lines: cohorts aged 64-68, 74-78 and 84-88 in 2002. Panel (b): Solid lines: cohorts aged 59-63, 69-73 and 79-83 in 2002. Dashed lines: model simulations.

L Numerical Procedure

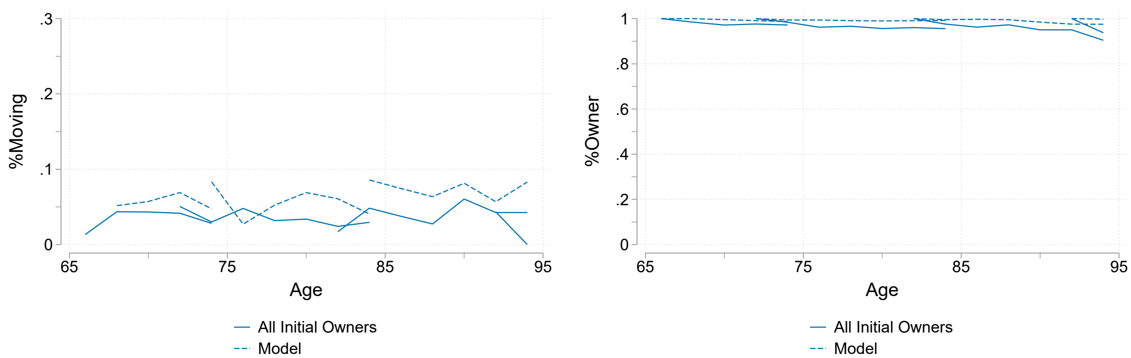
This appendix discusses the implementation of each of these procedures in more detail. I solve the model using backwards induction. At each age I compute the optimal savings, housing and consumption decision for all possible combinations of the state variables. I use the policy functions to compute the value function and iterate backwards.



(a) Mean Housing Wealth (b) Mean Liquid Wealth

Figure A.10: Model Fit - Wealth (Initial Owners, ELSA Data & Simulations)

Solid lines: cohorts aged 59-63, 69-73 and 79-83 in 2002. Dashed lines: model simulations.

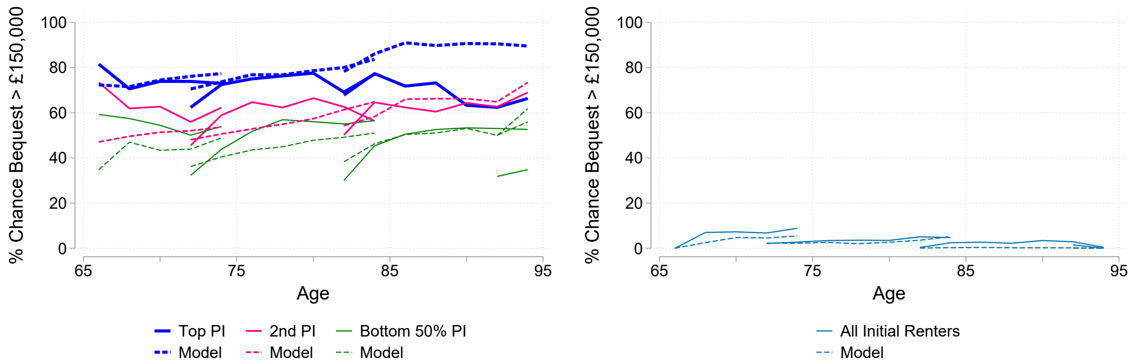


(a) Frequency of moves in the last 2 years (b) Homeownership rates by Cohort

Figure A.11: Model Fit - Mobility (Initial Owners, ELSA Data & Simulations)

Solid lines: cohorts aged 59-63, 69-73 and 79-83 in 2002.. Dashed lines: model simulations.

Discretization The model has four discrete state variables: age, health status, family structure and idiosyncratic bequest motive. There are four additional state variables that must be discretized: PI, housing, cash-on-hand, and the aggregate house price level as well as the additional transitory medical expense shock. PI is placed on an unequally spaced grid with 6 elements, where the grid points are concentrated towards the extremes of the distribution. Discretizeing tax policy is described in Appendix C.



