Life Insurance Demand under Ambiguous Mortality Risk

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Do you have life insurance contracts?

What is the life insurance contract?

What is the life insurance contract? (one sentence)

A life insurance contract is a legal agreement where an insurer promises to pay a specified sum to a beneficiary upon the insured's death, in exchange for periodic premium payments by the policyholder.

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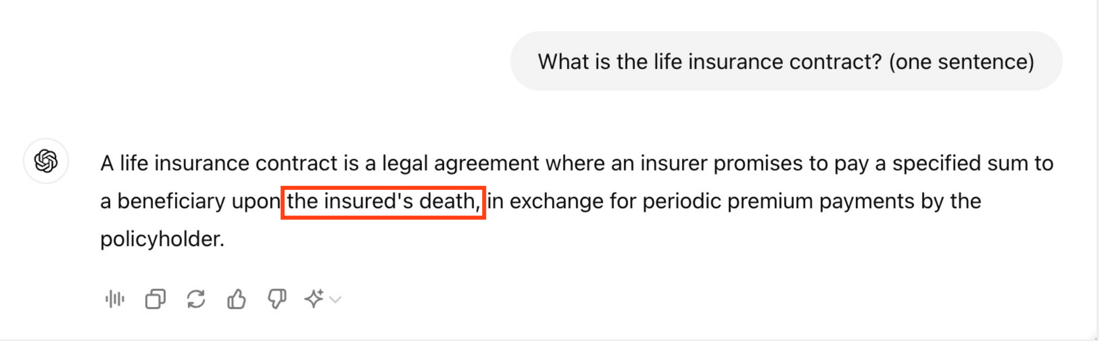
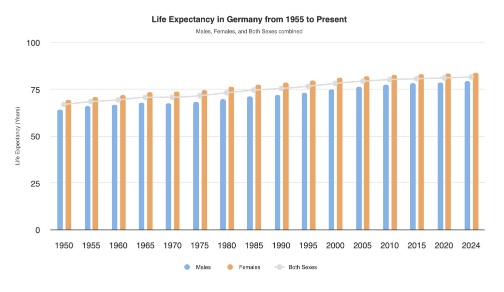
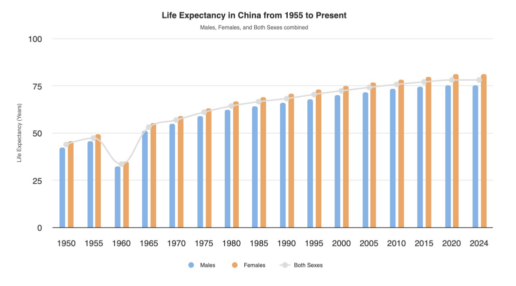


- The probability of death is the key!

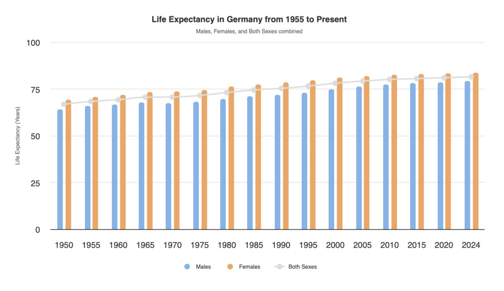


(a) Life expectancy in Germany



(b) Life expectancy in China

Highly unpredictable mortality risk: Postive



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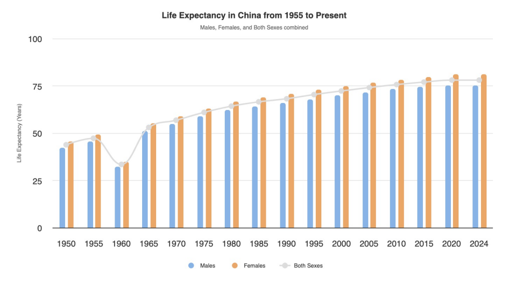

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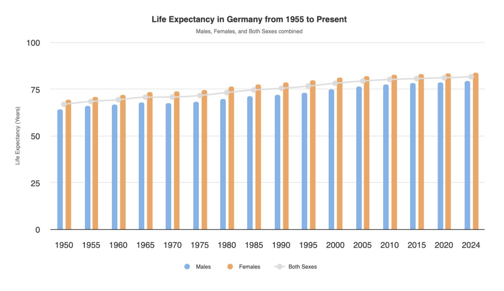

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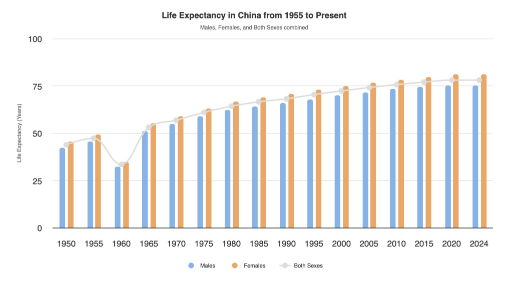

