Health and Mortality Delta: Assessing the Welfare Cost of Household Insurance Choice

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Research Questions

How does one construct an optimal portfolio of health and longevity products?

- Life insurance, annuities, supplementary health insurance and long-term care insurance
  - Available in various maturities and payout structures
  - No clear guidance on how to choose among these policies
- Standard risk measures in the retail financial industries
  - Equity products $\rightarrow$ Beta
  - Fixed-income products $\rightarrow$ duration
  - Health and longevity products $\rightarrow$ health and mortality delta
- Optimal portfolio choice as a solution to the life cycle problem: Choose a combination of policies (not necessarily unique) that replicates the optimal health and mortality delta
  - They can look at all products together whereas previous works look at each product in isolation

Research Question

How close is the observed insurance choice to being optimal?

- Measure welfare cost of market incompleteness and suboptimal portfolio choice in the HRS
    - Comment: They cannot disentangle welfare effect between market incompleteness and suboptimal portfolio choice. They simply assume that the insurance product market is complete and go from there.

Existing Literatures and Contribution

- Explain household demand for health and longevity products
    - Life insurance (Bernheim, 1991; Inkmann and Michaelides, 2011)
    - Annuities (Brown, 2001; Inkmann, Lopes, and Michaelides, 2011)
    - A key methodological contribution is to collapse household insurance choice into a pair of sufficient statistics, health and mortality delta, which explicitly account for the complementarity as well as the substitutability among different products.
- How should household pick different products?
    - A nearly rational household may hold a suboptimal portfolio of financial products even though markets are complete (Calvet, Campbell, and Sodini, 2007).
    - A key contribution here is to apply similar strategy as Calvet, Campbell, and Sodini's paper to insurance product setting.

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A Life-Cycle Model with Health and Mortality Risk

- Household faces health and mortality risk
  - Lives for at most T periods
    - Health states:

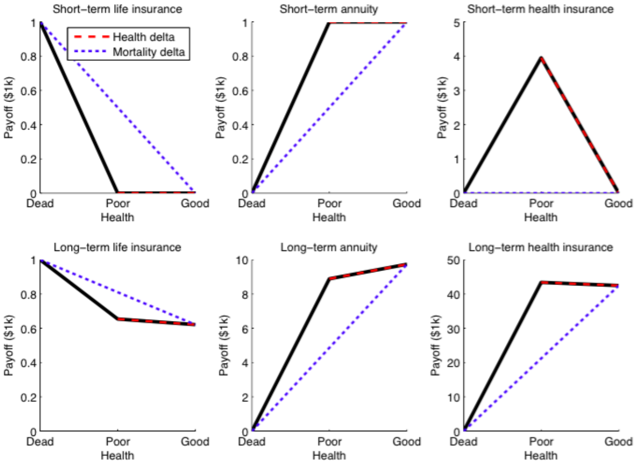
$$H_t = \{Dead = 1, Poor = 2, Good = 3\} \tag{1}$$

    - Health transition probability:

$$\pi_t(I, j) = Pr(h_{t+1} = j | h_t = i) \tag{2}$$

    - Out-of-pocket health expense: $M_t(h_t)$
- Receives income: Y_t
- Invests in health and longevity products of maturities 1 though $T - t$:
  1. L: Life insurance: Payoff of \$1k at death.
  2. A: Annuities: Payoff of \$1k in each period while alive.
  3. H: Supplementary health insurance: Payoff of $M_{t+1}(Poor) - M_{t+1}(Good)$ in poor health.
- Also saves in ruskless bond/loan at interest rate R.

Health and Mortality Delta for Insurance Products



Objective Function of the Households

- For each health state $h_t \in \{2, 3\}$ in period t, they define the household's objective function recursively as:

$$U_t(h_t) = \left\{ \omega(h_t)^\gamma C_t^{1-\gamma} + \beta \left[\pi_t(h_t, 1)\omega(1)^\gamma A_{t+1}(1)^{1-\gamma} + \sum_{j=2}^{3} \pi_t(h_t, j) U_{t+1}(j)^{1-\gamma} \right] \right\}^{1/(1-\gamma)} \quad (3)$$

  - with the terminal value

$$U_T(h_T) = \omega(h_T)^{\gamma/(1-\gamma)} C_T \quad (4)$$

  - $\omega(1)$: Bequest motive.
  - $\omega(2) < \omega(3)$: Consumption and health are "complements" (state-dependent utility).

