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Abstract

This study investigates the persistently low uptake of home equity release products in Australia by evaluating the Government's Home Equity Access Scheme (HEAS), which is integrated with means-tested pension income. We propose an alternative, flexible downsizing option that facilitates relocation and employ it to infer the demand for HEAS. Using a recursive utility model, we model retiree decisions around consumption, bequests, and exposure to house price and longevity risks across areas. The analysis accounts for means-testing rules and health-related expenditure variation across health states. Our findings show that asset-rich but income-poor retirees benefit the most from HEAS. However, the scheme's restrictive withdrawal rules, whereby allowable withdrawals decline as pension income increases, limit its usefulness for full pensioners and discourage participation by highly risk-averse individuals. We also find that HEAS is most attractive to those with low bequest motives and a high willingness to shift consumption over time. Furthermore, we identify key characteristics of suburbs where HEAS is more likely to be demanded: larger home equity sizes, lower current but higher predicted house prices, and longer life expectancy.

Keywords: Home equity release; Downsizing; Means tests; Social insurance; Recursive utility.

1 Introduction

Home equity release enables retirees to convert accumulated housing wealth into cash, helping fund daily spending as well as essential health and long-term care while reducing late-life financial risks. Demand side research predicts that unlocking home equity improves retirees' consumption and welfare (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017, 2020). However, the market size of home equity release products remains well below theoretical estimates in many economies (Davidoff et al., 2017; Dillingh et al., 2017; Fong et al., 2023; Fornero et al., 2016; Hanewald et al., 2025; Haurin and Moulton, 2017). Existing literature attributes this gap to precautionary motives (Nakajima and Telyukova, 2017), concerns about housing-market volatility and onerous loan terms (Chen and Yang, 2020), and strong bequest motives or sentimental attachment to the home (Dillingh et al., 2017), with comparable findings for Australia (Whait et al., 2019). The Australian Government's Home Equity Access Scheme (HEAS) offers an instructive case. Take-up is limited (Actuaries Institute, 2024), and its unique integration with the means-tested age pension calls for further investigation (Services Australia, 2023).[1] Therefore, this paper aims to explore the drivers of the limited uptake of HEAS, which include the design of this scheme and retirees' financial and risk profile, by considering a flexible downsizing option as an alternative.

Comparisons of HEAS with downsizing should account for spatial variation in both house prices and longevity.[2] For example, relocating to an area with lower house prices can increase liquidity infusion without substantially reducing living space. Moreover, the substantial differences in longevity across Australia underscore the potential benefits of relocating to optimise retirement outcomes.[3] These differences arise from variations in residents' health capital stocks and the environmental conditions of their current locations (Chetty et al., 2016; Grossman, 1972; Health Affairs, 2014). Consistent with this association, people who move to higher-mortality areas tend to experience higher mortality themselves (Deryugina and Molitor, 2018; Finkelstein et al., 2021).

Previous studies investigate the low demand for home equity release products from various perspectives, typically using time-separable additive utility frameworks to compare the expected utility of these products with alternative strategies for unlocking home equity. Benefits from residing in

[1] The age pension in Australia is a key component of the social welfare system for eligible retirees, determined through means tests assessing income and assets to establish payment rates.

[2] Retirees' preference for specific areas when relocating is also evidenced in empirical studies. Hugo (2013) notes that population growth is concentrated in urban peripheries, high-amenity areas, and resource-rich areas. Borsellino (2020) examines migration patterns among Australians aged 65 and older, revealing the emergence of new migration destinations with favourable life expectancy over the past 40 years.

[3] Focusing on areas at the Statistical Area Level 4 (SA4s) under the Australian Statistical Geography Standard (ASGS), provisional mortality data suggest that life expectancy at birth differs, ranging from 71.7 to 85.6 years for males and from 77.1 to 88.4 years for females (Australian Bureau of Statistics, 2023).

home equity are described by incorporating into their basic utility framework with either a constant elasticity of substitution (CES) utility (Cocco and Lopes, 2020; Piazzesi et al., 2007; Yogo, 2016), or a Cobb-Douglas utility (Hambel, 2020; Nakajima and Telyukova, 2017; Shao et al., 2019). Instead of using the time-separately additive utility, Xu et al. (2023) utilise the Epstein-Zin recursive utility framework (Epstein and Zin, 1989, 1991; Weil, 1989) to analyse the influence of home equity. Though their model provides a computationally efficient expression for optimal consumption, it restricts the release of home equity until death, reducing model flexibility and limiting insight into the role of home equity.[4] Moreover, existing approaches ignore spatial variation in house prices and longevity, even though these factors influence welfare comparisons across equity release strategies. Introducing such idiosyncratic risks within a recursive utility setting would improve computational efficiency and provide a more complete assessment of demand, thereby filling an important gap in the literature.

This paper employs a recursive Epstein-Zin utility framework to investigate the low uptake of HEAS, examining its relationship with the age pension and proposing a more flexible downsizing alternative which accounts for idiosyncratic longevity and house price risks. A Markov chain model is utilised in modelling health state transitions based on a generalised linear model (GLM) and to link health expenditures to each state (Fong et al., 2015; Xu et al., 2023).[5] To examine the relationship between home equity liquidation and health shocks, the model assumes that HEAS borrowers sell home equity and transition to residential aged care facilities (RACFs) upon reaching a severely disabled state, consistent with prior studies (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017, 2020; Shao et al., 2019).[6]

This paper also differs from prior studies incorporating home equity consumption into utility frameworks using either a CES or Cobb-Douglas utility function. Instead, we examine home equity consumption to compare the benefits of home equity release products, specifically assessing how much homeowners need to downsize to achieve the same utility as provided by products like HEAS. A smaller proportion of retained home equity suggests a higher demand for HEAS, as homeowners need to downsize more significantly to achieve the same level of utility that could have been directly obtained through HEAS. This comparison between HEAS and downsizing enables considering

[4] In other words, Xu et al. (2023) focus solely on the bequest motive, neglecting other objectives such as unlocking home equity for early liquidity infusion or deriving greater benefits from residing in substantial home equity within a recursive utility framework. Analysing the early liquidity infusion requires opportunities to realise home equity before death, discussed in research on home equity release products (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017).

[5] The original model relies on data from the University of Michigan Health and Retirement Study (HRS) spanning 1992–2018 (Health and Retirement Study, 2023) and is calibrated to the Australian context using SA4-level longevity data (Australian Bureau of Statistics, 2023). The calibration is based on empirical evidence indicating that variations in mortality rates predominantly affect the duration of the healthy stage rather than the length of time spent in disabled states (Harris and Sharma, 2018).

[6] This assumption reflects the inability to maintain home equity under severe disability (Service Australia, 2022).

idiosyncratic risks related to house prices and longevity.

Our results clarify why demand for HEAS remains subdued nationwide. We observe that asset-rich but cash-poor retirees benefit more from HEAS. Furthermore, the simulation reveals that HEAS is appealing to individuals with low bequest motives and high willingness to substitute consumption across different time periods. However, one significant difference between HEAS and other private market home equity release products is that HEAS offers more restrictive terms regarding maximum withdrawals. Particularly, for full pensioners needing substantial liquid assets as precautionary savings, their ability to withdraw funds under HEAS is markedly constrained. The restricted withdrawal capability of HEAS reduces its attractiveness, particularly for risk-averse retirees who perceive it as highly risky due to its inability to meet their needs for precautionary savings.[7]

The results also suggest possible reasons for the subdued demand at the postcode level. Using a min-max framework derived from the national-level HEAS-equivalent measure, we select suburbs where HEAS is more attractive and identify several characteristics of these suburbs.[8] The characteristics include larger home equity sizes, lower current but higher predicted house prices, and longer life expectancy. These factors help to explain the low demand for HEAS from a more granular perspective.

The first contribution of this study is the development of the model. We extend the recursive utility framework to examine how the interaction between the means-tested pension income and financial profiles shapes retirees' strategies. Compared with earlier work (e.g., Andréasson et al., 2017), our model provides a more detailed examination of means-testing rules, enabling a deeper discussion on scheme design at the national level. Moreover, the structure of this model leads to a computationally efficient simulation algorithm capable of accounting for idiosyncratic risks. In addition, by equating utility across HEAS and downsizing options, the model analyses resulting wealth trajectories, offering insights into the retirement-savings puzzle (Poterba et al., 2011; Suari-Andreu et al., 2019).

This study also contributes by offering a novel perspective on the low demand for home equity release products, addressing gaps in prior research that overlook area-specific risks. While downsizing is often considered an alternative to home equity release products (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017), existing studies neglect the potential benefits of relocating to another area.

[7] When the initial proportion of liquid assets is higher, more risk-averse homeowners prefer HEAS to their less risk-averse counterparts. This pattern aligns with findings by Blevins et al. (2020) in the US context.

[8] The demand for HEAS is evaluated by comparing the maximum retained home equity across various suburbs necessary to match the benefits of downsizing with those offered by HEAS. If the maximum retained home equity is lower in a particular suburb, we assume retirees choose to downsize and relocate to the corresponding suburb to achieve the same level of utility as that provided by utilising HEAS.

This omission results in the bias of estimating preference for home equity release products. Our model's flexibility in accounting for idiosyncratic house prices and longevity provides retirees with a more realistic and diverse set of choices, allowing for refined demand analysis at a granular level. The findings highlight the necessity of adjusting scheme design if HEAS is to become a mainstream retirement financing option.

The subsequent sections of this paper are structured as follows: Section 2 discusses the age pension system and home equity release in Australia. Section 3 presents the problem formation, encompassing models and empirical tactics. Section 4 shows estimated models and summarises statistics and parameters. Section 5 presents the main results concerning the influence of various variables on post-retirement strategies. Section 6 concludes this study and discusses future research.

2 Means-tested age pension and home equity release

This section models the design of HEAS, which is linked to means-tested pension income.[9]

2.1 Age pension

This paper models pension income as a means-tested benefit:

$$I_t = I_t\left(W_t,\ \mathbb{1}_{\text{Non-homeowner}}\right), \quad \text{where} -1 < \frac{\partial I_t}{\partial W_t} \leq 0. \tag{1}$$

where W_t represents the retiree's liquid assets at time t, and the indicator function $\mathbb{1}_{\text{Non-homeowner}}$ equals one if the individual is a non-homeowner and zero otherwise. The range of $\frac{\partial I_{t+1}}{\partial W_{t+1}}$ shows that each extra unit of liquid wealth lowers pension income, yet by less than a one-for-one amount. Equality $\frac{\partial I_{t+1}}{\partial W_{t+1}} = 0$ is achieved when a retiree is either a full pensioner or receives no pension at all. Moreover, because non-homeowner retirees are less privileged, they receive a higher pension income.

2.2 HEAS

This paper assumes retirees withdraw the restricted loan amount at the start of each period t. The ongoing mortgage interest is calculated at an annual rate ψ_t applied to the outstanding balance BAL_t.

Annual withdrawals are subject to two constraints. The first constraint stipulates that the combined loan draw-down and pension payment must not exceed 150% of the maximum pension rates,

[9] The Supporting Information file outlines the age pension rules and the design features of HEAS.

MPR_t.[10] The second constraint limits the outstanding loan balance to the principal limit, $\mathrm{PL}_{x,t}$, a ceiling determined by the borrower's age x and the value of the home equity, denoted as H_t. The latter reflects both the size of home, S_t, and the corresponding house price index (HPI).[11]

Based on the specified restrictions, the maximum annual payment that an individual can withdraw from HEAS is determined as follows:

$$A_t = \Big\{\min\Big[150\%\mathrm{MPR}_t - I_t, \mathrm{PL}_t - (1+\psi_{t-1})\,\mathrm{BAL}_{t-1}\Big]\Big\}^+, \tag{2}$$

which can be summarised as

$$A_t = A_t\left(W_t, \mathbb{1}_{\text{Non-homeowner}}, H_t, \mathrm{BAL}_t\right). \tag{3}$$

Here, the maximum payment depends on pension income I_t, captured by liquid wealth W_t and the indicator $\mathbb{1}_{\text{Non-homeowner}}$; the principal limit, which varies with home equity value H_t; and the outstanding balance BAL_t.

3 Problem formation

This section first introduces the influence of relocation. By incorporating area-specific health transition rates and HPIs, comparing and evaluating HEAS and downsizing options across diverse geographical areas become feasible. In addition, we employ a recursive utility framework to discuss borrowers' behaviour and analyse welfare implications with the calibrated multi-state model.

3.1 Impact of location

This subsection sets the foundation for discussing HEAS and downsizing options. The variables of interest in this subsection are generally separated into two categories: (i) the variables related to the original location o and the new location j; (ii) variables related to a non-mover in location j.

3.1.1 Home equity

A mover can sell the old residential property of size $S^{@o}$, and buy a new place of size S^{oj}. However, for a non-mover, the size of the living space is always $S^{@j}$. The extent of the change in the size of

[10]The simulation adjusts monetary variables for inflation, ensuring they are presented in real terms. As a result, all other monetary variables remain constant except for house prices.
[11]The simulation reveals a one to one relationship between age x and time t. Consequently $\mathrm{PL}_{x,t} = \mathrm{PL}_t$.

the house is computed according to the following equation:

$$\Delta S_t = S_t^{oj} - S_t^{@o} = \frac{H_t^{oj}}{\text{HPI}_{j,t}} - \frac{H_t^{@o}}{\text{HPI}_{o,t}}, \tag{4}$$

where $\text{HPI}_{\cdot,t}$ are HPIs across different areas at time t, indicating that retirees have the opportunity to relocate and access home equity without significantly diminishing its size, provided the HPI in the destination area is comparatively lower. If the retiree chooses to downsize but the new residential property is still located in the original area, $\text{HPI}_{o,t} = \text{HPI}_{j,t}$.

3.1.2 Health state and mortality

Following Xu et al. (2023), we model the health status of retirees with a four-state Markov chain: 1 (healthy), 2 (mildly disabled), 3 (severely disabled), and 4 (dead). This model allows the transitions between States 1 and 2 to capture the possibility of recovery from the mild disability (Braungart Fauth et al., 2007; Fong et al., 2015). In addition, this model does not allow transitions from State 3 to State 1 and State 2, indicating the low possibility of recovery from severe disability, which aligns with its chronic nature (Ferri and Olivieri, 2000; Olivieri and Pitacco, 2001). In this study, HEAS is assumed to be terminated for severely disabled users due to the presumed inability to maintain home equity effectively (Service Australia, 2022), which is consistent with previous studies (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017; Shao et al., 2019).

The transition intensities between two different states are denoted by $q_x(\cdot,\cdot)$, and the single-period (annual) transition probabilities $\pi_x(\cdot,\cdot)$, which are calculated using the transition intensities as follows:

$$\Pi_x = \begin{pmatrix} \pi_x(1,1) & \pi_x(1,2) & \pi_x(1,3) & \pi_x(1,4) \\ \pi_x(2,1) & \pi_x(2,2) & \pi_x(2,3) & \pi_x(2,4) \\ \pi_x(3,1) & \pi_x(3,2) & \pi_x(3,3) & \pi_x(3,4) \\ \pi_x(4,1) & \pi_x(4,2) & \pi_x(4,3) & \pi_x(4,4) \end{pmatrix} = \exp\left[\begin{pmatrix} q_x(1,1) & q_x(1,2) & q_x(1,3) & q_x(1,4) \\ q_x(2,1) & q_x(2,2) & q_x(2,3) & q_x(2,4) \\ 0 & 0 & q_x(3,3) & q_x(3,4) \\ 0 & 0 & 0 & 0 \end{pmatrix}\right], \tag{5}$$

where

$$\begin{aligned} q_x(1,1) &= -\big(q_x(1,2) + q_x(1,3) + q_x(1,4)\big), \\ q_x(2,2) &= -\big(q_x(2,1) + q_x(2,3) + q_x(2,4)\big), \\ q_x(3,3) &= -q_x(3,4). \end{aligned}$$

In line with the approach presented in Fong et al. (2015), we estimate health state transitions by employing a generalised linear model (GLM) featuring a logarithmic link function.

