Longevity, Health and Housing Risks Management in Retirement

Pierre-Carl Michaud and Pascal St-Amour*

ABSTRACT

Annuities, long-term care insurance and reverse mortgages remain puzzlingly unpopular to manage post-retirement longevity, health and housing price risks. We use a flexible life-cycle model structurally estimated with a unique stated-preference survey experiment of Canadian households to understand why. Key factors include high risk aversion, concern over long-run risks, strong discounting of valuation in disability states, imperfect housing substitutability and bequest motives. The remaining disinterest is accounted for by information frictions and inertia. We also document evidence of public insurance crowding out, spousal co-insurance and of responsiveness to products bundling.

*Pierre-Carl Michaud is at HEC Montreal, NBER and CIRANO. Pascal St-Amour (corresponding author, Pascal.St-Amour@unil.ch) is at HEC Lausanne, SFI and CIRANO. We are grateful for comments from Franca Glenzer, Katja Hannewald, Olivier L'Haridon, Olivia Mitchell, Cormac O'Dea, James Poterba, Jeroen van der Vaart, and seminar participants at NBER, CEMFI, NETSPAR, CEAR-RSI, and CEPAR as well as Western Ontario, and Bristol. We are also very thankful for comments and suggestions from the Editor (Urban Jermann), the Associated Editor, as well as two referees. Funding from the FRQSC (Quebec Society and Culture Research Council) and SSHRC (Social Science and Humanities Research Council) is thankfully acknowledged. The authors do not have any potential conflicts of interest, as identified in the JF Disclosure Policy. Replication package available at: https://github.com/pcmichaud/repl_msa_jf.git

Retirees face significant changes in their economic environment.[1] While they can expect to live longer, registered pensions plans have shifted away from defined benefit (DB) towards more volatile pension income from defined contributions (DC) and self-administered plans. Moreover, households' net worth has increased considerably, with housing and financial assets replacing pension and life insurance claims as the main drivers of growth, and mortgages accounting for most liabilities. The combined effects of longevity gains, riskier pension benefits, and increasing contribution of housing wealth, have important implications for two interrelated post-retirement decision problems: (i) risk management strategies and (ii) financial asset and home equity decumulation. Longer lifetimes raise the spectre of outliving one's assets and being exposed financially to illness associated with old age since means tested, publicly provided long-term care (LTC) do not insure against considerable residual out-of-pocket LTC spending risk.[2] Housing equity further complicates the decumulation problem if lumpy, illiquid and imperfectly substitutable with financial wealth.[3]

Three financial instruments are particularly relevant for addressing the insurance and decumulation problems. First, annuities (ANN) effectively

[1]See Table A1 in the Online Appendix A for evidence.

[2]See Ameriks et al. (2011); Achou et al. (2022) for imperfect public and private care substitution and Boyer et al. (2020b) for Canada, as well as Palumbo (1999); Scholz et al. (2006); De Nardi et al. (2010); Lockwood (2018); Ameriks et al. (2011, 2020a) for US evidence and discussion of LTC related risks. See also Ko (2022); Coe et al. (2023) for adverse selection, and demand issues in the LTCI market related to access to informal care-giving by children.

[3]See Cocco and Lopes (2020) for preference for ageing in place after retirement.

protect against longevity risk by converting financial wealth into guaranteed cash flows until death. Second, long-term care insurance (LTCI) pays state-dependent benefits when deteriorating health conditions severely limit activities of daily living (ADL), and protects against excessively rapid depletion of resources in the face of surging long-term care expenses. Third, reverse mortgages (RMR) allow house-rich and cash-poor households to tap into their home equity without having to move out of their residence. Indeed, unlike traditional home equity lines of credit (HELOC), RMR have more flexible debt servicing constraints, and limit exposure to both debt repayment and downward house price risks through their non-recourse protection.[4] Notwithstanding their potential relevance, these three instruments have proven remarkably unpopular in Canada with RMR and LTCI take-up rates even lower than those of annuities (Boyer et al., 2020b,a; Choinière-Crèvecoeur and Michaud, 2023). Moreover, post-retirement asset decumulation remains unabatedly slow, which could be explained by precautionary motives, bequests intentions, and utilitarian services of housing (De Nardi et al., 2010; Lockwood, 2018).

Methodology This apparent sub-optimality of instruments and decumulation strategies depends on the modeling choices underlying the theoretical prescriptions. This paper characterizes such a benchmark for the three risk management instruments *jointly* while allowing departure from the fully rational expectations paradigm. We solve and estimate a flexible household

[4]See Shao et al. (2015); Nakajima and Telyukova (2017); Shao et al. (2019); Cocco and Lopes (2020) for discussion of RMR design and demand.

life cycle (LC) model to assess the contributions of the following factors: (i) generalized recursive preferences towards risk and inter-temporal substitution, housing, health and bequests, (ii) biases in information processing and favoring inaction as well as in expectations, (iii) heterogeneity in both assets and (objective and subjective) risk exposure of households, as well as (iv) product packaging.

Our identification strategy departs from the standard Revealed Preferences framework by exploiting a unique Stated Preferences survey experiment. We commissioned a pan-Canadian experimental survey of 1,500 individuals aged 60 to 70 covering their financial situation, pension and home-owning statuses, as well as health, household composition, subjective expectations and preferences for risk management products. Respondents were asked to report the likelihoods of buying ANN, LTCI and RMR for a large set of characteristics (e.g. benefits, restrictions) and price combinations. The two related advantages are that (i) unlike non-experimental data, we effectively control for the unobserved (and potentially endogenous) investment opportunity set of agents and (ii) the randomization of contract attributes provides relevant information towards the identification of the model's deep parameters. Our estimation framework elicits probabilistic take-up and nests the fully rational model in a behavioral discrete choice model that allows for inertia and information frictions following the generalized logit formulation of Matejka and McKay (2015).

Second, we account for the considerable degree of heterogeneity among survey participants in tailoring individual-specific benchmarks. Objective house price distributions are obtained for the respondents' census metropolitan area (CMA), and are augmented by individual-specific subjective beliefs about these stochastic processes. Moreover, a dynamic micro-simulation model uses each respondents' health and socio-economic status to compute *personalized* objective health transitions probabilities, to which we also append individual-specific subjective beliefs. The objective and subjective housing and health distributions are combined to *individually* solve for and map welfare gains into probabilistic take-ups.

Main findings We find that the pure theoretical model explains well the observed lack of interest for these three products, but that both informational and inertia frictions are required to replicate observed take-up rates, price and benefits elasticities. Moreover, the out-of-sample performance of the theoretical model is remarkable. In an external validation exercise, we reproduce quite well both the life cycle asset decumulation expectations reported in the survey that were not used in the estimation, as well as population data on home-ownership rates and HELOC borrowing.

Our preference parameters have complex, non-monotone effects on the demand for the three instruments. First, we structurally estimate a high relative risk aversion index ($\gamma = 5.082$) which warrants a high demand for both (i) static insurance, and (ii) precautionary wealth reserves. Static insurance favors hedging longevity (ANN), and medical expenses (LTCI) risks, but precautionary wealth motives discourage depletion of financial and housing reserves through ANN and RMR. Second, we confirm the relevance of recursive preferences with inverse elasticity of inter-temporal substitution (EIS) parameter ($\varepsilon = 2.304 < 5.082 = \gamma$), consistent with (i) preference for early resolution of timing uncertainty (PERU), and (ii) concern over long-run risk (LRR). Third, we find evidence of time preference (i.e. valuation) shocks with strong discounts on the marginal utility of consumption and housing services in high-disability, relative to healthy states ($\nu = 0.135 < 1.0$). The implications are that households favor instruments insuring against both short- and long-run risks to both marginal utility and valuation. Long-run risks are particularly relevant for retirees to the extent that disability risk exposure increases in age, and correlates strongly with medical expenses and mortality, as well as with the conditions under which housing capital is liquidated. The LRR of outliving accumulated assets is hedged by annuities whose demand is larger under EZW relative to VNM preferences. The LRR valuation concern is particularly relevant for LTCI which effectively hedges long-run medical OOP risks, but pays out benefits specifically in those high-disability, low-valuation states. Conversely, RMR offers loans in current high-valuation (healthy) states and its long-run non-recourse protection will be appreciated when disability precipitates the liquidation of home capital offering poorly valued utilitarian services. Such hastened home sales expose households to idiosyncratic home price risks associated with under-maintenance and market timing errors. Our findings are thus consistent with detrimental LRR effects of recursive preferences for LTCI, and positive effects for RMR.

Fourth, we identify positive utilitarian services from housing consistent with a preference for ageing in place. Imperfect substitutability of residential and financial wealth hinders annuitization since home equity is less fungible and admissible for annuity purchases, and benefits the demand for both LTCI (more insurance of net income to maintain ownership) and RMR (tap into home home equity without moving out). Fifth, we estimate a non-negligible bequest intensity parameter ($b = 0.069$). When neutralized, financial and residential wealth previously earmarked for bequests can be reallocated for precautionary reserves and/or consumption purposes. The former hinders the demand for market insurance procured by ANN and LTCI, while the latter encourages liquidation of home equity through RMR.

Sixth, we confirm the crowding out of private insurance by public safety nets which penalizes both ANN and LTCI, while encouraging the liquidation of precautionary financial and residential reserves through ANN and RMR. We document the robustness of our results to (i) allowing for delayed purchases (instead of now-or-never), as well as to (ii) risky (instead of risk-less) returns on savings. We also show the importance of household composition. The death of a spouse induces a one-shot transfer of wealth to the widow(er) which is annuitized by low EIS agents ($1/\varepsilon = 0.43404 < 1.0$), and eliminates the demand for credit via RMR. Being single also removes the need to co-insure against own/spouse medical expenses, thereby lowering the demand for LTCI. Our final results concern non-indifference to product packaging. In particular, bundling RMR with ANN and/or LTCI tends to boost overall demand. In addition to providing more comprehensive hedging of LRR, cash inflows for RMR can be used to top-up insufficient pension claims and medical insurance, instead of for current consumption purposes.

Contributions We offer two contributions to the quantitative life cycle literature on slow asset decumulation,[5] annuities,[6] long-term care insurance,[7] and reverse mortgage.[8] First, we analyze these decisions *jointly*, estimating a unique set of preferences that explain demand for these products, and therefore bridge the gap between otherwise separate strands of the literature. Second, we integrate the role of housing decisions, valuation shocks, couples, informational and behavioral biases in financial choices related to decumulation. Among the most related papers is Koijen et al. (2016) who study annuities, life, and LTC insurance by comparing the differential net payoffs of the three instruments across health states (deltas). Whereas we also stress the importance of joint interactions between annuities and LTCI choices, we abstract from the life insurance decisions they consider,[9] thereby channeling all monetary transfers to survivors via bequests. Moreover, whereas they

[5]See Hurd (1989), Palumbo (1999), Ameriks et al. (2011), Ameriks et al. (2020a), De Nardi et al. (2010) and Lockwood (2018).

[6]See Inkmann et al. (2011), Lockwood (2012), Peijnenburg et al. (2016), Laitner et al. (2018), André et al. (2022) and O'Dea and Sturrock (2023). See Horneff et al. (2008) and Maurer et al. (2013) for models involving deferred variable annuities.

[7]See Pauly (1990), Brown and Finkelstein (2008), Lockwood (2018), Ameriks et al. (2018) and Boyer et al. (2020b).

[8]See Nakajima and Telyukova (2017), Blevins et al. (2020), and Cocco and Lopes (2020).

[9]Life insurance is typically decided at a younger age than in our sample (60–70). See Hong and Rios-Rull (2012, Fig. 1 and Tab. 1) for evidence and discussion. We rely on market completeness and on the parallels between life insurance benefits and bequest as luxury good parameter to discuss their effects on decumulation strategies in Online Appendix H.

assume perfect substitutability between risk-less bonds and housing wealth, we account for explicit utilitarian housing services, different risky returns, and borrowing constraints, as well as moving-in and -out costs. Importantly, we fully endogenize housing choices, thereby allowing us to consider the important interactions of housing with annuities, RMR and LTCI which are abstracted from in their paper. Finally, we differ in our explicit treatment of household composition risks (i.e. singles vs couples) for risk management which remains largely under explored.[10]

Inkmann et al. (2011) also emphasize bequest motives in a quantitative life-cycle model of annuities. While they consider continuous (rather than one-shot) annuitization, they nonetheless abstract from housing, mortgages (and therefore RMR) choices and risks as well as from morbidity (and therefore LTCI) decisions and risk exposure. Health risks and bequest motives are accounted for in the annuities model of Ameriks et al. (2011) who stress aversion to publicly provided long-term care as main motive for slow asset decumulation. However both LTCI (separately addressed in Ameriks et al., 2018), as well as housing and RMR choices are abstracted from. Finally our paper is related to the RMR analysis of Nakajima and Telyukova (2017) and Cocco and Lopes (2020) who both consider LC models with uninsurable idiosyncratic risks as well as bequests and precautionary motives in explaining the low demand for RMR. Whereas Nakajima and Telyukova (2017) admit endogenous house size which we abstract from, we are more general in al-

[10]Notable exceptions include De Nardi et al. (2021) who study post-retirement decumulation of savings in couples and Hubener et al. (2015) who study interactions with social security claiming decisions.

lowing full back and forth transitions between owner and renter statuses, as well as renter borrowing. Similar to us, Cocco and Lopes (2020) consider the role of bequests, uncertain LTC expenditures, and well as expected house price growth to explain low RMR take-up rates. However, they emphasize an age-increasing preference for aging-in-place that hinders house selling, as well as endogenous maintenance choices as a mean to tap into the housing equity without having to sell, neither of which we consider.[11] We also differ by explicitly considering conventional mortgage debt, allowing for more general access to credit via HELOC's, or consumer credit, rather than via RMR draw-downs exclusively, and by considering couples health dynamics in housing decisions, rather than singles only.

Other related papers include Hanewald et al. (2016) who allow for home equity extraction through both RMR, as well as through home reversion (HR) which allows owners to sell claims to their house without moving out in exchange for a lump-sum payment net of the expected NPV of the rental services. While they also consider joint LTCI and ANN purchases, they however abstract from valuation shocks and endogenous housing and borrowing decisions through HELOC's and conventional credit. The importance of housing capital illiquidity for the links between ANN and LTCI demand is also emphasized by Davidoff (2009, 2010), as well as by Achou (2021). These authors abstract from RMR decisions and consider illiquid home wealth caused by

[11] Preference for aging in place is partially captured by moving-in/out costs in our model. The absence of maintenance costs induces biases towards more RMR as the only mean to tap into house equity without selling the house, making the RMR puzzle more salient.

preference for aging in place and/or financial moving costs, resulting in home retention unless forced to sell due to illness, old age or extreme poverty. Similar to us, they also account for negative valuation shocks in the disabled states. Davidoff (2009, 2010) show that a natural complementarity between ANN and LTCI arises for non-owners whereby locked-in annuitized wealth limits self-insurance against disability shocks that can be attenuated through LTCI. This complementarity can be reversed for homeowners when illiquid housing becomes a substitute for ANN and LTCI that is maintained in good health and sold to cover disability and longevity expenses later in life. Importantly, none of these papers analyze a model of joint consumption, and home owning, ANN, LTCI and RMR decisions that allows for couples vs singles health risks, flexible owner-renter migrations, alternative borrowing capacities, distributional and behavioral biases, or long-run risks through EZW preferences as we do.

Indeed, we contribute to the literature on time preference (valuation) shocks under EZW utility.[12] Whereas research remains agnostic on the causes of shocks to the discount rate on future utility flows, we specifically relate these to disability to capture lower quality and quantity of life effects when activities of daily living are impaired. Because disability also covaries with the returns on the three instruments, the health state dependence has strong consequences for insurance demand by devaluing both costs and benefits under disability states. Moreover, we also add to the literature on long-run

[12] Albuquerque et al. (2016); Chen and Yang (2019); de Groot et al. (2022); Normandin and St-Amour (1998)

risks,[13] by emphasizing the effects of non-indifference to the timing of the resolution of uncertainty on demand for long-run hedging.

The remainder of the paper is as follows. Section I outlines the theoretical life cycle model, and Section II describes our stated-choice experiment. The structural econometric framework is detailed in Section III, with estimation results presented in Section IV. The implications for risk management are discussed in Section V, with concluding remarks in Section VI.

