Aging, Housing, and Long-Term Care

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Motivation

- Longevity risk and health shocks are intertwined with each other and impose significant challenges on financial budgets for the aged population in retirement.
- In the U.S. two-thirds of individuals currently aged 65 or above will need some form of LTC, either at home or a LTC facility (Chapman, 2012).
- 82% of LTC expenses have been covered by Medicaid. Demand for private LTC insurance is very low.
- A big percentage of elders at age 65 own a house, but the take-up of reverse mortgage is very low.

Literature

- Davidoff (2010): consumption commitment to their house and asset commitment to home equity, that may explain why the demand for LTC insurance is weak despite the large LTC risk.
- Davidoff (2010) investigates welfare gains of the retired by including RM and LTCI in a one-period model, providing evidence that home equity is a substitute for LTCI.
- If home equity is a substitute for LTCI, then accessing home equity using a RM complements LTCI (Ahlstrom et al., 2004).
- Shao et al. (2019) use a life-cycle model to show that the highest welfare benefits come from combining a RM with LTCI because of strong complementary effects between them.

Literature

- Ameriks et al. (2020) introduce health dependent utility.
- They find that slow dissaving of the elderly is mainly caused by the strong precautionary motive for LTC expenditure risk in late life, and quantify the very high marginal utility under LTC state.
- They, however, ignores the role of housing in retirees' slow dissaving.
- Nakajima and Telyukova (2020) focus on the impact of homeownership on slow dissaving by setting explicitly the different marginal utility of housing as homeowners and renters, and estimate the very high marginal utility under home ownership to interpret the slow dissaving.

Literature

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- Cocco and Lopes (2020) also explore the role of housing in the low dissaving by setting that homeowners deriving utility from aging in their house “aging in place” and explicitly consider the impact of retirees’ home maintenance and the retiree’s choice regarding whether to maintain the property.

- Both papers ignore the potential role of the health-related state utility and possibly underestimate the precautionary motive for medical expense risk according to the findings of Ameriks et al. (2020).

Literature

- Achou (2021) present quantitative evaluations of the extent to which illiquid housing may reduce LTCI demand.

- To explore this question, besides the role of bequest motive, LTC and medical expenditure, uncertain life span, they consider the impact of both housing and health-state utility on retirees' LTC purchases.

- Arhou (2021) used the low purchase of LTCI to estimate the structural model.

- Their results of low demand for LTCI might be a result of how they estimate the model

Our Paper

- This paper examines optimal choices of LTCI and RM in a multi-period life-cycle framework.

- We estimate the health transition matrix based on gender, income groups, and HRS waves, and thus understand the trend of morbidity compression or expansion

- We use health-dependent utility function to capture the differential marginal utility of consumption in LTC and non-LTC states.

- We assume aging-in-home benefits in the utility function of non-LTC states

Health States

- Based on Achou (2021) with minor modifications.
- *good health:* self-report excellent, very good, or good
- *bad health:* self-report fair or poor (with no more than one limitation in ADL or suffer from chronic diseases,
- *Home care:* report receiving home care and mobility score (*mobila*) equals 5 on a five-point scale.
- The *mobila* index is derived from five questions assessing difficulties with (i) walking several blocks, (ii) walking one block, (iii) walking across a room, (iv) climbing several flights of stairs, and (v) climbing one flight of stairs;

Health States

- *Nursing home:*
  - Participants in HRS are asked whether they live in a nursing home, but facility type must be inferred from responses regarding services provided.
  - We classify as a nursing home any residence with the characteristics of assisted living or a continuing care retirement community that provides assistance with ADLs.
  - Following Achou (2021), we also use reported days spent in a nursing home over the last two years, supplemented by exit interview data in the subsequent wave; if this total exceeds 300 days, the individual is classified as residing in a nursing home.
- *Death*

Health States

- We model the yearly transition probability using multinomial logistic regression if the initial health state is good, bad, or home care and using logistic regression if the initial health state is nursing home.

- $p_{ijt} = \exp\left(X\beta^{j}\right)/\sum_{k=1}^{5}\exp\left(X\beta^{k}\right)$ with $\gamma_{i0t} = 1,$ where $i \in \{1,2,3\}\ and\ j \in \{1,2,3,4,5\}$, or $i = 4$ and $j \in \{4,5\}$.

- We take as covariates x: a complete set of dummies for current health status and income, a cubic in age, age interacted with health status and income interacted with health status.

- Note that the HRS data are bi-annual, so we maximize the loglikelihood which is the sum of the logarithms of $p(s_{t+2} = j|s_t = i)$.

Utility Function

- In good health, bad health, and home care states
$$u(c_t, h_t) = \frac{[c_t^{\alpha}(\omega_t h_t)^{1-\alpha}]^{1-\gamma}}{1-\gamma}$$
- γ is the coefficient of relative risk aversion,
- α is the expenditure share in the non-durable consumption c_t
- $1-\alpha$ is the expenditure share in the housing consumption h_t.
- ω_t captures the aging in place benefits $\omega_t = \exp(\rho A_t)$.