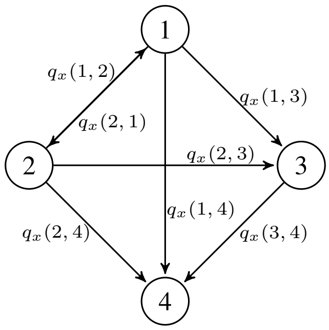


Figure 1. A four-state Markov chain model for health state transitions. States 1-4 represent the health conditions: healthy, mildly disabled, severely disabled, and dead. The notation $q_x(j,k)(j \in \{1,2,3\}, k \in \{1,2,3,4\})$ denotes the transition intensity from health state j to state k at a given age x.

The transition probability π_x^{oj} is the annual transition probability for an x-year-old mover from area o to area j. If this individual opts to move to a new place in the same area, $\pi_x^{oj} = \pi_x^{@j}$. We calibrate the transition model to the mortality rates at a granular geographical level. According to Finkelstein et al. (2021), the expression of the logarithmic average mortality rate of a mover from area o to area j is:

$$\log\left(\bar{m}^{oj}(x)\right) = g(x) + \kappa(\zeta_j + \bar{\vartheta}_j) + (1-\kappa)(\zeta_o + \bar{\vartheta}_o), \tag{6}$$

where $g(x)$ captures baseline age-specific mortality, ζ is the place effect of locations, and $\bar{\vartheta}$ is the average accumulated stock of health capital in locations. A calibrated parameter, $\kappa \in [0,1]$, is introduced to assign the relative weight of ζ, where a higher value of κ indicates that relocating to another area exerts a more pronounced effect on mortality. We assume that κ is uniformly consistent across different areas once calibrated.

To connect the health transition model and Equation (6), a parameter ς_x^{oj} is employed to make adjustments to the transition probability matrix Π_x in each area at the SA4 level. The modified annual transition probability matrix Π_x^{oj} is

$$\Pi_x^{oj} = \varsigma_x^{oj}[\Pi_x - \text{diag}(\Pi_x)] + D_x^{oj}, \quad \varsigma_x^{oj} \in [0,1], \tag{7}$$

where ς_x^{oj} is the input scaling factor, and D_x^{oj} is a diagonal matrix with diagonal elements

$$D_x^{oj}(i,i) = 1 - \sum_{j \neq i} \varsigma_x^{oj} \pi_x(i,j). \tag{8}$$

The underlying premise in employing adjustments is that the transition probabilities among various states are uniformly scaled down.[12] A higher value of ς_x^{oj} indicates a longer life expectancy and a reduced likelihood of transitioning out of the healthy states, as shown in the empirical evidence in Harris and Sharma (2018).

3.2 Utility preferences

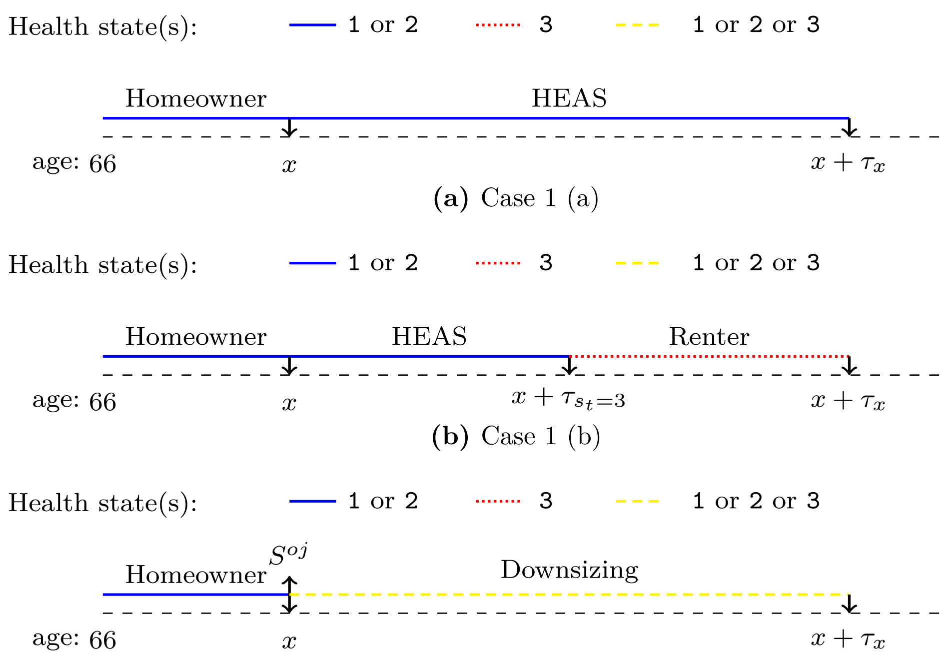
In this study, individuals benefit from consuming non-durable goods, C_t, and leaving bequests. The expected utility before the termination time T is:

$$\begin{aligned} V_t &= V(W_t, S, s_t, t) \\ &= \max_{O_t}\Big\{(1-\beta)C_t^{1-\rho} + \beta\Big[\mathbb{E}_t\Big[\sum_{k\neq 4}\pi_{x+t}(s_t, s_{t+1}=k)V(W_{t+1}, S, s_{t+1}=k, t+1)^{1-\gamma} \\ &\quad + \pi_{x+t}(s_t, s_{t+1}=4)b^\gamma W_{t+1}^{1-\gamma}\Big]\Big]^{\frac{1}{\theta}}\Big\}^{\frac{1}{1-\rho}}, \quad \theta = \frac{1-\gamma}{1-\rho}, \end{aligned} \tag{9}$$

where O_t represents the set of strategies at time t, specified in Subsection 3.2.3. The function V_t denotes the indirect utility value at time t, employing an Epstein-Zin framework (Epstein and Zin, 1989, 1991; Weil, 1989). In this context, β lies within $(0, 1)$ and represents the subjective discount factor, measuring individuals' preference to delay consumption. The parameter ρ is the reciprocal of the elasticity of intertemporal substitution (EIS). A lower EIS indicates a reduced willingness to postpone consumption, representing the preference for short-term gratification over long-term satisfaction. Additionally, γ stands for the coefficient of relative risk aversion, with γ greater than 1. Furthermore, b is a non-negative parameter representing the strength of the bequest motive. As the value of b increases, the strength of bequest motives becomes more pronounced.

Individuals optimise over home equity release and consumption to maximise the expected lifetime utility in Equation (9). The downsizing option is an alternative to HEAS. Figure 2 shows different strategies for using home equity based on health and age. Each line on the charts represents transitions of health states, from the age of retirement at 66 until death (represented by τ_x). Different styles of lines represent different combinations of health states. The expected utility for Cases 1 and 2 are compared to identify the more advantageous equity release strategies for retirees by comparing the expected utility of homeowners taking different strategies. These strategies are analysed across different health states and at varying geographic scales, beginning at the national level and then progressing to more granular levels.

[12]Multiplying every off-diagonal entry of the annual transition probability matrix Π_x by the factor ς_x^{oj} is mathematically equivalent to applying the same proportional-hazards factor ς_x^{oj} to each transition intensities $q_x(\cdot,\cdot)$.



(a) Case 1 (a)

(b) Case 1 (b)

(c) Case 2

Figure 2. Strategies for home equity release. Case 1(a): Individuals start as homeowners. At age x, they start using HEAS. They do not experience a decline in health to State 3 before death time τ_x. Case 1(b): Similar to Case 1(a), but under this scenario, they experience a decline in health to State 3 before death. They transition to RACFs at $\tau_{s_t=3}$. Case 2: Here, they start as homeowners. Then, they downsize - moving to a new property to free up some of the home's value.

3.2.1 Case 1: HEAS

In this subsection, we focus on HEAS users, whose behaviour is described by Case 1 in Figure 2. When entering into HEAS, individuals are typically in one of the two initial health states: healthy or mildly disabled, and they are allowed to maintain their homeownership while accessing their home equity. However, as their health deteriorates, particularly when transitioning to the severely disabled or dead state, the contract terminates. In the case of severe disability, the individual moves into RACFs to receive appropriate care and support. The first time an individual becomes severely disabled is denoted as $\tau_{s_t=3}$.

The equation describing the evolution of cash-on-hand for a current HEAS user is:

$$W_{t+1} = \begin{cases} \left(W_t + A_t^{@j} + I_t - C_t - HC_t(s_t) - HE_t^{@j}\right) R_t + \left[(1-\lambda_1)\, H_{t+1}^{@j} - BAL_{t+1}\right]^+, & \text{if } t \in \{\tau_x, \tau_{s_t=3}\}; \\ \left(W_t + A_t^{@j} + I_t - C_t - HC_t(s_t) - HE_t^{@j}\right) R_t, & \text{if else,} \end{cases} \tag{10}$$

where $HC_t(\cdot)$ denotes the dollar value of health care expenditure in period t, which varies with time and the current health state. In addition, $HE_t^{@j}$ denotes the dollar value of the housing expenses incurred in period t, including maintenance and insurance costs, influenced by $S^{@j}$. Here, gross interest rates are denoted by R_t, and λ_1 represents the proportional transaction costs incurred during the sale of home equity. This equation implies that, except for the withdrawals from HEAS, liquidity infusion occurs for HEAS users upon their instance of becoming severely disabled prior to death, at which point they are forced to sell their primary residence.

After transitioning to RACFs, the equation for the evolution of cash-on-hand is:

$$W_{t+1} = \left(W_t + I_t - C_t - HC_t(3) - RC_t^{@j}\right) R_t, \tag{11}$$

where $RC_t^{@j}$ denotes the rental costs, determined by the HPI and the size of RACFs, $S_t^{RACF@j}$, which is assumed to equal the size before transitioning to RACFs. For simplicity of computation, we assume the transitions to RACFs are restricted to the same area at the SA4 level.

3.2.2 Case 2: downsizing

This subsection further investigates the downsizing options in the Australian context, illustrated as Case 2 in Figure 2. The corresponding evolution of cash-on-hand is

$$W_{t+1} = \begin{cases} \left(W_t + I_t - C_t - HC_t(s_t) - HE_t^{@o} - (1+\lambda_2)\, H_t^{oj} + (1-\lambda_1)\, H_t^{@o}\right) R_t, & \text{if } t = 1; \\ \left(W_t + I_t - C_t - HC_t(s_t) - HE_t^{@o}\right) R_t + (1-\lambda_1)\, H_{t+1}^{oj}, & \text{if } t = \tau_x; \\ \left(W_t + I_t - C_t - HC_t(s_t) - HE_t^{@o}\right) R_t, & \text{if else}, \end{cases} \tag{12}$$

where λ_2 is the proportional transaction costs for buying home equity. This equation indicates that, within the model, downsizers have an opportunity to select a liquidity infusion at the start of the simulation.

3.2.3 Aged care subsidies

Aged care subsidies are provided for individuals who cannot afford basic living expenses. We assume that to maintain a minimum standard of living, the consumption level must not fall below a certain threshold denoted by C_f. In cases where an individual's budget cannot support the minimum consumption level, the government is assumed to be responsible for providing additional subsidies to increase consumption to this threshold, that is, at the start of the next period, if the liquid wealth W_{t+1} is less than C_f, it is reset to C_f.

3.2.4 Optimal strategies

The decision regarding utilising HEAS or downsizing is determined at age x. Similarly, the decision about the size of the retained home equity denoted as S^{oj}, is also made at age x. Therefore,

$$O_t = \begin{cases} \{S^{oj}, C_t\}, & \text{for } t = 1 \text{ and downsizing;} \\ C_t, & \text{if else.} \end{cases} \tag{13}$$

To maximise the expected lifetime utility in Equation (9), subject to the corresponding equation describing cash-on-hand evolution in Cases 1 and 2, the optimal consumption in period t is given by

$$\begin{aligned} C_t^* = &\Bigg\{\beta\Bigg\{\mathbb{E}_t\Bigg[\sum_{k\neq 4}\pi_{x+t}\left(s_t, s_{t+1}=k\right)V_{t+1}^{1-\gamma} + \pi_{x+t}\left(s_t, s_{t+1}=4\right)b^{\gamma}W_{t+1}^{1-\gamma}\Bigg]\Bigg\}^{\frac{1}{\theta}-1} \\ &\times \mathbb{E}_t\Bigg[R_t\Bigg[\sum_{k\neq 4}\pi_{x+t}\left(s_t, s_{t+1}=k\right)V_{t+1}^{\rho-\gamma}C_{t+1}^{-\rho}\mu_{t+1} + \pi_{x+t}\left(s_t, s_{t+1}=4\right)\frac{b^{\gamma}}{1-\beta}W_{t+1}^{-\gamma}\Bigg]\Bigg]\Bigg\}^{-\frac{1}{\rho}}, \end{aligned} \tag{14}$$

where

$$\mu_{t+1} = 1 + \frac{\partial(A_{t+1} + I_{t+1})}{\partial W_{t+1}}. \tag{15}$$

Here μ_{t+1} denotes the momentum of influence liquid wealth exerting on HEAS withdrawals and pension income at time $t+1$. The derivation of the optimal consumption is provided in Appendix A. According to Equation (3), under the assumption that individuals do not withdraw from HEAS unless the sum of pension income and withdrawals is equal to 150% maximum pension rate,[13] the momentum μ_{t+1} can be rewritten as

$$\mu_{t+1} = \begin{cases} 1, & \text{If } 150\%\mathrm{MPR}_{t+1} - I_{t+1} < \mathrm{PL}_{x,t+1} - (1+\psi)\,\mathrm{BAL}_t; \\ 1 + \frac{\partial I_{t+1}}{\partial W_{t+1}}, & \text{If } 150\%\mathrm{MPR}_{t+1} - I_{t+1} \geq \mathrm{PL}_{x,t+1} - (1+\psi)\,\mathrm{BAL}_t \text{ or no HEAS.} \end{cases} \tag{16}$$

Here, according to Equation (1), the momentum μ_{t+1} falls within the range of $(0, 1]$, and an increase in the coefficient of the derivative $\frac{\partial I_{t+1}}{\partial W_{t+1}}$ reduces the value of μ_{t+1}, considering the range of the derivative itself.

From Equation (14), a lower μ_{t+1} leads to a higher optimal consumption strategy, given that all utility indexes are positive. In addition, Equation (16) demonstrates that concerns about age pension reductions are insignificant for HEAS users until the principal limit is reached. Therefore, for those who are not HEAS users or cannot withdraw more due to reaching the principal limit, the coefficient

[13] This assumption suggests that if the remaining principal limit is insufficient to meet the 150% maximum pension rate, HEAS users cease withdrawals and defer access until the following year.

of the derivative $\frac{\partial I_{t+1}}{\partial W_{t+1}}$ is 1, which is the highest in the range and leads to the lowest μ_{t+1}. This can be interpreted as a tendency to consume more to reduce wealth and thereby qualify for a higher level of pension income. For HEAS users who have not reached the principal limit, the coefficient of the derivative $\frac{\partial I_{t+1}}{\partial W_{t+1}}$ is 0, which is the lowest and leads to the highest μ_{t+1}. This can be interpreted as a tendency to consume less, save more, and possibly extract more from home equity.