(a) Initial Owners

(b) Initial Renters

Figure A.12: Model Fit - Bequest Probabilities (ELSA Data & Simulations)

Solid lines: cohorts aged 59-63, 69-73 and 79-83 in 2002. Dashed lines: model simulations.

Housing, which is both a state and a choice variable, is discretized[10] using a single point to denote current renters and 14 additional points for homeowners. The first 12 points of this grid are placed at the median of the 12 quantiles of the 2002 housing wealth distribution of my ELSA sample (conditional on being below £1,250,000 which covers over 99% of homeowners in the sample) with two additional points placed at £1,250,000 and £2,500,000.

To avoid spurious discontinuities arising from this approximation choice I use a finer grid to simulate the Regression Discontinuity results reported in Table 6. I use 31 possible housing choices and increase the number of points in the region of the tax discontinuity.

Cash-on-hand is placed on a grid with 82 points placed on an exponential scale. I use a small number of cash-on-hand points for the available resource because the solution method (described below) involves calculating an exact solution to the Euler Equation at each point. The log of the aggregate house price level is placed on a grid with 8 elements and the transitory component of medical expenses is placed on a grid with 3 elements.[11] Both use the method of Tauchen (1986).

Consumption and next period liquid wealth are not placed on a grid. Instead, individuals can choose any feasible level of consumption and next period liquid wealth. In total, the value function and policy functions are calculated for 3,542,400 combi-

[10]Numerous notches in the transaction tax mean that the budget set is non-convex. This necessitates the practical choice to discretize both state variable and housing choice.

[11]Results with 3 or 5 points for the transitory shock are indistinguishable

nations of state variables for each age and policy regime.

Computing the Solution to the Household's Problem In order to tractably solve this problem while maintaining a high level of accuracy I model the choice of housing as a discrete choice and follow the modified version of the endogenous grid-point method (EGM) algorithm for discrete continuous dynamic choice models in Iskhakov et al. (2017).[12] This variation on the EGM algorithm (Carroll, 2006) uses discrete choice (housing) conditional Euler equations to find conditional consumption and savings policies.

The continuation value of the model studied in this paper is not globally concave due to the presence of the consumption floor and the discrete housing decision which introduce kinks in the value function.[13] Consequently, the optimal policies delivered by the EGM step do not necessarily correspond to the optimal policies of the model. In order to ensure that the globally optimum consumption value is selected from the multiple solutions to the Euler Equation, due to the presence of non-convexities, I construct the (housing choice specific) upper envelope over segments of the (housing choice specific) value function in regions of the endogenous cash-on-hand grid where multiple solutions are detected. This procedure follows the method described in Iskhakov et al. (2017). For saving below the consumption floor, the marginal utility of saving is 0 and I follow Hubbard et al. (1995) in replacing the consumption floor with an indicator function in the Euler equation.

Unconditional policy and value functions are recovered by taking the maximum over each discrete choice. In this paper, cash-on-hand is not deterministic and I adapt their method by controlling for household savings (the deterministic component of cash-on-hand) as the end of period state variable.

The DC-EGM method specifies a grid for the post-decision savings state and returns the housing choice-specific optimal policies and value functions on an endogenous grid. Consequently, an extra step is needed before it is possible to compare the payoff associated with different housing choices for at initial cash-on-hand — the upper envelope calculation. I refer to this step as *regularization* and interpolate each of

[12] Fella (2014) also proposes an EGM algorithm for non-smooth non-convex problems

[13] Typically kinks which occur due to next period non-concavities are referred to as *primary* kinks while kinks that perpetuate backwards from future period non-concavities are referred to as *secondary* kinks. The presence of further uncertainty in future periods helps to smooth out some of the secondary kinks, but the approach used here accounts for both types of kinks.

the housing choice-specific value functions and policy functions onto a pre-specified exogenous cash-on-hand grid that is common across housing choices. In the *regularization* step, when interpolating the value function for households who choose to locate at the borrowing constraint for the next period I use the analytic solution for their value function (given the computed expected value function associated with the borrowing constraint) next period.