Intertemporal Budget Constraint

- Household maximizes subject to the inter-temporal budget constraint

$$W_{t+1} = A_{t+1} + Y_{t+1} - M_{t+1} \tag{5}$$

where

$$A_{t+1}(j) = B_t + \sum_{i \in L,A,H} \sum_{n=1}^{T-t} (P_{i,t+1}(n-1|j) + D_{i,t+1}(n-1|j))B_{i,t}(n) \tag{6}$$

denote the household's wealth prior to receiving income and paying health expenses, if health state j is realized in period t+1.

- Bond prices at time t: B_t
- Benefits from policy i at time t: $D_{i,t}$
- Premium of the policy i at time t: $P_{i,t}$

Proposition 1: Optimal Health and Mortality Delta under Complete Markets

- Define total wealth:

$$\widehat{W}_t(h_t) = W_t + \sum_{s=1}^{T-t} \frac{\mathbb{E}_t[Y_{t+s} - M_{t+s}|h_t]}{R_s} \tag{7}$$

- Average propensity to consume: $c_t(h_t)$
- Optimal consumption: $C_t^* = c_t(h_t)\widehat{W}_t(h_t)$
- Health delta:

$$\Delta_t = A_{t+1}(Poor) - A_{t+1}(Good) \tag{8}$$

or

$$\Delta_{i,t} = P_{i,t+1}(n-1|2)+D_{i,t+1}(n-1|2)-P_{i,t+1}(n-1|3)+D_{i,t+1}(n-1|3) \tag{9}$$

- Mortality delta:

$$\delta_t = A_{t+1}(Dead) - A_{t+1}(Good) \tag{10}$$

or

$$\delta_{i,t} = D_{i,t+1}(n-1|1) - P_{i,t+1}(n-1|3) + D_{i,t+1}(n-1|3) \tag{11}$$

Proposition 1: Optimal Health and Mortality Delta under Complete Markets

- Optimal health delta:

$$\Delta_t^* = \frac{(\beta R)^{1\gamma} C_t^*}{\omega(h_t)} \left(\frac{\omega(Poor)}{c_{t+1}(Poor)} - \frac{\omega(Good)}{c_{t+1}(Good)} \right) + \left(\sum_{s+1}^{T-t} \frac{\mathbb{E}_{t+1}[M_{t+s}|Poor]}{R^{s-1}} - \sum_{s=1}^{T-t} \frac{\mathbb{E}_{t+1}[M_{t+1}|Good]}{R^{s-1}} \right)$$

- Optimal mortality delta:

$$\delta_t^* = \frac{(\beta R)^{1\gamma} C_t^*}{\omega(h_t)} \left(\omega(Dead) - \frac{\omega(Good)}{c_{t+1}(Good)} \right) + \sum_{s=1}^{T-t} \frac{\mathbb{E}_{t+1}[Y_{t+s} - M_{t+s}|Good]}{R^{s-1}}$$

Proposition 2: Optimal Portfolio Allocation

- Define health and mortality delta for each policy $i = \{L, A, H\}$ of term n:

$$\Delta_{i,t}(n) = Payoff_{i,t+1}(n-1|Poor) - Payoff_{i,t+1}(n-1|Good) \tag{12}$$

$$\delta_{i,t}(n) = Payoff_{i,t+1}(n-1|Dead) - Payoff_{i,t+1}(n-1|Good) \tag{13}$$

- A feasible portfolio policy (that satisfies the budget constraint and borrowing/portfolio constraints) is optimal if:

$$\Delta_t^* = \sum_{i \in \{L,A,H\}} \sum_{n-1}^{T-t} \Delta_{i,t}(n) B_{i,t}(n) \tag{14}$$

$$\delta_t^* = \sum_{i \in \{L,A,H\}} \sum_{n=1}^{T-t} \delta_{i,t}(n) B_{i,t}(n) \tag{15}$$

Proposition 3: Welfare Cost of Deviations from the Optimal Health and Mortality Delta