Utility Function

- In nursing home state

$$u(c_t, h_t) = (\theta_{LTC})^{-\gamma} \frac{\left[c_t^{\alpha} h_t^{1-\alpha} + \kappa_{LTC}\right]}{1-\gamma} 1^{-\gamma}$$

- θ_{LTC} affects the marginal utility of an additional dollar spent in the LTC state, and κ_{LTC} controls the degree to which an expenditure in the LTC facility is valued as a luxury good or a necessity, in the sense that it provides a utility floor or need.

- In death state

$$v(b_t) = \left(\theta_{BEQ}\right)^{-\gamma} \frac{\left[b_t + \kappa_{BEQ}\right]^{1-\gamma}}{1-\gamma}$$

Medical Expenditure

- We model the OOP medical expenditures as being distributed lognormally and estimate the mean and standard deviation of the lognormal distribution.

- Log OOP medical expenses are modeled as a linear function of a cubic in age, sex, prior health status, income quintile, and age interacted with all other variables.

- Using the residuals from this first regression, we regress the squared residuals on the same set of state variables as in the first regression to find the conditional variance of medical expenses.

LTC Costs, Pension Income

- Based on Genworth Cost of Care Survey 2018, the median costs for a private room in nursing home is $100,375. The cost of home care is about $50,336.

- LTC costs growth rate 3.5%.

- Pension income y

Housing Price Growth

- Use ARMA–GARCH process based on previous literature Chinloy et al., 1997; Chen et al., 2010; Li et al., 2010).

- We estimate our house price model using the U.S. nationwide monthly house price index from January 1991 to May 2025.

- ADF test rejects the unit root hypothesis at the 5% significance level, indicating house price growth rates is stationary

- We set the maximum AR lag at 2 and the maximum MA lag at 4
- optimal lags for the conditional mean and conditional variance models using BIC.

- The ARMA(1,1`)–GARCH(1, 1) model is the best model

Optimization

- The individual chooses her consumption, RM LTV ratio, and LTCI coverage rate to maximize

$$V(t, s_t, G_t) = \max_{c_t, RM, I \geq 0} \{U(c_t, h_t) + \beta E_t[\mathbb{I}_{s_{t+1} \neq 5} V(t+1, s_{t+1}, G_{t+1}) + \mathbb{I}_{s_{t+1}=5}\, v(W_{t+1})]\},$$

$$0 \leq t \leq T-1$$

- Budget constraints

$$a_1 = \begin{cases} e^{r_f}(a_0 + y - c_0 + RM - P \times I - OOP_{0,s_0}), & s_0 = 1,2 \\ e^{r_f}(a_0 + y - c_0 + RM - (1 - GI - I)LTC_{0,s_0} - OOP_{0,s_0}), & s_0 = 3 \\ e^{r_f}(a_0 + y - c_0 - (1 - GI - I)LTC_{0,s_0} - OOP_{0,s_0}), & s_0 = 4 \end{cases}$$

Optimization

$$a_{t+1} = \begin{cases} e^{r_f}(a_t + y - c_t - P \times I - OOP_{t,s_t}), & s_t = 1,2 \\ e^{r_f}(a_t + y - c_t - (1 - GI - I)LTC_{t,s_t} - OOP_{t,s_t}), & s_t = 3 \\ e^{r_f}(a_t + y - c_t + 1_{\{s_{t-1} \in \{1,2,3\}\}} \max\{HV_t - RMLB_t, 0\} - (1 - GI - I)LTC_{t,s_t} - OOP_{t,s_t}), & s_t = 4 \end{cases}$$

$$W_{t+1} = \begin{cases} a_{t+1} + \max\{HV_{t+1} - RMLB_{t+1}, 0\}, & s_t = 1,2,3 \\ a_{t+1}, & s_t = 4 \end{cases},$$