Optimal Policy in Simulation Simulated households do not have to live on the discrete points of the cash-on-hand space where housing choices are determined. Consequently, in the simulations I compute optimal choices assessing each housing choice and allowing simulated households to consume equally spaced proportions of their cash-on-hand (after housing adjustment) on a 501 point grid.

Minimising the GMM Criterion The GMM criterion function may have multiple local minima. MSM estimates are typically found by employing multi-start derivative free algorithms. I proceed in two steps.

First, I evaluate the objective function at 3,000 candidate parameter vectors drawn from a **14**-dimensional (the number of parameters to be estimated) *Sobol sequence*. I rank the vectors by the value of the objective and use the top 1% candidate parameter vectors to generate a new hypercube on the parameter space. I take the minimum and maximum parameter value in each dimension to produce the smallest hypercube surrounding the polytope defined by the convex hull of the highest ranked candidate parameter vectors. This greatly reduces the overall admissible parameter space without necessarily producing tight bounds on any individual parameter. I iterate on this procedure 5 times. Sampling points from the hypercube slows the rate at which regions of the parameter space are discarded, trading off the gain from reducing the parameter space against eliminating potentially profitable search regions too quickly. This is similar to the averaging of the best estimate and new draws from a Sobol sequence in the *Tik-Tak algorithm* described in Arnoudy et al. (2019). I iterate this step 5 times. The second stage samples from the new hypercube to generate starting values for the BOBYQA algorithm (Powell, 2009), a trust region based numerical optimizer. Typically, BOBYQA uses fewer evaluations of the objective function than other derivative free methods (for example the Nelder-Mead Simplex method Nelder and Mead, 1965). By combining the BOBYQA method with the multiple starting points selected above it appears that the parameters obtain the global minimum.

At each stage of the estimation I parallelize both the calculation of the dynamic programming problem and simulation and the initial candidate parameter vector using the facilities of the University College London Computer Science High Performance Computing Cluster.

In estimation, I construct moment conditions within the model by simulating 150,000 households drawn from the initial distribution. Inference corrects for the simulation error introduced by this procedure (see Equation A.11). Counterfactual exercises in Sections 7 and 8 use 500,000 simulated households each.

Computing Standard Errors I calculate the Jacobian of the moment conditions with respect to the parameters by numerical differentiation with a five point stencil in each dimension (central differencing).

References

Altonji, J. G. and L. M. Segal (1996). Small-Sample Bias in GMM Estimation of Covariance Structures. *Journal of Business & Economic Statistics 14*(3), 353–366.

Ameriks, J., A. Caplin, S. Laufer, and S. V. Nieuwerburgh (2011). The Joy of Giving or Assisted Living? Using Strategic Surveys to Separate Public Care Aversion from Bequest Motives. *The Journal of Finance 66*(2), 519–561.

Arnoudy, A., F. Guvenen, and T. Kleineberg (2019). Benchmarking Global Optimizers. Working Paper.

Battistin, E., A. Brugiavini, E. Rettore, and G. Weber (2009). The Retirement Consumption Puzzle: Evidence from a Regression Discontinuity Approach. *American Economic Review 99*(5), 2209–2226.

Besley, T., N. Meads, and P. Surico (2014). The incidence of transaction taxes: Evidence from a stamp duty holiday. *Journal of Public Economics 119*, 61–70.

Bozio, A., G. Laroque, and C. O'Dea (2017). Discount rate heterogeneity among older households: a puzzle? *Journal of Population Economics 30*(2), 647–680.

Carroll, C. D. (2006). The method of endogenous gridpoints for solving dynamic stochastic optimization problems. *Economics Letters 91*(3), 312–320.

Cocco, J. F. and P. Lopes (2020). Aging in Place, Housing Maintenance, and Reverse Mortgages. *The Review of Economic Studies 87*(4), 1799–1836.