- V_t^* under optimal policy $\{\Delta^*_{t+s-1}, \delta^*_{t+s-1}\}_{s=1}^{n}$
- V_t under alternative policy $\{\Delta_{t+s-1}, \delta_{t+s-1}\}_{s=1}^{n}$
- Welfare cost over n periods:

$$
\begin{aligned}
L_t(n) &= \frac{V_t}{V_t^*} - 1 \\
&\approx \frac{1}{2}\sum_{s=1}^{n}\sum_{i=2}^{3}\left[\frac{\partial^2 L_t(n)}{\Delta_{t+s-1}(i)^2}(\Delta_{t+s-1}(i) - \Delta^*_{t+s-1}(i))^2\right. \\
&+ \frac{\partial^2 L_t(n)}{\delta_{t+s-1}(i)^2}(\delta_{t+s-1}(i) - \delta^*_{t+s-1}(i))^2 \\
&+ 2\frac{\partial^2 L_t(n)}{\partial\Delta_{t+s-1}(i)\partial\delta_{t+s-1}(i)}(\Delta_{t+s-1}(i) - \Delta^*_{t+s-1}(i)) \\
&\left. x(\delta_{t+s-1}(i) - \delta^*_{t+s-1}(i))\right]
\end{aligned}
$$

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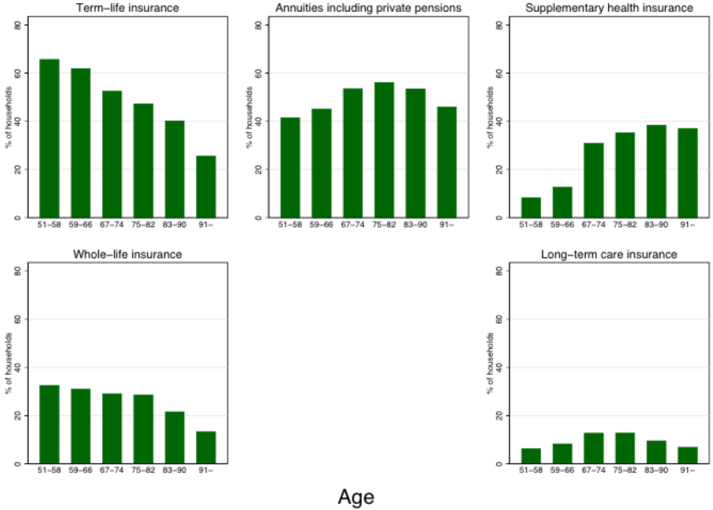
Health and Retirement Study

- Representative panel of U.S. households whose primary respondent is aged 51 and older, interviewed every 2 years since 1992.
- Focus on sub-sample males.
- Use a profit model to estimate mortality rate as a function of observed health problems.
- Define 3 health states:
  1. Death
  2. Poor
     - Predicted mortality rate is higher than median, and
     - Ratio of health expenses to income in higher than median.
  3. Good:
     - Alive and not in poor health.

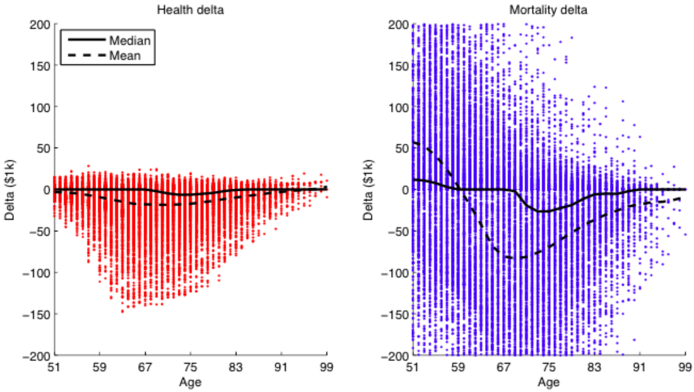
Key Input for the Welfare Calculation

- Estimated for each cohort
  1. Health and transition probabilities
  2. Out-of-pocket health expenses (after employer-provided insurance and Medicare)
  3. Income including Social Securities (exclude annuities and private pensions)
  4. Actuarially fair prices for health and longevity products
     - They claim that the results are not sensitive to the loadings
- Observed for each household:
  1. Term- and whole-life insurance
  2. Annuities including private insurance
  3. Supplementary health (Medigap) insurance
  4. Long-term care insurance

Ownership Rate of Health and Longevity Products



Health and Mortality Delta Implied by the Observed Household Portfolios



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Determinants of the Observed Health and Mortality Delta