I. Model

Overview We consider heterogeneous agents subject to exogenous disability, mortality and housing price shocks, who either live as singles or in couples. Individuals make periodic consumption and housing (own, rent) choices, as well as one-shot ANN, LTCI, and RMR decisions at the initial period. They face market imperfections from home moving costs, bounded leverage and credit/debit interest rates spreads, yet also benefit from social insurance programs. Agents have generalized recursive (EZW) preferences over a composite good composed of consumption and housing services whose health-dependent marginal utility is lower in the high disability states. They also benefit from warm-glow utility associated with bequeathable wealth.

[13] Bansal and Yaron (2004); Epstein et al. (2014); Kaltenbrunner and Lochstoer (2010); Albuquerque et al. (2016); Chen and Yang (2019); de Groot et al. (2022)

A. *Households, health statuses and insurance*

Time $t \in [0, T]$ is discrete, with 0 being the date of interview, T being maximal longevity and decisions being updated every 3 years.[14] Agents live in households as singles (i) or couples (ij), where i is respondent and j is spouse. Similar to Ameriks et al. (2020a); Davidoff (2009); Achou (2021), the possible health states for alive agents are denoted by $\mathcal{A} = \{G, \ell, L\}$, respectively good health (G), low (ℓ) and high (L) limitations in activities of daily living (ADL). Letting $\mathcal{D}$ denote death, the health status is $s_{it} \in \mathcal{S} = \{\mathcal{A}, \mathcal{D}\}$ for single agent i, and is $s_{ijt} \in \mathcal{S}^2$ for couple ij, with corresponding indicators $\mathbb{1}_t^s$. We assume Markovian health processes with exogenous, age-, and person-specific transition probabilities.[15] Aside from death being an absorbing state, the elements of the transition matrices are unrestricted, thereby allowing bi-directional transitions between better and worse states. The household medical expenditures are health-dependent and location-specific and are given as $M_{it} = M(s_{it} \in \mathcal{S})$ and $M_{ijt} = M(s_{ijt} \in \mathcal{S}^2)$, where health deteriorations induce larger health spending.[16]

[14] The time interval between updating was selected through a trial and error procedure to optimize the necessary trade-offs between realism and computational time that are discussed in Online Appendix B.

[15] We follow standard practices in assuming that no new couples are formed for $t \geq 1$, i.e. neither singles nor widowers find new spouses (e.g. Nakajima and Telyukova, 2017). For tractability, we also assume that the widowed spouse's transition probabilities revert back to her distribution as single who is thus indistinguishable from a widow(er) in terms of health, such that the ij notation accommodates all family arrangements.

[16] See Table VI. We assume that medical expenditures are additive across spouses, i.e we abstract from informal care-giving provided by the healthy spouse and/or children (see

Consistent with the timing in the survey experiment, all market insurance choices occur only at time 0.[17] Households insure against longevity risk through annuities sold to the household head i paying one unit of numeraire upon survival ($s_{it} \in \mathcal{A}$) and zero upon death ($s_{it} = \mathcal{D}$) per unit of benefits b^A. The total cost of an annuity is $P_i^A b^A$ where P_i^A is the price per unit of coverage and will vary across respondents. Insurance against LTC expenditures is offered to the household head i and is characterized by the benefits denoted as b^L paid out conditional upon state $s_{it} = L$ only, and by the premium $P_i^L b^L$ to be paid only in $s_{it} \in \{G, \ell\}$ states.[18] In the survey experiment, the subsequent scenarios presented to respondents separately alter both prices (P_i^A, P_i^L) and benefits (b^A, b^L).

B. *Housing markets, states and decisions*

Prices, states, and flows Let $p_t^H \equiv \log(P_t^H)$ denote the log of house price P_t^H and let P_t^R denote the rental price.[19] We follow Cocco and Lopes (2020) in assuming that housing prices follow a random walk with drift rate g, and are conditionally log-normal, while the rental prices P_t^R are proportional to

---

Ko, 2022; Coe et al., 2023, for evidence), as well as from potential scale economies that could mitigate formal care expenses (e.g. single apartment rented in care-providing facility by two disabled spouses).

[17] We relax this timing restriction in Section B by allowing for optimal delaying of insurance decisions.

[18] Consistent with market practices, we assume lapsing LTCI coverage when households fail to pay the premium.

[19] We subsequently omit the i and ij subscripts to ease notation.

house value:

$$p_t^H = g + p_{t-1}^H + \sigma^H \epsilon_t; \quad \epsilon_t \sim \text{NID}\,(0,1), \tag{1a}$$

$$P_t^R = \phi P_t^H, \quad \phi \in (0,1). \tag{1b}$$

Consistent with survey responses, the home and rental price dynamics (g, σ, ϕ) in (1) are evaluated at the Census Metropolitan Area (CMA) level.[20]

Households' current homeowning status is denoted $H_t \in \{0,1\}$ (rent, own), with pairs (H_t, H_{t+1}) denoting renters (0,0), buyers (0,1), sellers (1,0) and (continuing) owners (1,1). The extensive margin housing choices neither allows for up- nor down-sizing, yet permit full in and out transitions to houses of similar (market) values. The net housing wealth is zero for non-owners and otherwise equal to the house value net of principal and interest r_d on mortgages:

$$W_t^H = H_t \left[P_t^H - (1 + r_d) D_t \right]. \tag{2a}$$

We follow Gorea and Midrigan (2018) by modeling mortgages as perpetuals with falling coupons, i.e. the next-period mortgage value D_{t+1} is either $\xi^D \in (0,1)$ of the outstanding mortgage for continuing owners, or a collateral share

[20] Admittedly, individual house volatility faced by agents could be under estimated by city-level distributions by omitting idiosyncratic risks components related to maintenance, neighborhood, school quality, ... Ideally, house price data would have been available at a more refined level (e.g. street or borough). Unfortunately, privacy requirement meant the we could only obtain information on the city of residence in the survey.

$\omega^D \in (0, 1)$ of house value for new mortgages:

$$D_{t+1} = H_{t+1}\left[H_t \xi^D D_t + (1 - H_t)\omega^D P_t^H\right]. \tag{2b}$$

The household's net cash flows from housing X_t^H in function of status (H_t, H_{t+1}) is:

$$\begin{aligned} X_t^H =& (1 - H_{t+1})H_t[P_t^H - (1 + r_d)D_t] - H_{t+1}(1 - H_t)(1 - \omega^D)P_t^H \\ & - H_{t+1}H_t(1 - \xi^D + r_d)D_t - (1 - H_{t+1})P_t^R \end{aligned} \tag{2c}$$

i.e. sellers cash-in W_t^H, i.e. house price P_t^H net of principal and interest on outstanding mortgages $(1 + r_d)D_t$; buyers pay $(1 - \omega^D)P_t^H$ of house value as collateral; owners pay amortization $(1 - \xi^D)$ plus interest r_d on outstanding mortgages D_t; renters pay rental price P_t^R.

Residential market imperfections are proxied by imposing different moving costs on sellers $(k = s)$ and buyers $(k = b)$:

$$\begin{aligned} MC_t &= H_t(1 - H_{t+1})MC_t^s + (1 - H_t)H_{t+1}MC_t^b, \\ MC_t^k &= \tau_0^k + \tau_1^k P_t^H, \quad k = s, b \end{aligned} \tag{3}$$

where τ_0^k are the fixed and τ_1^k are the variable moving costs, with buyer's moving costs τ_1^b calibrated at the CMA level to integrate heterogeneity in land transfer taxes.

Reverse mortgage A reverse mortgage contract is only offered to agents with positive home equity $W_t^H > 0$ and specifies the maximal loan at origination, as well as the nominal and effective amounts due at termination:

$$H_{t+1}L_0 \leq \mathbb{1}_{D_t<\omega^R P_t^H}\left(\omega^R P_t^H H_t\right), \quad t=0 \tag{4a}$$

$$L_t = L_0 \exp\left[\left(r+\tau^R\pi^R\right)t\right], \tag{4b}$$

$$b_t = \min[L_t, P_t^H]. \tag{4c}$$

The maximal reverse mortgage loan L_0 in (4a) is a share ω^R of the house value at origination P_t^H that is lent to admissible home owners whose outstanding conventional mortgage D_t is lower than the RMR loan.[21] The RMR is terminated when the house is sold at time $t \geq 1$, and the nominal amount due by the borrower L_t in (4b) compounds the interest given by the risk-free rate r plus a risk premium $\pi^R = \pi(s_0)$ which under fair pricing could be household-specific and account for the initial health status of all members s_0 since the latter determines the decision to sell. The effective amount due at termination b_t in (4c) is the lesser of the nominal debt and the selling price (non-recourse protection). The scenarios presented to respondents below will vary both the maximal LTV ω^R and the risk premium $\tau^R\pi^R$ charged for the RMR, where τ^R is a load factor equal to one at actuarially-fair pricing.

[21] As in the US, Canadian households are first required to repay any outstanding conventional mortgages with reverse mortgage loans to maintain top seniority of RMR issuer with respect to home secured loans. Observe that since the RMR debt is not repaid before the house is sold, debt-servicing borrowing constraints linked to the agent's income are absent from (4a).

C. Financial and borrowing constraints

Net revenue flows The exogenous household income Y_t pools all income sources of living household members and is independent of health status (e.g. pension income).[22] Additional net financial flows Z_t aggregate net proceeds from annuity, LTC insurance and RMR choices, and differ across initial ($t = 0$) and subsequent periods ($t \geq 1$):

$$Z_t = \begin{cases} H_t H_{t+1}(L_0 - D_0) - \left[P^A b^A + P^L b^L\right], & t = 0, \\ \left[\mathbb{1}_t^A b^A + \mathbb{1}_t^L b^L\right] - (\mathbb{1}_t^G + \mathbb{1}_t^\ell) P^L b^L - H_t(1 - H_{t+1}) b_t, & t \geq 1. \end{cases} \tag{5a}$$

Time-0 owners receive the reverse mortgage loan net of any outstanding mortgage ($L_0 - D_0$) while households purchase $P^A b^A$ of ANN and $P^L b^L$ of LTCI. For the subsequent periods, annuities b^A are cashed-in if alive, insured agents with high ADL limitations receive the insurance benefit b^L, and otherwise continue to pay the premium. Home sellers repay the effective reverse mortgage payment b_t given by (4c).

Means-tested government transfers TR_t aggregates financial W_t, and housing wealth W_t^H in (2a), plus income Y_t to determine eligibility to aid covering a consumption floor $C_{\min}$, plus rental costs and medical expenses

[22] Agents could theoretically self-insure through endogenous labor supply decisions. However, only 21% of Canadian aged 65 to 74 continued working in 2022, with 9% out of necessity and 12% by choice (sources Statistics Canada). Since our surveyed urban respondents are either at or close to retirement, and are wealthier than the population (see Table I), our sampled elders working out of choice are likely even fewer, warranting our modeling strategy of abstracting from endogenous labor income for self-insurance purposes.

for poor households:[23]

$$TR_t = \max\left[C_{\min} + (1 - H_{t+1})P_t^R + M_t - \left(W_t + W_t^H + Y_t\right), 0\right]. \tag{5b}$$

The household's net cash-on-hand X_t sums financial wealth, net housing proceeds, income and financial flows and (if any) transfers, net of medical and moving costs:

$$X_t = W_t + X_t^H + Y_t + Z_t + TR_t - (M_t + MC_t) \tag{5c}$$

Budget and borrowing constraints The household allocates cash-on-hand X_t in (5c) between financial wealth $W_{t+1}/(1 + r_t)$, and non-housing consumption C_t subject to the budget constraint:

$$\frac{W_{t+1}}{1 + r_t} + C_t \leq X_t. \tag{5d}$$

Financial market frictions are modeled in two ways. First, the effective interest rate r_t is higher for borrowers ($\mathbb{1}_t^b = 1$) than for creditors, especially

[23]The federal public pension plan includes the first pillar Canada Pension Plan (CPP), covering most retirees, the Old Age Security Pension (OAS) applicable to those who have never worked or are still working and the Guaranteed Income Supplement (GIS) for low revenues. See Government of Canada, public pensions website for details. The maximal monthly pension for singles aged 65 in 2025 were 1,433C$ (CPP), 1,087 C$ (GIS) and 728C$ (OAS). There are also supplements to GIS for those living alone. Low income individuals in Canada do not pay for nursing homes and medical expenses which is captured through the coverage of medical expenses M_t in the public transfer (5b).

for borrowing renters ($r < r_h < r_r$):

$$r_t = \mathbb{1}_t^b \left[H_t r_h + (1 - H_t) r_r\right] + (1 - \mathbb{1}_t^b) r \tag{6a}$$

Second, the maximum amount that can be borrowed is determined by both an income test (all agents), and by a home equity test (home owners only) for HELOC:

$$-W_{t+1} \leq (1 - H_t)\omega_y Y_t + H_t \min\left[\omega_y Y_t, \omega_1^h P_t^H, \omega_2^h \max\left(P_t^H - D_t, 0\right)\right]. \tag{6b}$$

The debt servicing requirements (6b) restrict renters to borrow at most ω_y of income. HELOC's allow eligible owners to borrow at most the lesser of three elements: (i) ω_y of income, (ii) ω_1^h of house price, or (iii) ω_2^h of the house value minus outstanding mortgages.

D. *Preferences and household's problem*

We rely on Epstein and Zin (1991); Weil (1990) (EZW) recursive preferences to model the household's objective function. Given the current state set S_t and continuation utility $V_t = V(S_t)$, the household's problem is select controls I_t to solve:

$$V_t = \max_{\{I_t\}} \left\{ (1-\beta)\nu_t^{\varepsilon} u_t^{1-\varepsilon} + \beta \left[\mathbb{E}_t V_{t+1}^{1-\gamma} \right]^{\frac{1-\varepsilon}{1-\gamma}} \right\}^{\frac{1}{1-\varepsilon}}, \tag{7a}$$

$$\nu_t = (1-\mathbb{1}_t^L) + \mathbb{1}_t^L \nu, \quad \nu \in (0,1), \tag{7b}$$

$$u_t = n_t^{-1} C_t^{\rho} S_t^{H\,1-\rho}, \tag{7c}$$

$$S_t^H = [\phi + H_t \nu^H] P_0^H, \tag{7d}$$

$$V_{t+1} = b^{\frac{\varepsilon}{1-\varepsilon}} X_{t+1}, \quad \text{for } s_{it+1} = \mathcal{D}, \tag{7e}$$

where state and controls sets (S_t, I_t) are described below. The conditional expectations $\mathbb{E}_t$ are taken over the joint health statuses $s_{t+1} \in \mathcal{S}^2$, and housing prices $P_{t+1}^H \in \mathcal{R}_+$ processes. The optimization (7) is subject to constraints in (4), (5), and (6), with time-varying sets of controls I_t and states S_t given as:

$$I_t = \left\{ C_t, H_{t+1}, \mathbb{1}_{t=0}(b^A, b^L, L_0) \right\}, \tag{8}$$

$$S_t = \left\{ D_t, W_t, s_t, H_t, P_t^H, \mathbb{1}_{t\geq 1}(b^A, b^L, L_0) \right\}. \tag{9}$$

Unsurprisingly, analytical solutions to this problem are intractable and we resort to numerical methods described in Online Appendix B to solve the model.

The household's problem (7) encompasses key preference parameters. First, in the recursive utility (7a), the parameter β is a subjective discount factor, ε is the inverse EIS which is disentangled from risk aversion γ, and where the restriction $\varepsilon = \gamma$ yields the Expected Utility (VNM) paradigm. Second, the health-dependent time preference shocks $\nu_t = \nu(s_t) \in (0,1]$

in (7b) capture heavier discounting at rates $(1-\beta)\nu_t^{\varepsilon}$ of future flows under severe disability $s_t = L$. Shocks to time preferences thus induce changes in the effective discount factor that alter the valuation of future costs and benefits (*valuation risk*).[24] Whereas the literature often remains agnostic as to which underlying factor(s) may alter ν_t, we relate these factors explicitly to disability level s_t. Heavier discounting of future flows under severe disability can be justified through the significant decline in both quality and quantity of life for disabled agents.[25]

Third, we follow Nakajima and Telyukova (2017); Vestman (2019), by using a Cobb-Douglas with consumption share ρ to aggregate consumption and homeowning utilitarian services S_t^H, whereas the utility flows are averaged for couples by dividing by the equivalent scale for household size n_t in utility (7c).[26] Fourth, the housing services S_t^H in (7d) are benchmarked by the rent paid $P_t^R = \phi P_t^H$ by renters ($H_t = 0$), and the incremental benefit ν^H

[24] Albuquerque et al. (2016); Chen and Yang (2019); de Groot et al. (2022); Normandin and St-Amour (1998)

[25] See Blundell et al. (2024); Finkelstein et al. (2013); Koijen et al. (2016); Peijnenburg et al. (2017); De Nardi et al. (2010); De Nardi et al. (2021); Russo (2023) for quality of life arguments. Bahk et al. (2019, Tab. 1, p. 3) report a 2017 Korean life expectancy of 84.4 (no disability) dropping by 6.7 years (least severe disability) and by 34.6 years (most severe disability). See also Steensma et al. (2017); Lefebvre and Carrière (2022) for additional Canadian evidence.