To simplify the simulation by avoiding the consideration of the principal limit, we approximate the momentum for HEAS users as

$$\mu_{t+1} = 1 + \frac{1}{2}\frac{\partial I_{t+1}}{\partial W_{t+1}}. \tag{17}$$

Because the coefficients of the derivative $\frac{\partial I_{t+1}}{\partial W_{t+1}}$ are 0 and 1 in the two different cases in Equation (16), the average of these coefficients is used to estimate the overall coefficient. This implies that we assume HEAS users are more willing to forgo their status as full pensioners than non-HEAS users or those reaching the principal limit, as they can withdraw more from home equity and benefit from consumption and higher precautionary savings. However, they still prefer to avoid excessive withdrawals from HEAS, especially compared to the scenario where the principal limit has not been reached.[14]

4 Data

This section outlines the data, models, and parameter calibrations underpinning our simulation analysis, providing the empirical and methodological basis for the subsequent interpretation of results. Methodological details are available in the Supporting Information file.

4.1 Macroeconomic scenarios

We predict three key macroeconomic indicators over the subsequent 30-year period: national HPIs, cash rate targets, and accumulative inflation. Macroeconomic scenarios are simulated using a lattice model calibrated to the predicted national HPIs. We consider the area-specific house price risk based on a hierarchical house price model, where logarithmic house price growth rate of the i^{th} suburb is modelled as a log-linear function. This framework nests a common macro factor structure while allowing each suburb to respond with its own sensitivity vector.

[14] This momentum affects optimal consumption only when HEAS users cease to be full pensioners, a scenario with a low probability given the baseline scenario's assumption of an initially illiquid financial profile.

4.2 Mortality and health transition

We fit national mortality to a Gompertz curve. SA4 areas are grouped into five life-expectancy bands, each linked to a calibrated multi-state transition matrix that reproduces the Gompertz mortality, with individuals entering healthy at 65 and dying no later than 105. Calibration indicates that lower mortality shifts additional years into good health, leaving expected durations in mild and severe disability at about 2.7 and 2.4 years. The national baseline employs the mid-band matrix.

4.3 Parameters

The parameters under the baseline scenario for utility and health expenditure are consistent with prior research but have been adapted to the Australian setting, using a exchange rate of AUD/USD=1.5 (Xu et al., 2023). An exception is made for the fixed expenditure for those in a severely disabled state to account for the costs associated with entry into RACFs. Given the rental yield rate (4%), initial house price, and the assumption that the average size of RACFs is equivalent to the initial living space, the annual payments for accommodation are approximately $35,000 at the national level.[15] A fixed payment of $40,000 is calibrated and set for those in severely disabled states. Consequently, the rental and fixed payments combination totals around $75,000, aligning closely with our estimates for total costs on entering RACFs and the values set in Xu et al. (2023). The maintenance ratios are consistent with the setting in Cocco and Lopes (2020). Because agents structure their fees and commissions differently, we assume the transaction cost rates for sellers and buyers after retirement are 1% and 3% respectively.

5 Results

This section presents the numerical results of utilising HEAS and downsizing options to release home equity. We compare these two options, considering various financial and risk profiles via sensitivity analysis.[16] In addition, we consider the geographically idiosyncratic house price and longevity risks and analyse the demand for HEAS at the postcode level, using the Greater Sydney Area as an example to evaluate and contrast these two options.[17]

[15]The symbol "$" represents Australian Dollar (i.e. AUD) throughout this paper.

[16]The Supporting Information file presents the algorithm's introduction and the national-level sensitivity analysis for the downsizing option and the health-transition model.

[17]According to Australian Securities & Investments Commission (2018), we assume that homeowners' average starting age x for home equity release either through HEAS or downsizing is 75 in our subsequent analysis.

Table 1. Parameters: means-tests for age pension, baseline scenario calibration, and other assumed values.

Description	Parameter	Value
Baseline scenario calibration		
Inverse of EIS	ρ	2
Risk aversion	γ	5
Bequest motive intensity	b	2
Initial wealth	W	\$40,000
Initial house price	H	\$900,000
Initial living space	S	193m^2
Size of RACF	S^{RACF}	S
Other assumed parameters		
Discount factor	β	0.96
Maintenance ratio	HE_t/H_t	1%
Rental yield rate	RC_t/H_t	4%
Nominal HEAS rate	ψ_t	3.95%
Transaction cost rate: seller	λ_1	1%
Transaction cost rate: buyer	λ_2	3%
Annual cost: healthy	$HC(1)$	\$1,500
Annual cost: mildly disabled	$HC(2)$	\$15,000
Annual cost: severely disabled state	$HC(3)$	\$75,000
Basic annual costs for RACF	$HC^{\text{RACF}}(3)$	\$40,000
Maximum pension rates	MPR	\$26,611

Notes: This table displays the calibrated parameters used under the baseline scenario. In the sensitivity analysis, adjustments are made to the bequest motives, EIS, and the allocations of total initial wealth. The size of RACF consistently matches the initial home equity size. Parameters for the means-tests of age pension are provided in the Supporting Information file.

5.1 HEAS enhances healthy ageing

This subsection analyses the liquid wealth and consumption of non-durable goods among homeowners who utilise HEAS. Users are categorised into three groups based on their health state during each time period, under the assumption that only healthy or mildly disabled individuals are eligible to access HEAS. Severely disabled individuals are considered former HEAS users who receive an early liquidity infusion upon transitioning to RACFs. The liquidity infusion is assumed to occur at the end of each period, as represented in Equation (10). Figure 3 illustrates the diverging trends in optimal consumption and liquid wealth for current and previous HEAS users.

According to the simulated results, healthy and mildly disabled individuals start with the same amount of liquid wealth and home equity, with liquid wealth levels increasing and then decreasing as they age until the time of death. This hump shape of liquid wealth for healthy users suggests most liquid wealth consists of savings for health expenditures (Ameriks et al., 2020; De Nardi et al., 2025). The wealth accumulation rate of the healthy group is higher because of their lower average health expenditures and longer expected remaining lifetime. The rate at which liquid assets are depleted later in life is limited by the amount of liquid wealth available.

For severely disabled individuals, liquidity infusion from the sale of home equity, after repaying the total loan amount, increases consumption levels at the later stages of retirement. However, even when liquidity is infused early in life, individuals consume less as they must save more to safeguard against future high expenditures, including health expenses and accommodation contributions. This illustrates the risks of losing home equity at an early age, which is associated with home equity release products (Cocco and Lopes, 2020; Nakajima and Telyukova, 2020).

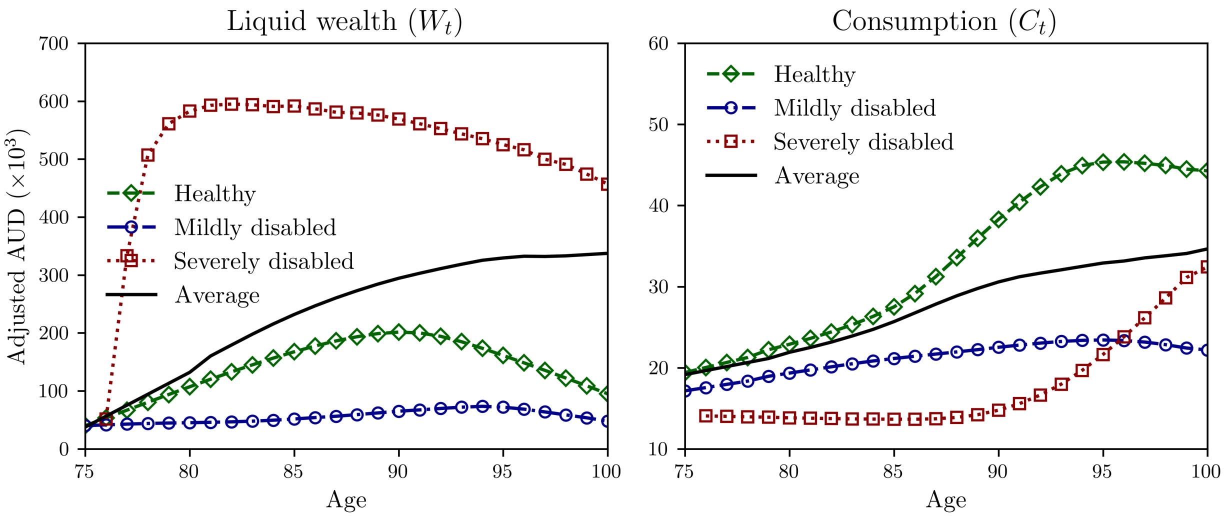


Figure 3. Simulated liquid wealth and consumption for current and previous HEAS users. This figure categorises users into three groups based on health states: healthy, mildly disabled, and severely disabled. All users are assumed to be healthy or mildly disabled at the beginning of the simulation. Liquidity infusion due to severe health deterioration is assumed to happen at the end of each time period.

A noticeable rises in liquid wealth and consumption trajectories arise from precautionary savings and possible liquidity infusion. This pattern is consistent with previous empirical works, which show that wealth can be stationary or rising for many years after retirement (Poterba et al., 2011). This suggests that limited income and liquid assets, combined with means-tested social insurance, help to understand the retirement-savings puzzle. Moreover, as time progresses, their consumption levels improve, assuming the availability of spending more for extra services in RACFs without considering limited consumption abilities due to disability. If we assume a health-state-dependent utility from consuming non-durable goods as previous studies (Shao et al., 2019; Yogo, 2016), HEAS users will consume less and save more, driven by a comparatively stronger bequest motive. To focus on the influence of limited withdrawals from HEAS, we do not consider the influence of health on the utilisation rate of consumption.

5.1.1 Restriction of HEAS payment limits total benefits

To examine whether the imposition of a principal limit diminishes the appeal of HEAS, we conduct simulations involving HEAS users with the same total assets but varying levels of initial liquidity at the outset of the simulation, as reflected in Figure 4.

The medium liquidity scenario, which serves as the baseline, encompasses retirees who possess significant home equity, valued at $900,000 but have limited liquid assets amounting to $40,000. The low liquidity scenario features retirees with large home equity ($940,000) and no liquid assets. The high liquidity case represents retirees with relatively lower home equity ($800,000) but comparatively more liquid wealth ($140,000).

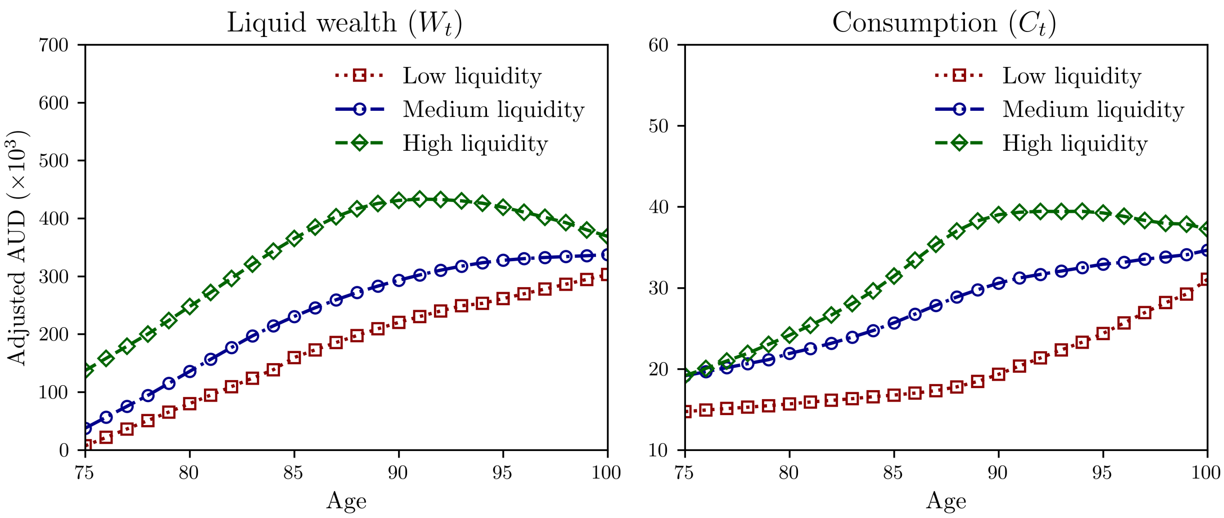


Figure 4. Comparative analysis of different levels of liquidity: impact on wealth accumulation and consumption. Three liquidity scenarios are presented as follows: low ($W = 0, H = \$940,000$), medium ($W = \$40,000, H = \$810,000$), and high liquidity ($W = \$140,000, H = \$800,000$).

Figure 4 shows that HEAS users with high liquidity generally maintain greater levels of liquid wealth, driven by interest accrued from precautionary savings when the likelihood of liquidity infusion after transitioning to RACFs is low. In contrast, HEAS users with low liquidity, typically full pensioners when healthy or mildly disabled (as indicated in Figure 3), cannot adequately fulfil their savings needs due to HEAS payments being capped at 50% of the maximum pension rate. Nakajima and Telyukova (2017) similarly observe that restricted withdrawal options in government-funded home equity release products reduce their attractiveness in the United States. Our findings indicate that, given the strong linkage between the age pension and HEAS, this limitation is particularly pronounced in Australia, especially for retirees with low incomes and limited liquid assets.

5.1.2 Sensitivity analysis: HEAS

We conduct a sensitivity analysis to investigate the impact of different risk profiles on the optimal consumption strategies and liquid wealth trajectories of HEAS users.[18]

We compare the baseline scenario, characterised by a moderate bequest motive intensity of $b = 2$, with two alternative scenarios: one with stronger bequest motives ($b = 10$) and another with weaker bequest motives ($b = \frac{1}{2}$). Figure 5(a) reveals a higher consumption level while saving less for those with lower bequest motives, echoing previous research (Lockwood, 2018).

We also analyse the impact of risk aversion by comparing scenarios with varying levels of risk aversion: $\gamma = 2$ and $\gamma = 7$, against the baseline scenario of moderate risk aversion $\gamma = 5$. As shown in Figure 5(b), HEAS users with higher risk aversion consume less and accumulate more precautionary savings. This result indicates that withdrawals from HEAS fail to meet the precautionary savings needs of risk-averse users.

Furthermore, we examine the influence of the EIS, represented by the inverse of ρ. We analyse a baseline scenario with a medium EIS ($\rho = 2$), and compare it with a higher EIS scenario ($\rho = \frac{5}{4}$) and a lower EIS scenario ($\rho = 5$). As shown in Figure 5(c), HEAS users with lower EIS prioritise short-term satisfaction over long-term gratification, thereby consuming more and saving less during the early years of retirement. However, the reduction in precautionary savings ultimately constrains their liquid wealth, limiting their financial capacity to increase consumption later in life.