where $RMLB_t$ is the reverse mortgage value at time t,

$a_t \geq 0$,

$c_t \geq \underline{c}$,

$0 \leq RM \leq \overline{RM}$,

$0 \leq I \leq 1 - GI$,

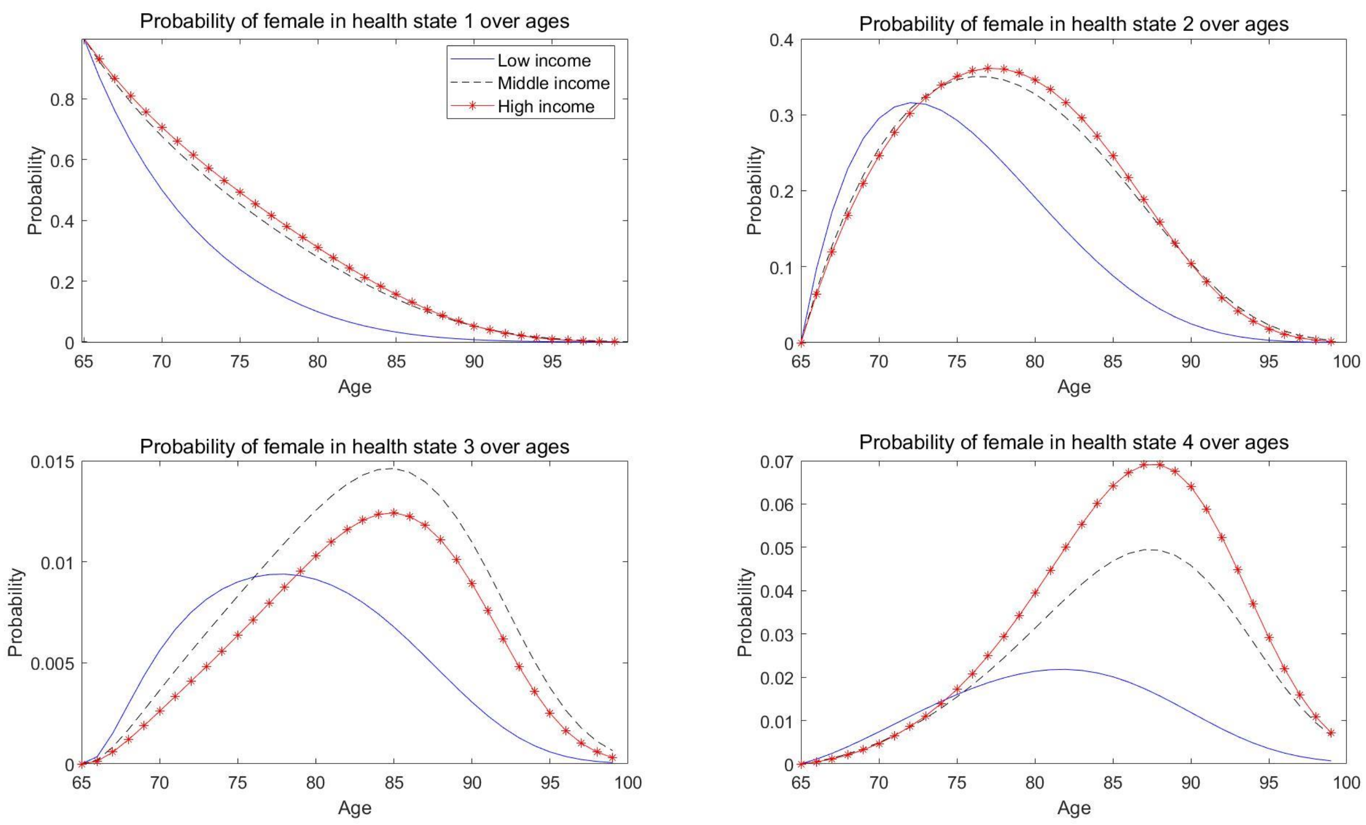
Euler Equation

- We derive the following Euler equation

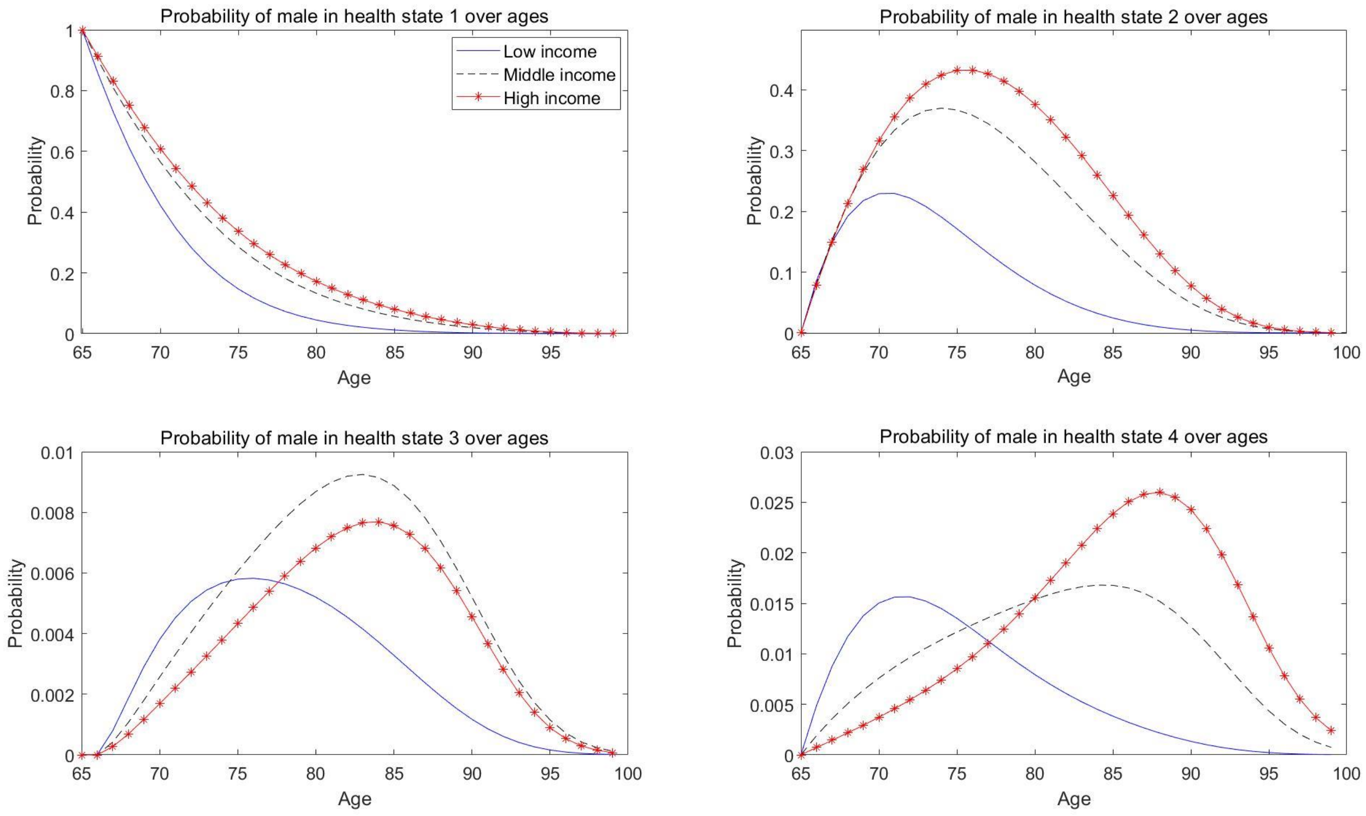
$$C_t = \begin{cases} \max\{\underline{c}, \{\frac{\beta e^{r_f}(\omega_t h_t)^{\nu}}{\eta} E_t[\mathbb{I}_{s_{t+1}\neq 5}\eta C_{t+1}^{\nu-\gamma}(\varpi_{t+1}h_{t+1})^{-\nu} + \mathbb{I}_{s_{t+1}=5}\theta_{BEQ}^{-\gamma}(\kappa_{BEQ}+B_{t+1})^{-\gamma}]\}^{\frac{1}{\nu-\gamma}}, & s_t = 1,2,3 \\ \max\{\underline{c}, \{\frac{\beta e^{r_f}\theta_{LTC}^{\gamma} h_t^{\nu}}{\eta} E_t[\mathbb{I}_{s_{t+1}\neq 5}\eta \theta_{LTC}^{-\gamma} C_{t+1}^{\nu-\gamma} h_{t+1}^{-\nu} + \mathbb{I}_{s_{t+1}=5}\theta_{BEQ}^{-\gamma}(\kappa_{BEQ}+B_{t+1})^{-\gamma}]\}^{\frac{1}{\nu-\gamma}}, & s_t = 4 \end{cases}$$

- We follow Shao et al.(2019) to use the endogenous grid method and a regression approach to solve the optimization problem backward step by step.
- By predefining after-consumption wealth, the endogenous grid method alleviates computing efficiency when the number of state variables increases.
- A linear regression method is used to estimate a parametric function for the optimal choice variables based on simulated house value paths since house values are path-dependent.

Health Transition Probabilities



Health Transition Probabilities



Life Expectancy

		1998 wave			2010 wave	