[26] We follow Scholz et al. (2006) in setting $n_t = 1.55$ for couples, and $n_t = 1$ for singles. See also De Nardi et al. (2021); Nakajima and Telyukova (2017) for similar equivalent scale values.

provided from home ownership ($H_t = 1$).[27] Finally, equation (7e) assumes that agents receive warm-glow utilitarian services that are proportional[28] to total wealth bequeathed at death,[29] with b capturing the strength of the bequest motive. Desirable properties regarding preference for life over death of similar EZW utility with bequests have been verified in the literature.[30]

---

[27]We fix housing prices at the initial time, P_0^H, such that changes in housing services S_t^H are caused by endogenous housing decisions H_t only, rather than by exogenous fluctuations in housing prices.

[28]We follow the literature assuming that bequests benefits are proportional to cash on hand (e.g. Collin-Dufresne et al., 2017; Gomes and Michaelides, 2005; Inkmann et al., 2011). We use the correction advocated by Kraft et al. (2022) in scaling the bequest intensity with curvature ε to ensure that b corresponds to bequest motivation under EZW preferences. The affine alternative $V_{t+1} = b^{\frac{\varepsilon}{1-\varepsilon}}(X_{t+1} + \kappa)$ with $\kappa > 0$ allows for bequests as luxury good (see Lockwood, 2018; De Nardi, 2004; De Nardi et al., 2010; Ameriks et al., 2011, in VNM contexts). The affine formulation could not be implemented in the estimation process due to the poor identification of κ. The theoretical implications of b and κ are nevertheless explored in Online Appendix H, with comparative statics effects analyzed in Section A.

[29]A more realistic treatment of gift-giving would allow for (i) timing (e.g. inter-vivo vs bequests) and (ii) marginal valuation of gifts by recipients (e.g. high-value inter-vivo gifts for first home purchase by children). However the additional complications (OLG structure with young and old agents, altruistic motives over young welfare for elder donor, joint solution of young and elder's problem, ...) render this alternative intractable. Observe nevertheless that high valuation by recipients when high housing prices is indirectly captured through high cash-on-hand X_{t+1} providing high warm-glow benefits in (7e).

[30]Preference for longevity is theoretically verified with EZW utility in the absence of bequests ($b = 0$, Hugonnier et al., 2013, 2022), and is found empirically, even when bequests are allowed ($b > 0$, Córdoba and Ripoll, 2017; St-Amour, 2024). Homogeneity properties

E. *Long-run risks and the demand for insurance*

The literature on long-run risks (LRR) emphasizes the importance of stochastic factors that alter the expected growth rate and volatility of consumption in the long run. Such risks are abstracted from under VNM, but are accounted for by EZW preferences (e.g. Bansal and Yaron, 2004; Epstein et al., 2014). Concerns over LRR are particularly relevant for the risk management and asset decumulation strategies of retirees. Indeed, disability risk is highly persistent, increasing in age, correlates positively with mortality and medical expenses. Disability also correlates with idiosyncratic housing prices risks arising from insufficient maintenance and market timing errors linked to precipitated home liquidation, while also lowering valuation of costs and benefits ν_t in (7b).

To better understand the relevance of LRR in our setting, consider a simplified version of the model shutting down both housing services ($\rho = 1$) and bequests ($b^{\varepsilon/(1-\varepsilon)} = 0$). It can then be shown[31] that the inter-temporal marginal rate of substitution (IMRS) simplifies to:

$$M_{t+1} = \beta \left(\frac{\nu_{t+1}}{\nu_t}\right)^{\varepsilon} \left(\frac{C_{t+1}}{C_t}\right)^{-\varepsilon} \left(\frac{V_{t+1}}{\mathrm{CE}_t(V_{t+1})}\right)^{\varepsilon-\gamma}, \tag{10}$$

entail that welfare V_t is proportional to wealth, with empirical findings confirming that marginal value is increasing in longevity, i.e. both the marginal value of wealth and level of utility increase in longevity, consistent with a willingness to pay for additional lifetime, and a willingness to transfer resources to high longevity future states.

[31] For example, by adapting Hansen et al. (2008, p. 273) or Chen and Yang (2019, p. 230).

where $\text{CE}_t(V_{t+1}) = [\mathbb{E}_t V_{t+1}^{1-\gamma}]^{1/(1-\gamma)}$ is the certainty-equivalent of continuation value V_{t+1}. From first principles, an asset will provide valuable insurance if it pays high benefits in high IMRS states.[32] Imposing VNM preferences ($\gamma = \varepsilon$) on (10) reveals that this insurance property is then exclusively attributable to short-run (realized) positive covariance with valuation growth ν_{t+1}/ν_t and/or negative covariance with consumption growth C_{t+1}/C_t, i.e. agents prefer insurance benefits paid out in high valuation ν_{t+1} and/or low consumption C_{t+1} states.

Unlike VNM, EZW preferences ($\gamma \neq \varepsilon$), also price expected long-run movements to valuation ν_{t+k} and consumption C_{t+k} for $k > 1$ that are encoded in the deviations between the continuation utility's realization V_{t+1}, and its (non-stochastic) certainty-equivalent $\text{CE}_t(V_{t+1})$.[33] Under preference for early resolution of uncertainty (PERU) induced by $\gamma > \varepsilon$, long-run insurance services are provided through negative covariance with $V_{t+1}/\text{CE}_t(V_{t+1})$, i.e. the asset pays high benefits in future detrimental states when next-period continuation utility is below its current certainty-equivalent value. Equivalently, EZW/PERU preferences imply that both the short-run (realized) and long-run (expected) valuation (resp. consumption) risks are priced negatively (resp. positively), i.e. an asset provides valuable insurance services if it pays high future benefits in bad states of the world occurring in both the short-run ($k = 1$) and the long-run ($k > 1$) that are associated with high valuation

[32] For example, as captured by the insurance premia, i.e. the difference between the risk-free and expected rates of return $R_{f,t+1} - \mathbb{E}_t(R_{i,t+1})$.

[33] See Kaltenbrunner and Lochstoer (2010); Albuquerque et al. (2016); Chen and Yang (2019); de Groot et al. (2022) for discussions.

ν_{t+k} and/or low consumption C_{t+k}.

The choice of EZW instead of VNM preferences is dictated by both ex-ante theoretical pragmatism, and ex-post empirical testing considerations. First, the disentangling of attitudes towards a-temporal risk (γ) from those towards inter-temporal substitution (ε) is expected to be relevant to explain the *joint* demand for ANN (presumably more EIS), LTCI (presumably more RRA), and RMR (presumably both EIS and RRA). Moreover, the valuation of long-run risks in (10) that is only made possible by EZW ($\varepsilon \neq \gamma$), and not by VNM ($\varepsilon = \gamma$) is intuitively pertinent to retirees faced with age-increasing exposure to disability and death risks. Second, the VNM model is a nested special case of the generalized EZW preferences; the relevance of the two models can be assessed ex-post through a formal test of $H_0 : \varepsilon = \gamma$ (i.e. VNM), against the alternative of $H_1 : \varepsilon \neq \gamma$ (i.e. EZW). Since we structurally estimate the latter, this test is implemented below through a Wald test (see footnote 51). Note that we do not interpret this ex-ante theoretical pragmatism and ex-post empirical confirmation as general validation of EZW against VNM preferences. Indeed, this assessment is purely local, i.e. within the very specific context of the surveyed demand for decumulation, housing and the three financial instruments that is accounted for in our preference model (7) with time preference shocks ν_t, housing utilitarian services S_t^H, and bequests intensity b.

II. Data

A. Survey design

In April/May 2019, we fielded an online survey with *Asking Canadians* targeting individuals aged 60 to 70 from the 11 largest census metropolitan areas (CMA) in Canada, i.e. the cities with most important increases in house prices and therefore with the highest potential for home equity extraction.[34] The survey, detailed in Online Appendix I, covers (i) background socio-demographic and financial information, (ii) risk perceptions, (iii) knowledge of financial products, and (iv) stated preference experiments for annuities, long-term care insurance and reverse mortgages. We imputed missing values for financial variables using unfolding bracket questions and imposed top-coding.[35] We also relied on filters for sample selection,[36] resulting in a complete usable dataset with 1,581 households (74% of whom are in couples).

[34] *Asking Canadians* is a web-based panel with more than 2 million members, where respondents are rewarded for their participation using a loyalty point system. The CMA's we considered and housing prices are listed in Table III.

[35] Missing-values imputations were done using chained multivariate regression, conditional on bracketing. Income responses were top-coded at 500,000C$ and financial wealth as well as mortgage debt at 80 with 1,000,000C$.

[36] Starting with an initial sample of 3,057 respondents, we dropped 550 renters (non eligible for RMR), and 446 respondents with outlier responses to questions on home equity, mortgage balance and payments, rent, retirement age (max 10 years before retiring) and income, or couples with more than 10 years age difference. Finally, we removed 480 respondents with missing and non-imputable critical information.

Descriptive (unweighted) statistics in Table I reveal that survey respondents in panel (a) are aged 65, are 60% male and 74% are married with a spouse of similar age. Household annual income is close to 110,000C$, with mean house value over 711,000C$ and relatively low mortgages of 28,500C$.[37] Respondents also report average financial wealth of 325,300C$ with only 5% reporting assets less than 5,000C$. A comparison with a sample population data with similar age, marital status and CMA characteristics taken from the 2019 Survey of Financial Security (SFS) in panel (b), with t-stats on the differences in means in column (c) identifies some differences between the two samples. While the age of both respondents and spouses, as well as the house values are similar, household income and mortgage values are both lower, whereas survey respondents are also richer and less likely to have very low savings, and therefore are presumably more interested in asset decumulation strategies. Notwithstanding these caveats, our survey appears reasonably representative of Canadian urban retirees.

[Insert Table I about here]

B. Health status, beliefs and preference heterogeneity

Health status Given our focus on long-term care risk and that Canada has a universal health insurance system for other medical expenditures, health status in the model is defined on the basis of limitations with instrumental (IADL) or basic (ADL) activities of daily living.[38] Respondents are classified

[37]Amounts are reported in Canadian dollars (C$, 2019 exchange: 1.0C$ = 0.75US$).

[38]IADL: preparing meals, doing shopping, doing housework, managing bills, going to the toilet or taking medication. ADL: eating, washing, dressing, moving inside the house

as being in good health (G: no limitations), mild limitations (ℓ: some IADL, at most one ADL) and as having severe limitations (L: two or more ADL). The distribution of health status reveals that the sample is generally healthy, with less than 5% among singles, and 6.5% among couples reporting current limitations.

Longevity expectations Respondents reported their subjective probability of surviving up to age 85. Figure 1 shows the CDF for the respondent (panel a) and spouse (panel b). Comparing with objective life tables reveals survival over-optimism; male (resp. female) respondents report a subjective 72% (resp. female 73%) probability of surviving up to 85, compared to an objective likelihood of only 51.4% (resp. female 63.7%).[39]

`[Insert Figure 1 about here]`

House price levels, dynamics, and expectations Table II reports the housing prices and rental levels, as well as land transfer taxes. The statistics highlight strong regional variation with higher home prices in BC (Victoria, Vancouver) and Ontario (Toronto, Hamilton, Ottawa) compared to the Prairies (Edmonton, Calgary, Winnipeg), and Eastern provinces (Montreal, Quebec and Halifax). Rental to own price ratios, and land transfer taxes are comparatively more similar across CMA's.

---

and getting in and out of bed.

[39]Objective probabilities at age 65 in 2019 obtained from Life Tables (Statistics Canada, 2023). Retirees' over-optimism regarding survival at 85 is a common finding in the literature (e.g. Hurd and McGarry, 2002) while younger respondents tend to be pessimistic (O'Dea and Sturrock, 2023; Heimer et al., 2019).

[Insert Table II about here]

Table III documents the realized (panel a) and forecasted price dynamics in the period before and after the survey (panel b). Overall, we again find heterogeneity in average growth rates over the recent period (2010-2017), with Toronto and Vancouver house prices increasing at a rate of 6.4% and 6.2% per year respectively compared to more modest growth in Montreal (1.4%) and Calgary or Edmonton (respectively 0.7% and -0.01%). Panel (b) also report robust growth rates after the survey, i.e. between 2020-2024 [column (4)], and that are expected to remain high up to 2027 [columns (5) and (6)].

[Insert Table III about here]

Figure 2(a) plots the households' subjective expected house price growth in the 10 years after the survey. The subjective beliefs appear pessimistic; respondents assign a high (30%) probability of a drop in prices, with less favourable outlooks for residents of Calgary and Edmonton, as well as a low (10%) probability on price increases of more than 40% over the next decade in other CMAs. These subjective beliefs can be contrasted with objective house price measures both prior to, and after the survey took place to gauge potential biases. Figure 2.(b) and Table III.(a) both indicates a near doubling of house prices (Toronto, Vancouver and Hamilton) and 15-40% increases in house prices in other CMAs prior to the survey. Moreover, these favorable house price increases are persistent in the subsequent period (Table III.(b)). Overall, subjective beliefs stated in 2019 by respondents can be characterized as pessimistic relative to objective home price increases in both the previous and subsequent decades.

`[Insert Figure 2 about here]`

C. *The stated-choice experiment*

The core component of the survey in Online Appendix I is a stated-choice experiment designed to elicit demand for three risk management products of interest, where each respondent was presented with 4 separate price/benefits scenarios per product. In order to reduce the complexity, the scenarios were presented one product at a time, i.e. joint (bundled) products scenarios were omitted from the survey.[40] All applicable taxes were accounted for in presenting both net costs and benefits.

Annuities Consistent with the literature, the intro screen shown to respondents with positive financial wealth reviews relevant information on the main features of annuities, i.e. the immediate one-shot premium to be paid and the monthly benefit starting next year and paid until death.[41] To neutralize other explanations for low take-up, we emphasize that there is neither default risk (payments will be made no matter the circumstances), nor inflation risk by considering indexed benefits. In the spirit of Boyer et al. (2020a), respondents are presented with scenarios corresponding to two different level

[40] The theoretical implications of product bundling are analyzed in Section V.

[41] See Benartzi et al. (2011); Brown et al. (2021); Luttmer et al. (2022) on the importance of framing, minimizing complexity and emphasizing salient features in annuities decisions. We abstract from deferred annuities.

of annuitization of financial wealth repeated twice (20% and 50% of $W_{i,0}$), for which the price is drawn randomly twice (without replacement) using four markups $\tau_A \in [0.5, 1.75]$ on the actuarial premium P^A.[42] For each of the four scenarios, respondents are asked to report the probability of purchase within the next year.

Long-term care insurance The intro screen was shown to respondents who do not yet have LTCI. As in Boyer et al. (2020b), respondents are informed about the monthly benefits for agents with two or more limitations in activities of daily living (defined in earlier segment, see footnote 38) and the monthly market premium to be paid otherwise. We stressed ideal conditions whereby there is no default risk, that premiums cannot increase over time and that benefits (either 2,000C$ or 4,000C$ per month) would be adjusted for inflation. Each scenario are presented twice, with a randomization of the markup $\tau_L \in [0.5, 1.75]$ on actuarial premium P^L calculated by age group (60-64, 65-70) and gender and purchase probabilities are recorded.