5.2 Downsizing brings early liquidity infusion without health deterioration

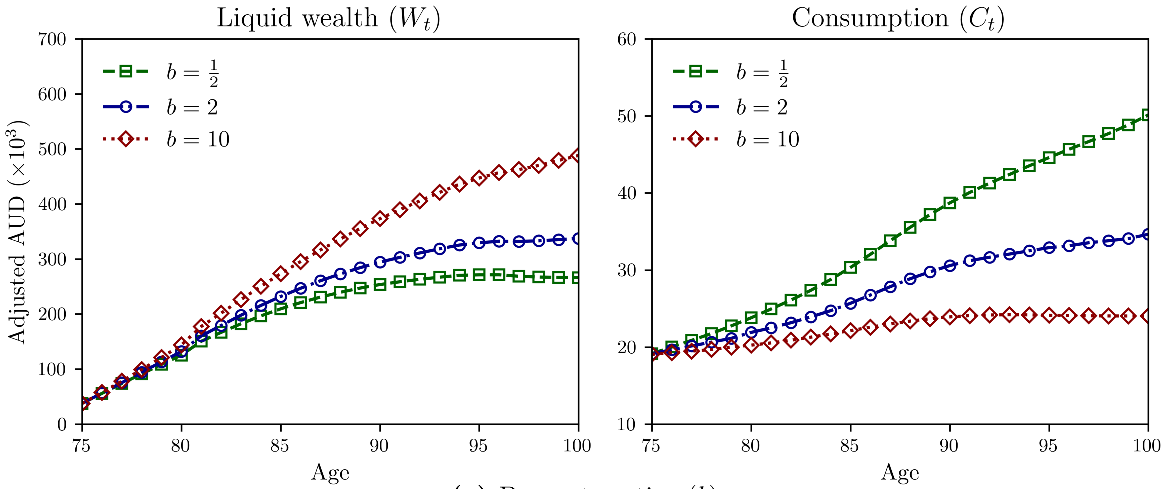
This subsection mainly focuses on homeowners' optimal strategies and liquid wealth trajectories after downsizing their primary residence. We focus on downsizing that deliver the same benchmark utility as HEAS. Unlike prior studies (Cocco and Lopes, 2020; Nakajima and Telyukova, 2017, 2020; Shao et al., 2019), our baseline model does not incorporate utility gains from home equity size. This assumption increases the relative benefit of liquidity infusion from downsizing, making it optimal for individuals to retain only a small portion of their home equity to maximise utility.[19] Accordingly, we concentrate on retirees who adopt downsizing strategies under an HEAS-equivalent framework.

Figure 6 shows liquid wealth and consumption after the HEAS-equivalent downsizing strategies about expected utility under the baseline scenarios.[20] This approach allows us to investigate the

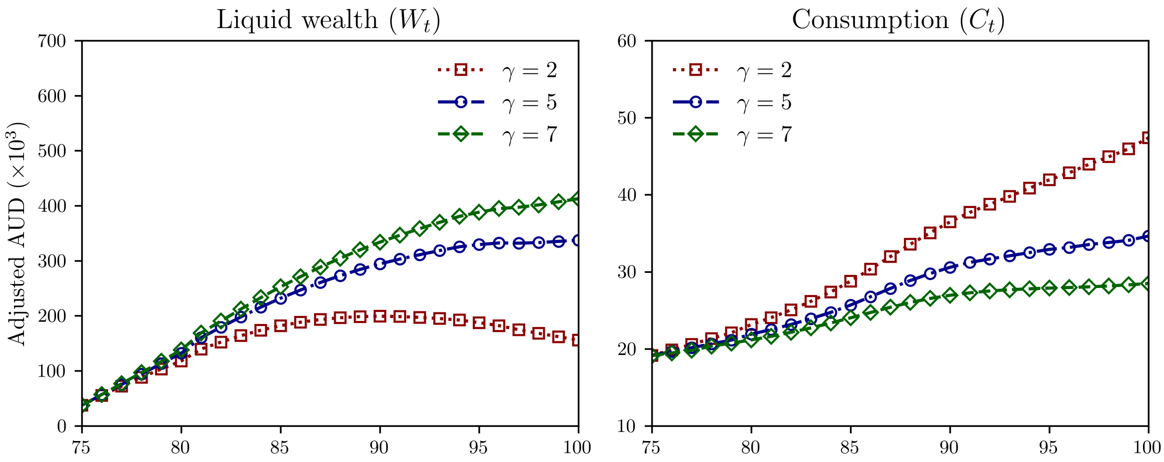
[18] The parameter values follow those used in previous research, such as Xu et al. (2023).

[19] Under the baseline scenario, the optimal proportion of home equity retained after downsizing averages 14.75%.

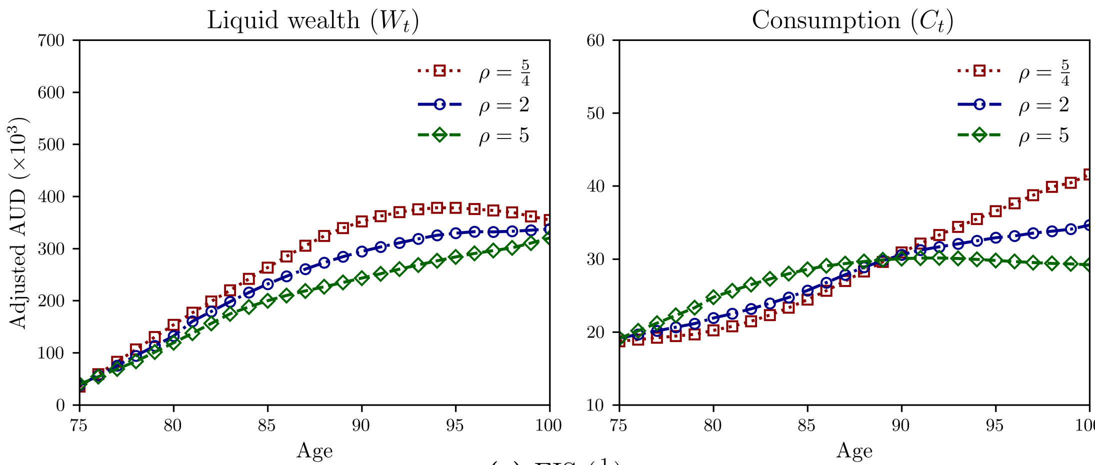
[20] On average, the HEAS-equivalent retained home equity sizes are 76.75% of the initial home equity size, significantly larger than the optimal level of 14.75%. Given the possibility of existing two downsizing strategies that bring the same utility as that of HEAS, our analysis only focuses on the strategy where the retained home equity surpasses the optimal level.



(a) Bequest motive (b)



(b) Risk aversion (γ)



(c) EIS ($\frac{1}{\rho}$)

Figure 5. Impact of risk profile on savings and consumption for HEAS users: bequest motive, risk aversion and EIS. The baseline and two additional scenarios are analysed for each parameter to assess the impact of different risk profiles while other parameters are fixed.

potential benefits of maintaining a larger home equity size in the following sections.

Figure 6 also indicates that wealth trajectories for healthier homeowners tend to be more concave, with average liquid wealth gradually being depleted after retirement. In addition, the HEAS-equivalent manner limits the asset unlocked from home equity, increasing the overall concavity of wealth trajectories. This suggests that the role of home equity can help understand the retirement-savings puzzle (Suari-Andreu et al., 2019).

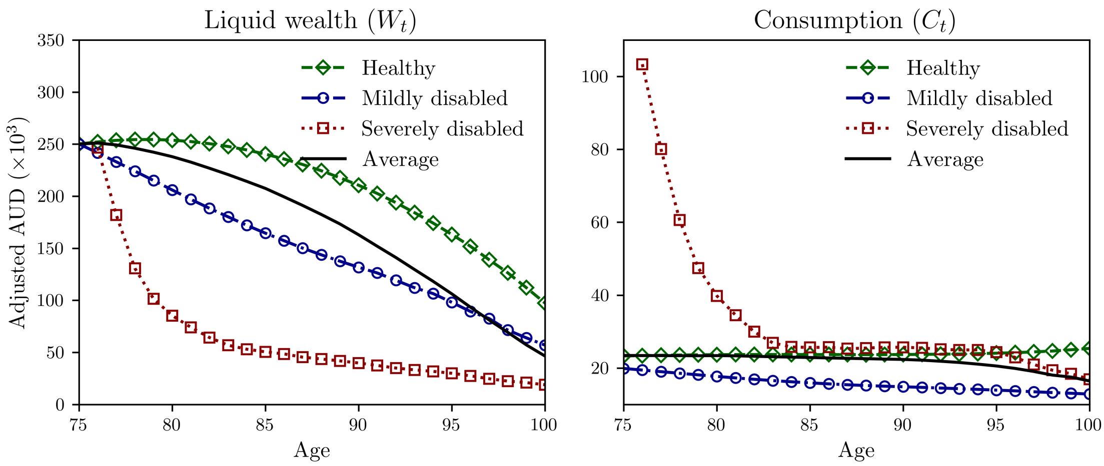


Figure 6. Simulated liquid wealth and consumption trajectories after downsizing: HEAS-equivalent case. This figure shows trajectories for homeowners in different health states after the HEAS-equivalent downsizing strategies under the baseline scenarios.

5.3 Comparing HEAS and downsizing

To measure the various benefits of living in home equity with different sizes, we assume that the expected utility obtained from living in a home with equity size S, denoted as $U(S)$, is analogous to the utility from consumption, disregarding any bequest motives, as indicated in Equation (9).[21] Therefore, the lifetime utility gained from living in home equity with size S is

$$U(S, s_t, t) = \left\{(1-\beta)\chi S^{1-\rho} + \beta\left[\sum_{k\neq 4} \pi_{x+t}(s_t, s_{t+1}=k)U(S, s_{t+1}=k, t+1)^{1-\gamma}\right]^{\frac{1}{\theta}}\right\}^{\frac{1}{1-\rho}}, \tag{18}$$

In this context, χ is a parameter that measures the relative utility derived from home equity compared to consumption.

We estimate the attractiveness of a HEAS-equivalent downsizing strategy by a specific ratio, α_S, representing the remaining utility gained from living in the retained home equity size. This ratio is calculated by dividing the utility from living in the retained portion of home equity by that obtained

[21]The macroeconomic scenarios do not influence the welfare gained from home equity size, and the home equity size has been chosen from the beginning of the simulation.

from living in the original total home equity. Because relocation under the baseline scenario is not allowed and the size of RACFs is assumed as the initial home equity size,

$$\alpha_S = \frac{U(S^{new@j})}{U(S^{@j})}, \text{ where } V_t^{\text{Downsizing}}(S^{new@j}) = V_t^{\text{HEAS}}. \tag{19}$$

Here, a lower value of α_S indicates a greater attractiveness of HEAS, implying that homeowners must endure more loss in the gratification from home equity size after downsizing to achieve the same utility level provided by HEAS. The parameter in Equation (18) is eliminated when dividing one utility function for home equity size by another.

Based on the measure of utility from home equity size after downsizing in a HEAS-equivalent mannner, we explore how varying risk and financial profiles influence the attractiveness of HEAS, which is shown in Table 2. Risk profiles are defined by bequest motive, risk aversion, and EIS. Financial scenarios are differentiated by liquidity levels: low ($W = 0, H = \$940,000$), medium ($W = \$40,000, H = \$900,000$), and high ($W = \$140,000, H = \$800,000$).

We observe that retirees with a stronger bequest motive, higher EIS, and less liquid assets tend to utilise HEAS to obtain the same level of utility because they suffer more utility loss from downsizing their home equity. We also find that more risky homeowners with lower liquid assets are more inclined to HEAS than more risk-averse (i.e. less risky) ones. These quantitative results are consistent with our previous sensitivity analysis.

However, when the liquidity increases, homeowners with a higher risk aversion prefer HEAS, indicating the adverse influence of limited HEAS withdrawals. To illustrate this, we analyse the impact of liquidity on liquid wealth trajectories for retirees who prefer to downsize with different risk aversion. Figure 7 indicates that more risk-averse individuals perceive HEAS as less attractive in the low liquidity scenario, because they have a higher requirement for precautionary savings. In contrast, less risk-averse retirees are better positioned to benefit from HEAS. As liquidity increases, HEAS becomes more appealing to those with higher levels of risk aversion.[22]

[22]This pattern aligns with Tajaddini et al. (2025), showing that individuals who trust the pension system more, signalling lower risk aversion, hold fewer investment properties outside the principal residence, demonstrating a reduced need for precautionary savings.

Table 2. Attractiveness of HEAS-equivalent downsizing strategies α_S: risk and financial profiles.

Liquidity	Bequest motive (b)			EIS ($1/\rho$)			Risk aversion (γ)		
	0.5	2	10	0.2	0.5	0.8	2	5	7
Low	0.741	0.778	0.818	0.786	0.778	0.769	0.774	0.778	0.786
Medium	0.754	0.792	0.831	0.794	0.792	0.788	0.789	0.792	0.795
High	0.769	0.809	0.837	0.811	0.809	0.799	0.816	0.809	0.802

Notes: This table compares the attractiveness α_S of downsizing strategies that offer the same utility as HEAS, tailored to various risk and financial profiles. Lower α_S levels correlate with increased HEAS attractiveness, necessitating significant downsizing and potential utility losses from decreased home equity. It assesses financial scenarios by liquidity: low ($W = 0, H = \$940,000$), medium ($W = \$40,000, H = \$900,000$), and high liquidity ($W = \$140,000, H = \$800,000$).

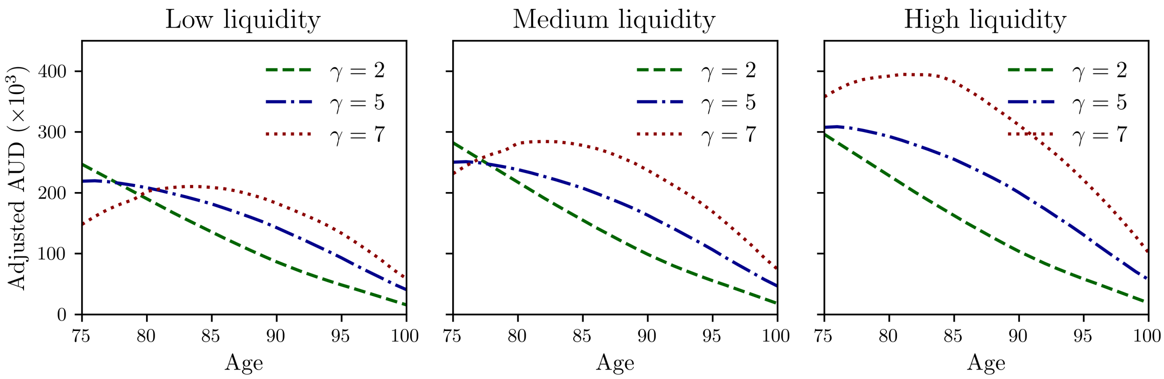


Figure 7. Impact of liquidity on liquid wealth trajectories for retirees who prefer to downsize with different risk aversion: HEAS-equivalent case. We evaluate financial scenarios based on liquidity levels: low ($W = 0, H = \$940,000$), medium ($W = \$40,000, H = \$900,000$), and high liquidity ($W = \$140,000, H = \$800,000$).

5.4 Demand analysis at the postcode level

This subsection discusses the attractiveness of HEAS when relocation between various areas is allowed.[23] The demand for home equity release is analysed using the average initial cash on hand, life expectancies, and the current house price level at the SA4 level.

Individuals in various areas adopt different downsizing strategies to ensure the utility matches utilising HEAS. Therefore, the definition of α_S in Equation (19) changes in the context of relocation. The one that leads to the maximum proportion of retained home equity utility is given to measure the relative attractiveness of utilising HEAS in a certain area:

$$\alpha_S = \max_j \frac{U(S^{oj})}{U(S^{@o})} = \max_j \frac{U\left(H^{oj}/\text{HPI}_j\right)}{U\left(H^{@o}/\text{HPI}_o\right)}, \text{ where } V_t^{\text{Downsizing}}(S^{oj}) = V_t^{\text{HEAS}} \text{ for all } j, \quad (20)$$

where

$$V_t^{\text{Downsizing}}(S^{oj}) = V_t^{\text{HEAS}} \text{ for all } j,$$

[23] The destination is assumed to be limited to within the same Greater Capital City Statistical Area.

with j being the index of suburbs. Similarly, the areas with a lower α_S are defined as more HEAS-preferred.