Male	Low Income	Middle Income	High Income	Low Income	Middle Income	High Income
Life expectancy in good health	5.3423	7.6137	8.4790	5.3262	9.5594	9.6133
Life expectancy in bad health	2.7397	5.9753	7.3559	3.2376	8.3301	9.5107
Life expectancy in home care	0.0967	0.1625	0.1292	0.1722	0.2709	0.2149
Life expectancy in nursing home	0.2202	0.3499	0.4374	0.3287	0.4768	0.7429
Total life expectancy	8.3988	14.1015	16.4014	9.0647	18.6373	20.0819
Ratio of life expectancy in good health	0.6361	0.5399	0.5170	0.6342	0.6779	0.5861
Ratio of life expectancy in bad health	0.3262	0.4237	0.4485	0.3855	0.5907	0.5799
Ratio of life expectancy in home care	0.0115	0.0115	0.0079	0.0205	0.0192	0.0131
Ratio of life expectancy in nursing home	0.0262	0.0248	0.0267	0.0391	0.0338	0.0453
Female	Low Income	Middle Income	High Income	Low Income	Middle Income	High Income
Life expectancy in good health	6.6179	10.4171	10.9967	6.7158	10.5426	11.8789
Life expectancy in bad health	4.6955	6.5910	6.6854	4.5102	8.5729	7.9936
Life expectancy in home care	0.1711	0.2700	0.2158	0.1108	0.3890	0.2540
Life expectancy in nursing home	0.4043	0.8454	1.1036	0.3445	1.0753	1.3388
Total life expectancy	11.8887	18.1235	19.0015	11.6812	20.5798	21.4653
Ratio of life expectancy in good health	0.5567	0.5748	0.5787	0.5649	0.5817	0.6252
Ratio of life expectancy in bad health	0.3950	0.3637	0.3518	0.3794	0.4730	0.4207
Ratio of life expectancy in home care	0.0144	0.0149	0.0114	0.0093	0.0215	0.0134
Ratio of life expectancy in nursing home	0.0340	0.0466	0.0581	0.0290	0.0593	0.0705