Reverse mortgages The intro screen was shown to homeowners who do not yet have a RMR contract describing the percentage of net home equity which can be borrowed, and the fixed interest on the loan amount. We make explicit reference to net home equity (house value minus outstanding mortgages) as basis for maximal borrowing, state that cumulated interests

[42]The market premia vary by age and gender, and are computed using yields on annuities for Canadian singles provided by CANNEX, a private data provider on life insurance and annuity products. Unlike the actuarially fair pricing discussed below, the market premia do not integrate the agent's health status.

need to be paid out only when the RMR buyer moves out (sells or dies) and stress the non-recourse guarantee on RMR loans whereby the amount due at house sale or agent's death could not exceed the house value at that date. We also emphasize that home owners would not be forced to sell their home by RMR providers, and that there is no contract risk (e.g. risk that the lender defaults or changes rules). For each of the four scenarios, we first set the age-dependent maximal LTV ratio that can be borrowed (30% for 60-64, 40% for 65-70) and consider 50% and 100% of that maximal loan-to-value (LTV). We repeat each twice and randomize (without replacement) the interest rate charged on the loan (from 2, 4, 6 and 8%), thereby spanning the actual rate of 6% on RMRs observed on the Canadian market. For each respondent, we collect the four probabilities of purchase for these RMR products.

Take-up probabilities, product knowledge and elasticities Table IV reports statistics on product take-up, prior knowledge,[43] as well as elasticities. Responses indicate very low take-ups for ANN and RMR (10.8% and 7.3%) and sizable zero take-ups across all scenarios for the two instruments (55.8% and 63.8%), despite moderate knowledge (26.9% and 28.7%). Conversely, despite less prior knowledge of 10.9%, respondents report higher take-up intentions for LTCI with a 17.4% probability of buying and a lower 39.2% probability of never buying. Both price and benefits elasticities are of the correct sign for all three products.

[Insert Table IV about here]

[43]Before being presented with the scenarios, respondents were asked whether they knew (i.e. a lot, a little, not at all) about each of the products.

III. Empirical framework

Overview Our empirical strategy involves calibrating a subset of the model's deep parameters, and structurally estimating the remaining subset. The estimation involves considerable heterogeneity, with CMA-specific housing price dynamics and medical costs, as well as agent-specific and age-dependent disability and mortality shocks distributions. The NLLS estimation is therefore computationally intensive since the model must be individually solved for each of the 1,581 respondents and for the welfare gains over the 12+1 scenarios, i.e. 20,553 times for each parameter iteration. The reporting model follows the generalized logit framework of Matejka and McKay (2015) in converting welfare gains from purchasing the instrument in a given price/benefit scenario into log odds ratios. Behavioral biases associated with information processing and inertia are respectively accounted for through the product-specific loading on the welfare gains, and product- and agent-specific intercept term. The reporting model therefore nests the pure discrete-choice paradigm (infinite loading and no inertia) as a special case.

A. Calibration of auxiliary parameters and stochastic processes

Auxiliary parameters The choice for the calibrated auxiliary parameters is reported in Table V and detailed in Online Appendix C. The (real) interest rate in panel a is set at 1%, with higher mortgage, HELOC and credit card rates obtained from market data. The borrowing constraints in panel b are also market-based, with amortization calculated for a typical 25-year mortgage. Rental rates are calibrated at their CMA-specific averages in Table II, column (3), with moving costs set from typical fixed and variable real estate and moving companies, with CMA-specific Land Transfer Taxes (LTT) variable rates for buyers in Table II, column (4). Finally, the consumption floor in panel d is set at 18,200C$, and obtained from first-pillar public pension programs, whereas the annualized discount factor is set to $\beta = 0.97$.

[Insert Table V about here]

House prices We use data from Teranet on historical house price indices by census metropolitan area, as well as CMA-level deflators to compute the annual real growth rates g and volatility σ over the period 1997 to 2017 reported in columns (1), and (2) of Table III. An Augmented Dickey Fuller (ADF) test in column (3) does not reject the null of a unit root for p_t^H in (1a) for all CMA's except Ottawa.[44] Disparities between subjective and objective house prices distributions are also accounted for. We model the perceived expected return as well as standard deviation as $g_i = \mu_i g_c$ and $\sigma_{T,i} = \zeta_i \sigma_c$ where μ_i and ζ_i are respondent-specific over-optimism or pessimism parameters relative to the estimated drift g_c and volatility σ_c.[45] The corresponding

[44]The literature has identified predictable components in housing prices at higher frequencies (i.e. monthly or quarterly, e.g. Case and Shiller, 1989, 2003; Poterba, 1991). Implementing such predictability would involve additional state variables in an already strained numerical solution framework. Moreover, for our annual Canadian residential prices, both the ADF test results in Table III, column (3), and the weak evidence of residual serial correlation in Δp_t^H allow us to conclude that the data is broadly consistent with the random walk hypothesis in (1).

[45]Survey responses on the subjective probability that house prices with increase (or decrease) over the next 10 years are used to estimate μ_i and ζ_i. See Online Appendix E

estimated distributions are plotted in Figure 2(c,d), confirming that respondents are much more pessimistic about house price growth with an average μ of 0.10 in panel c, but correctly perceive the volatility of house prices with an average ζ of 0.96 in panel d.

Health risk process and expenditures Respondent- (and spouse-) specific rates of transitions $q^n_{ijt}(s, s')$ across health states $(s, s') \in \{G, \ell, L, D\}^2$ are required to solve the model. The survey asks about current health status in terms of common health conditions (mental health problems, hypertension, diabetes, heart disease, stroke, cancer and lung disease), as well as about smoking status and gives information on age, gender as well as education and socio-economic status markers. Following Boyer et al. (2020b), we use a dynamic health microsimulation model to measure the objective transitions of each respondents as a function of these inputs. Next, we also account for subjective survival expectations. We use the objective parameters from the preceding step to compute the predicted objective probability of surviving to age 85. For both respondent and spouses, we then estimate a bias correction to the objective distribution to recover the subjective survival probabilities $\tilde{q}_{ijt}(s, \mathcal{D}')$.[46]

Figure 1(c) shows a scatter plot of respondent's objective probabilities of

for details.

[46] See the discussion of equations (1) and (2) in the Online Appendix E for details on how we use these simulated health profiles to estimate a respondent-specific dynamic multinomial logit model for the Markov transition probabilities $q_{it}(s, s')$, and how the objective survival probabilities $q_{it}(s, \mathcal{D}')$ are corrected to recover the subjective survival distributions $\tilde{q}_{it}(s, \mathcal{D}')$.

surviving to age 85. There is substantial heterogeneity in the sample, along with a positive correlation within couples. In panel d, we report a scatter plot of the distribution of mortality belief parameters for respondents and spouses. A positive (resp. negative) value of this mortality belief parameter denotes a respondent who is more pessimistic (resp. optimistic) than the prediction from the objective health model. Over-optimism with respect to own survival is again confirmed with average mortality correction $\xi = -1.42$ in equation (2) of Online Appendix E, however with considerable heterogeneity, as well as correlation in these beliefs, which was to be expected given that the respondent also reports the survival probability for the spouse. Finally, the health costs estimates are computed by CMA and health status from Table VI, and display sharp increases medical expenditures in deteriorated states and considerable regional variation.

`[Insert Table VI about here]`

B. *Structural estimation*

Respondents' characteristics The set $\boldsymbol{X}_i$ of individual-i's observable characteristics at the time of the survey experiment include age, pre- and post-retirement incomes Y_t and health status for both respondent and spouse (if any) s_{ijt}. It also includes household level variables such as home ownership status H_t, marital status, CMA (metropolitan area), financial wealth W_t, the value of the house P_t^H, and mortgage D_t as well as the health transition probabilities for both respondent and spouse q_{ijt}^n that were estimated separately from the micro-simulation described earlier.

Reporting model Each respondent $i = 1, \dots, N$ was presented with scenarios indexed $k = 1, \dots, K$ consisting of a three-dimensional tuple for the prices $\boldsymbol{P}_{i,k} = (P^A_{i,k}, P^L_{i,k}, \pi^R_{i,k})$ and for benefits $\boldsymbol{B}_{i,k} = (b^A_{i,k}, b^L_{i,k}, L_{0,i,k})$ of annuities, LTC insurance and reverse mortgage products, for which (s)he reported purchasing probabilities $p_{i,k} \in [0, 1]$.[47] Let $\boldsymbol{\theta} = (\gamma, \varepsilon, \nu, \rho, \nu^H, b)$ denote the estimated structural parameters, conditional upon which the continuation utility solving (7) in scenario k is defined as $V_{i,k}(\boldsymbol{\theta}) \equiv V(\boldsymbol{X}_i, \boldsymbol{P}_{i,k}, \boldsymbol{B}_{i,k}, \boldsymbol{\theta})$. The indirect utility gain to respondent i of purchasing product k can be written as:

$$\tilde{V}_{i,k}(\boldsymbol{\theta}) = V_{i,k}(\boldsymbol{\theta}) - V_{i,0}(\boldsymbol{\theta}), \tag{11}$$

where $V_{i,0}$ is the no-participation benchmark case corresponding to $\boldsymbol{B}_{i,0} = \boldsymbol{P}_{i,0} = (0, 0, 0)$.

We next consider the mapping of indirect utility gains $\tilde{V}_{i,k}(\boldsymbol{\theta})$ to respondents' decisions allowing for departures from the fully rational life-cycle model. Matejka and McKay (2015) show that, under mild assumptions, choice under rational inattention can be represented using a generalized logit model with a individual-specific intercept and a scale parameter that dampens the effect of experience utility on decision utility.[48] We follow this insight

[47]The number of presented scenarios $K_i \leq 12$ is respondent-specific, as respondents with insufficient financial resources were presented with fewer choices.

[48]The links between rational inattention due to costly information acquisition and/or processing and stochastic choices are also explored in Sims (2003); Caplin et al. (2019) among others. Extensions are discussed in Steiner et al. (2017) who provide rationales for

by assuming that respondents make decisions based on a noisy measure of the indirect utility gain in (11) associated with a particular scenario. They purchase product k if:

$$-\delta^*_{i,n(k)} + \tilde{V}_{i,k}(\boldsymbol{\theta}) + \upsilon_{i,k} > 0, \tag{12}$$

where $n(k)$ maps scenario k to the product type $\{A, L, R\}$. The error term $\upsilon_{i,k}$ follows a logistic distribution with product-specific scale parameter $\sigma_{\upsilon,n}$ measuring the importance of noise in self-reports relative to the signal coming from the utility differences. This idiosyncratic noise can be motivated by the presence of unspecified features of the environment in the scenarios presented. It also captures inattention to the information provided by the welfare change $\tilde{V}_{i,k}$. The parameter $\delta^*_{i,n}$ is a respondent-i and product-type $n = A, L, R$ specific fixed effect that captures inertia. Given welfare gain $\tilde{V}_{i,k}$ in (11), the larger is $\delta^*_{i,n}$, the less likely is respondent i to purchase a product of type n in a given scenario.[49]

Following Matejka and McKay (2015), the self-reported probability $p_{i,k} \in [0, 1]$ for respondent i of purchasing the financial product in scenario k can be contrasted with its theoretical counterpart, defined as

$$p_{i,k}(\boldsymbol{\theta}) = \frac{\exp(-\delta_{i,n(k)} + \lambda_{\upsilon,n(k)}\tilde{V}_{i,k}(\boldsymbol{\theta}))}{1 + \exp(-\delta_{i,n(k)} + \lambda_{\upsilon,n(k)}\tilde{V}_{i,k}(\boldsymbol{\theta}))}. \tag{13}$$

logit representations with status-quo bias in the context of rational inattention.

[49] This approach is also similar in spirit to Ameriks et al. (2020b) who discuss attenuation biases in risky asset holdings and to Handel and Kolstad (2015) who also emphasize product-specific informational and inertia in the context of health insurance.

where $\delta_{i,n} = \delta^*_{i,n}/\sigma_{v,n}$ and $\lambda_{v,n} = 1/\sigma_{v,n}$. A respondent who makes choices free of noise ($\sigma_{v,n} \to 0$) and inertia ($\delta_{i,n} = 0$) will purchase the product in scenario k with degenerate probability $\mathbb{1}_{\tilde{V}_{i,k}>0} \in \{0,1\}$ determined only by the sign of the indirect utility gain $\tilde{V}_{i,k}$. As discussed in Online Appendix F, the estimation relies on a within-respondent transformation per product on the log-odds ratio to eliminate $\delta_{i,n(k)}$; the OLS estimator of $\lambda_{v,n(k)}$ from the log-odds ratio on the welfare gain is then concentrated-out, to obtain a non-linear least squares (NLLS) estimator of the deep parameters $\boldsymbol{\theta}$. Importantly, the within transformation implies that the deep parameters are not identified through the take-up *levels* of financial instruments, but through their *changes* induced by modifying their prices and benefits attributes. The predicted take-up levels can be recovered ex-post and compared to observed ones for in-sample validation.

C. *Pricing, distributions and biases*

Table VII summarizes the main features regarding pricing, risks distributions and biases affecting both the budget constraint and decision process. First, in panel (a), column (1), the survey (Section II), estimation (Section III), and results (Section IV) all rely on CMA-specific housing market prices and objective risks distributions. In column (2), the three financial instruments ANN, LTCI and RMR also quote CMA-specific market prices, and rely on objective distributions, but do not integrate the agent's health status. The loads on the market prices for the three instruments vary between 0.5 and 1.75; they are not meant to capture realistic features (and may span non-profitable combinations), but rather to elicit price and benefit elasticities that both play a key role in the structural estimation as explained earlier. In column (3), the market prices and loads are used in the households' budget constraints, but we allow for subjective probability beliefs on housing prices and longevity, as well as for informational and status-quo biases in the decision process.

[Insert Table VII about here]

Second, panel (b) refers to the comparative statics analysis presented in Section V. Column (1) again relies on residential market prices and objective distributions for housing. However, we use agent-specific, actuarially-fair pricing and unit loads in column (2), with objective distributions that do integrate the agents' health status for the three instruments (see Online Appendix G for details). In column (3), we either allow or close the subjective probability beliefs on housing and longevity to gauge their effects on decisions. Finally, we abstract from informational and status-quo behavioral biases to elicit pure theoretical demand for risk management.

IV. Estimation results

We first report the model's estimated preferences parameters. We then discuss the estimated informal friction, and inertia behavioral biases. The model's performance is finally addressed from both in-sample and out-of-sample perspectives.

A. Preferences, information frictions and inertia

Preference parameters Table VIII(a) reports the estimated preference parameters; all are of correct sign and statistically significant. The RRA parameter (std. error) $\gamma = 5.082$ (0.002) is indicative of high risk aversion, and the inverse EIS parameter $\varepsilon = 2.304$ (0.005) corresponds to a low elasticity of inter-temporal substitution $1/\varepsilon = \ 0.43404 < 1.0$. Both parameters are comparable with estimates found in the empirical EZW literature.[50] The null of VNM $H_0 : \gamma = \varepsilon$ against the alternative of EZW preferences is rejected.[51] The RRA and inverse EIS estimates are thus supportive of (i) the separation of attitudes toward a-temporal risk from those toward inter-temporal substitution, (ii) the valuation of long-run risks that were both deemed important in our modeling of preferences, as well as (iii) preference for early resolution of uncertainty (PERU) consistent with $\varepsilon < \gamma$.

`[Insert Table VIII about here]`

Relative to being in good health or mild disability, $\nu(G, \ell) \equiv 1.0$, we find evidence of strong time preference shocks with heavy discounting under severe disability $\nu(L) = \nu = 0.135$ (0.001). This finding is consistent with a

[50] The Swedish cross-sectional estimates of Calvet et al. (2021) have median RRA of 5.30 and median EIS of 0.42. Inkmann et al. (2011) calibrate the RRA at 5.0 and the EIS at 0.50, whereas Gomes and Michaelides (2005) calibrate the RRA at 5.0, with EIS between 0.2 and 0.8.