Crawford, R. and P. Mei (2018). An overview of the ELSA 'end of life' data. Technical report.

Davidoff, T., P. Gerhard, and T. Post (2017). Reverse mortgages: What homeowners (don't) know and how it matters. *Journal of Economic Behavior & Organization 133*, 151–171.

De Nardi, M., E. French, J. B. Jones, and R. McGee (2021). Why Do Couples and Singles Save During Retirement? NBER WP 28828.

Duffie, D. and K. J. Singleton (1993). Simulated Moments Estimation of Markov Models of Asset Prices. *Econometrica 61*(4), 929–952.

Favilukis, J., S. C. Ludvigson, and S. Van Nieuwerburgh (2017). The Macroeconomic Effects of Housing Wealth, Housing Finance, and Limited Risk Sharing in General Equilibrium. *Journal of Political Economy 125*(1), 140–223.

Feldstein, M. S. (1969). The Effects of Taxation on Risk Taking. *Journal of Political Economy 77*(5), 755–764.

Fella, G. (2014). A generalized endogenous grid method for non-smooth and non-concave problems. *Review of Economic Dynamics 17*(2), 329–344.

Gelman, A. and G. Imbens (2017). Why High-Order Polynomials Should Not Be Used in Regression Discontinuity Designs. *Journal of Business & Economic Statistics 0*(0), 1–10.

Gourinchas, P.-O. and J. A. Parker (2002). Consumption over the Life Cycle. *Econometrica 70*(1), 47–89.

Hubbard, R. G., J. Skinner, and S. P. Zeldes (1995). Precautionary Saving and Social Insurance. *Journal of Political Economy 103*(2), 360–399.

Iskhakov, F., T. H. Jørgensen, J. Rust, and B. Schjerning (2017). The endogenous grid method for discrete-continuous dynamic choice models with (or without) taste shocks. *Quantitative Economics 8*(2), 317–365.

Jordà, s., K. Knoll, D. Kuvshinov, M. Schularick, and A. M. Taylor (2019). The Rate of Return on Everything, 1870–2015. *The Quarterly Journal of Economics 134*(3), 1225–1298.

Kolesár, M. and C. Rothe (2018). Inference in Regression Discontinuity Designs with a Discrete Running Variable. *American Economic Review 108*(8), 2277–2304.

Laitner, J. and F. T. Juster (1996). New Evidence on Altruism: A Study of TIAA-CREF Retirees. *The American Economic Review 86*(4), 893–908.

Lee, D. S. and D. Card (2008). Regression discontinuity inference with specification error. *Journal of Econometrics 142*(2), 655–674.

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics 142*(2), 698–714.

Nakajima, M. and I. A. Telyukova (2020). Home Equity in Retirement. *International Economic Review 61*(2), 573–616.

Nelder, J. A. and R. Mead (1965). A Simplex Method for Function Minimization. *The Computer Journal 7*(4), 308–313.

Pakes, A. and D. Pollard (1989). Simulation and the Asymptotics of Optimization Estimators. *Econometrica 57*(5), 1027–1057.

Pischke, J.-S. (1995). Measurement Error and Earnings Dynamics: Some Estimates from the PSID Validation Study. *Journal of Business & Economic Statistics 13*(3), 305–314.

Powell, M. J. D. (2009). The BOBYQA algorithm for bound constrained optimization without derivatives. Working Paper.

Tauchen, G. (1986). Finite state markov-chain approximations to univariate and vector autoregressions. *Economics Letters 20*(2), 177–181.

van der Klaauw, W. (2012). On the Use of Expectations Data in Estimating Structural Dynamic Choice Models. *Journal of Labor Economics 30*(3), 521–554.

van der Klaauw, W. and K. I. Wolpin (2008). Social security and the retirement and savings behavior of low-income households. *Journal of Econometrics 145*(1–2), 21–42.

Waters, T. (2017). TAXBEN: The IFS tax and benefit microsimulation model.