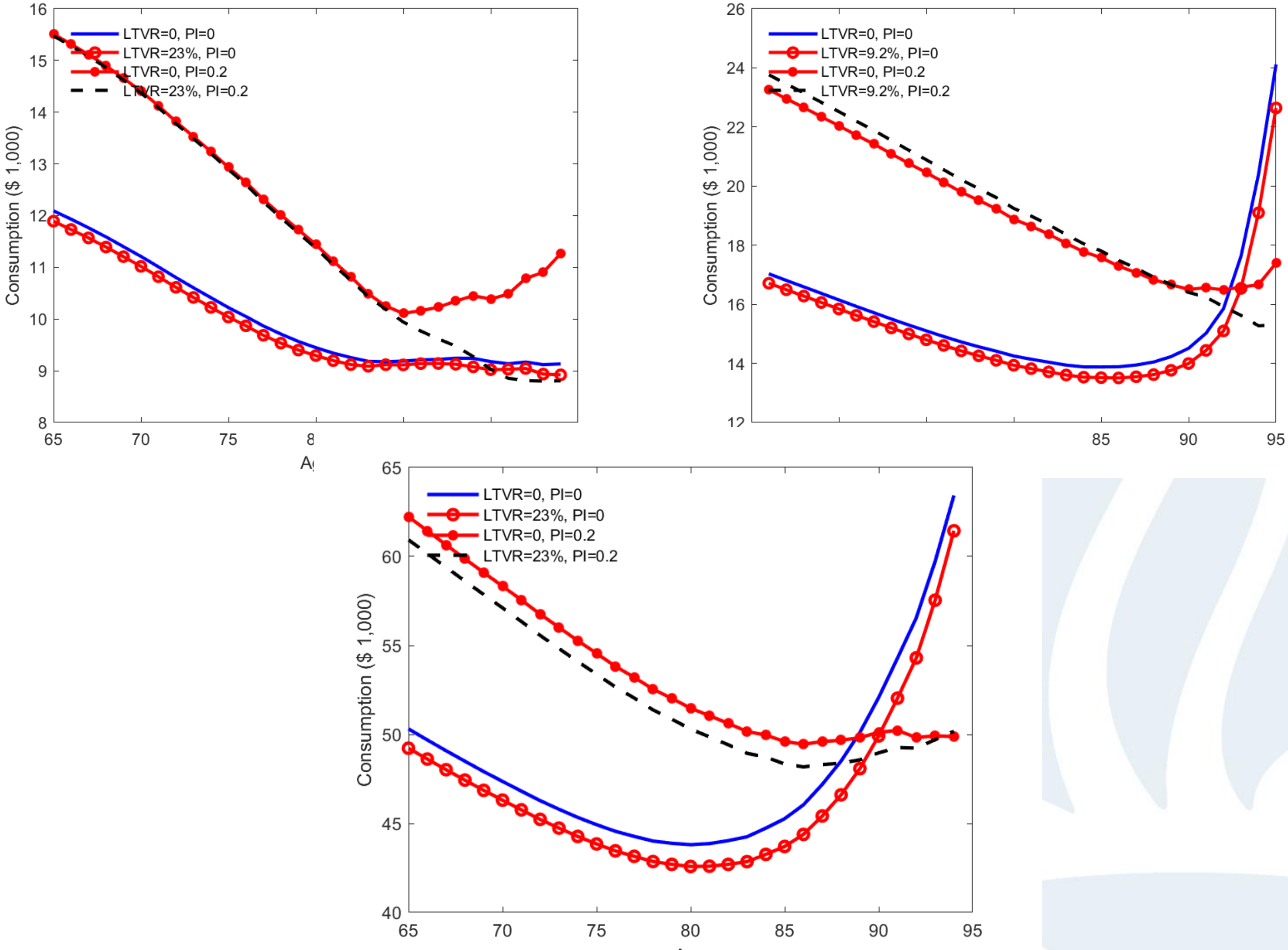
Parameter Setting

Parameter	Explanation	Value	Source
r_f	Nominal risk-free rate	0.04	10-year treasury note rate
g_{CPI}	Inflation rate	0.015	Dept. of Labor
GI	Percentage of LTC costs covered by govt.	0.8	Bowblis et al. (2024)
π	Mortgage insurance premium spread	0.02	
$\overline{RM}$	Maximal RM take-out ratio	23%	HUD
γ	Risk aversion	5	Shao et al.(2019)
β	Utility discount factor	0.96	Shao et al.(2019)
η	Non-housing consumption aggregation	0.736	Shao et al.(2019)
ρ	Degree of home attachment	0.019	Cocco and Lpoes (2020)
θ_{LTC}	LTC consumption strength	0.67	Ameriks (2020)
κ_{LTC}	Degree of LTC as luxury goods	0	Achou (2021)
θ_{Beq}	Bequest motive strength	1.09	Ameriks (2020)
κ_{Beq}	Degree of bequest as luxury goods	7.83	Ameriks (2020)
$\underline{C}$	Consumption floor	$8800	Shao et al. (2019)
h_1	Housing consumption as a proportion of house value if living at home	5.56%	Shao et al. (2019)
h_2	Housing consumption as a proportion of house value if living in nursing homes	2.78%	Shao et al. (2019)
LTC_3	Initial annual LTC cost in State 3	$50k	Genworth care survey
LTC_4	Initial annual LTC cost in State 4	$100k	Genworth care survey
g_{LTC}	LTC growth rate	3.5%	Genworth care survey