[51] A formal Wald test of $\gamma = \varepsilon$ can be performed as a test of the VNM restriction (see Smith, 1999, for finite sample properties and alternatives). The test statistic value of $W =$ 127 571 unambiguously rejects the null of $H_0 : \varepsilon = \gamma$ corresponding to VNM against the alternative of $H_1 : \varepsilon \neq \gamma$ corresponding to EZW preferences.

reduction in both life quality and quantity for severely disabled persons (cf. footnote 25). Our results also reveal a consumption share $\rho = 0.963$ (0.001) that is somewhat higher than values found in the literature,[52] as well as a positive utilitarian benefit of home ownership $\nu_h = 0.31$ (0.06). Whereas the bulk of utilitarian flow u_t in (7c) is attributable to consumption, housing capital provides separate utility services S_t^H in (7d) and is thus imperfectly substitutable with financial wealth. Finally, we find evidence of a bequest motive with $b = 0.069$ (0.001) that is within the range of equivalent estimates.[53]

Information frictions and inertia Recall from (13) that behavioral biases are captured by informational content $\lambda_{v,n} = 1/\sigma_{v,n}$ and inertia $\delta_{i,n} = \delta^*_{i,n}/\sigma_{v,n}$, where $\sigma_{v,n}$ gauges the noise added to the utility gradient. Table VIII(b) reports the λ estimates for ANN: 0.03 (0.002), for LTCI: 0.204 (0.009) and for RMR: 0.04 (0.003). The parameters are all positive, finite and statistically significant, confirming that respondents' choices load positively on the estimated utility gradients of purchasing particular products and cannot be attributed to purely random decisions (corresponding to $\lambda_{v,n} = 0$). Table VIII(c) reports the statistics for the agents- and product-specific $\delta_{i,n(k)}$. The estimates reveal that inertia is higher and less dispersed

[52] Cocco and Lopes (2020, Tab. 6) use a CES with consumption share parameter $\theta^{1/\varepsilon} = 0.75$, while Nakajima and Telyukova (2017, Tab. 1) also rely on a Cobb-Douglas with consumption share $\eta = 0.792$.

[53] Gomes and Michaelides (2005, eq (2)) use EZW preferences with bequest motive $b^\rho = 2.5^5 = 97.66$ for their benchmark specification, which is close to our corresponding measure under the normalization advocated by Kraft et al. (2022) $b^{\varepsilon/(1-\varepsilon)} = 109.22775$.

for both ANN and RMR, and is lower and more dispersed for LTCI. Other unreported results confirm that inertia correlates with respondent gender, age, product knowledge, education, and income, confirming our interpretation as product-specific status-quo biases.[54]

B. Model performance

B.1. In sample

Take-up rates We use a comparative statics exercise to identify the respective contributions to the take-up rates of (i) the model-only predictions and (ii) the model augmented with informational and status-quo biases. Toward this purpose, we set $(\lambda_{v,n}, \delta_{i,n}) = (\infty, 0)$ to obtain the pure theoretical discrete choice model where the sign of welfare gradients entirely determines binary take-up decisions, and contrast this with the estimated model with biases $(\lambda_{v,n}, \delta_{i,n}) \in \mathbb{R}^2$ set at estimated values in Table VIII(b,c). Table IX(a) confirms that the pure model-based specification in column (3) performs reasonably well in explaining the low demand of 0.108 (ANN), 0.174 (LTCI) and 0.073 (RMR) in the data column (1). Indeed, the puzzles are much less salient with predicted take-up rates of 0.466 (ANN), 0.132 (LTCI) and 0.488 (RMR). The remaining discrepancies between observed and theoretical take-up rates can be rationalized by activating the imperfect informational

[54] When regressed on observables, we find that inertia is (i) higher for female (ANN, RMR) and for older respondents (LTCI, RMR), (ii) lower for agents with prior knowledge (ANN), with university degrees (ANN, LTCI), or with higher total income (LTCI), and (iii) orthogonal to family composition. Correlation coefficients are around 0.40 for the three products, suggesting common inertia traits affecting all products.

content of utility gradients ($\lambda_{v,n}$), and the deviations related to preference for status-quo ($\delta_{i,n}$) in column (2), following which the take-up rates fall to 0.089 (ANN), 0.157 (LTCI), and 0.061 (RMR) and are remarkably well aligned with the data.

`[Insert Table IX about here]`

Price-benefit elasticities The behavioural biases can also be expected to alter price and benefit responsiveness of demand. Table IX(b,c) confirms that the pure model-based estimates in column (3) correctly reproduce the observed and anticipated negative price and positive benefits elasticities. However, the theoretical elasticities are excessive relative to observed ones in the absence of biases. Reintroducing the latter in column (2) maintains expected signs, yet dampens responses and yields elasticities that are somewhat lower than observed values. Overall, we conclude that the model provides a good benchmark to explain in-sample decisions, but that inertia frictions must be accounted in order to replicate observed take-up levels and elasticities.

B.2. Out-of-sample

Asset decumulation We complete our model validation by performing an out-of-sample (OOS) exercise to assess the model's ability to reproduce asset decumulation survey data not used in the estimation. More precisely, we revert to the no-participation benchmark case $V_{i,0}(\boldsymbol{\theta})$ and gauge our framework's capacity to replicate the self-assessed probabilities of having exhausted all financial wealth by the time that respondents reach age 85. For each of the 1,370 persons who provided a probability for this question (asked prior to being presented with product scenarios), we use their individual health, socio-economic and CMA-level house-price levels and distributions to simulate the financial paths predicted by the model and compute the share with zero or negative wealth at age 85. Contrasting the survey data in column (1) and the model predictions in column (2) of Table X reveals that both the distribution (panel a), and especially the socio-economic gradients of wealth decumulation (panel b) are well replicated. This out-of-sample validation provides additional support for our model and confirms that the predicted risk management choices are *also* consistent with the households' implicit asset decumulation strategies.

[Insert Table X about here]

Home ownership and HELOC borrowing The previous OOS exercise was restricted to reproducing variables available *in our survey*, rather than from external sources. It is nevertheless interesting to look at the model's ability to match observables of interest from other databases, such as the SFS age-75, unconditional (i) home ownership rate, as well as (ii) use of HELOC's borrowing. The SFS is a cross-section and therefore moments are unconditional. Hence, we cannot replicate the (conditional) sampling in our survey which imposes respondents were homeowners between the ages of 60 and 70. With this caveat in mind, we observe a SFS ownership rate of 63% among elders aged 75 not living in LTC institutions, which is closely matched by the model-predicted ownership rate (67%) for non-institutionalized (i.e. $s \in \{H, \ell\}$) agents aged 75. The observed SFS rate of HELOC's borrowing at age 75 is 10%, and is larger than the predicted rate of 3.7%. The difference can be explained by noting that observed HELOC borrowing is often done by agents with positive wealth (e.g. for leveraged portfolio purposes), whereas it is only resorted to by agents with negative net wealth in the model. Notwithstanding the caveat of sample comparability, this additional OOS exercise on matching ownership and HELOC's provides additional support for our model, yet should be subject to caution given that the data sources and sampling are different.

V. Implications for risk management strategies

To summarize, our structural estimation provides good in- and out-of-sample performance and indicates (i) high RRA, (ii) concern over long-run risks, (iii) preference for early resolution of uncertainty, (iv) strong time discounting in disability states, (v) imperfect substitutability between housing and financial capital and (vi) importance of bequest motives. The implications of these findings for risk management and decumulation strategies are that agents will (i) have strong demand for both static insurance, as well as precautionary wealth reserves,[55] (ii) demand more of instruments that hedge long-run risks and facilitate early resolution of long-run uncertainty, (iii) discount more heavily both benefits received and costs incurred in fu-

[55]See Weil (1993); Wang et al. (2016); Douenne (2020) for the theoretical and empirical links between risk aversion and precautionary reserves in the context of recursive preferences.

ture disability states, (iv) reluctantly substitute housing into financial wealth for precautionary reserves and/or consumption purposes, and (v) set aside and insure financial and residential wealth reserves earmarked for bequest purposes.

In order to better understand the role of the model parameter estimates and assumptions in matching the demand for risk management, we rely on a comparative statics exercise whereby we (i) abstract from all informational as well as status-quo biases by setting $(\lambda_{v,n(k)}, \delta_{i,n(k)}) = (\infty, 0)$, (ii) set fixed benefits levels for the three products,[56] and (iii) impose fair pricing at the respondent level (discussed in Online Appendix G) to gauge the households' theoretical demand for the three risk management products in an idealized setting. The take-up rates from the comparative statics exercise are reported in Table XI.[57]

`[Insert Table XI about here]`

[56] The benefits were set for ANN (50% of W annuitized), LTCI (50% of m_s insured against) and RMR (55% of P^H).

[57] Since prices used in the experiment spanned below and above market prices and were therefore not necessarily fair at the individual level, the baseline optimal take-up of the three products in Table XI differs from the model-based rates reported in Table IX(a, column 3). Indeed, the baseline (vs model-based) take-up of fairly priced annuities is 0.603 (vs 0.466), that of LTCI is 0.029 (vs 0.132) and that of reverse mortgages is 0.701 (vs 0.488), suggesting that the price/benefits combinations in the experiment were less advantageous than fair for ANN, RMR, and more advantageous than fair for LTCI. Interestingly, the fair-pricing full annuitization result of Yaari (1965) is verified with a take-up rate of 0.94 for ANN when housing, valuation shocks and couples are abstracted from, providing further support for the model.

A. Preferences

EZW vs VNM preferences Recall from Table VIII(a) that our estimated parameters rejected VNM ($\gamma = \varepsilon$) and confirmed PERU ($\gamma = 5.082 > \varepsilon = 2.304$). This non-indifference to timing is consistent with preference for instruments that hedge LRR and whose effects are identified by contrasting baseline with row 1 of in Table XI. The long-run risk of outliving accumulated assets is hedged by ANN whose demand is higher under EZW. The long-term risks of high out-of-pocket expenditures are hedged by LTCI. However, the LTCI benefits are paid out in low-valuation disability states which will debase long-run insurance value, resulting in a much lower LTCI demand under EZW. Finally, RMR allows access to current highly valued loans (conditional on being healthy) and offers downside housing price risks protection linked to insufficient maintenance and housing market timing errors through its non-recourse feature. Because such risks are exacerbated by disability, and since the latter is also associated with low valuation ν_{t+k} of housing capital S^H_{t+k} in (7d), RMR also provides indirect insurance against the long-run risk of low housing valuation consistent with higher demand under EZW than VNM.[58]

[58] In a robustness exercise, we re-estimated the complete VNM model rather than only imposing the $H_0 : \varepsilon = \gamma$ restriction at the EZW-estimated parameters. Relative to EZW, the re-estimation of VNM led to a deterioration of performance, with an SSE: $7831.3 \to 7897.5$, confirming the rejection of the VNM restriction in footnote 51, and very limited effects on estimated parameters: $\gamma : 5.082 \to 4.975$, $b : 0.069 \to 0.061$, $\nu : 0.135 \to 0.134$; $\nu_h : 0.31 \to 0.309$; $\rho : 0.963 \to 0.963$.

Valuation risk Table VIII(a) revealed that, relative to the other health states, high disability states significantly lower the expected future marginal utility of wealth ($\nu(s_t = L) = \nu = 0.135 < 1.0$), and therefore the expected future marginal benefit (resp. cost) of income received (resp. paid out). This discount results in two opposing forces for annuities. On the one hand, the marginal value of state-independent benefits is lower, impairing the demand for ANN. On the other hand, so is the expected marginal utility value of precautionary wealth accumulated by highly risk averse households, thereby increasing the willingness to annuitize wealth. When valuation risk is abstracted from (row 2.a) or mitigated (row 2.b), the net effect on annuities is limited. In comparison, the disability-contingent benefits under LTCI have low marginal utility value; abstracting from or mitigating valuation risk results in sizeable increases in the demand for medical insurance.[59] Third, reducing valuation risk impairs the RMR advantage related to hedging low housing valuation in disability states and explains the drop in reverse mortgages demand.

Preferences for housing Recall that despite a low utility weight of housing ($1 - \rho = 0.037$), the positive home ownership utility ($\nu_h = 0.31$) imply that homeowners consider financial and residential wealth as imperfect substitutes. Removing utilitarian services from housing altogether ($\rho = 1, \nu_h = 0$) in row 3.a is equivalent to imposing perfect substitution be-

[59] See also De Donder and Leroux (2021) for a similar negative effect of state-dependent preferences on LTCI demand in a static setting.

tween financial and residential wealth.[60] More fungible housing capital balances are annuitized, and justify a moderate reduction in LTCI. Conversely, perfect substitutability significantly lowers demand for RMR, reflecting the declining relevance of ageing in place made possible by the reverse mortgages. Moreover, our estimates identified a low housing share of total expenses in our survey $(1-\rho) =$ 0.037. Increasing that share to 30% in row 3.b increases the household's demand for housing and exposure to background residential price risk; both ANN and RMR demand falls while demand for LTCI increases.

Bequest motivations Our estimated bequest motives ($b = 0.069$) are associated with positive bequeathable wealth reserves. When $b = 0$ in row 4.a, wealth previously earmarked for bequests may be converted into (i) precautionary wealth reserves, and/or (ii) consumption. More self-insurance through precautionary reserves reduces demand for market insurance against longevity and medical expenses, explaining the fall in both ANN and LTCI, whereas removing the need to accumulate and insure financial and residential bequest reserves warrants more consumption through RMR.[61] Moreover, our parametrization (7e) is consistent with the EZW preferences literature in assuming that bequests are proportional to cash on hand (see footnote 28). An alternative involves introducing a new constant term κ in the bequest

[60] See Koijen et al. (2016) for an application on annuities and LTCI with perfect substitutability between bonds and housing capital.

[61] See also Nakajima and Telyukova (2017) for similar negative effects of bequests on RMR.

function by replacing (7e) with:

$$V^d_{t+1} = V_{t+1}(\mathcal{D}) = \hat{b}(X_{t+1} + \kappa), \quad \hat{b} \equiv b^{\frac{\varepsilon}{1-\varepsilon}} \tag{14}$$

where $\hat{b}$ retains the correction advocated by Kraft et al. (2022). The parameter $\kappa > 0$ is associated with Bequests as Luxury Good (BLG) whereby only those sufficiently rich households will behave as if intending to leave positive bequests.[62] As can be seen from row 4.b, allowing for BLG with a calibrated $\kappa = 50$ (corresponding to 50,000 C\$) has almost identical effects on the predicted shares as shutting down bequest motives altogether in row 4.a, consistent with a luxury good interpretation of $\kappa > 0$.

B. Budget constraint and household composition

Public insurance and LTC expenditures Eliminating the state-provided resource floor in row 5 entails greater exposure to disposable resources risk. This increase in background risk explains the larger demand for net income stabilization through ANN and LTCI and a lower demand for the liquidation of precautionary wealth through RMR. Conversely, when medical expenditures are abstracted from in row 6, the capitalized value of net income increases and is annuitized by and richer households. Shutting down medical expenditures risks unsurprisingly eliminates the demand for insurance procured by LTCI, and warrants a reduction of precautionary wealth

[62] See Lockwood (2018); De Nardi (2004); De Nardi et al. (2010); Ameriks et al. (2011) for discussion of BLG with VNM preferences. We provide a theoretical analysis of BLG with EZW preferences in a simplified model in Online Appendix H.

reserves through an increase in RMR.

Risky returns Our baseline model assumes that the returns on savings are constant and set at the risk-free rate $r = r_f$. We investigate the effects of allowing for stochastic returns by replacing r in (5d) with $\tilde{r} = r_f + \pi(\mu + \sigma\epsilon)$ where π is a risky portfolio share, (μ, σ) are a risk-premium and volatility calibrated from Toronto Stock Exchange (TSX), and ϵ is standard Normal.[63] Consistent with the theoretical results in Online Appendix H, stochastic returns have a dual effect on wealth accumulation. First, the higher expected returns on savings ($\mu > 0$) induces more current consumption at low EIS ($1/\varepsilon = 0.43404 < 1.0$) which penalizes ANN and LTCI, and favors RMR. Second, higher volatility ($\sigma > 0$) induces more precautionary wealth reserves which again discourages ANN and LTCI as well as RMR purchases. The results in row 7.a show that both ANN and LTCI fall while RMR increases. In row 7.b we also investigate the effects of home price risk by doubling the CMA-specific volatility σ^H reported in column (2) of Table III. Addi-

[63]We set the risky portfolio share $\pi = 0.40$ and rely on a 5-points Gauss-Hermite integration to integrate the error term ϵ. The increase in the state space considerably increased computation time, prohibiting the implementation of stochastic returns at the estimation stage. To the best of our knowledge, no information is available regarding risky portfolio shares on RRSP's and TFSA's held by Canadian retirees. We adapted the shares reported in Boyer et al. (2022) for younger cohorts (age 25-55) for RRSP's (60% risky share) and TFSA's (40% risky share) that are expected to be lower for retirees. Indeed, standard financial planners' rule of thumb of 100 (e.g. justETF.com), or 110 minus age (e.g. Fidelity.ca) yield values close to the one we use for our sample aged between 60 and 70. We did experiment with other values between 30% and 50% without major qualitative effect on the results.

tional housing risks also leads to a decrease in annuitized wealth, and more long-term care insurance, and has negligible effects on RMR.