Explanatory variable	Health delta				Mortality delta			
	(1)		(2)		(3)		(4)	
Poor health	1.13	(3.13)	0.91	(2.49)	-15.50	(-3.42)	-1.98	(-0.44)
65 or older	-10.46	(-4.34)	-4.40	(-1.79)	-150.00	(-11.28)	-100.00	(-7.49)
Married			-0.13	(-0.29)			42.60	(7.69)
Has living children			0.98	(1.69)			33.49	(4.27)
Education:								
High school graduate			-0.39	(-1.02)			21.09	(5.54)
College graduate			3.27	(5.68)			126.00	(20.08)
Self-reported health status:								
Poor			1.16	(2.15)			39.46	(5.65)
Fair			0.13	(0.28)			19.60	(3.51)
Very good			0.02	(0.04)			-15.05	(-2.51)
Excellent			1.90	(2.68)			-11.77	(-1.73)
(Age − 51)/10	-1.79	(-1.28)	17.02	(8.59)	-23.93	(-1.67)	151.59	(8.98)
× Poor health	-2.68	(-3.79)	-4.35	(-6.14)	-1.69	(-0.31)	-19.97	(-3.71)
× 65 or older	-3.16	(-1.34)	-11.34	(-4.64)	44.85	(2.64)	-17.43	(-1.01)
× Married			-2.82	(-3.77)			-40.07	(-6.85)
× Has living children			-5.02	(-4.57)			-40.17	(-4.65)
× High school graduate			-7.60	(-12.23)			-49.33	(-11.62)
× College graduate			-19.95	(-18.75)			-170.00	(-22.17)
× Poor			-3.20	(-2.78)			-38.39	(-4.31)
× Fair			-1.93	(-2.19)			-21.64	(-3.25)
× Very good			3.73	(4.29)			28.94	(4.43)
× Excellent			4.73	(4.36)			39.30	(5.31)
$(\text{Age} - 51)^2/100$	-6.44	(-5.71)	-12.38	(-10.32)	-38.65	(-4.00)	-83.69	(-8.49)
× Poor health	0.61	(3.24)	1.14	(6.04)	1.53	(1.20)	5.81	(4.50)
× 65 or older	8.04	(6.82)	11.11	(9.32)	38.79	(3.97)	60.56	(6.22)
× Married			0.81	(4.24)			7.98	(6.05)
× Has living children			1.38	(4.88)			8.79	(4.48)
× High school graduate			1.93	(11.93)			11.45	(11.47)
× College graduate			4.39	(15.50)			33.97	(18.46)
× Poor			0.94	(3.02)			8.21	(3.73)
× Fair			0.63	(2.68)			4.89	(3.02)
× Very good			-1.04	(-4.64)			-7.01	(-4.64)
× Excellent			-1.41	(-5.21)			-9.95	(-5.89)
Birth cohort:								
1911–1915	-0.70	(-1.27)	-0.79	(-1.49)	0.25	(0.13)	-0.96	(-0.49)
1916–1920	-4.67	(-7.23)	-3.54	(-5.79)	-10.97	(-4.63)	-6.97	(-3.06)
1921–1925	-5.83	(-7.94)	-3.58	(-5.14)	-16.26	(-5.96)	-7.23	(-2.76)
1926–1930	-9.07	(-10.53)	-5.59	(-6.76)	-25.71	(-7.61)	-11.78	(-3.59)
1931–1935	-7.00	(-7.41)	-3.63	(-4.00)	-19.33	(-4.85)	-4.81	(-1.24)
1936–1940	-6.56	(-6.55)	-2.48	(-2.57)	-6.43	(-1.43)	9.93	(2.26)
1941–1945	-6.51	(-6.36)	-2.22	(-2.23)	15.17	(3.09)	30.23	(6.23)
1946–1950	-6.40	(-6.32)	-2.12	(-2.16)	37.09	(6.28)	48.77	(8.40)
1951–1955	-6.79	(-6.60)	-2.72	(-2.73)	27.15	(3.25)	43.84	(5.28)
R^2 (%)	6.60		13.00		12.08		15.83	
Observations	32,778		32,341		32,778		32,341	