We list 20 suburbs with the lowest α_S to indicate they are HEAS preferred suburbs, as shown in Figure 8, with κ, defined in Equation (6), changing between 0 and 1.[24] When lifespan changes after relocation are not considered ($\kappa = 0$), the HEAS-preferred suburbs tend to exhibit distinct characteristics. These include substantial home equity size, relatively lower current house prices, and higher predicted house prices in the future.[25] These features greatly decrease the level of α_S, which indicates they must downsize more to achieve the equivalent utility using HEAS. As κ increases to 1, certain suburbs with relatively higher life expectancy transition to more HEAS-preferred. This occurs because individuals need to downsize more when moving to suburbs with shorter life spans to cover the loss in utility. This shift is perceived as a desire for an extended and healthy retirement.[26][27]

Therefore, this minimum-maximum framework facilitates the analysis of characteristics in HEAS-preferred suburbs, offering a novel perspective for understanding the demand for HEAS: The appeal of HEAS can be enhanced by adopting pricing that reflects idiosyncratic characteristics. For example, withdrawal limits could be relaxed in suburbs with smaller home equity sizes, higher current house prices, lower expected house price growth, or shorter life expectancy.

Table 3. Top 20 postcodes of HEAS preferred suburbs changing with parameter κ.

$\kappa = 0$					$\kappa = 1$				
2569	2571	2568	2555	2748	2569	2571	2555	2568	2178
2563	2178	2573	2574	2769	2164	2563	2769	2573	2574
2164	2567	2572	2768	2171	2748	$2154^{(+)}$	$2155^{(+)}$	$2153^{(+)}$	2171
$2774^{(-)}$	2559	$2558^{(-)}$	$2778^{(-)}$	$2759^{(-)}$	2768	2567	2572	$2126^{(+)}$	2559

Notes:

- This table shows the top 20 postcodes of suburbs selected in an ascending order based on the value of α_S. The left panel corresponds to $\kappa = 0$, while the right panel lists the updated postcodes after κ is increased to 1. The suffix $^{(+)}$ indicates newly included postcodes after increasing κ, whereas $^{(-)}$ indicates those replaced due to the change in κ.
- The postcodes presented correspond to the following suburbs in the Greater Sydney Area: 2569 – Bargo; 2571 – Berrima; 2568 – Cawdor; 2555 – Bringelly; 2748 – Orchard Hills; 2563 – Menangle Park; 2178 – Kemps Creek; 2573 – Douglas Park; 2574 – Hill Top; 2769 – The Ponds; 2164 – Wetherill Park; 2567 – Harrington Park; 2572 – Buxton; 2768 – Glenwood, Parklea, & Stanhope Gardens; 2171 – Cecil Hills; 2774 – Oran Park; 2559 – Leppington; 2558 – Claymore; 2778 – Rossmore; 2759 – Saint Clair & Erskine Park; 2154 – Castle Hill; 2155 – Rouse Hill; 2153 – Baulkham Hills; 2126 – Cherrybrook.

[24] More details on the selected suburbs are provided in Table 3.

[25] Our results align with Davidoff (2015), highlighting that the US Home Equity Conversion Mortgage, analogous to HEAS, is more attractive during housing booms.

[26] The spatial summary of cash-on-hand, longevity, and housing data are provided in the Supplementary Information file.

[27] The result shows that even when the assumption regarding the impact of relocation on mortality is significantly altered, the top 10 preferred suburbs remain largely unchanged. This indicates that home equity has a more dominant influence than longevity.

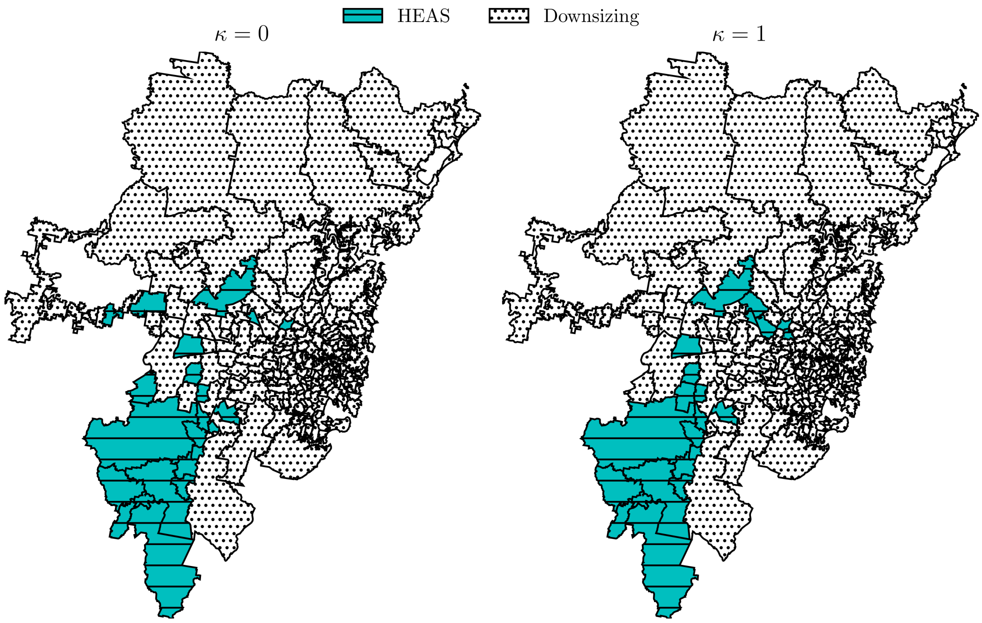


Figure 8. HEAS preference across suburbs in the Greater Sydney Area. This figure shows that 20 suburbs preferred for HEAS are ranked by the lowest α_S values, varying κ in $\{0, 1\}$. When $\kappa = 0$, lifespan changes after relocation are not considered, and these suburbs feature substantial home equity and lower house prices, indicating a need for significant downsizing to match HEAS utility. When $\kappa = 1$, suburbs with higher life expectancies gain favour, highlighting a shift toward valuing a longer, healthier retirement.

6 Conclusion and discussion

This paper advances the literature by developing a recursive utility framework, incorporating the Australian means-tested pension and contrasting the pension-dependent HEAS with downsizing. It derives a utility-equivalent metric that inversely tracks HEAS demand, which can be applied at granular geographical scales.

Our results indicate that asset-rich but cash-poor retirees benefit most from HEAS. However, rarly liquidation after moving to RACFs reduces these gains, and HEAS withdrawal caps fall short for homeowners who rely heavily on the age pension. Therefore, highly risk-averse individuals regard HEAS as too risky, although a higher initial share of liquid assets makes HEAS more appealing to them. After accounting for idiosyncratic house prices and health transitions, we find that HEAS is preferred in suburbs with larger home equity sizes, lower current but higher predicted house prices, and longer life expectancy, highlighting the need to refine scheme design if HEAS is to become a mainstream source of retirement financing.

While this study provides insights into the interplay between HEAS and means tests for age pension, it does not account for other means-tested social insurances for long term care. Given the potential impact of these tests on retirees' financial calculations and decisions, health-related expenditures may be biasedly estimated. This could, in turn, influence our understanding of the demand for home equity release in the retirement phase. Future research could incorporate the role of these services into this framework, ensuring a more accurate and comprehensive analysis.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to revise the grammar and correct typographical errors. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Appendix A Derivation of the optimal consumption

The first-order condition for C_t implies that

$$\begin{aligned}(1-\beta)C_t^{-\rho} = \beta \left\{ \mathbb{E}_t \left[\sum_{k\neq 4} \pi_{x+t}\left(s_t, s_{t+1}=k\right) V_{t+1}^{1-\gamma} + \pi_{x+t}\left(s_t, s_{t+1}=4\right) b^{\gamma} W_{t+1}^{1-\gamma} \right] \right\}^{\frac{1}{\theta}-1} \\ \times \mathbb{E}_t \left[R_t \sum_{k\neq 4} \pi_{x+t}\left(s_t, s_{t+1}=k\right) V_{t+1}^{-\gamma} \frac{\partial V_{t+1}}{\partial W_{t+1}} + R_t \pi_{x+t}\left(s_t, s_{t+1}=4\right) b^{\gamma} W_{t+1}^{-\gamma} \right].\end{aligned} \tag{21}$$

Let C_t^* denote the optimal consumption at time t, and W_{t+1}^* denote the liquid assets in period $t+1$ under the optimal consumption in period t. The first-order condition for W_t implies that

$$\begin{aligned}C_t^* = \Bigg\{ \beta \Bigg\{ \mathbb{E}_t \Bigg[\sum_{k\neq 4} \pi_{x+t}\left(s_t, s_{t+1}=k\right) V_{t+1}^{1-\gamma} + \pi_{x+t}\left(s_t, s_{t+1}=4\right) b^{\gamma} W_{t+1}^{1-\gamma} \Bigg] \Bigg\}^{\frac{1}{\theta}-1} \\ \times \mathbb{E}_t \Bigg[R_t \Bigg[\sum_{k\neq 4} \pi_{x+t}\left(s_t, s_{t+1}=k\right) V_{t+1}^{\rho-\gamma} C_{t+1}^{-\rho} \mu_{t+1} + \pi_{x+t}\left(s_t, s_{t+1}=4\right) \frac{b^{\gamma}}{1-\beta} W_{t+1}^{-\gamma} \Bigg] \Bigg] \Bigg\}^{-\frac{1}{\rho}}.\end{aligned} \tag{22}$$

The relationship between $\partial W_{t+1}^*/\partial W_t$ and $\partial C_t^*/\partial W_t$ can be derived from budget constraint equations:

$$\frac{\partial W_{t+1}^*}{\partial W_t} = \left(1 + \frac{\partial (A_t + I_t)}{\partial W_t} - \frac{\partial C_t^*}{\partial W_t}\right) R_t. \tag{23}$$

Replacing $(1-\beta)\left(C_t^*\right)^{-\rho}$ in Equation (22) with Equation (21), and using the relationship shown in (23), we have

$$\frac{\partial V_t}{\partial W_t} = (1-\beta)\left(1 + \frac{\partial (A_t + I_t)}{\partial W_t}\right) V_t^{\rho} C_t^{-\rho}, \tag{24}$$

which is the envelope condition for the preferences. Therefore, the first-order equation for consumption C_t can be written as

$$\begin{aligned}C_t^* = \Bigg\{ \beta \Bigg\{ \mathbb{E}_t \Bigg[\sum_{k\neq 4} \pi_t\left(s_t, s_{t+1}=k\right) V_{t+1}^{1-\gamma} + \pi_t\left(s_t, s_{t+1}=4\right) b^{\gamma} W_{t+1}^{1-\gamma} \Bigg] \Bigg\}^{\frac{1}{\theta}-1} \\ \times \mathbb{E}_t \Bigg[R_t \Bigg[\sum_{k\neq 4} \pi_t\left(s_t, s_{t+1}=k\right) V_{t+1}^{\rho-\gamma} C_{t+1}^{-\rho} \mu_{t+1} + \pi_t\left(s_t, s_{t+1}=4\right) \frac{b^{\gamma}}{1-\beta} W_{t+1}^{-\gamma} \Bigg] \Bigg] \Bigg\}^{-\frac{1}{\rho}},\end{aligned} \tag{25}$$

where

$$\mu_{t+1} = 1 + \frac{\partial (A_{t+1} + I_{t+1})}{\partial W_{t+1}}. \tag{26}$$

Appendix B Algorithm for simulation

This algorithm employs a backward method to account for both HEAS and the downsizing option. Future macroeconomic scenarios at time $t+1$ are classified into upward and downward situations compared to the current situation at time t based on house prices. The average of these conditions estimates the expectation in Equations (9) and (14) when calculating value functions given the current wealth, including liquid asset and home equity, macroeconomic indicator, and health state. The optimal consumption is determined by minimising this absolute difference between theoretical and numerical consumption (`scipy.optimize.minimize_scalar`). The relationships between wealth levels on the grids, value functions, and consumption are interpolated or extrapolated and stored as functions. These relationships from the latter period are then linearly interpolated and extrapolated when calculating consumption and value functions in the current period (`scipy.interpolate.interp1d`).[28]

For HEAS users, the algorithm is divided into two parts: one for the severely disabled and one for the healthy/mildly disabled. The value functions for the severely disabled state are established first because there is no recovery from this state. The value functions for the healthy/mildly disabled states are similar except for the transition rates between different states. The value functions for the severely disabled are incorporated to consider the severe health deterioration. For the downsizing option, the proportion of the retained home equity is iterated over a linear space from 0.025 to 0.975 with 50 intervals. The value functions and consumption on the wealth grids are solved backward for each initial downsizing options.

Both consumption and wealth should be restricted by specific boundaries. Consumption is limited by possessed liquid wealth and the corresponding lowest consumption level C_f, which is the common lower boundary. For current HEAS users and downsizers, the upper wealth boundary is estimated by assuming they always remain healthy and adopt the lowest level of consumption. For severely disabled individuals who used to be HEAS users, the upper boundary is estimated by the liquidity infusion after being forced to sell the primary residence. All boundaries are estimated under medium-level macroeconomic scenarios.

[28] The algorithm is implemented in Python, and key functions are noted in brackets throughout this Appendix.

Supporting Information

This Supporting Information file documents the empirical inputs and calibration steps that underpin the models and results reported in the main paper. Section A outlines the means tests that govern the Australian age pension and the withdrawal constraints attached to the Home Equity Access Scheme (HEAS). Section B details the location-specific mortality and health-transition models. Section C sets out the vector-autoregression and hierarchical house-price model used to generate the macroeconomic and market scenarios. Sections D and E present sensitivity analysis that compare downsizing with HEAS under alternative preference parameters and under different assumptions about health transitions. Section F offers spatial summaries of baseline cash on hand, life expectancy, and housing characteristics across the Greater Sydney Area.

A Age pension and HEAS

The Australian age pension system is connected to HEAS payments. This section explores the means tests applied to the age pension and discusses the payments offered through HEAS.

A.1 Means-tests for age pension

Means tests for age pension in Australia determine pension payments, which assesses retirees' income and assets to ensure assistance is reasonably allocated. The age pension income for an individual is

$$I_t = (\mathrm{MPR}_t - \max\{\mathrm{Means}_{\mathrm{income},t}, \mathrm{Means}_{\mathrm{assets},t}\})^+, \tag{A.1}$$

where MPR_t represents the maximum pension rates, and $\mathrm{Means}_{\mathrm{income},t}$ and $\mathrm{Means}_{\mathrm{assets},t}$ are the respective outcomes of the income and assets tests. This equation implies the test that results in the lowest payment rate applies.

