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Optimal portfolio choice with longevity and health insurance: A developing country context

CHENG WAN[1], Hazel Bateman[1], and Katja Hanewald[1]

[1]CEPAR, UNSW Sydney

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Outline

1 – Outline

1 – Background

Rapid population ageing & growing awareness of health risks due to COVID-19
Developing countries: basic public insurance $\rightarrow$ catastrophic medical expenditure

- Government - public insurance system not adequate, how to expand?
- Individuals - retirement risks (longevity, medical, aged care), how to manage them?

Challenging task!

- Future survival probabilities, health cost risks (incl. aged care), economic environment
- Societal changes: family values, growing female labour force participation, etc.

Q: What's the optimal portfolio for retirees in a less-well developed retirement system?

1 – Annuity puzzle

Theory - Annuities are part of an optimal portfolio
Practice - Voluntary annuitisation rates are low

Many explanations (e.g., Benartzi et al., 2011) - three key reasons

- **Precautionary savings** due to uncertain health-related expenditures (e.g., Koijen et al., 2016; Pang and Warshawsky, 2010; Peijnenburg et al., 2017)
- **Stochastic mortality and correlated health costs** (Laitner et al., 2018; Reichling and Smetters, 2015)
- **Adverse selection** (e.g., Braun et al., 2019; Brown and Finkelstein, 2009; Finkelstein and Poterba, 2004)

Remarks

- Not wise to plan retirement only with retirement **INCOME** products - health risks matter!
- Limited research considering longevity and health insurance simultaneously

1 – Our paper

A life-cycle model with annuity, critical illness insurance (CII), and long-term care insurance (LTCI) in a less-well developed retirement system (urban China)

- Multiple health states and random health costs
- Choice of health investment determines post-illness mortality
- Different weights on the marginal utility of consumption in poorer health states
- Sensitivity of health transitions, pricing, preferences, and subsidy

1 – Main contributions

1. The first paper to include critical illness insurance in a life-cycle model where existing studies only consider a life annuity and long-term care insurance (Koijen et al., 2016; Pang and Warshawsky, 2010; Peijnenburg et al., 2017; S. Wu et al., 2016).

2. Consider health investment and health-state dependent utility of consumption simultaneously (Peijnenburg et al., 2017; Yogo, 2016)

2 – Outline

2 – The individual decision

An individual decides his optimal portfolio at retirement.

- Period – from retirement (male, age 60) to death (age 105).
- Portfolio - annuities, CII, LTCI, and savings
- Utility of consumption depends on health state H_t, weighted by η_{H_t}

$$u(c_t|H_t) = \eta_{H_t} c_t^{1-\gamma}/(1-\gamma) \tag{1}$$

- One-off portfolio choice

Individual has three health investment choices for medical expenditures, and the post-illness mortality rates depend on these choices.
Individual has typical wealth and public insurance (pension + medical insurance)

2 – Pricing

Insurance products (standalone):

- Life annuity product: industry mortality curve
- Critical illness insurance: industry incidence and mortality curves
- Long-term care insurance: estimated from the China Health and Retirement Longitudinal Study (CHARLS)

Real discount rate: 1.5%
Real Interest rate: 2%

2 – Decision process and transitions

At retirement: choose insurance portfolio and pay premiums, one-off choice
Other periods:

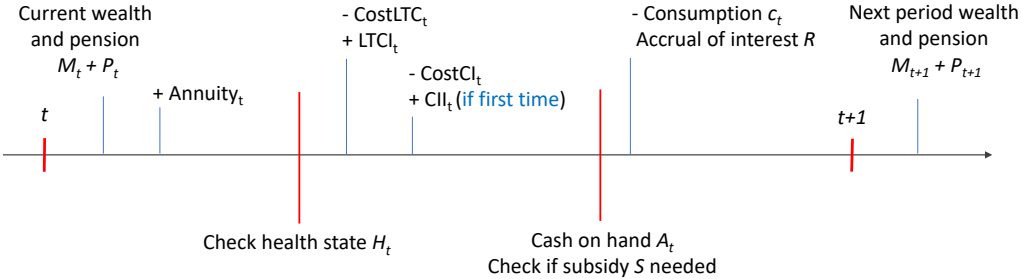

Figure 1: Decision and transition for each period t

2 – Calibrated parameters 1/2

Preferences (base case)