Delay option Our empirical and theoretical frameworks both impose a now-or-never environment in which agents may only purchase the three instruments at $t = 0$ (corresponding to current age of respondent). We therefore abstract from optimal delaying strategies whereby a current lack of interest may conceal an intent to buy the products at later ages (e.g. Milevsky, 2001, for optimal timing of annuity purchases).[64] On the one hand, optimal waiting may be warranted if new information on longevity, health, and housing prices is privately revealed to the agent. On the other hand, the gains from delaying may evaporate if that new information is correctly anticipated and priced by the market and the agent remains uninsured during the waiting period.[65]

[64] The questionnaire (available in the Online Appendix I) specifically asked for the probability of purchasing the instrument if offered by a trusted institution *within the next year* (for ANN and RMR, period not explicit for LTCI). No mention was made of the possibility of purchase after that period, and no question was asked regarding delayed intentions after one year. Consequently, it is not possible to distinguish a low purchase probability in a given price/benefit scenario from lack of interest or from an (implicit) defer strategy.

[65] Theory suggests there is no option value in waiting before purchasing insurance if either (i) no new information or learning occurs in the interim or (ii) new information arises, but the insurer correctly anticipates and prices the adverse selection component associated with revisions on risk exposure (e.g. in longevity or morbidity risks, Boyer et al., 2020b; Dionne and Doherty, 1994). See also American Association for LTCI or AARP for more on the disadvantages of waiting before purchasing LTCI.

We investigate the effect of allowing risk management take up in $t = 4, 7, 10$ years in addition to current purchases at $t = 0$, where actuarially-fair instruments prices at $t = 0$ are adjusted for later purchases through age-dependent yields and premia.[66] In row 8 we gauge how many would still purchase at $t = 0$ when the option of waiting 4, 7, or 10 years is also available; a reduction compared to our now-or-never benchmark therefore indicates optimal deferring.[67]

Overall we find some evidence of optimal delaying; allowing for timing flexibility at $t > 0$ reduces current $t = 0$ purchase intentions by 8.4% for ANN and by 19.1% for RMR, but has no effects for LTCI. Age-increasing premia for long-term care insurance and annuities (see footnote 66) internalize the changes in disability and death rate exposures and erode the benefits of waiting and remaining uninsured especially for LTCI and to a lesser extent

[66] The upper limit at 75 was selected mainly for computational reasons, and to reflect the fact that annuities, long-term care insurance and reverse mortgages are seldom purchased after that age. The $t = 0$ actuarially-fair prices are adjusted upwards with market-provided age premia to factor in the changes in mortality and disability risks exposure associated with ageing, as well as the adverse selection risks associated with private information. The gender-adjusted ANN yields are thus linearly increased by about 2.0% between 65 and 75, whereas the LTCI premia are linearly increased by 9.0% over the same period. Consistent with market practices, RMR premia remain age-independent, with the bulk of adjustments typically stemming from the LTV restrictions which we abstract from.

[67] The indirect utility is computed for all alternative purchase periods and we compute the difference in utility between purchasing it now and the maximal utility over purchasing it at any future date. We then compute how many respondents have a positive difference (would still purchase now, rather than wait).

for ANN. On the other hand, the RMR premia is age-independent, consistent with market practices. Moreover, the RMR loan is expensive and must be cashed-in immediately (rather than as a line of credit) in both our survey and model. Consequently, the currently rich and healthy agent prefer to wait until assets are sufficiently depleted, and/or unforeseen medical expenses occur before borrowing through an expensive RMR. Furthermore, we did impose a cut-off at age 75 for delay options for computational and realism reasons; even larger optimal delaying effects for reverse mortgages could be expected had we permitted borrowing through RMR lines of credit and/or beyond 75, when age-increasing exposure to disability becomes more acute.

All in all, activating the delay option does not alleviate the fact that a flexible model *still* predicts high $t = 0$ take-up rates for ANN and RMR. Equivalently, there is limited option value to waiting that would warrant not purchasing the instrument at $t = 0$, and could possibly explain low observed take-ups. Matching the observed rates (column 1 in Table IX) by the model (column 3) requires re-activating the informational and status-quo biases (column 2).

Household composition We analyze the effects of household composition by simulating the death of a spouse and inheritance of household resources by the widow(er). The one-shot transfer of spousal resources implies that the richer surviving widow.er has fewer incentives to co-insure herself (resp. spouse) from the spouse's (resp. own) medical expenditure risk. In row 9 of Table XI(b), the windfall in inherited wealth is annuitized, and reduces the demand for RMR credit, whereas the elimination of co-insurance motives reduces the demand for LTCI.

C. Biased expectations

Survival First, recall from Figure 1 that respondents tend to be over-optimistic with respect to both their own and their spouse's longevity. Removing these biases in row 10.a of Table XI(c) is thus tantamount to shortening people's expected lifespans. Lower life expectancy unsurprisingly reduces the attractiveness of both ANN and LTCI, since the individual is more likely to die younger and before reaching a deteriorated health state, whereas lower savings requirements raises the demand for RMR credit.[68]

Second, the discussion of equation (2) in the Online Appendix E explains that survival optimism was modeled as an age-independent constant bias $\xi = -1.42$ over the objective measures to fit self-reported subjective beliefs. Heimer et al. (2019) instead identify age-dependent patterns whereby pessimistic young agents under-state survival probabilities (e.g. though excessive weight on rare, catastrophic events such as natural disasters), and gradually become increasingly optimistic (e.g. through increasing weight on the natural ageing process) as they age. We incorporate this increasing optimisim of elders in two steps. Since over-optimism between ages 60-85 is already accounted for through subjective beliefs in in the estimation, we first maintain the anchoring of the death process to replicate the objective probability of surviving to age 85. We next append a linear trend to that process

[68] See also O'Dea and Sturrock (2023) who find that survival pessimism partially explains the low demand for life annuities in the UK.

based on the Heimer et al. (2019) estimates whereby the agent will over-estimate subjective survival probabilities *even more* after 85.[69] The results in row 10.b show very limited effects of increasing over-optimism relative to the benchmark whereby only ANN displays a moderate increase, whereas LTCI and RMR hardly change.

Housing prices Unlike survival, recall also from Figure 2(a,c) that respondents were overly pessimistic regarding home price appreciation. Removing these biases in row 11 implies more robust expected house price returns that justify keeping large residential balances and lowers the demand for both annuities and reverse mortgages. The demand for RMR is further reduced since they are equivalent to a put option on the house with positive value when residential price are expected to decrease (Davidoff, 2015). House-richer agents also buy more of the relatively costly LTCI insurance.

D. Preference for product bundling

The risk management scenarios presented in both the survey and in the model were evaluated independently of each other as respondents separately considered the purchase of a single instrument at a time. On the one hand, this assumption can be considered as realistic given current marketing practices. On the other hand, retirees could theoretically choose any risk management combination, raising the issue of optimal product bundling.

[69] See the discussion of equation (3) in the Online Appendix E. We set $h = -0.5$ to recover the over-optimism patterns similar to Heimer et al. (2019). Lowering to $h = -0.75$ a negligible effect on the results.

To analyze the attractiveness of such combinations, we set up a large grid of potential bundles of ANN, LTCI, and RMR, varying the product characteristics at actuarially-fair prices,[70] and again abstracting from informational and status-quo biases. Table XII reports the take-up rates along the extensive margin (i.e. whether the bundle is purchased or not) by allowing joint (column 1) versus independent (column 2) product selection. The results in panel a confirm that joint bundles would increase demand for all three products: ANN ($0.603 \rightarrow 0.703$), LTCI ($0.029 \rightarrow 0.105$) and RMR ($0.701 \rightarrow 0.756$). Panel b reveals that the key drivers are the increases in demand for bundles involving RMR, such as the LTCI-RMR ($0.003 \rightarrow 0.031$), ANN-RMR ($0.374 \rightarrow 0.462$), as well as ANN-LTCI-RMR ($0.02 \rightarrow 0.07$) bundles, whereas RMR on its own falls ($0.304 \rightarrow 0.193$).

`[Insert Table XII about here]`

Non-indifference to bundling suggests at least two interpretations. First, households demand more of ANN and LTCI when offered in a basket in-

[70] For annuities, we consider the fraction of financial wealth that would be annuitized. For long-term care insurance we consider the fraction of medical costs in the case of severe disability which would be insured. Finally, we consider the fraction of eligible home equity (55% of home equity) that could be used to extract a reverse mortgage. We allow for 5 equally spaced levels on the unit interval, i.e. 125 different bundles, computing expected utility of each respondent for each bundle, and comparing optimal choice at actuarially-fair prices with two choice sets: with (joint) and without (independent) interactions among the three financial products. Note that a same person may *separately* choose two or more products, resulting in positive distribution mass off the main diagonal of the take-up matrix under the Independent scenario.

cluding RMR which allows them to use the reverse mortgaged loans to top-up insufficient pension claims and medical insurance, rather than use the borrowed funds for consumption purposes.[71] Second, the long-run risks induced by age-increasing exposure to disability risk and its consequences for longevity, consumption and valuation, as well as housing returns are imperfectly hedged by the three individual instruments. Bundling ANN, LTCI and RMR may thus allow a more complete LRR insurance coverage, consistent with the importance of complementarity and substitutability between risk management products advocated by Ameriks et al. (2011); Koijen et al. (2016); Cocco and Lopes (2020).

VI. Conclusion

This paper has emphasized the importance of (i) preferences towards risks, inter-temporal substitution, housing and disability-dependent discounting, (ii) heterogeneity in both objective and subjective beliefs regarding housing and health risks, as well as (iii) household composition, (iv) public insurance and (v) product bundling in explaining the low demand for ANN, LTCI and RMR. Our flexible model goes a long way in rationalizing the disinterest for the three instruments, yet behavioural frictions (informational and inertia) must be appended to better align take-up rates and responsiveness to price and benefits combinations.

We have omitted a number of elements which are potentially also relevant.

[71] See also Hanewald et al. (2016) for a similar finding whereby RMR loans are used to purchase additional ANN and LTCI coverage.

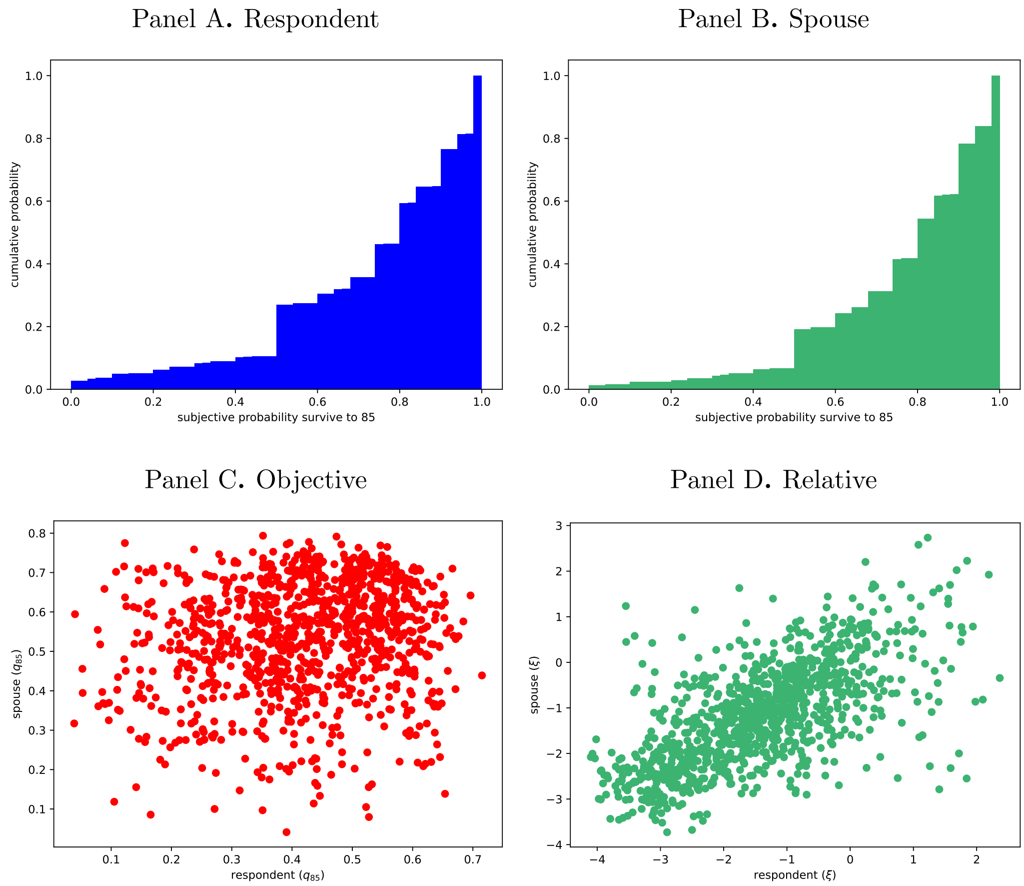
First, we focused on the sub-sample of homeowners exclusively. This restriction is consistent with the prevalence of homeownership among Canadian retirees,[72] and was required to analyze RMR whose relevance depends on ownership. Still, the information from current renters (550 individuals in the original sample) may also be useful to understand ANN and LTCI and could be fruitfully integrated. Second, we omitted life insurance as an alternative to costly bequeathable wealth against the risk of living too short.[73] Finally, we have voluntarily focused on respondents at or near retirement, conditioning on contemporary financial and residential assets to explain take-up rates. Backward induction arguments require that projected post-retirement risk exposure and decumulation strategies be accounted for in pre-retirement labor supply, consumption, and housing decisions, and therefore could be integrated in disposable net worth at retirement. These features might play an important role in understanding ANN, LTCI and RMR disinterest, but their integration is beyond the scope of the current project and is left on the research agenda.

[72]Between 2011-2021, the ownership rate was 62.6% among primary household maintainers aged 55-74 and 68.9% after age 75 (source Statistics Canada).

[73]Online Appendix H provides discussion on the theoretical links between life insurance and bequests as luxury goods under market completeness, as well as on the likely effects on asset decumulation strategies.

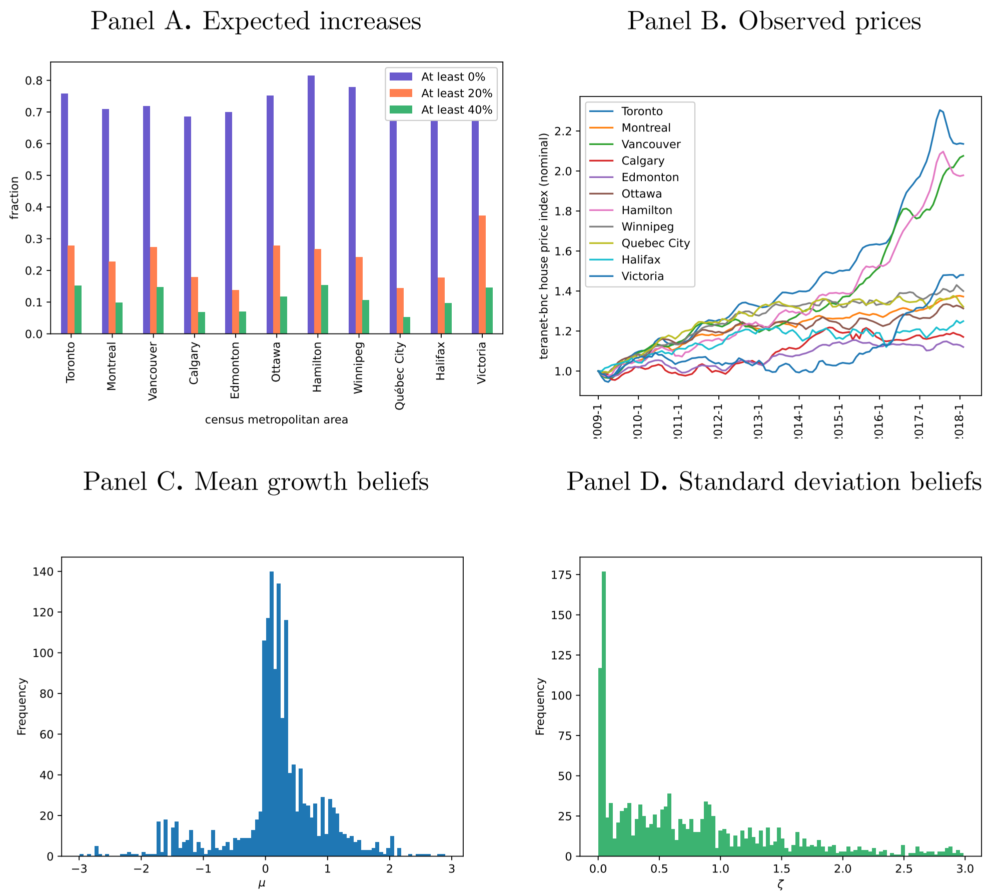
Figures

Figure 1. Probabilities of survival to age 85



Notes: Reported own (a) and spouse (b) survival probabilities. (c) Joint distribution of objective probabilities accounting for health conditions and other individual characteristics. (d) Joint distribution of relative subjective beliefs (w.r.t. objective risk); a positive (resp. negative) number indicates pessimist (resp. optimistic) beliefs.