The income test assesses the regular income of retirees in two parts. The first part is generated from other social security benefits, which does not include funding from HEAS. The second part is deemed from the financial assets of individuals (Retirement Essentials, 2024). The current deeming rates are 0.25% on financial assets up to threshold $\beta_{\text{income},t}$ and 2.25% on financial assets over these thresholds.[1] Therefore, the means of income tests is

$$\text{Means}_{\text{income},t} = \frac{\text{MPR}_t}{\text{TS}^{(2)}_{\text{income},t} - \text{TS}^{(1)}_{\text{income},t}} \times \left[0.25\%W_t + 2\%(W_t - \beta_{\text{income},t})^+ - \text{TS}^{(1)}_{\text{income},t}\right]^+, \quad \text{(A.2)}$$

where W_t is financial assets of the individual, and $\text{TS}^{(\cdot)}_{\text{income},t}$ denotes different income thresholds. The positive-part operator ensures that no reduction in pension applies until deemed income exceeds the lower threshold. The fraction in front rescales the excess deemed income so that the final pension income is fully phased out precisely when the deemed income reaches the upper threshold $\text{TS}^{(2)}_{\text{income},t}$. Thus, if deemed income lies below $\text{TS}^{(1)}_{\text{income},t}$ the test yields zero, whereas any income above $\text{TS}^{(2)}_{\text{income},t}$ produces a tested result that exceeds the maximum pension rate.[2]

Similarly, retirees' assets are tested with different thresholds. Home equity is not considered an asset when calculating pension if it is a primary residence. However, it affects how age pension is assessed under the assets test. According to Service Australia (2024), the means of assets tests is

$$\text{Means}_{\text{assets},t} = \frac{\text{MPR}_t}{\text{TS}^{(2)}_{\text{assets},t} - \text{TS}^{(1)}_{\text{assets},t}} \times (W_t - \text{TS}^{(1)}_{\text{assets},t})^+, \quad \text{(A.3)}$$

where

$$\text{TS}^{(1)}_{\text{assets},t} = \beta_{\text{assets},t}\mathbb{1}_{\text{Non-homeowner}} + \alpha_{1\text{assets},t}, \quad \text{and} \quad \text{TS}^{(2)}_{\text{assets},t} = \beta_{\text{assets},t}\mathbb{1}_{\text{Non-homeowner}} + \alpha_{2\text{assets},t}. \quad \text{(A.4)}$$

Here, the indicator function $\mathbb{1}_{\text{Non-homeowner}}$ shows whether individuals are non-homeowners at time t. As in the income test, $\text{TS}^{(\cdot)}_{\text{assets},t}$ indicates different thresholds regarding assets tests, influenced by parameters $\alpha_{\text{assets},t}$ and $\beta_{\text{assets},t}$. These thresholds also vary with housing status because non-homeowner retirees, being less privileged, receive a higher pension income.

The final results from means tests of age pension are shown as a stepwise function of W_t when there are no other sources of income except for HEAS payments, as shown in Figure A.1.

[1] The deemed income follows a piecewise structure based on the threshold $\beta_{\text{income},t}$. Specifically, when $W < \beta_{\text{income},t}$, It is given by $0.25\%W$. When $W > \beta_{\text{income},t}$, it takes the form $0.25\%\beta_{\text{income},t} + 2.25\%(W - \beta_{\text{income},t})$, which simplifies to $0.25\%W + 2\%(W - \beta_{\text{income},t})$.

[2] Table A.1 presents the parameter values used for means tests. The symbol "$" represents Australian Dollar (i.e. AUD) throughout this file.

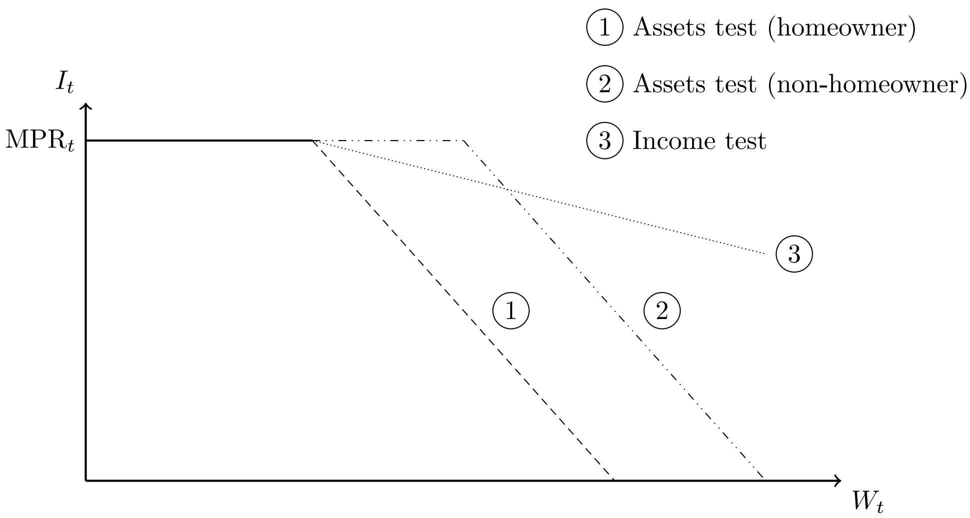


Figure A.1. Means tests for age pension: a comparative analysis between homeowner and non-homeowner situations. This figure illustrates how the assets test is the primary determinant in means test outcomes for homeowners. In contrast, for non-homeowners, income tests initially play a crucial role in defining pension income limits before the assets test becomes the principal limiting factor.

Table A.1. Parameters: means-tests for age pension.

Description	**Parameter**	**Value**
Threshold of income test: 1st	$\text{TS}^{(1)}_{\text{income}}$	\$5,304
Threshold of income test: 2nd	$\text{TS}^{(2)}_{\text{income}}$	\$63,351
Threshold of assets test (homeowner): 1st	$\alpha_{1\text{assets}}$	\$301,750
Threshold of assets test (homeowner): 2nd	$\alpha_{2\text{assets}}$	\$674,000
Increase in deeming thresholds of income test	β_{income}	\$60,400
Increase in thresholds of assets test (non-homeowner)	β_{assets}	\$242,000
Annual maximum pension rates	MPR	\$26,611

Notes: The data are drawn from Services Australia (2024) and Service Australia (2024). We express all values in current dollars and model inflation explicitly in the simulation; therefore, the parameters appear as time-dependent terms in the formulas.

A.2 Withdrawals from HEAS

In this paper, we assume a HEAS user withdraws the restricted loan amount as a lump sum payment at the start of each period t.[3] The ongoing mortgage interest is calculated as an annual rate against the outstanding balance, BAL_t. The outstanding balance at the beginning of the period t is defined as follows:

$$\text{BAL}_t = (1 + \psi_{t-1})\,\text{BAL}_{t-1} + A_t, \quad t = 1, 2, \ldots, \tag{A.5}$$

[3] A retiree can obtain a loan from HEAS through a fortnightly payment plan, an annual lump sum payment, or a combination of both.

where A_t is the maximum annual HEAS payment drawn at the beginning of each period and ψ_t is the fixed HEAS interest rate published in the Australian Government Gazette (Services Australia, 2023).

One restriction on HEAS withdrawal is that the combined loan and pension payment cannot exceed 150% of MPR_t, subject to future inflation adjustments. The other restriction is that the total loan amount a borrower owns is constrained by the principal limit, denoted as $\mathrm{PL}_{x,t}$, which ensures that the loan amount remains within acceptable limits and aligns with the borrower's circumstances. The principal limit is based on both the borrower's age x and the value of the home equity used as collateral for the loan:

$$\mathrm{PL}_{x,t} = \lfloor 10^{-4} H_t \rfloor \times \mathrm{ACP}_x, \tag{A.6}$$

where ACP_x is the age component listed in Table A.2, H_t is the current house price, and S_t is the underlying home-equity size relevant for H_t. The floor operator rounds the house value down to the nearest $10,000 before applying the age factor ACP_x.

Table A.2. Age component amount (ACP_x).

Age	Amount	Age	Amount	Age	Amount	Age	Amount	Age	Amount
60	$2,080	66	$2,630	72	$3,330	78	$4,210	84	$5,330
61	$2,160	67	$2,740	73	$3,460	79	$4,380	85	$5,550
62	$2,250	68	$2,850	74	$3,600	80	$4,560	86	$5,770
63	$2,340	69	$2,960	75	$3,750	81	$4,740	87	$6,000
64	$2,430	70	$3,080	76	$3,900	82	$4,930	88	$6,240
65	$2,530	71	$3,200	77	$4,050	83	$5,130	89	$6,490
								90+	$6,750

Notes: This table shows the age component amount, reflecting how age affects withdrawals under HEAS (Service Australia, 2023).

Based on the specified restrictions, the maximum annual payment that an individual can withdraw from HEAS is determined as follows:

$$A_t = \Big\{ \min\Big[150\%\mathrm{MPR}_t - I_t, \mathrm{PL}_{x,t} - (1+\psi_{t-1})\,\mathrm{BAL}_{t-1} \Big] \Big\}^+ . \tag{A.7}$$

The positive-part operator enforces non-negative withdrawals, whereas the inner minimum operator applies whichever of the two concurrent constraints is more restrictive, thereby ensuring that each advance remains within the policy's admissible bounds. In this setting, the available payment varies with house-price uncertainty (through $\mathrm{PL}_{x,t}$) and with inflation (through MPR_t).

B Mortality and Health Transition Modelling

B.1 Mortality model

A continuous-time survival model is proposed to describe the i^{th} individual's mortality rate at a given age x, depending on the accumulated stock of health capital ϑ_i and the place effect ζ_j associated with the retiree's current location indexed by j. Chetty et al. (2016) adopt a Gompertz specification where the logarithmic mortality rate $m_{ij}(x)$ that individual i living in location j would experience at age x is

$$\log\left(m_i^{@j}(x,t)\right) = g(x) + \zeta_j + \vartheta_i, \tag{B.1}$$

where $g(x)$ is a function on x, capturing the baseline age profile of mortality. The individuals of interest in this research are generally separated into two categories: (i) movers who live in an original location o move to j and then stay in the destination location j; (ii) non-movers who stay in location j all the time. Both ζ_j and ϑ_i are assumed to be time constant, and the only systematic changes in mortality risk over time originate from ageing and changes in location.

Table B.1. Average mortality rates and associated life expectancies.

Average mortality rate	Associated average life expectancy
$\bar{m}^{@j}(x,t) = \exp[g(x) + \zeta_j + \bar{\vartheta}_j]$	L_j: average life expectancy in area j
$\bar{m}(x,t) = \exp[g(x) + \bar{\zeta} + \bar{\vartheta}]$	$\bar{L}$: population-weighted average life expectancy

Two different kinds of average mortality rates of non-movers, derived from Equation (B.1) and associated life expectancies, are shown in Table B.1. In the table, $\bar{\vartheta}_j$ denotes the average health capital of non-movers in j, $\bar{m}^{@j}(x)$ denotes the mortality rate of an average non-mover in j at age x, and $\bar{\vartheta}$ denotes the average health capital over the full population of non-movers. $\bar{\zeta}$ denotes the population-weighted average of the ζ_j, and $\bar{m}(x)$ denotes the mortality rate of an average non-mover.

According to Equation (B.1) which assumes that age, place effects, and health capital are additively separable, the new expression of the logarithmic average mortality rate of a mover from area o to area j is

$$\log\left(\bar{m}^{oj}(x)\right) = g(x) + \zeta_j + \bar{\vartheta}_o. \tag{B.2}$$

To deduce the mortality rate at the SA4 level, we posit that $\bar{\zeta} + \bar{\vartheta}$ from Table B.1 equals zero. We then calculate $\zeta_j + \bar{\vartheta}_j$ based on the 10-year average of life expectancy L_j of the j^{th} area. Finkelstein et al. (2021) find that one unit increase in average life expectancy is associated with a 0.23

unit increase in migration's causal effect on individuals' life expectancy. Therefore, we introduce a calibrated parameter, κ, confined to the interval $[0, 1]$, to assign the relative weight of ζ:

$$\kappa = \frac{\zeta}{\zeta + \bar{\vartheta}}, \tag{B.3}$$

where a higher value of κ indicates that relocating to another area exerts a more pronounced effect on mortality. We assume that κ is uniformly consistent across different areas once calibrated. Given this premise, we can re-express Equation (B.2) as:

$$\log\left(\bar{m}^{oj}(x)\right) = \kappa(\zeta_j + \bar{\vartheta}_j) + (1-\kappa)(\zeta_o + \bar{\vartheta}_o), \tag{B.4}$$

which expresses a mover's log-mortality as a convex combination of the destination-specific component and the origin-specific component, with κ acting as the weight on the destination. This construction allows the model to interpolate smoothly between full retention of origin risk ($\kappa = 0$) and complete adoption of destination risk ($\kappa = 1$).

This subsection investigates the patterns of mortality rates in Australia using life tables from 2009 to 2021, accessible through the ABS website that includes national life tables and SA4-level life expectancies (Australian Bureau of Statistics, 2023a). The national mortality rate model is fitted to the national mortality rates for females aged 45 to 100 from 2011 to 2021. The estimated expression for $g(x)$ is:

$$g(x) = -11.817 + 0.106x, \tag{B.5}$$

using a Gompertz model.

Figure B.1 shows the distribution of average life expectancy across various areas at the SA4 level. For analytical purposes, these areas are categorised into five groups based on their respective life expectancy ranges: $[72.5-77.5), [77.5-80), [80-82.5), [82.5-85)$, and $[85-87.5)$.[4] The structure of Equation (B.4) implies that all life expectancies, taking into account migration and derived from mortality rates, should fall within one of the specified five brackets.[5]

B.2 Health transition

We assume that individuals are in good health at the onset of age 65. The health state transition is assumed to happen at the end of each year, which can be regarded as the beginning of the next year.

[4] This categorisation facilitates the creation of five unique transition models, each corresponding to a specific life expectancy bracket.

[5] After assessing future mortality rates, each one of these models is chosen and integrated into the corresponding expected utility.

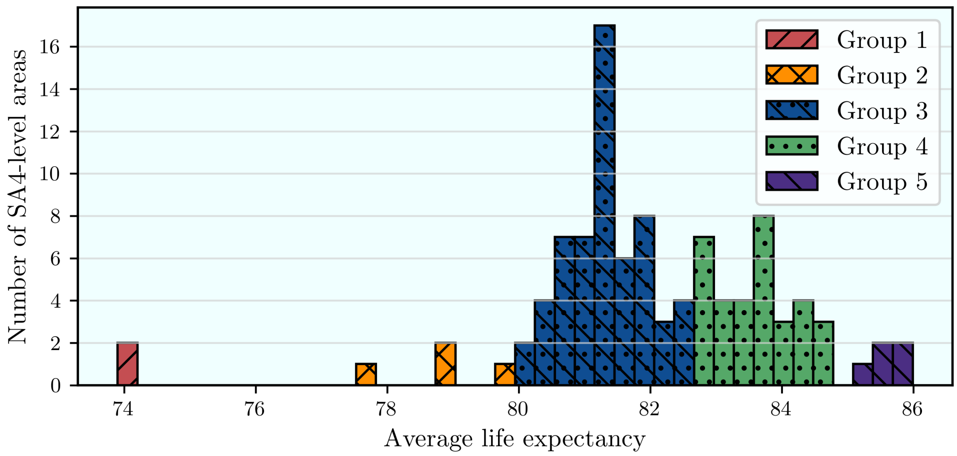


Figure B.1. Distribution of average life expectancy in various areas at the SA4 level. These areas are categorised into Groups 1 to 5 based on life expectancy ranges $[72.5-77.5)$, $[77.5-80)$, $[80-82.5)$, $[82.5-85)$, and $[85-87.5)$, with data from Australian Bureau of Statistics (2023a). These categories aid in creating distinct transition models for each range.

According to the data in Table B.2, the results of selecting the Poisson generalised linear models are shown in Table B.3. The Akaike information criterion (AIC), Bayesian information criterion (BIC), and deviance (D_c) are utilised. These metrics aid in comparing and ranking different models based on their fit while penalising for model complexity. For each response variable μ in the dataset, the design matrix X is constructed from the means of different age groups. This matrix holds polynomial terms up to degree K, which is iteratively evaluated from 0 up to 3. The matrix column x^i denotes the i^{th} power of the predictor. The forward selection algorithm is applied for every K, using AIC as the measure of improvement. For each K, the powers of the variables selected are listed in column i_{selected}. For each fitted model, relevant metrics are computed and stored: AIC, BIC, deviance, and the selected predictors. The deviance change, denoted as ΔD_c, is computed as the difference between the deviance of the simplest model (i.e., $K = 0$) and the current model. It indicates the improvement in fit relative to the simplest model. For each model, the significance of the deviance change is tested using the χ^2 distribution, yielding a p-value. A lower p-value indicates that the improvement in deviance is statistically significant and that the model is a better fit than the simpler model. The bolded rows in column K indicate the best model for each response variable based on all criteria.