- Risk aversion $\rho = 3$ (İmrohoroğlu and Zhao, 2018)
- Time preferences $\beta = 0.999$ (İmrohoroğlu and Zhao, 2018)
- Bequest strength $b = 50$ (Friedman and Warshawsky, 1990)
- $\eta_{H_t=\text{CI}} = 1.2$, $\eta_{H_t=\text{LTC}} = 0.7$ (X. Wang and C. Wang, 2020)

Critical illness medical costs (estimated based on Fang et al., 2018 and D. Wu et al., 2018)

$$\text{CostCI} \sim \text{Lognormal}\left(11.86,\ 0.92^2\right), \tag{2}$$

Long-term care cost (estimated based on CHARLS):

$$\text{CostLTC(Age)} \sim \text{Lognormal}\left(6.13 + 0.02 \times \text{Age},\ 1.46^2\right), \tag{3}$$

2 – Calibrated parameters 2/2

Table 1: Calibration methods for health transition probability matrix

	Healthy	Critically ill	Long-term care	Death
Healthy	1-rest	Industry incidence curve	CHARLS estimates	Adjusted from industry mortality curve for pension business
Critically ill	0	1-rest	CHARLS estimates	Adjusted industry mortality, incidence curves, and kx
Long-term care	0	Industry incidence curve	1-rest	CHARLS estimates
Death	0	0	0	1

Life expectancy at age 60: 21.2 years (national: 18.4, industry pension curve: 25)

2 – Bellman function

$$V_t(M_t, H_t) = \max_{c_t, \omega_\mathsf{a}, \omega_\mathsf{c}, \omega_\mathsf{l}} E_t \left\{ u(c_t|H_t) + \beta \left[\sum_{j=1}^{3} \pi_t(H_t, j) V_{t+1}(M_{t+1}, H_{t+1} = j) + \pi_t(H_t, 4) v(M_{t+1}) \right] \right\},$$

$$\begin{aligned}
\text{s.t.} \\
A_t &= M_t + P_t + \mathsf{Annuity}_t + \mathsf{CII}_t + \mathsf{LTCI}_t - \mathsf{CostCI}_t - \mathsf{CostLTC}_t - c_t, \\
M_{t+1} &= RA_t, \\
A_t &\geqslant 0, \\
c_t &\geqslant S, \\
\omega_\mathsf{a}, \omega_\mathsf{a}, \omega_\mathsf{l} &\geq 0, \\
\omega_\mathsf{a} + \omega_\mathsf{c} + \omega_\mathsf{l} &\leqslant M.
\end{aligned}$$

Solved numerically by backward induction with the endogenous grid-points method (Carroll, 2006)

3 – Outline

3 – Optimal allocation

- High demand for CII (with adequate health investment and fewer budget constraints);
- High demand for annuity (if pension is low)
- Small demand for LTCI
- A lower health investment (*Half* or *Quarter*) is better, CII demand drops
- Substantial welfare gain, especially for those with less wealth or pension

Allocation of wealth		Choice of health investment		
		Adequate	Half	Quarter
Wealth = 1 million, Pension = 3,000	Annuity	10%	0%	0%
	CII	30%	5%	0%
	LTCI	5%	5%	5%
	Savings	55%	90%	95%
	Utility	-0.36	-0.23	**-0.21**
	Wealth gain	12%	26%	54%
Wealth = 1 million, Pension = 1,000	Annuity	40%	65%	40%
	CII	25%	5%	0%
	LTCI	5%	5%	10%
	Savings	30%	25%	50%
	Utility	-0.83	**-0.64**	-0.68
	Wealth gain	32%	100%	100%
Wealth = 150,000, Pension = 3,000	Annuity	0%	0%	0%
	CII	80%	73%	27%
	LTCI	13%	27%	33%
	Savings	7%	0%	40%
	Utility	-2.68	-1.39	**-1.03**
	Wealth gain	39%	78%	100%
Wealth = 150,000, Pension = 1,000	Annuity	93%	100%	47%
	CII	0%	0%	33%
	LTCI	7%	0%	20%
	Savings	0%	0%	0%
	Utility	-11.16	**-9.89**	-9.97
	Wealth gain	65%	97%	100%

3 – Health-state dependent utility

- Modify the results - still largely determined by the economic background
- Higher demand for health insurance when the weight η_{H_t} is higher, trade-off with longevity insurance
- Annuity demand: 0 $\rightarrow$ 10% or 20% (high wealth & pension)