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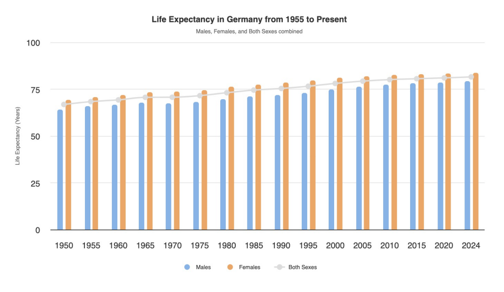

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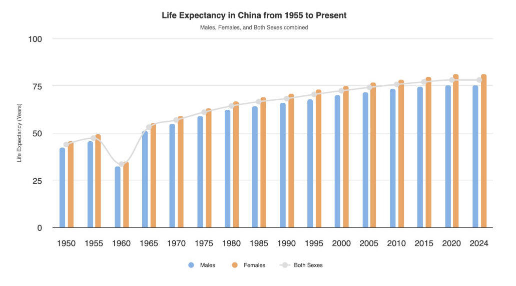

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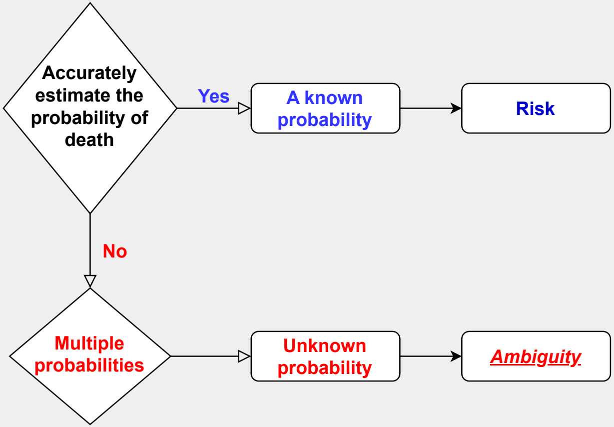

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- We assume that the utility is state-dependent, which relies on the **survival** or **death** states;
- We characterize the **optimal life insurance demand** under the **smooth ambiguity framework**.

Main findings

- We show that the **impact of ambiguous mortality risk** on **life insurance demand** is contingent upon the circumstances;

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- We find that ambiguity aversion could explain the under-insurance puzzle.

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Our work:

- Introduction of ambiguous mortality risk into the life insurance contract and explain the under-insurance puzzle by ambiguity aversion!

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  - k is interpreted as the strength of bequest motive.

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Classical life insurance contract

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Proposition 1 (No ambiguity)

Let $\tau \geq 0$ and $(1+\tau)\pi < 1$. When $k \leq \frac{(1+\tau)(1-\pi)V'(w_0+y)}{(1-(1+\tau)\pi)V'(w_0)}$, the optimal contract $I^* = 0$. If $\frac{(1+\tau)(1-\pi)V'(w_0+y)}{(1-(1+\tau)\pi)V'(w_0)} < k < \frac{(1+\tau)(1-\pi)}{1-(1+\tau)\pi}$, the optimal contract $0 < I^* < y$. If $k > \frac{(1+\tau)(1-\pi)}{1-(1+\tau)\pi}$, the optimal contract $I^* > y$. In particular, $I^* = y$ if and only if $k = \frac{(1+\tau)(1-\pi)}{1-(1+\tau)\pi}$.

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  where $\mathbb{E}_{\pi_i}$ denotes the conditional expectation, given $\Pi = \pi_i$.
- The function ϕ characterizes the individual's attitude towards ambiguity:
  - An increasing and linear ϕ: ambiguity neutrality;
  - An increasing and concave ϕ: ambiguity aversion.

The probability of death Π is a random variable!

- Π with n possible outcomes $\pi_i \in (0,1), i = 1,..,n$, with known probabilities $(q_1, ..., q_n) > 0, \sum_{i=1}^{n} q_i = 1$.

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- The insurer has information about the insured's **distribution** of uncertain mortality:
  - Expected value premium principle, i.e.,

$$P(I) = (1+\tau) \cdot \widehat{\pi} \cdot I,$$

where $\widehat{\pi} := \mathbb{E}_F[\Pi] = \sum_{i=1}^n q_i \pi_i$.