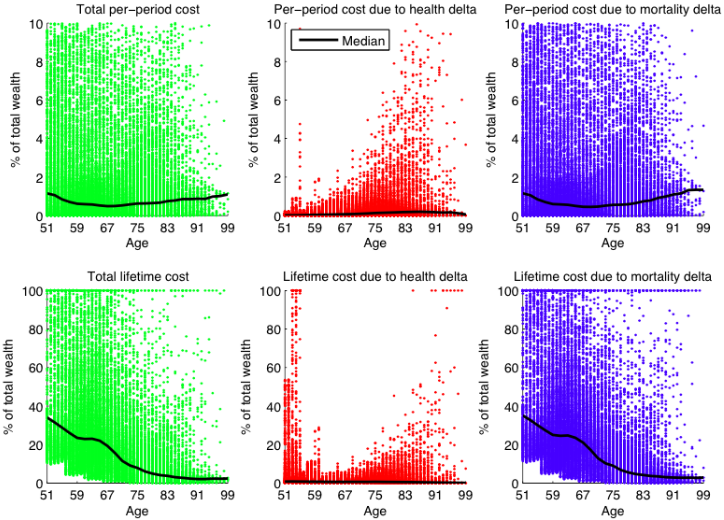
How close is the observed insurance choice to being optimal?

- Welfare cost depends on preferences:
  - Risk aversion: $\gamma = 4$ based on Barsky et al. (1997)
  - Estimate $\omega(1)$ and $\omega(2)$ to minimize the welfare cost per period, summed across all households:

$$\frac{1}{H}\sum_{h=1}^{H} L_h(\omega(1), \omega(2)) \tag{16}$$

Parameters	Symbol	Value
Subjective discount factor	β	0.96
Relative risk aversion	γ	4
Utility weight for death	$\omega(1)$	5.00
	x	(0.13)
Utility weight for poor health	$\omega(2)$	0.84
	x	(0.02)
Utility weight for good health	$\omega(3)$	1.00

Welfare Cost of the Observed Health and Mortality Delta



Extensions and Robustness

- They show that the results are robust to:
  1. Non-actuarial pricing of insurance policies
  2. Different strengths of the bequest motives
  3. Including heterogeneous preference parameters is computationally challenging, but preliminary results indicate that:
     - Most heterogeneity in $\omega(1)$, the bequest motive
     - Welfare costs do not reduce by much

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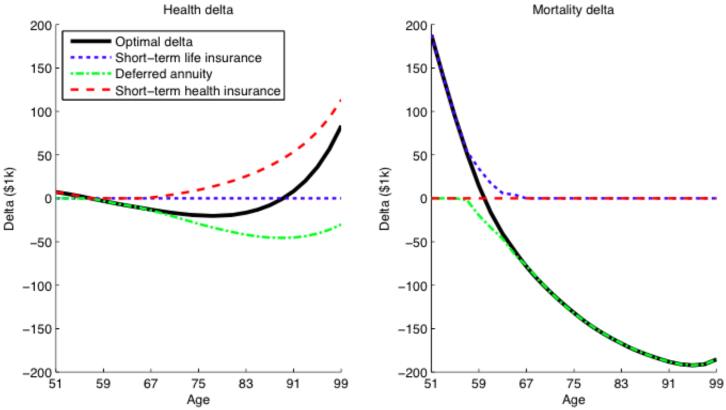
How does one construct an optimal portfolio of health and longevity products?

- Male born 1936-1940:
  - Good health and initial wealth of \$66,000 at age 51
  - Lives at most 30 periods, each corresponding to 2 years
  - Death with certainty at age 111.
- Policy choice:
  1. Short-term (2-year) life insurance
  2. Deferred (until age 65) annuity
  3. Short-term (2-year) health insurance
  4. Bond at interest rate of 2%

Optimal Health and Mortality Delta over the Life Cycle



Conclusion

- Retail financial advisors and insurance companies should report the health and mortality delta of their health and longevity products.
  - Just as mutual fund companies report beta and duration.
- These risk measures will:
  - Facilitate stadardization of products.
  - Identify overlap between existing products.
  - Identify risks that are not insured by existing products → new product development

Conclusion

- Potential welfare gains from completing missing markets and by eliminating suboptimal portfolio choice.
  - Lifetime welfare cost about 27% of wealth at age 51-58
- Alternatively, evidence for preference heterogeneity that is uncorrelated with marital status, children, private information about health...

Question?