		Weights for marginal utility			
	CI	1.2	1	0.8	1.2
	LTC	0.7	1	0.8	1.2
Wealth = 1 million, Pension = 3,000	Annuity	10%	0%	20%	10%
	CII	30%	25%	25%	35%
	LTCI	5%	5%	5%	10%
	Savings	55%	70%	50%	45%
	Wealth gain	12%	14%	8%	32%
Wealth = 1 million, Pension = 1,000	Annuity	40%	45%	55%	25%
	CII	25%	25%	20%	25%
	LTCI	5%	5%	5%	5%
	Savings	30%	25%	20%	45%
	Wealth gain	32%	37%	100%	19%
Wealth = 150,000, Pension = 3,000	Annuity	0%	0%	0%	0%
	CII	80%	73%	73%	67%
	LTCI	13%	20%	13%	33%
	Savings	7%	7%	13%	0%
	Wealth gain	39%	61%	32%	100%
Wealth = 150,000, Pension = 1,000	Annuity	93%	87%	87%	73%
	CII	0%	0%	0%	0%
	LTCI	7%	13%	13%	27%
	Savings	0%	0%	0%	0%
	Wealth gain	65%	66%	94%	71%

3 – Sensitivity Analysis: health transition

	Assumptions of transitions between critically ill (CI) and needing long-term care (LTC)		
Scenario 1 (Benchmark)	Transition from CI state to LTC state = Transition from Healthy to LTC state Transition from LTC state to CI state = Transition from Healthy to CI state		
Scenario 2	CI to LTC = Healthy to LTC × 2 LTC to CI = Healthy to CI × 1	Scenario 3	CI to LTC = Healthy to LTC × 1 LTC to CI = Healthy to CI × 2
Scenario 4	CI to LTC = Healthy to LTC × 2 LTC to CI = Healthy to CI × 2	Scenario 5	CI to LTC = Healthy to LTC × 5 LTC to CI = Healthy to CI × 1
Scenario 6	CI to LTC = Healthy to LTC × 1 LTC to CI = Healthy to CI × 3	Scenario 7	CI to LTC = Healthy to LTC × 5 LTC to CI = Healthy to CI × 3

- Benchmark results confirmed
- Annuity demand decreases when transitions to CI and LTC rise
- Largest change: Annuity (60% - 100%, low wealth & pension), CII (25% - 35%, high wealth & pension), LTCI (0 - 40%, low wealth & pension)

3 – Sensitivity Analysis: pricing

Previous: industry pricing, each insurance priced separately wrt their own health transitions for pricing
Now: priced with the same joint health transition matrix

1. Health matrix, pricing and evaluation, **unmatched**
2. Health matrix, pricing and evaluation, **matched**
3. The previous seven health transition assumptions tested

Results

- Benchmark results confirmed
- Annuity demand increases substantially from 10% to 35% (high wealth & pension)

3 – Sensitivity Analysis: preferences

Vary preference parameters

- Risk aversion: $\rho = 2, 3, 4, 5$
- Time preference: $\beta = 0.96, 0.985, 0.999$
- Strength of bequest motif: $\beta = 0, 5, 10, 50, 100$

Results (high wealth & pension group)

- Stable demand for CII and LTCI
- More risk averse $\rightarrow$ more annuity (0-10%)
- More patient $\rightarrow$ more annuity (0-10%)
- Higher bequest strength $\rightarrow$ less annuity (30%-0)

4 – Outline

4 – Conclusion

The first paper to include critical illness insurance in a life-cycle model where existing studies only consider a life annuity and long-term care insurance (Koijen et al., 2016; Pang and Warshawsky, 2010; Peijnenburg et al., 2017; S. Wu et al., 2016). The individual has a health-state dependent utility function and chooses among three levels of health investment, facing random health transitions and random health-related costs. Key findings:

- Demand for CII is high, but still depends on the choice of health investment
- High demand for annuity if pension is low & small demand for LTCI
- Allowing for health-state dependent utility and health investment simultaneously results in different trade-offs among the three insurance products, depending on a retiree's economic background.

Suggestions for insurance companies and governments in developing countries

- Targeting - different products for the relevant population segments
- Price - bundled products priced by a joint health transition matrix
- Priority - given a small proportion of wealth, the next insurance to purchase/expand generating the largest welfare

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Contact: cheng.wan@student.unsw.edu.au

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