Survival ambiguity and welfare

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Motivation

Traditional life-cycle models (Yaari (1965)) assume that survival probabilities are known (survival risk/uncertainty). We assume survival probabilities are unknown (survival ambiguity).

Why? Many of the factors that determine survival probabilities are unobservable. ...but the family of distributions from which one's survival probabilities are drawn is known.
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- We assume survival probabilities are *unknown* (survival ambiguity).

- Why? Many of the factors that determine survival probabilities are unobservable.

- ...but the family of distributions from which one’s survival probabilities are drawn is known.
This paper does 4 things

1. Measure survival ambiguity by income quintile. Individuals form prior expectations about survival risk based on their position in the income distribution. Two survival types and length of life is a compound lottery.

2. Compute the welfare cost of survival ambiguity by income quintile (without annuities). The cost is: Large — over 1% of total lifetime consumption. Regressive — hits the poor 4x harder than the rich.

3. Evaluate the role of private insurance (annuities): With annuities, survival ambiguity improves welfare. Welfare gains from annuities even larger under ambiguity.

4. Evaluate the role of public insurance (Social Security): SS does not help to hedge survival ambiguity.
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Measurement of ambiguity
Structural calibration

Age is continuous $t \in [0; 1]$. Unconditional prob surviving to age $t$ is $(t)$. Survival type is low $(t)$ or high $(t)$. Income quintiles denoted $i = 1; 2; 3; 4; 5$. At $t = 0$, $p_i$ is the subjective (prior) probability of being a low type for an individual in quintile $i$. Expected utility maximizers make plans with a convex combination $p_i(t) + (1 - p_i(t))$. Given the actual survival data by quintile $i(t)$, our calibration problem:

$$\min (t); (t); p_i_{L} = \int_{0}^{T} \sum_{i=1}^{5} \int_{1}^{2} f_i(t) [p_i(t) + (1 - p_i(t))] g dt$$
Structural calibration

- Age is continuous $t \in [0, 1]$. Unconditional prob surviving to age $t$ is $\Phi(t)$. 

- Survival type is low ($t$) or high ($t$)

- Income quintiles denoted $i_2 f, i_2 f, i_3 f, i_4 f, i_5 f$.

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- Expected utility maximizers make plans with a convex combination $p_i(t) + (1 - p_i(t))$. 

- Given the actual survival data by quintile $i(t)$, our calibration problem:

$$\min_{\Phi(t)} \int_0^1 f_i(t) \left[ p_i(t) + (1 - p_i(t)) \right] dt$$
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- At $t = 0$, $p_i$ is the subjective (prior) probability of being a low type for an individual in quintile $i$. Expected utility maximizers make plans with a convex combination $p_i\Phi(t) + (1 - p_i)\bar{\Phi}(t)$. 

\[ \int_0^1 f_i(t) \left[ p_i\Phi(t) + (1 - p_i)\bar{\Phi}(t) \right] g_2 dt \]
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- Given the actual survival data by quintile $\Phi_i(t)$, our calibration problem:

$$\min_{\Phi(t), \bar{\Phi}(t), p_i} \mathcal{L} = \sqrt{\sum_{i=1}^{5} \int_{0}^{1} \left\{ \Phi_i(t) - [p_i\Phi(t) + (1 - p_i)\bar{\Phi}(t)] \right\}^2 dt}$$
Figure 1. Calibration of Mortality and Binary Ambiguity by Income Quintile

Note: Solid lines are data. Dashes and circles are calibrated.
Welfare cost of ambiguity
Theory

Define three objective functionals

\[ J = \int_0^1 \left[ p(t) \right] u(c(t)) \, dt \]

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and three optimal consumption paths

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Theory

- Define three objective functionals

\[ J^* = \int_0^1 [p\Phi(t) + (1 - p)\bar{\Phi}(t)]u(c(t))dt \]
\[ J = \int_0^1 \Phi(t)u(c(t))dt \]
\[ \bar{J} = \int_0^1 \bar{\Phi}(t)u(c(t))dt \]
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\[ c^*(t) = \arg \max J^* \]

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The cost of ambiguity is the fraction of the optimal control that the decision maker would give up to know $(t) p J(c(1 + t)) + (1 - p J(c(1 + t)) = J(c(t))$

Ambiguity is costly because decisions are distorted away from their full information counterparts where the individual fully optimizes based on known survival risk.
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• Ambiguity is costly because decisions are distorted away from their full information counterparts where the individual fully optimizes based on known survival risk.
In our life-cycle consumption-saving model, the survival ambiguity can be as large as 1% of total lifetime consumption. Survival ambiguity is highly regressive: cost to the poorest quintile is 4 times larger than the cost to the richest quintile. Why? The poor rationally believe there is a strong chance they are a low survival type, causing them to save very little relative to what they would save if they knew they were a high type: ambiguity causes a painful "undersaving" problem among the poor who are the high survival type.
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Figure 4. Fair Comparison of Consumption under Binary Ambiguity

Note: Plus marks are consumption under ambiguity. Circles are consumption when the survival type is known in advance.
Our welfare calculations are conservative for two reasons:

1. Individuals maximize expected utility (they are not ambiguity averse). Dimmock, Kouwenberg, Mitchell, and Peijnenburg (2016) estimate that half the population are ambiguity averse. Distaste for ambiguity would further increase the welfare cost of ambiguity.