Figure 2. Subjective and objective home prices distribution



Notes: (a) Reported expected house price increases (in %) over the next 10 years, by CMA. (b) Observed home prices, source National Bank - TeraNet House Price Index by CMA (2009=1). (c) Beliefs about price growth ($\mu = 1$ is historical estimate). (d) Beliefs on standard deviation of house price shocks ($\zeta = 1$ is historical census metropolitan area (CMA) estimate). Outliers below -3 and above 3 removed.

Tables

Table I. Descriptive statistics and representativeness

Variable	(a) Survey mean	(a) Survey std	(a) Survey med.	(b) Pop. (SFS) mean	(b) Pop. (SFS) std	(b) Pop. (SFS) med	(c) Dif. t-stat
age resp.	65.1	3.09	65	65	3.15	65	0.77
male	0.6	0.49	1	0.51	0.5	1	4.63
married	0.74	0.44	1	0.71	0.45	1	1.49
age spouse	64.63	4.47	65	63.33	6.86	62	4.77
househ. Inc.	109.8	89.3	89.0	124.4	116.2	96.3	−3.5
home value	710.7	444.6	600.0	734.7	512.1	625.0	−1.25
mortgage	28.5	81.5	0.0	89.8	147.3	0.0	−12.49
wealth	325.3	224.7	300.0	210.2	268.5	100.0	11.62
low savings	0.05	0.22	0	0.21	0.41	0	−11.86
Sample size	1 581			1 090			

Notes: Panel (a): The sample from the survey is that of households in 2019 who are homeowners, live in one of the 11 CMAs in Canada and where one member is between the age of 60 and 70. Panel (b): Population data from the Survey of Financial Security (SFS) for 2019 used for comparison with the survey. Same sample selection criteria used on the SFS. Nominal values (income, house, mortgage, wealth) in KC$. Low savings: less that 5,000C$. t-stats computed over difference in mean, adjusted for sample sizes.

Table II. Housing prices levels, rents and transfer taxes

CMA	Own (1)	Rent (2)	$\phi = P^R/P^H$ (3)	τ_1^b (LTT) (4)
Victoria	777 993	1 507	0.023	0.017
Vancouver	1 012 280	1 792	0.021	0.018
Edmonton	365 673	1 272	0.042	0
Calgary	460 201	1 323	0.034	0
Winnipeg	317 931	1 262	0.048	0.013
Toronto	929 673	1 635	0.021	0.032
Hamilton	692 419	1 291	0.022	0.015
Ottawa	529 613	1 517	0.034	0.013
Montreal	468 604	903	0.023	0.012
Quebec	292 743	899	0.037	0.01
Halifax	369 819	1 255	0.041	0.015

Notes: CMA: Census Metropolitan Area. Sources: CHMC, Housing Market Outlook, Spring 2023; (1) House prices (nominal, C$) are for 2020, average MLS (Centris for Montreal and Quebec). (2) monthly rentals are average two-bedroom (see CHMC documentation website for rental survey methodology), private, unsubsidized structures with minimum 3 units on the market for at least 3 months; (3) ϕ is annual rental cost to house price ratio; (4) Land Transfer Taxes (LTT) by CMA (not applicable in AB) calculated as percentage of average price levels, sources Ratehub.ca LTT calculators.

Table III. Housing prices dynamics

CMA	(a) Price dynamics 1991-2018			(b) Recent growth 2020-		
	mean g	vol σ^H	ADF-p	2024(F)	2027(L)	2027(H)
	(1)	(2)	(3)	(4)	(5)	(6)
Victoria	0.036	0.058	0.946	0.05	0.01	0.081
Vancouver	0.044	0.056	0.993	0.044	0.031	0.068
Edmonton	0.036	0.086	0.355	0.031	0.015	0.039
Calgary	0.03	0.081	0.493	0.07	0.038	0.062
Winnipeg	0.028	0.042	0.772	0.042	0.011	0.054
Toronto	0.044	0.037	0.999	0.039	0.02	0.05
Hamilton	0.043	0.034	0.996	0.057	0.041	0.056
Ottawa	0.026	0.025	0	0.061	0.044	0.061
Montreal	0.025	0.033	0.815	0.072	0.058	0.082
Quebec	0.026	0.039	0.815	0.08	0.123	0.148
Halifax	0.019	0.025	0.92	0.114	0.067	0.095

Notes: CMA: Census Metropolitan Area. (a) (1)–(3) Mean growth and standard error from real house price indices source Teranet, period 1991-2018, with p-value from the augmented Dickey-Fuller test (ADF-p). (b) Sources: CHMC, Housing Market Outlook, Spring 2025 mean growth rate from 2020 to 2024 (4), to 2027 low (5) and high (6).

Table IV. Take-up probabilities, knowledge and elasticities

	ANN (1)	LTCI (2)	RMR (3)
(a) Take-up rates			
1. prob. buys	0.108	0.174	0.073
2. prob. zeros (all scen.)	0.558	0.392	0.638
(b) Prior knowledge			
3. knows product	0.269	0.109	0.287
(c) Price and benefit (within) elasticities			
4. price	−1.037	−0.783	−1.021
5. benefit	0.978	0.543	0.057

Notes: 1. average probability of buying the product over all scenarios. 2. fraction of respondents who report zero probability of purchase over all scenarios for a given product. 3. fraction of respondents who respond that they know *a lot* about a particular product. 4. and 5. price and benefit elasticity estimate from a fixed effect regression of the (log) probability of purchasing the product on the (log) price and (log) benefit in the scenario.

Table V. Calibrated auxiliary parameters

Parameter	Eq.(#)	Interpretation	Value/Range
		(a) Financial rates:	
r	(4b), (6a)	Interest/discount rate	0.01
r_d	(2c)	Borrowing rate (mortgage)	0.03
r_h	(6a)	Borrowing rate (owners)	0.05
r_r	(6a)	Borrowing rate (renters)	0.095
		(b) Borrowing constraints:	
ω^D	(2b)	Mortgage LTV	0.80
ξ^D	(2b)	Mortgage amortization	0.9622
ω^R	(4a)	Reverse mortgage LTV	0.55
(ω_1^h, ω_2^h)	(6b)	Owners credit limit	(0.80,0.33)
ω^r	(6b)	Renters credit limit	0.65
		(c) Housing:	
ϕ	(1b)	Rental price parameter	Table II (3)
(τ_0^s, τ_1^s)	(3)	Seller's moving costs	(1.50,0.05)
(τ_0^b, τ_1^b)	(3)	Buyer's moving costs	(0.50,Table II (4))
		(d) Consumption floor and discounting:	
$C_{\min}$	(5b)	Consumption floor	18.2
β	(7a)	Subjective discount factor	0.97

Notes: Nominal values $(b^A, P^A, b^L, P^L, \tau_0^s, \tau_0^b, Y_t, X_{\min}, M_t)$ set in 1,000C$ units.

Table VI. Annual medical expenditures per person

CMA	Health status		
	G	ℓ	L
Victoria	2 734	5 086	40 647
Vancouver	2 816	5 256	41 063
Edmonton	2 536	5 240	24 937
Calgary	2 538	5 282	24 862
Winnipeg	2 583	4 986	31 208
Hamilton	2 200	3 420	32 097
Toronto	2 235	3 466	32 162
Ottawa	2 165	3 374	32 031
Montreal	2 560	4 107	22 780
Quebec	2 532	4 062	22 589
Halifax	2 334	5 182	41 390

Notes: Sources: 2009 Survey of Household Spending and 2002 General Social Survey. Covers medical, home care, and nursing home expenses. Adjusted in 2019 C$. Health status G refers to good health, ℓ refers to some iADL limitations and L at least 2 ADL limitations.

Table VII. Pricing, distributions and biases

	Budget constraint (eqs. 1–6)		Decisions (eq. 7)
	Housing	Instruments	
	(1)	(2)	(3)
(a) Survey, estimation, and results (Sections II, III, and IV)			
Pricing	Market	Market	(same)
Loads on prices	—	$\tau \in [0.5, 1.75]$	(same)
Risks:			
- distribution	Objective	Objective	Subjective
- health-dependent	—	No	Yes
Behavioral biases	—	—	Yes
(b) Comparative statics (Section V)			
Pricing	Market	Actuarially fair	(same)
Loads on prices	—	$\tau \equiv 1.0$	(same)
Risks:			
- distribution	Objective	Objective	Subject./Objec.
- health-dependent	—	Yes	Yes
Behavioral biases	—	—	No

Notes: Prices for housing, and instruments (ANN, LTCI and RMR) and loads on instruments' prices. Risks distributions (Housing prices, health, and longevity) used for pricing and decisions. Behavioral biases (informational and status-quo). Actuarially-fair pricing at the agent-specific level (see Online Appendix G for details).

Table VIII. NLLS structural parameters estimates

Parameter	Eq.(#)	Interpret.	Estim.	Std. Err.
		(a) Preferences		
γ	(7a)	RRA	5.082	0.002
ε	(7a)	Inverse EIS	2.304	0.005
ν	(7b)	Time preference shock	0.135	0.001
ρ	(7c)	Consumption share	0.963	0.001
ν_h	(7d)	Own home utility	0.31	0.06
b	(7e)	Bequest intensity	0.069	0.001
		(b) Info content utility gradients		
$\lambda_{v,A}$	(13)	ANN loading	0.03	0.002
$\lambda_{v,L}$	(13)	LTCI loading	0.204	0.009
$\lambda_{v,R}$	(13)	RMR loading	0.04	0.003
within SSE		7 831.3		

(c) Inertia biases

	ANN	LTCI	RMR
mean	3.469	2.429	3.8
s.d.	1.615	1.997	1.385
p25	2.418	1.001	3.4
p50	4.519	2.897	4.537
p75	4.614	4.202	4.607

Notes: (a) Estimates obtained numerically using the concentrated non-linear least square estimator. (b) Upon convergence, point estimates are used to retrieve the concentrated parameters $\lambda_{v,j}$ for product $j = A, L, R$. Clustered standard errors at the level of the respondent are computed using the numerical gradient of the NLS errors. The within (concentrated NLS) sum of squared errors is also reported.

Table IX. Take-up rates, price and benefits elasticities

	Data (1)	Estimated (2)	Model-based (3)
(a) Take-up rates			
ANN	0.108	0.089	0.466
LTCI	0.174	0.157	0.132
RMR	0.073	0.061	0.488
(b) Price elasticities			
ANN	−1.037	−0.181	−1.731
LTCI	−0.783	−0.241	−1.935
RMR	−1.02	−0.087	−0.84
(c) Benefits elasticities			
ANN	0.977	0.187	1.656
LTCI	0.543	0.092	1.346
RMR	0.057	0.06	0.252

Notes: Column (1), Data: Mean take-up rates and price and benefits elasticities estimated from sample. Column (2), Estimated: Predicted using the estimates default-bias $\hat{\delta}_{i,n(k)}$ and noise $\hat{\lambda}_{\upsilon,n(k)}$. Column (3), Model-based: Predicted by only the life-cycle model utility gradients obtained by setting $(\lambda_{\upsilon,n(k)}, \delta_{i,n(k)}) = (\infty, 0)$. Elasticities in panels b, c calculated at the mean from a product-based regression of choice probabilities on price and benefits, with fixed effects. For annuities and long-term care insurance, we use a log-log specification.

Table X. Probabilities of exhausting financial wealth by age 85

	Survey (1)	Model (2)
(a) Statistics		
mean	0.428	0.261
std	0.376	0.343
p25	0.02	0
p50	0.4	0.062
p75	0.8	0.471
(b) OLS regression coefficients		
Constant	0.6847***	0.6510***
Wealth quart. (ref 1st)		
2nd	−0.0721***	−0.1514***
3rd	−0.1904***	−0.2806***
4th	−0.2703***	−0.3043***
Home equity quart. (ref 1st)		
2nd	−0.0486*	−0.1080***
3rd	−0.1041***	−0.1463***
4th	−0.1067***	−0.1916***
Ret. income quart. (ref 1st)		
2nd	−0.0198	−0.1604***
3rd	−0.0907***	−0.2094***
4th	−0.1392***	−0.0844***
Nb. obs.	1 370	

Notes: Probability of zero financial wealth at age 85. Column (1), Data: probability the respondent will have spent down all financial wealth by the time (s)he reaches age 85. Column (2), Model: we simulate (1,000 replications) for each respondent the path of financial wealth forward until age 85 and calculate number with non-positive wealth. Rely on subjective mortality and house price risk. Panel a: distribution moments of reported (data) and simulated (model) probabilities. Panel b: regression estimates of these probabilities on quartile dummies (the first is the reference category) for financial wealth, home equity and retirement income. Includes controls for gender and marital status in the regression. * denotes $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

Table XI. Counter-factual optimal take-up at fair prices

Nb.		ANN (1)	LTCI (2)	RMR (3)
Nb.	Baseline	0.603	0.029	0.701
	(a) Preferences			
1	VNM ($\varepsilon = \gamma = 5.082$)	0.549	0.334	0.42
2.a	No valuation risk ($\nu = 1.0$)	0.608	0.776	0.557
2.b	Mid valuation risk ($\nu = 0.5$)	0.617	0.279	0.629
3.a	No pref. for housing ($\rho = 1.0, \nu_h = 0$)	0.617	0.025	0.595
3.b	Higher housing share ($\rho = 0.7$)	0.598	0.212	0.536
4.a	No bequest motive ($b = 0$)	0.543	0.004	0.868
4.b	Beq. as lux. good ($b = 0.069, \kappa = 50$)	0.546	0.004	0.859
	(b) Budget constraint and household composition			
5	Low resource floor ($X_{\text{min}} = 0$)	0.655	0.097	0.423
6	No medical expend. ($m_s = 0$)	0.625	0	0.739
7.a	Risky returns ($r \to \tilde{r}$)	0.508	0.024	0.825
7.b	Riskier housing ($\sigma^H \to 2 \times \sigma^H$)	0.574	0.037	0.694
8	Delay option ($t = 0 \to t \in (4, 7, 10)$)	0.519	0.029	0.51
9	Singles ($ij \to i$)	0.695	0.012	0.586
	(c) Biased expectations			
10.a	No over-optim. surv. ($\xi = 0$)	0.509	0.004	0.736
10.b	Age-incr. over-optim. surv.	0.628	0.031	0.702
11	No over-pessim. house price ($\zeta = 0$)	0.506	0.048	0.632

Notes: Optimal take-up under counter-factual scenarios (Nb. 1–11). Abstracting from informational and status-quo biases by setting $(\lambda_{v,n(k)}, \delta_{i,n(k)}) = (\infty, 0)$ and calculated at agent-specific fair prices detailed in Online Appendix G, and fixed benefits set for ANN (50% of W annuitized), LTCI (50% of m_s insured against) and RMR (55% of P^H). Row 4.b replaces bequest specification (7e) with $V_{t+1}(\mathcal{D}) = \hat{b}(X_{t+1} + \kappa), \hat{b} \equiv b^{\frac{\varepsilon}{1-\varepsilon}}$.

Table XII. Demand for bundling

Bundle	Joint (1)	Independent (2)
(a) Total demand		
ANN	0.703	0.603
LTCI	0.105	0.029
RMR	0.756	0.701
(b) Distribution		
∅	0.073	0.089
RMR	0.193	0.304
RMR-LTCI	0.031	0.003
LTCI	0.001	0.001
ANN	0.167	0.204
ANN-RMR	0.462	0.374
ANN-LTCI	0.004	0.005
ANN-LTCI-RMR	0.07	0.02

Notes: Extensive margins (yes/no) take-up rates evaluated at actuarially-fair prices, and abstracting from informational and status-quo biases. Joint: Respondents choose among all possible bundles involving ANN, LTCI and RMR. Independent: Each product chosen independently from other. Panel (a) reports the total demand for each product, i.e. sum over all bundles involving the product. Panel (b) reports the distribution across the bundles.