To connect the health transition and mortality models, a parameter ς_x^{oj} is employed to make adjustments to the transition probability matrix in each area at the SA4 level.The optimal ς_x^{oj} is determined by minimising the discrepancy between the predicted mortality rate derived from Equation (B.1) and the mortality prediction using the transition matrix.

Table B.2. The number of transitions between different health states and the number of exposure years in different health states.

Group	Transition							Exposure		
	$1 \to 2$	$1 \to 3$	$1 \to 4$	$2 \to 1$	$2 \to 3$	$2 \to 4$	$3 \to 4$	1	2	3
50 – 54	67	21	8	52	13	2	4	4527.18	361.92	121.51
55 – 59	280	40	55	212	69	27	16	10816.97	1136.76	387.61
60 – 64	458	74	114	436	129	37	36	15721.89	1811.16	692.93
65 – 69	553	112	193	474	147	86	79	16610.65	2146.23	802.31
70 – 74	575	107	226	441	178	97	86	13975.53	2079.22	948.19
75 – 79	579	144	257	349	157	116	171	10807.98	2164.77	1071.76
80 – 84	570	162	315	338	190	166	242	7512.86	2131.81	1242.44
85 – 89	445	172	302	235	211	212	312	3870.87	1826.11	1457.01
90 – 94	218	92	160	86	156	172	296	1235.42	965.27	1006.33
95 – 100	52	24	51	18	76	75	174	235.92	265.35	421.37
Total	3797	948	1681	2641	1326	990	1416	85315.27	14888.60	8151.45

Notes: 1 is the healthy state, 2 is the mildly disabled state, 3 is the severely disabled state, and 4 is the dead state. This table is sourced from Xu et al. (2023).

Figure B.2 displays the calibrated health state status across five groups for the next 35 years. There is a consistent increase in life expectancy. This figure demonstrates that a lower mortality rate correlates with a higher proportion of healthy individuals across all ages. The curve shapes for mildly and severely disabled states suggest that a decrease in mortality rates delays the onset of disability. We quantify the expected duration in each state using the area under the respective curves, indicating that variations in mortality rates predominantly affect the duration of the healthy stage rather than the length of time spent in disabled states by utilising this calibration method, consistent with Harris and Sharma (2018).[6] The national-level health transition model is classified in Group 3 and used under the baseline scenario, and the predicted proportions of health states are shown in Figure B.3.[7]

[6] Our findings reveal a decrease in the expected healthy lifespan from 15.6 years in Group 5 to 14.7 years in Group 1. In addition, the expected durations in mildly and severely disabled states remain relatively stable, approximately equaling 2.7 years and 2.4 years, respectively.

[7] The transition matrix is presumed to stay constant from age 100 until 105 for all areas, and we assume that all individuals die at the age of 105.

Table B.3. Model selection of the Poisson generalised linear models.

	K	i_{selected}	AIC	BIC	D_c	ΔD_c	p-value
$\sigma_x(1,2)$	0	0	1260.881	1261.184	1183.716		
	1	0,1	135.858	136.463	56.694	1127.023	0.000
	2	0,2,1	99.105	100.013	17.940	1165.776	0.000
	3	0,3	96.914	97.519	17.750	1165.967	0.000
$\sigma_x(1,3)$	0	0	820.491	820.794	756.750		
	1	0,1	110.289	110.894	44.548	712.202	0.000
	2	0,2,1	79.721	80.629	11.980	744.770	0.000
	3	0,3	80.865	81.470	15.124	741.626	0.000
$\sigma_x(1,4)$	0	0	1609.726	1610.028	1541.789		
	1	0,1	88.906	89.511	18.969	1522.820	0.000
	2	0,2	80.399	81.004	10.462	1531.327	0.000
	3	0,2	80.399	81.004	10.462	1531.327	0.000
$\sigma_x(2,1)$	0	0	257.075	257.377	184.560		
	1	0,1	150.751	151.356	76.236	108.323	0.000
	2	0,2,1	92.927	93.834	16.412	168.148	0.000
	3	0,3,1,2	90.160	91.371	11.645	172.914	0.000
$\sigma_x(2,3)$	0	0	250.926	251.229	183.656		
	1	0,1	115.322	115.927	46.052	137.605	0.000
	2	0,2,1	94.471	95.379	23.201	160.455	0.000
	3	0,3,2,1	79.028	80.238	5.758	177.898	0.000
$\sigma_x(2,4)$	0	0	547.857	548.160	486.059		
	1	0,1	81.265	81.870	17.467	468.592	0.000
	2	0,2	76.319	76.924	12.520	473.539	0.000
	3	0,3	75.783	76.388	11.984	474.075	0.000
$\sigma_x(3,4)$	0	0	486.555	486.857	422.322		
	1	0,1	80.934	81.539	14.702	407.620	0.000
	2	0,1	80.934	81.539	14.702	407.620	0.000
	3	0,1	80.934	81.539	14.702	407.620	0.000

Notes: For each degree K, a forward selection algorithm is applied. The selected variable powers for each K are presented in the column i_{selected}. The deviance change, ΔD_c, represents the difference in deviance between the simplest model ($K = 0$) and the corresponding model.

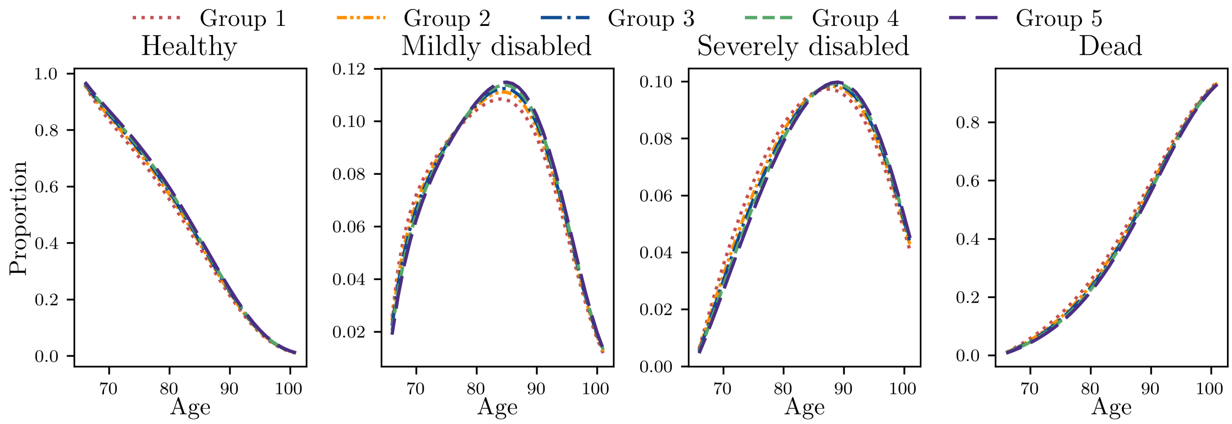


Figure B.2. Health state projections over 35 years for five groups with varying mortality rates. This figure shows a higher proportion of healthy individuals with delayed disability onset and lower mortality. Further analysis of curve areas reveals an obvious change in healthy life expectancy across groups, while time in two disabled states remains stable.

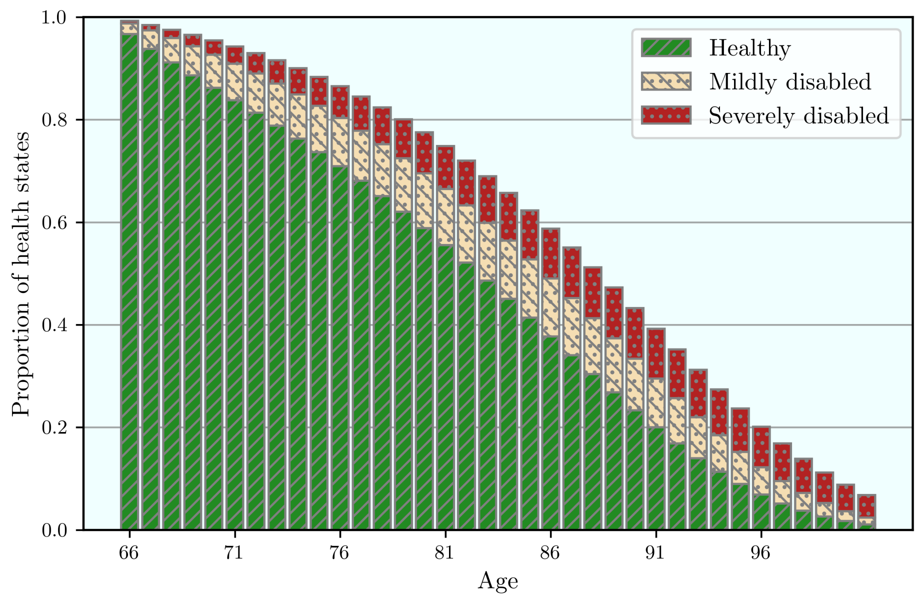


Figure B.3. Proportions of predicted health states for female individuals aged 65 who are in good health at the start of the simulation. These proportions are predicted based on the calibrated multi-state model at the national level.

C Exploring the macroeconomic scenarios

C.1 Model specification

Macroeconomic variables in Table C.1 are employed to simulate national-level economic dynamics for potential future scenarios. They are preprocessed by logarithmic differentiation and principal component analysis (PCA).[8] The variables are subsequently incorporated into a vector autoregression (VAR) model:

$$\begin{bmatrix} h_t \\ r_t \\ cpi_t \\ \boldsymbol{f}_t \end{bmatrix} = \overset{\texttt{Lag Matrix}}{\Phi} \begin{bmatrix} h_{t-1} \\ r_{t-1} \\ cpi_{t-1} \\ \boldsymbol{f}_{t-1} \end{bmatrix} + \overset{\texttt{Errors}}{\boldsymbol{v}_t}, \tag{C.1}$$

where h_t, r_t, and cpi_t are the 1st-order logarithmically differentiated HPI, cash rate target, and consumer price index, respectively. Risk factors f_t are selected from principal components, by considering both information criteria and the number of sudden shifts in the residuals of the VAR model. The matrix Φ captures the joint movement of the risk factors over time, whereas $\boldsymbol{v}_t$ contains the one-step-ahead errors.

Table C.1. Description and preprocessing method of macroeconomic variables.

Variable	Description	Order of log diff.	Sources
HPI_t	National house price index	1*	CoreLogic & ABS
CRT_t	Cash rate target	1* 2 8	RBA
CPI_t	Consumer price index	1*	
EXR_t	Exchange rate	1	
GDP_t	Gross domestic product	1	
RS_t	Retail sales	4	
PDA_t	Private dwelling approvals	1	
AXS_t	Australian securities exchange	1	Yahoo Finance

Notes: Orders marked with * indicate that PCA does not process these logarithmically differentiated variables. Orders 1, 2, 4, and 8 correspond to quarterly, semi-annual, annual, and biennial growth, respectively. Median HPIs are sourced from Australian Bureau of Statistics (2023b) and CoreLogic data. Other macroeconomic data are collected from Reserve Bank of Australia (2023) and retrieved via Yahoo Finance using the functions provided in Banasiak (2016).

We consider the area-specific house price risk based on a hierarchical model. The logarithmic house price growth rate of the i^{th} suburb is modelled as a log-linear function:

$$h_{i,t} = [1 \quad h_t \quad i_t \quad cpi_t \quad \boldsymbol{f}_t{}^{\top}]\boldsymbol{\psi}_i, \tag{C.2}$$

where the vector of coefficients for the i^{th} suburb is denoted as $\boldsymbol{\psi}_i$. This specification nests a common macro factor structure while allowing each suburb to respond with its own sensitivity vector. The intercept captures a local mean-growth effect that is orthogonal to national dynamics.

[8] Logarithmic differentiation involves taking natural logs of a variables and then differentiating. The derivative of a log variable represents a proportional (percentage) change, making it easier to analyse growth rates.

C.2 Model selection

The model selection process is fitted to quarterly data from Q1 2006 to Q4 2023. Table C.2 presents the seven principal components, which are considered potential candidates for risk factors. The selection of risk factors will consider two key aspects: information criteria, including AIC and BIC, as well as the frequency of sudden deviations between the fitted interest rates and historical data. The principal components will be incorporated into the VAR model both forwardly and backwardly, using different lags. The component that yields the best information criteria is retained, as shown in Table C.3. When the lag is set to 2, and principal components are selected based on BIC, the number of sudden jumps minimises. After removing these sudden jumps, none of the predicted interest rates falls outside the acceptable range ($\geq 10\%$ per annum).

Table C.2. PCA loading matrix.

	$\log(\frac{\text{EXR}_t}{\text{EXR}_{t-1}})$	$\log(\frac{\text{GDP}_t}{\text{GDP}_{t-1}})$	$\log(\frac{\text{RS}_t}{\text{RS}_{t-4}})$	$\log(\frac{\text{PDA}_t}{\text{PDA}_{t-1}})$	$\log(\frac{\text{ASX}_t}{\text{ASX}_{t-1}})$	$\log(\frac{\text{CRT}_t}{\text{CRT}_{t-2}})$	$\log(\frac{\text{CRT}_t}{\text{CRT}_{t-8}})$
PC1	0.2405	0.3641	0.5279	0.2578	0.2891	0.3593	0.5017
PC2	-0.5142	-0.0949	0.1635	-0.3971	-0.4932	0.4517	0.3081
PC3	0.4209	-0.6581	-0.0114	-0.4087	0.3458	0.3121	0.0751
PC4	0.1736	0.6049	-0.1818	-0.7317	0.1555	-0.1027	0.0290
PC5	0.4596	-0.0905	0.5503	-0.1646	-0.5414	-0.3930	-0.0556
PC6	0.1902	0.2125	0.1014	0.0512	-0.1484	0.6007	-0.7231
PC7	0.4723	0.0779	-0.5902	0.2092	-0.4629	0.2089	0.3476

Table C.3. Model selection with AIC and BIC using forward and backward selection.

	Forward	Backward
Lag = 1		
AIC	-27.717	-27.712
	(PC7 , PC6 , PC5 , PC3)	(PC1 , PC2 , PC3 , PC4 , PC5 , PC6 , PC7)
BIC	-25.278	-25.278
	(PC7 , PC6)	(PC6 , PC7)
Lag = 2		
AIC	-27.830	-27.830
	(PC6, PC7 , PC5 , PC4 , PC3)	(PC3 , PC4 , PC5 , PC6 , PC7)
BIC	-26.193	-26.193
	(PC6 , PC7 , PC5)	(PC5 , PC6 , PC7)

C.3 Estimation and prediction

Table C.4 presents the different percentiles of forecasts for three key indicators over the subsequent 30-year period: national HPIs, cash rate targets, and accumulative inflation. The values of 0% and 100% represent the two extreme scenarios that are least likely to occur in the simulation. We simulate the macroeconomic scenarios using a lattice model based on predicted national HPIs. Each current node representing the macroeconomic state is associated with two distinct nodes for the next period, representing changes in macroeconomic variables based on house prices. The number of financial situations in each period t is $t + 1$, arranged according to predicted HPIs. Till the last year of simulation ($t = 30$), the "0-0-...-" trajectory symbolises a steady decrease in home values, whereas the "0-1-...-30" trajectory implies a consistent rise in house prices throughout the same period. The first "0" represents the scenario at time 0, which is unique.

Table C.4. Predicted macroeconomic scenarios based on house prices using the lattice model (2024–2054).