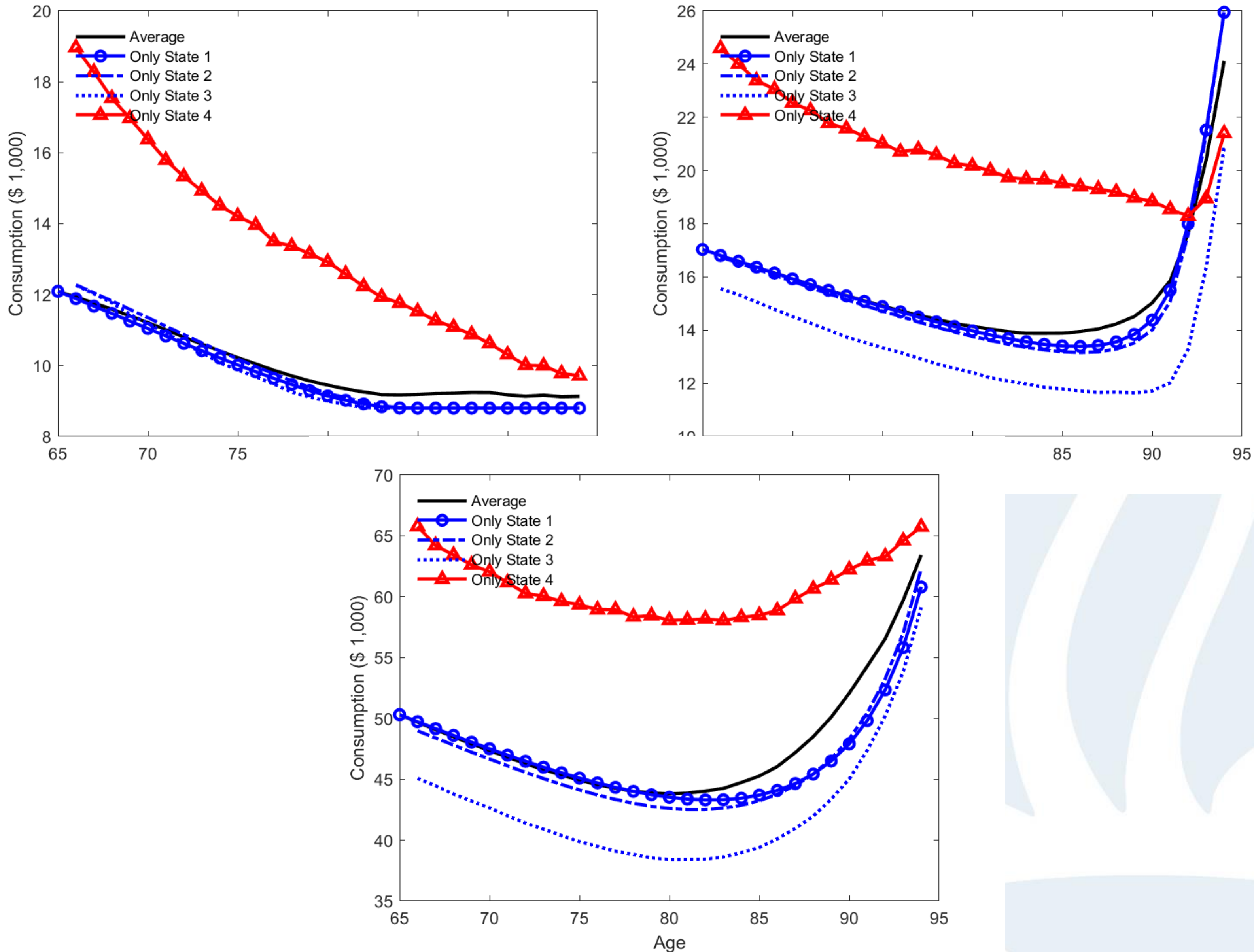
Baseline Results

Male			
	LTCI	RM	Welfare improvement-CEV
Low income	0.2	0.184	27.7414%
Middle income	0.2	0.138	24.6526%
High income	0.2	0	17.6050%
Female			
	LTCI	RM	Welfare improvement-CEV
Low income	0.2	0	29.7607%
Middle income	0.2	0.092	38.9981%
High income	0.2	0	23.3402%