Life insurance contract under smooth ambiguity (I)

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    where $\widehat{\pi} := \mathbb{E}_F[\Pi] = \sum_{i=1}^n q_i \pi_i$.
- The smooth ambiguity objective for the insured with the life insurance contract:

$$\begin{aligned} W(I) &:= \sum_{i=1}^n q_i \phi\Big((1-\pi_i)V(w_0 + y - P(I)) + \pi_i B(w_0 + I - P(I))\Big) \\ &:= \mathbb{E}_F[\phi(U(\Pi, I))], \end{aligned}$$

  where $\mathbb{E}_F$ is the expectation under the distribution F, i.e., $\mathbb{P}(\Pi = \pi_i) = q_i$ and

$$U(\Pi, I) := (1-\Pi)V(w_0 + y - P(I)) + \Pi B(w_0 + I - P(I)).$$

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Proposition 2 (Ambiguity neutrality)

Let $\tau \geq 0$, $\phi(x) = x$ and $(1+\tau)\widehat{\pi} < 1$. When $k \leq \frac{(1+\tau)(1-\widehat{\pi})V'(w_0+y)}{(1-(1+\tau)\widehat{\pi})V'(w_0)}$, the optimal contract $I^*_{neutral} = 0$. When $\frac{(1+\tau)(1-\widehat{\pi})V'(w_0+y)}{(1-(1+\tau)\widehat{\pi})V'(w_0)} < k < \frac{(1+\tau)(1-\widehat{\pi})}{1-(1+\tau)\widehat{\pi}}$, the optimal contract $0 < I^*_{neutral} < y$. When $k > \frac{(1+\tau)(1-\widehat{\pi})}{1-(1+\tau)\widehat{\pi}}$, the optimal contract $I^*_{neutral} > y$. In particular, we have $I^*_{neutral} = y$ if and only if $k = \frac{(1+\tau)(1-\widehat{\pi})}{1-(1+\tau)\widehat{\pi}}$.

Comparison ambiguity neutrality with ambiguity aversion (I)

- I_ϕ^*: the optimal insurance demand with concave ϕ (under ambiguity-aversion).

- I^*_ϕ: the optimal insurance demand with concave ϕ (under ambiguity-aversion).

Proposition 3

Let $(1+\tau)\widehat{\pi} < 1$. The optimal life insurance demand for a risk-and-ambiguity-averse insured is higher in the presence of ambiguity than in its absence, i.e., $I^*_\phi > I^*_{neutral}$ if and only if $\frac{\partial U(\Pi, I^*_{neutral})}{\partial \Pi} < 0$. Moreover, $I^*_\phi < I^*_{neutral}$ if and only if $\frac{\partial U(\Pi, I^*_{neutral})}{\partial \Pi} > 0$. In particular, $I^*_\phi = I^*_{neutral}$ if and only if $\frac{\partial U(\Pi, I^*_{neutral})}{\partial \Pi} = 0$, where $\frac{\partial U(\Pi, I^*_{neutral})}{\partial \Pi} = -V(w_0 + y - P(I^*_{neutral})) + B(w_0 + I^*_{neutral} - P(I^*_{neutral}))$.

Example 1

Let $(1+\tau)\widehat{\pi} < 1$ with $\tau \geq 0$. When $V = B$, we have $I^*_\phi \geq I^*_{neutral}$. If further requires $\tau = 0$, we have $I^*_\phi = I^*_{neutral} = y$.

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Example 2

Let $(1+\tau)\widehat{\pi} < 1$ with $\tau > 0$. When $k > \frac{(1+\tau)(1-\widehat{\pi})}{1-(1+\tau)\widehat{\pi}}$, $c \geq 0$ and $V(x) > 0$ for all $x \geq 0$, we have $I_\phi^* < I_{neutral}^*$.

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Greater ambiguity aversion

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Proposition 4 (Greater ambiguity aversion)

Let $(1+\tau)\widehat{\pi} < 1$. In the presence of ambiguity, optimal life insurance demand for a risk-and-ambiguity averse insured increases with greater ambiguity aversion, i.e., $I^*_{R\phi} > I^*_{\phi}$ if $\frac{\partial U(\Pi, I^*_{\phi})}{\partial \Pi} < 0$. Moreover, $I^*_{R\phi} < I^*_{\phi}$ if $\frac{\partial U(\Pi, I^*_{\phi})}{\partial \Pi} > 0$. In particular, we have $I^*_{R\phi} = I^*_{\phi}$ if $\frac{\partial U(\Pi, I^*_{\phi})}{\partial \Pi} = 0$, where $\frac{\partial U(\Pi, I^*_{\phi})}{\partial \Pi} = -V(w_0 + y - P(I^*_{\phi})) + B(w_0 + I^*_{\phi} - P(I^*_{\phi}))$.

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- **Outlook:**
  - Incorporating other **risks**: non-performance risk...
  - Considering other **frameworks**: multi-period model; dynamic model...
  - Other **insurance contracts**: long-term care insurance; climate-related insurance...

Thank you for your attention!

Preprint is coming soon...

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