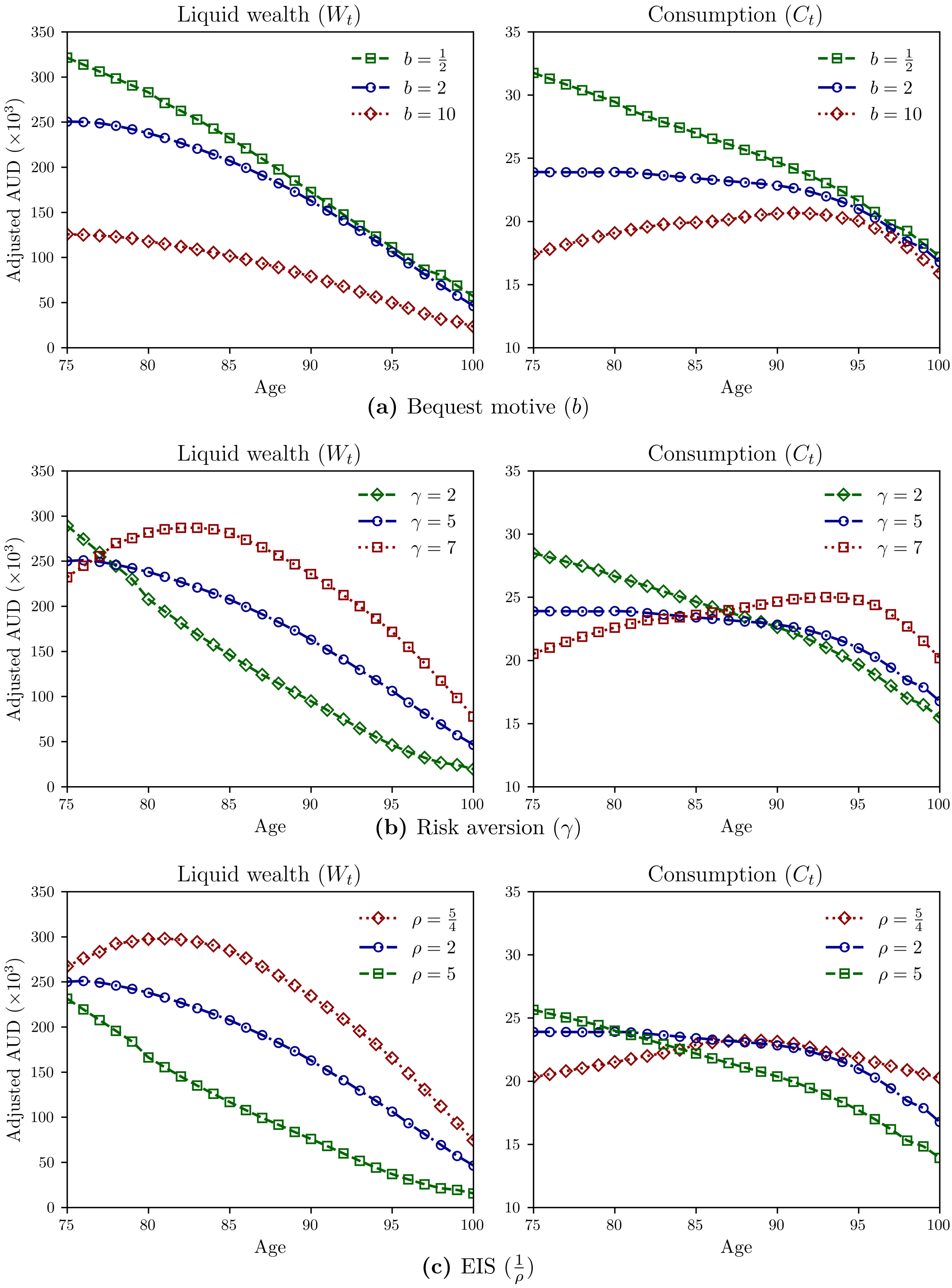
	5	10	15	20	25	30
Relative HPI						
0	1.134229	1.425801	1.760003	2.119761	2.470448	2.762984
20%	1.137251	1.443881	1.808696	2.239406	2.732062	3.273454
40%	1.140483	1.464054	1.861401	2.351868	2.953824	3.697883
60%	1.143837	1.484146	1.917483	2.481983	3.218123	4.170865
80%	1.147230	1.502554	1.974844	2.623678	3.509686	4.738545
100%	1.150625	1.520702	2.036208	2.777628	3.886390	5.631857
Cash rate target (%)						
0	3.579194	3.007518	2.544945	2.174291	1.880456	1.753938
20%	3.574038	2.986083	2.506668	2.094916	1.749694	1.677203
40%	3.568672	2.958142	2.451538	2.037882	1.695408	1.505818
60%	3.562778	2.926295	2.391911	1.945234	1.577477	1.396229
80%	3.555854	2.891417	2.330037	1.848984	1.450412	1.144636
100%	3.547421	2.853019	2.269099	1.768613	1.366204	1.056408
Relative accumulative inflation						
0	1.122258	1.272612	1.442554	1.636993	1.858870	2.111115
20%	1.122214	1.272737	1.443168	1.636560	1.856285	2.105394
40%	1.122134	1.272463	1.442933	1.636323	1.855536	2.104257
60%	1.122027	1.271980	1.441873	1.634393	1.852241	2.099432
80%	1.121903	1.271532	1.440763	1.632077	1.848649	2.094610
100%	1.121774	1.271154	1.439829	1.630903	1.847427	2.091550

Notes: This table presents the 0/20%/40%/60%/80%/100% percentiles of the predicted relative HPI alongside the corresponding cash rate targets and relative accumulative inflation. The cash rate targets and relative cumulative inflation are estimated based on the average values within each scenario, categorised by HPI percentiles.

D Sensitivity analysis: downsizing

The concept of HEAS-equivalence is similarly employed in the sensitivity analysis of risk profiles for individuals who prefer to downsize. Various parameters in risk preference suggest different scenarios. The expected utility gained from downsizing options shown in Figure D.1 equals the maximised utility that HEAS users with identical risk profiles gain at the national level.

Figure D.1(a) displays the consumption and liquid wealth trends for downsizers with different



(a) Bequest motive (b)

(b) Risk aversion (γ)

(c) EIS ($\frac{1}{\rho}$)

Figure D.1. Impact of risk profile on savings and consumption for retirees who prefer to downsize: bequest motive, risk aversion and EIS. This figure explores how different parameters influence homeowners' decisions and behaviour after downsizing their primary residence to match the same HEAS utility outcomes under the same scenarios.

bequest motives after downsizing their homes in the HEAS-equivalent manner. For homeowners, opting for HEAS with a lower bequest level leads to a more substantial reduction in home equity to achieve this increased level of utility.[9] This significant decrease in home equity size deters homeowners from downsizing, potentially making HEAS a preferable option. In addition, Figure D.1(b) shows that individuals with lower risk aversion must downsize more to attain the same level of utility. This suggests that more risk-averse individuals perceive HEAS as less attractive in the low liquidity scenario. Moreover, Figure D.1(c) demonstrates that individuals with higher EIS can downsize less to attain utility levels comparable to those of HEAS users with the same risk profile. Consequently, they can maintain a higher level of home equity size after downsizing in the HEAS-equivalent manner than those with lower EIS. This enhances the attractiveness of HEAS for those with higher EIS.

E Sensitivity analysis: health transition model

We also examine the behaviour of homeowners whose health transitions are described by different models. This sensitivity analysis assumes the downsizing option is constrained at the same SA4 level. Figure E.1 shows that the wealth trajectories and optimal consumption are not sensitive to different health transition models. However, compared to those who adopt the HEAS-equivalent downsizing option, those in areas with longer life expectancy tend to downsize more to achieve the same level of utility provided by HEAS, which is used to support a longer lifetime. Therefore, we can conclude that HEAS primarily attracts individuals with higher life expectancy.

The sensitivity of the health transition model increases when the assumption that downsizing is restricted to the same geographic area is removed. Our research illustrates its impact when downsizing across different areas is permitted. By calibrating κ, we observe shifts in HEAS preferences across certain suburbs.

F Spatial Summary of Cash-on-Hand, Longevity, and Housing Data

The average initial cash on hand, life expectancies, and current house price level at the SA4 level are shown in Figure F.1. The average home equity size and predicted house price at the postcode level are shown in Figure F.2.

[9]The elevated initial liquid wealth indicates a more substantial infusion of liquidity from home equity at the beginning of simulation.

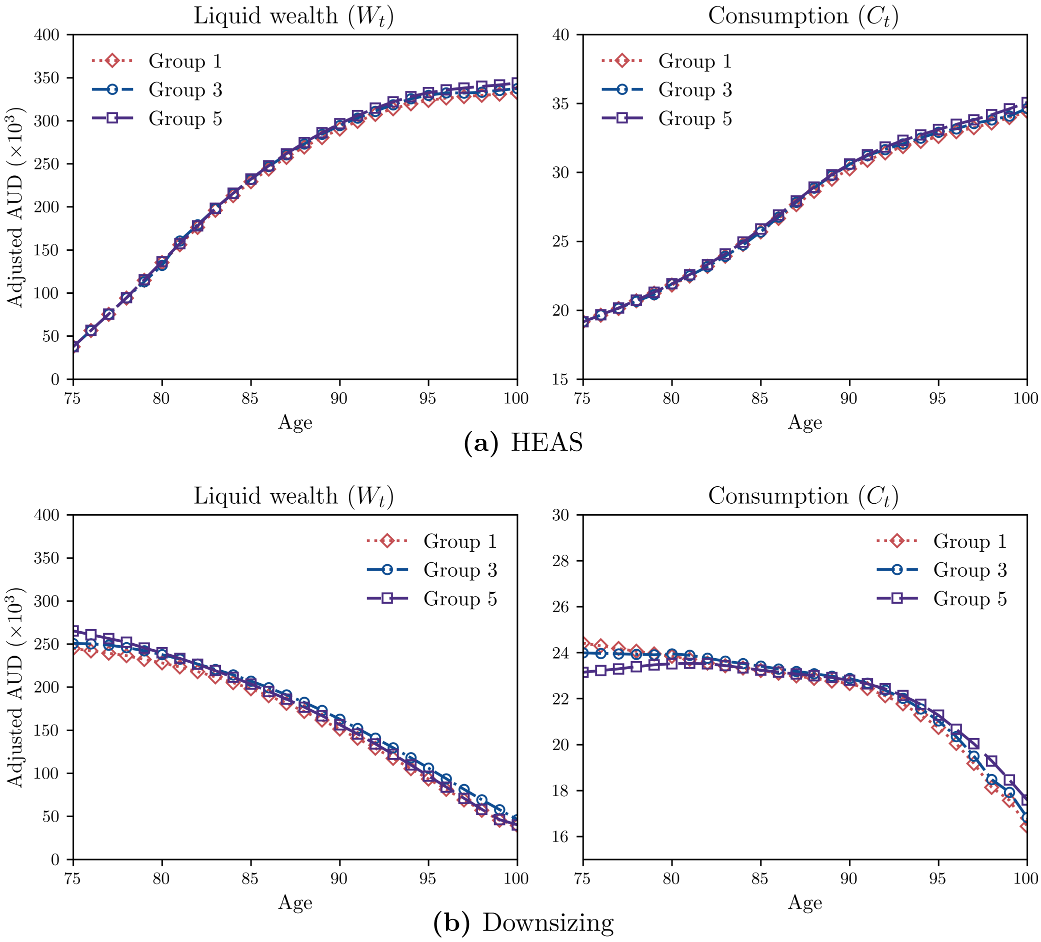


Figure E.1. Influence of life expectancy on liquid wealth trajectories and optimal consumption strategies of HEAS users and those who prefer the HEAS-equivalent downsizing strategy.

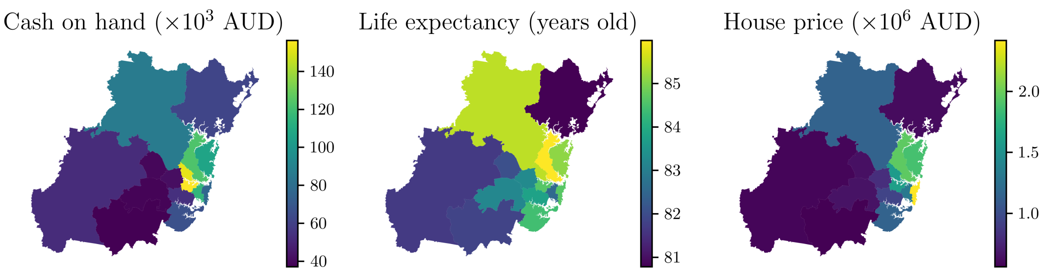


Figure F.1. The average initial cash on hand, the mean life expectancy over the past decade, and the average current house prices at the SA4 Level. The average cash on hand is estimated according to HILDA data as shown in Table F.1. The life expectancy is based on data from Australian Bureau of Statistics (2023a). Average house prices are estimated based on the Annual Sales Data 2023 from NSW Valuer (2024) without the top 10% in each area to diminish the influence of outliers.

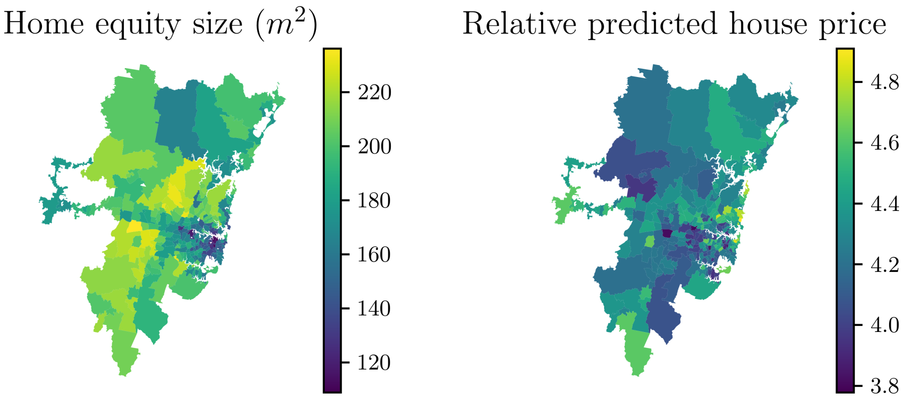


Figure F.2. The average size of home equity and predicted relative house price at the postcode level. The average home equity size is derived from the number of bedrooms in each dwelling as shown in Table F.2. The relative house price is calculated as the ratio of the predicted house price index 30 years later to the current level, based on the house price model described by Equation (C.2).

Table F.1. Estimation of initial cash on hand for retirees in the Greater Sydney Area.

Variable name	Variable description
pwoccdi	Own credit card debt
pwothdi	Other debt: loans and mortgages
pwobani	Own bank accounts
pwsupwi	Superannuation account

Notes: This table utilises data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey to estimate the initial cash on hand for female retirees aged 70 to 80 across 80 suburbs in the Greater Sydney Area. The table incorporates bank account balances, superannuation accounts, credit card liabilities, and other debts. Note that although postcode-level data is available, the estimates use SA4-level averages to enhance the precision and inclusivity of the financial assessment for all suburbs within it.

Table F.2. Estimated sizes of home equity based on the number of bedrooms.

Number of bedrooms	Home equity (m^2)
0	40
1	65
2	120
3	175
4	230
5	285
6+	340

Notes: This table presents the estimated dwelling sizes based on the number of bedrooms in private dwellings, using data from the 2021 Census of Population and Housing (Australian Bureau of Statistics, 2022). This estimation method assumes a direct correlation between the number of bedrooms and home equity value. Note that the categories "Not stated" and "Not applicable" from the census data have been excluded from this analysis.

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