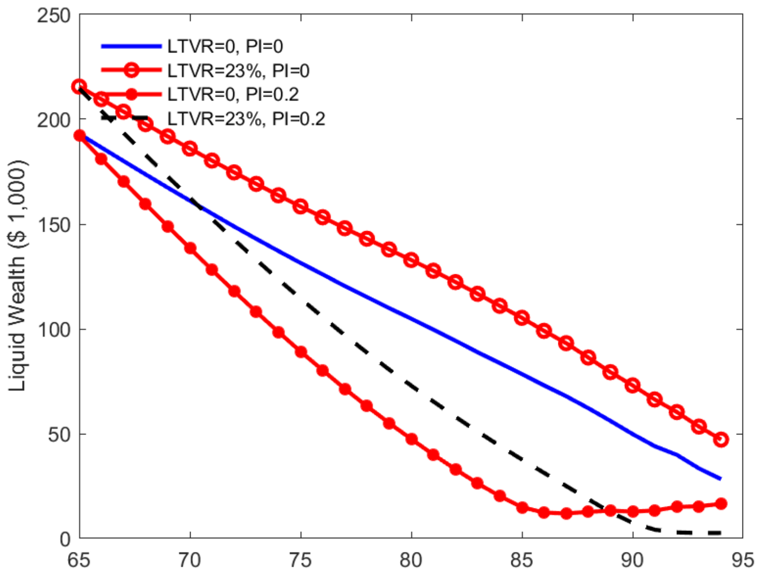
Consumption Female

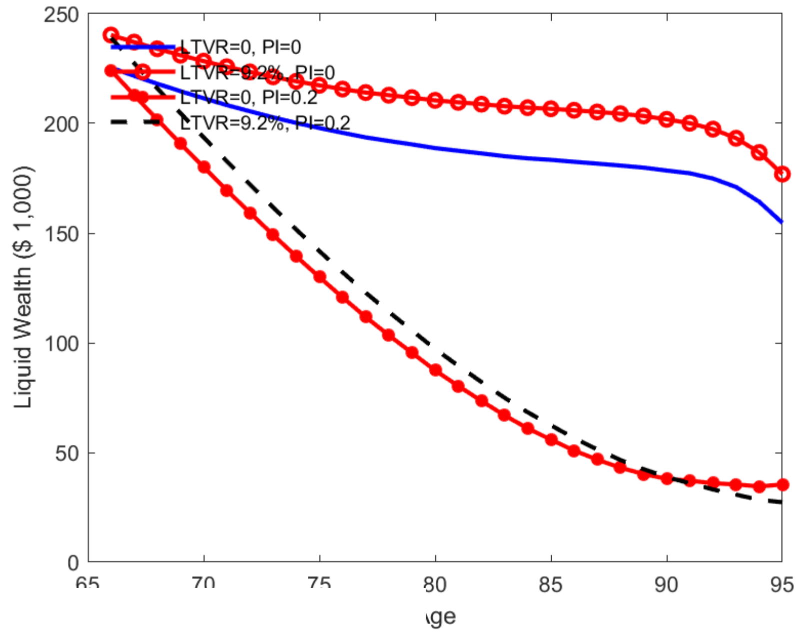


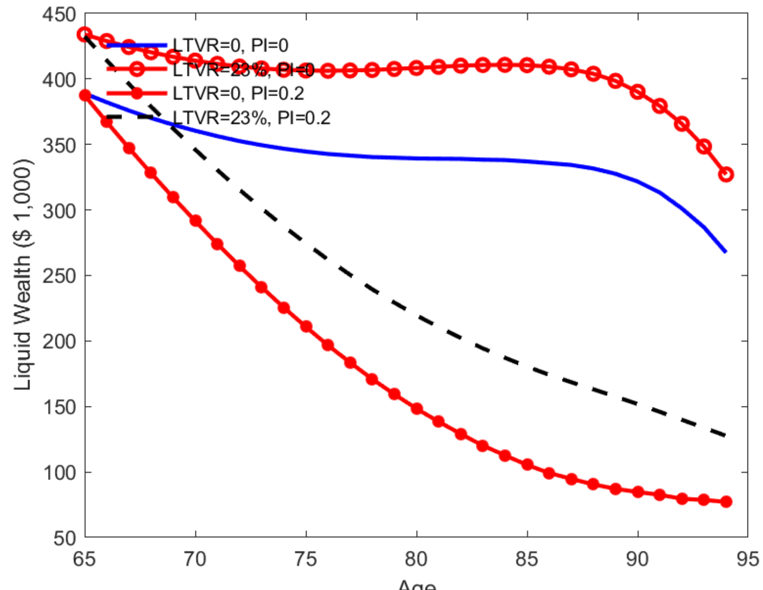
Consumption Female



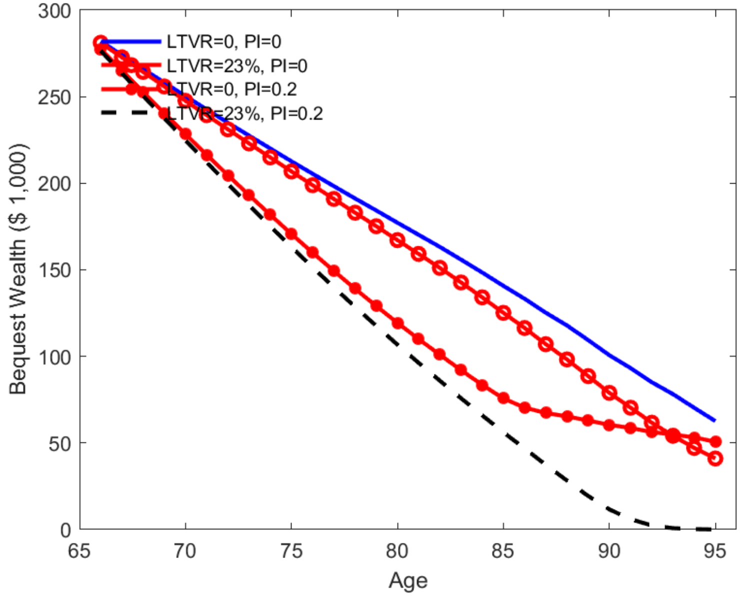
Liquid Wealth Female

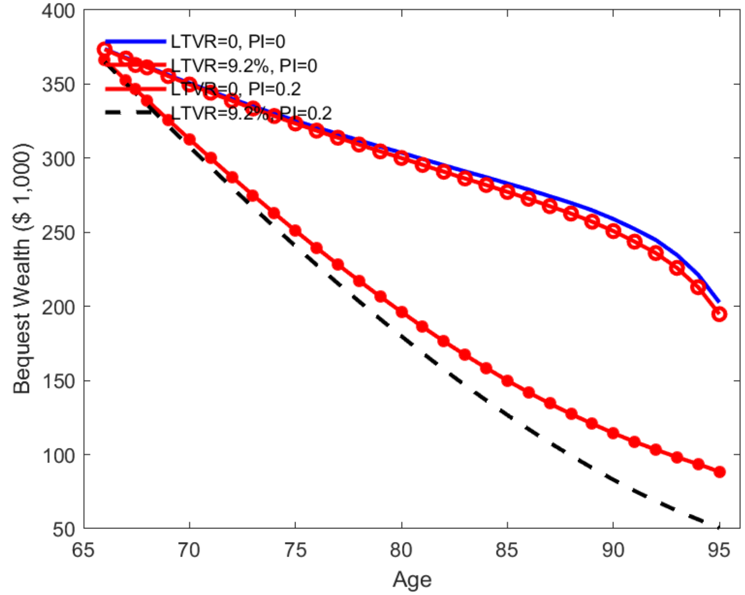


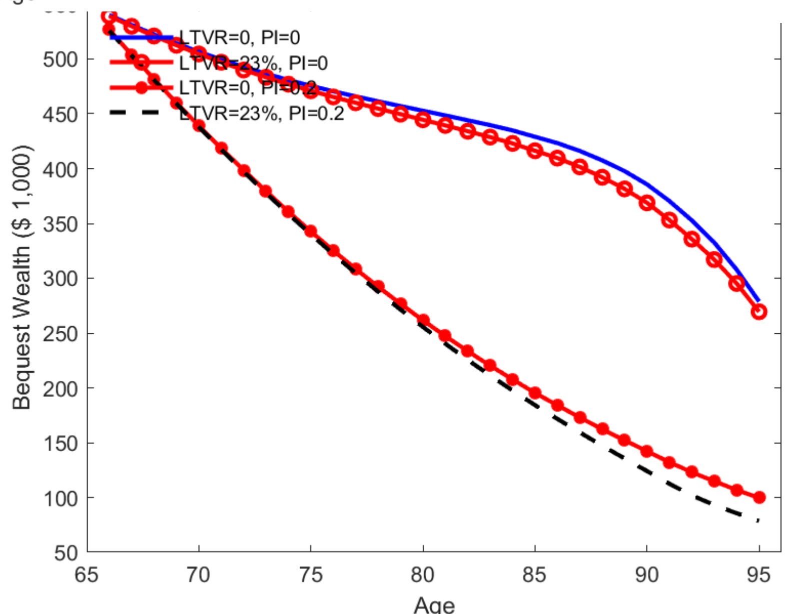




Bequest Female







Results of Morbidity Expansion

Male Middle Income			
	LTCI	RM	Welfare improvement-CEV
Wave98	0.2	0.138	24.6526%
Wave10	0.2	0.138	28.8434%
Female Middle Income			
	LTCI	RM	Welfare improvement-CEV
Wave98	0.2	0.092	38.9981%
Wave10	0.2	0.046	47.0480%

Results of LTC Marginal Utility

Male Middle Income			
Theta	LTCI	RM	Welfare improvement-CEV
0.67	0.2	0.138	24.6526%
1	0.2	0.23	10.1324%
1.23	0.2	0.23	7.5749%
1.53	0.2	0.23	6.6340%
Female Middle Income			
	LTCI	RM	Welfare improvement-CEV
0.67	0.2	0.092	38.9981%
1	0.2	0.23	16.0367%
1.23	0.2	0.23	8.5681%
1.76	0.2	0.23	4.5063%

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Questions? Comments?

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