REFERENCES

Achou, Bertrand, 2021, Housing liquidity and long-term care insurance demand: A quantitative evaluation., *Journal of Public Economics* 194, 104353.

Achou, Bertrand, Philippe De Donder, Franca Glenzer, Minjoon Lee, and Marie-Louise Leroux, 2022, Nursing home aversion post-pandemic: Implications for savings and long-term care policy., *Journal of Economic Behavior and Organization* 201, 1–21.

Albuquerque, Rui, Martin Eichenbaum, Victor Xi Luo, and Sergio Rebelo, 2016, Valuation risk and asset pricing, *The Journal of Finance* 71, 2861–2903.

Ameriks, John, Joseph Briggs, Andrew Caplin, Matthew D. Shapiro, and Christopher Tonetti, 2018, The long-term-care insurance puzzle: Modeling and measurement, Unpublished manuscript, Stanford University.

Ameriks, John, Joseph Briggs, Andrew Caplin, Matthew D. Shapiro, and Christopher Tonetti, 2020a, Long-term-care utility and late-in-life saving., *Journal of Political Economy* 128, 2375–2451.

Ameriks, John, Andrew Caplin, Steven Laufer, and Stijn Van Nieuwerburgh, 2011, The joy of giving or assisted living? using strategic surveys to separate public care aversion from bequest motives., *Journal of Finance* 66, 519 – 561.

Ameriks, John, Gabor Kezdi, Minjoon Lee, and Matthew D. Shapiro, 2020b, Heterogeneity in expectations, risk tolerance, and household stock shares: The attenuation puzzle., *Journal of Business and Economic Statistics* 38, 633 – 646.

André, Eric, Antoine Bommier, and François Le Grand, 2022, The impact of risk aversion and ambiguity aversion on annuity and saving choices, *Journal of Risk and Uncertainty* 65, 33–56.

Bahk, Jinwook, Hee-Yeon Kang, and Young-Ho Khang, 2019, The life expectancy gap between registered disabled and non-disabled people in Korea from 2004 to 2017, *International Journal of Environmental Research and Public Health* 16, 1–9.

Bansal, Ravi, and Amir Yaron, 2004, Risks for the long run: A potential resolution of asset pricing puzzles, *The Journal of Finance* 59, 1481–1509.

Benartzi, Shlomo, Alessandro Previtero, and Richard H. Thaler, 2011, Annuitization puzzles., *Journal of Economic Perspectives* 25, 143 – 164.

Blevins, Jason R., Wei Shi, Donald R. Haurin, and Stephanie Moulton, 2020, A dynamic discrete choice model of reverse mortgage borrower behavior., *International Economic Review* 61, 1437 – 1477.

Blundell, Richard, Margherita Borella, Jeanne Commault, and Mariacristina De Nardi, 2024, Old age risks, consumption, and insurance., *American Economic Review* 114, 575 – 613.

Boyer, M. Martin, Sébastien Box-Couillard, and Pierre-Carl Michaud, 2020a, Demand for annuities: Price sensitivity, risk perceptions, and knowledge, *Journal of Economic Behavior and Organization* 180, 883–902.

Boyer, M. Martin, Philippe d'Astous, and Pierre-Carl Michaud, 2022, Tax-Preferred Savings Vehicles: Can Financial Education Improve Asset Location Decisions?, *The Review of Economics and Statistics* 104, 1–45.

Boyer, M. Martin, Philippe De Donder, Claude Fluet, Marie-Louise Leroux, and Pierre-Carl Michaud, 2020b, Long-term care insurance: Information frictions and selection., *American Economic Journal: Economic Policy* 12, 134 – 169.

Brown, Jeffrey R., and Amy Finkelstein, 2008, The interaction of public and private insurance: Medicaid and the long-term care insurance market., *American Economic Review* 98, 1083 – 1102.

Brown, Jeffrey R., Arie Kapteyn, Erzo F. P. Luttmer, Olivia S. Mitchell, and Anya Samek, 2021, Behavioral impediments to valuing annuities: Complexity and choice bracketing., *Review of Economics and Statistics* 103, 533 – 546.

Calvet, Laurent, John Y. Campbell, Francisco J. Gomes, and Paolo Sodini, 2021, The cross-section of household preferences., NBER Working Paper Series 28788, National Bureau of Economic Research.

Caplin, Andrew, Mark Dean, and John Leahy, 2019, Rational inattention, optimal consideration sets, and stochastic choice., *Review of Economic Studies* 86, 1061 – 1094.

Case, Karl E., and Robert J. Shiller, 1989, The efficiency of the market for single-family homes., *American Economic Review* 79, 125 – 137.

Case, Karl E., and Robert J. Shiller, 2003, Is there a bubble in the housing market?, *Brookings Papers on Economic Activity* 2003, 299–342.

Chen, Zhanhui, and Bowen Yang, 2019, In search of preference shock risks: Evidence from longevity risks and momentum profits, *Journal of Financial Economics* 133, 225–249.

Choinière-Crèvecoeur, Ismael, and Pierre-Carl Michaud, 2023, Reverse mortgages and financial literacy, *Journal of Financial Literacy and Wellbeing* 1, 79–102.

Cocco, Joao F., and Paula Lopes, 2020, Aging in place, housing maintenance, and reverse mortgages., *Review of Economic Studies* 87, 1799 – 1836.

Coe, Norma B., Gopi Shah Goda, and Courtney Harold Van Houtven, 2023, Family spillovers and long-term care insurance., *Journal of Health Economics* 90.

Collin-Dufresne, Pierre, Michael Johannes, and Lars A. Lochstoer, 2017, Asset pricing when 'this time is different', *The Review of Financial Studies* 30, 505–538.

Córdoba, Juan Carlos, and Marla Ripoll, 2017, Risk aversion and the value of life, *Review of Economic Studies* 84, 1472–1509.

Davidoff, Thomas, 2009, Housing, Health, and Annuities, *Journal of Risk and Insurance* 76, 31–52.

Davidoff, Thomas, 2010, Home equity commitment and long-term care insurance demand, *Journal of Public Economics* 94, 44–49.

Davidoff, Thomas, 2015, Can 'high costs' justify weak demand for the home equity conversion mortgage?., *The Review of Financial Studies* 28, 2364 – 2398.

De Donder, Philippe, and Marie-Louise Leroux, 2021, Long term care insurance with state-dependent preferences., *Health Economics* 30, 3074 – 3086.

de Groot, Oliver, Alexander Richter, and Nathaniel Throckmorton, 2022, Valuation risk revalued, *Quantitative Economics* 13, 723–759.

De Nardi, Mariacristina, 2004, Wealth inequality and intergenerational links., *Review of Economic Studies* 71, 743 – 768.

De Nardi, Mariacristina, Eric French, and John Bailey Jones, 2010, Why do the elderly save? The role of medical expenses, *Journal of Political Economy* 118, 39–75.

De Nardi, Mariacristina, Eric French, John Bailey Jones, and Rory McGee, 2021, Why do couples and singles save during retirement?, Working Paper 28828, National Bureau of Economic Research.

Dionne, Georges, and Neil A. Doherty, 1994, Adverse selection, commitment, and renegotiation: Extension to and evidence from insurance markets, *Journal of Political Economy* 102, 209–235.

Douenne, Thomas, 2020, Disaster risks, disaster strikes, and economic growth: The role of preferences, *Review of Economic Dynamics* 38, 251–272.

Epstein, Larry G., Emmanuel Farhi, and Tomasz Strzalecki, 2014, How much would you pay to resolve long-run risk?., *American Economic Review* 104, 2680 – 2697.

Epstein, Larry G., and Stanley E. Zin, 1991, Substitution, risk aversion and the temporal behavior of consumption and asset returns: An empirical analysis, *Journal of Political Economy* 99, 263–268.

Finkelstein, Amy, Erzo F.P. Luttmer, and Matthew J. Notowidigdo, 2013, What good is wealth without health? The effect of health on the marginal utility of consumption., *Journal of the European Economic Association* 11, 221–258.

Gomes, Francisco, and Alexander Michaelides, 2005, Optimal life-cycle asset allocation: Understanding the empirical evidence, *The Journal of Finance* 60, 869–904.

Gorea, Denis, and Virgiliu Midrigan, 2018, Liquidity constraints in the U.S. housing market, NBER Working Paper w23345, National Bureau of Economic Research.

Handel, Benjamin R., and Jonathan T. Kolstad, 2015, Health insurance for 'humans': Information frictions, plan choice, and consumer welfare., *American Economic Review* 105, 2449 – 2500.

Hanewald, Katja, Thomas Post, and Michael Sherris, 2016, Portfolio choice in retirement–what is the optimal home equity release product?, *Journal of Risk and Insurance* 83, 421–446.

Hansen, Lars Peter, John C. Heaton, and Nan Li, 2008, Consumption strikes back? measuring long-run risk., *Journal of Political Economy* 116, 260 – 302.

Heimer, Rawley Z., Kristian Ove R. Myrseth, and Raphael S. Schoenle, 2019, Yolo: Mortality beliefs and household finance puzzles, *Journal of Finance* 74, 2957–2996.

Hong, Jay H., and Jose-Victor Rios-Rull, 2012, Life insurance and household consumption., *American Economic Review* 102, 3701 – 3730.

Horneff, Wolfram J., Raimond H. Maurer, and Michael Z. Stamos, 2008, Life-cycle asset allocation with annuity markets, *Journal of Economic Dynamics and Control* 32, 3590–3612.

Hubener, Andreas, Raimond Maurer, and Olivia S. Mitchell, 2015, How Family Status and Social Security Claiming Options Shape Optimal Life Cycle Portfolios, *The Review of Financial Studies* 29, 937–978.

Hugonnier, Julien, Florian Pelgrin, and Pascal St-Amour, 2013, Health and (other) asset holdings, *Review of Economic Studies* 80, 663–710.

Hugonnier, Julien, Florian Pelgrin, and Pascal St-Amour, 2022, Valuing life as an asset, as a statistic and at gunpoint, *The Economic Journal* 132, 1095–1122.

Hurd, Michael D., 1989, Mortality risk and bequests, *Econometrica* 57, 779–813.

Hurd, Michael D., and Kathleen McGarry, 2002, The predictive validity of subjective probabilities of survival*, *The Economic Journal* 112, 966–985.

Inkmann, Joachim, Paula Lopes, and Alexander Michaelides, 2011, How deep is the annuity market participation puzzle?, *The Review of Financial Studies* 24, 279 – 319.

Kaltenbrunner, Georg, and Lars A. Lochstoer, 2010, Long-run risk through consumption smoothing., *The Review of Financial Studies* 23, 3190 – 3224.

Ko, Ami, 2022, An equilibrium analysis of the long-term care insurance market., *Review of Economic Studies* 89, 1993 – 2025.

Koijen, Ralph S. J., Stijn Van Nieuwerburgh, and Motohiro Yogo, 2016, Health and mortality delta: Assessing the welfare cost of household insurance choice., *Journal of Finance* 71, 957 – 1010.

Kraft, Holger, Claus Munk, and Farina Weiss, 2022, Bequest motives in consumption-portfolio decisions with recursive utility., *Journal of Banking and Finance* 138.

Laitner, John, Dan Silverman, and Dmitriy Stolyarov, 2018, The role of annuitized wealth in post-retirement behavior., *American Economic Journal: Macroeconomics* 10, 71 – 117.

Lefebvre, Judith, and Yves Carrière, 2022, Trends in partial disability-free life expectancy between the ages of 45 and 70 in canada, 2000?2014, *Canadian Journal on Aging / La Revue canadienne du vieillissement* 41, 320?326.

Lockwood, Lee M., 2012, Bequest motives and the annuity puzzle., *Review of Economic Dynamics* 15, 226 – 243.

Lockwood, Lee M., 2018, Incidental bequests and the choice to self-insure late-life risks., *American Economic Review* 108, 2513 – 2550.

Luttmer, Erzo F.P., Priscila de Oliveira, and Dmitry Taubinsky, 2022, Failures of contingent reasoning in annuitization decisions, Manuscript, UC Berkeley.

Matejka, Filip, and Alisdair McKay, 2015, Rational inattention to discrete choices: A new foundation for the multinomial logit model, *American Economic Review* 105, 272–98.

Maurer, Raimond, Olivia S. Mitchell, Ralph Rogalla, and Vasily Kartashov, 2013, Lifecycle portfolio choice with systematic longevity risk and variable investment? linked deferred annuities, *Journal of Risk and Insurance* 80, 649–676.

Milevsky, Moshe A., 2001, Optimal annuitization policies: Analysis of the options, *North American Actuarial Journal* 5, 57–69.

Nakajima, Makoto, and Irina A. Telyukova, 2017, Reverse Mortgage Loans: A Quantitative Analysis, *The Journal of Finance* 72, 911–950.

Normandin, Michel, and Pascal St-Amour, 1998, Risk aversion, taste shocks and equity premia, *Journal of Applied Econometrics* 13, 256–281.

O'Dea, Cormac, and David Sturrock, 2023, Survival Pessimism and the Demand for Annuities, *The Review of Economics and Statistics* 105, 442–457.

Palumbo, Michael G., 1999, Uncertain medical expenses and precautionary saving near the end of the life cycle, *Review of Economic Studies* 66, 395–421.

Pauly, Mark V., 1990, The rational nonpurchase of long-term-care insurance, *Journal of Political Economy* 98, 153–168.

Peijnenburg, Kim, Theo Nijman, and Bas J. M. Werker, 2017, Health cost risk: A potential solution to the annuity puzzle., *Economic Journal* 127, 1598 – 1625.

Peijnenburg, Kim, Theo Nijman, and Bas J.M. Werker, 2016, The annuity puzzle remains a puzzle, *Journal of Economic Dynamics and Control* 70, 18 – 35.

Poterba, James M., 1991, House price dynamics: The role of tax policy and demography, *Brookings Papers on Economic Activity* 1991, 143–203.

Russo, Nicolo, 2023, Health-dependent preferences, consumption, and insurance, Manuscript, Goethe University Frankfurt.

Scholz, John Karl, Ananth Seshadri, and Surachai Khitatrakun, 2006, Are Americans saving optimally for retirement?, *Journal of Political Economy* 114, pp. 607–643.

Shao, Adam W., Hua Chen, and Michael Sherris, 2019, To borrow or insure?

long term care costs and the impact of housing, *Insurance: Mathematics and Economics* 85, 15–34.

Shao, Adam W., Katja Hanewald, and Michael Sherris, 2015, Reverse mortgage pricing and risk analysis allowing for idiosyncratic house price risk and longevity risk, *Insurance: Mathematics and Economics* 63, 76–90.

Sims, Christopher A., 2003, Implications of rational inattention., *Journal of Monetary Economics* 50, 665 – 690.

Smith, David C., 1999, Finite sample properties of tests of the Epstein-Zin asset pricing model, *Journal of Econometrics* 93, 113–148.

St-Amour, Pascal, 2024, Valuing life over the life cycle, *Journal of Health Economics* 93.

Statistics Canada, 2023, Life tables, Canada, Provinces and Territories, , Table 13-10-0837.

Steensma, Colin, Lidia Loukine, and Bernard Choi, 2017, Evaluating compression or expansion of morbidity in canada: trends in life expectancy and health-adjusted life expectancy from 1994 to 2010, *Health Promotion and Chronic Disease Prevention in Canada* 37, 68–76.

Steiner, Jakub, Colin Stewart, and Filip Matejka, 2017, Rational inattention dynamics: Intertia and delay in decision-making, *Econometrica* 85, 521–553.

Vestman, Roine, 2019, Limited stock market participation among renters and homeowners., *The Review of Financial Studies* 32, 1494 – 1535.

Wang, Chong, Neng Wang, and Jinqiang Yang, 2016, Optimal consumption and savings with stochastic income and recursive utility, *Journal of Economic Theory* 165, 292–331.

Weil, Philippe, 1990, Nonexpected utility in macroeconomics, *Quarterly Journal of Economics* 105, 29–42.

Weil, Philippe, 1993, Precautionary savings and the permanent income hypothesis, *Review of Economic Studies* 60, 367–383.

Yaari, M., 1965, Uncertain lifetime, life insurance and the theory of the consumer, *Review of Economic Studies* 52, 137–150.