2. No limits on cognition. Individuals have rational prior beliefs about the survival probabilities that they face, and they rationally update those beliefs according to Bayes' rule. In other words, individuals optimally cope with ambiguity.

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On the other hand, we potentially overstate the welfare costs for two reasons:

1. Only two survival types. With a continuum of survival types, the magnitude of the welfare cost goes down but the regressivity result persists.

2. Individuals form priors about survival type based solely on their position in the income distribution. While survival risk is strongly connected to income class (e.g., Cristia (2009)), other non-income factors could be informative about survival type.
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Private insurance (annuities)
Survival ambiguity with competitive annuity markets

Two survival types as before.

For simplicity, no income heterogeneity. (Everyone has the same prior probability of being a low type, \( p \)).

Individuals save for retirement with competitive annuity contracts as in Yaari (1965) but expanded to incorporate ambiguity.

Insurance companies cannot separate people by survival type because that information is unknown.

Instead, they pool everyone together and offer a zero-profit contract with competitive return:

\[
\frac{d}{dt} \left[ p(t) + (1-p)(t) \right] p(t) + (1-p)(t)
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\( p \), \( t \).
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r(t) = -\frac{\frac{d}{dt} [p\Phi(t) + (1 - p)\Phi(t)]}{p\Phi(t) + (1 - p)\Phi(t)}.
\]
In contrast, without ambiguity, insurance companies have full information about survival type and offer separate competitive contracts to each type.

\[
\begin{align*}
    r(t) &= \frac{d}{dt}(u(t))
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If \( u(c) \) is concave, Jensen's inequality ensures that people would rather live with ambiguity and earn return \( r(t) \) than learn their survival type at \( t = 0 \) and earn return \( r(t) \) or \( r(t) \).

Ambiguity distorts \( c \) away from what the individual would do with full information about survival risk (which is bad). But ambiguity also causes competitive insurance companies to pool risk across survival type.
• In contrast, without ambiguity, insurance companies have full information about survival type and offer separate competitive contracts to each type

\[ r(t) = -\frac{d}{dt} \frac{\Phi(t)}{\Phi(t)}, \quad \bar{r}(t) = -\frac{d}{dt} \frac{\bar{\Phi}(t)}{\bar{\Phi}(t)}. \]
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- Ambiguity distorts \( c \) away from what the individual would do with full information about survival risk (which is bad).

- \textit{But} ambiguity also causes competitive insurance companies to pool risk across survival type.
The value of annuitization

We have shown that (i) ambiguity reduces welfare in the absence of annuities, and (ii) ambiguity increases welfare in the presence of annuities. These two results combine to create a final result: welfare gains from competitive annuities are larger with ambiguity than without ambiguity. Past studies underestimate the welfare gains from annuitization because they abstract from survival ambiguity. Competitive annuities not only insure survival risk as past studies have established, but they also pool risk across survival type.
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- Past studies underestimate the welfare gains from annuitization because they abstract from survival ambiguity.

- Competitive annuities not only insure survival risk as past studies have established, but they also pool risk across survival type.
Annuities insure survival risk by utilizing the assets of the deceased to provide a premium to surviving annuitants, and they insure survival type by paying a premium that reflects pooling across unknown survival types. Hence, while asymmetric information about survival risk can rationalize thin annuity markets, ambiguity about survival risk makes thin annuity markets even more puzzling.
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Social Security
An irrelevance result

Therefore, almost as a tautology, SS cannot act as insurance against ambiguity. It would need to make payments that are contingent on information in order to reduce the welfare cost of ambiguity. That is, if SS benefits were contingent on survival type in the absence of ambiguity but pooled across survival type in the presence of ambiguity, then SS would reduce the welfare cost of ambiguity.

While SS can improve welfare by providing a life annuity, the cost of survival ambiguity is the same whether SS exists or not (SS does not affect willingness to pay for immediate resolution of ambiguity). Likewise, the welfare gain from SS's provision of a life annuity is the same with or without ambiguity.
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Thank you