Retirement Saving, Annuity Markets, and Lifecycle Modeling

James Poterba
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Outline

- Shifting Composition of Retirement
- Saving: Rise of Defined Contribution Plans
- Mortality Risks in Retirement
- Existing Annuity Products: Prices and Quantities
- Explaining Small Annuity Markets
- New Markets for Trading Mortality Risk
U.S. Private Retirement System: The Shift from Defined Benefit to Defined Contribution

- 1980: Roughly Three Quarters of Pension Contributions in the U.S. to Defined Benefit Plans
- 2005: 73% of Pension Contributions to Defined Contribution (401(k), 403(b)) Style Plans
- DC Plan and IRA Assets in 2006: $8.3 Trillion ($16.4T in total retirement assets)
- Future Retirees will have Lifetime Exposure to 401(k)s
401(k) Eligibility & Participation
Rates, 1984-2003 SIPP
Cohort Patterns of 401(k) Participation

Participation Rate

Age
Lifecycle Funds and “Automatic Pilot” Accumulation Vehicles

- Key Question: What is the Optimal Glide Path Shifting from Equity to Fixed Income as Participants Age?
- Need Dynamic Model of Optimal Lifetime Portfolio Choice
Equity Glidepath for Largest Lifecycle Funds

<table>
<thead>
<tr>
<th>Years Until Retirement</th>
<th>Fidelity Price</th>
<th>Vanguard Price</th>
<th>T Rowe Price</th>
<th>Principal</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>90%</td>
<td>90%</td>
<td>92.5%</td>
<td>85%</td>
</tr>
<tr>
<td>20</td>
<td>75</td>
<td>80</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>0</td>
<td>50</td>
<td>45</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Retirement Income Funds</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>17.5</td>
</tr>
</tbody>
</table>
What Determines Optimal Age-Specific Equity Exposure?

- Correlation Between Shocks to Present Value of Human Capital and Equity Market Returns
- Individual / Household Risk Tolerance
- Background Risk
- Options for Varying Future Labor Supply
- Public and Private Insurance Guarantees on Retirement Consumption
- Complex Dynamic Problem: Campbell / Viceira, Gomes / Cocco / Maenhout
- Do Lifecycle Funds Solve the Right Problem?
Shifting Focus from Accumulation of Assets to Drawing Down Assets in Retirement

- Search for Simple Rules: X% Per Year
- Uncertain Longevity: Classic Yaari Analysis, Absent Bequest Motives and Late-Life Medical Cost Uncertainty, Individuals Should Fully Annuitize
- More Complex Analysis: Potential Medical and Nursing Home Costs, Bequest Motives
Longevity Risk

- Conditional on Attaining Age 25, Probability of Reaching Age 65 is 0.858 for Men, 0.905 for Women
- Conditional on Age 65, Probability of Dying by 75 is 0.254 for Men, 0.189 for Women
- Conditional on Age 65, Probability of Living to 90 is 0.181 for Men, 0.275 for Women
<table>
<thead>
<tr>
<th>Age</th>
<th>E( Remaining Years)</th>
<th>S.D. Remaining Years</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>55.6</td>
<td>14.5</td>
<td>0.26</td>
</tr>
<tr>
<td>35</td>
<td>46.2</td>
<td>13.5</td>
<td>0.29</td>
</tr>
<tr>
<td>45</td>
<td>37.0</td>
<td>12.3</td>
<td>0.33</td>
</tr>
<tr>
<td>55</td>
<td>28.3</td>
<td>10.7</td>
<td>0.38</td>
</tr>
<tr>
<td>65</td>
<td>19.9</td>
<td>9.1</td>
<td>0.46</td>
</tr>
<tr>
<td>75</td>
<td>12.8</td>
<td>6.9</td>
<td>0.54</td>
</tr>
</tbody>
</table>
Dispersion of Longevity Outcomes for Married 65-Year-Old Couple

- 38.4 Expected Remaining Person-Life-Years
- 13.5 Expected Years Together
- Expected Years Lived by Widowed Wife: 6.8
- Expected Years Lived by Widower: 4.5
- First Death: 25% Chance by Age 73, 50% by Age 78
- Second Death: 50% Chance After Age 90, 25% After Age 93
- Prob(Wife Survives Husband) = 57.5%
Are Mortality Perceptions Rational?

Hurd / McGarry Compare Subjective Mortality Probabilities in Health and Retirement Survey with Actual

Men: Survey Average Survival Probability to Age 75: 0.622. “Actual” from Mortality Table: 0.594. Women: 0.663 and 0.746.

Survival to 85: Subjective 0.388 for Men (0.242 “actual”), 0.460 and 0.438 for Women
Mortality Variation

- Time Series: Mortality Rates Have Fallen, But at Different Rates for Different Ages (How to Extrapolate?)
- Cross-Sectional: Socio-Economic Status is Strongly Correlated with Mortality Rates
- Time Series/Cross Section Interaction: SES Differential is Growing
## Annual Mortality Improvement Rate

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Men, 65-74</strong></td>
<td>-0.53%</td>
<td>-1.61%</td>
<td>-1.05%</td>
</tr>
<tr>
<td><strong>Men, 75-84</strong></td>
<td>-0.58</td>
<td>-0.99</td>
<td>-0.78</td>
</tr>
<tr>
<td><strong>Men, 85+</strong></td>
<td>-0.56</td>
<td>0.29</td>
<td>-0.14</td>
</tr>
<tr>
<td><strong>Women, 65-74</strong></td>
<td>-1.61</td>
<td>-0.49</td>
<td>-1.07</td>
</tr>
<tr>
<td><strong>Women, 75-84</strong></td>
<td>-1.57</td>
<td>-0.35</td>
<td>-0.98</td>
</tr>
<tr>
<td><strong>Women, 85+</strong></td>
<td>-1.09</td>
<td>0.29</td>
<td>-0.42</td>
</tr>
</tbody>
</table>
Life Expectancy for 65-year-old Males, by Birth Cohort

Top 50%
Bottom 50%
Intertemporal Consumption Choices with Stochastic Mortality

- Euler Equation with Mortality Risk:
  \[ U'(C_{t,a}) = S_{t,a} \times \frac{(1+r_t)/(1+\delta)}{1+\delta} \times U'(C_{t+1,a+1}) \]

- \( S_{t,a} \) = Probability of a-Year Old Surviving for One Year at time t

- \( S_t \) becomes small in old age: strong anti-saving force in absence of bequest motives
Empirical Issues Concerning Late-Life Consumption

- Key Finding: Heterogeneity is Key
- Does Falling Survivorship Rate Affect Slope of Consumption Profile?
- Do Households Draw Down Assets? International Evidence – Large Differences
- Annuity Purchases vs. Life Insurance: AHEAD Data Households 70+, 8% of Couples Own an Annuity, 78% Own a Life Insurance Policy
Existing Private Annuity Markets

- Sales of New Single-Premium Immediate Annuities: $12.8 Billion in 2007
- Variable Annuity Market is Much Larger but Few Assets are Annuitized
- Defined Benefit Pension Plans Provide Group Annuities
- Public Annuities: Social Security, Medicare
Reported Annuity Income: 2004 Survey of Consumer Finances

- Annuitized Income/Total Income for 65-85 Year Old Households: 49.5% (DB Pension Income, Social Security & DI, Private Annuities)
- 85+ Households: Annuity/Total > 80%
- Rising Annuity Share Because of SS & Medicare
- Income from Private Annuities = $14.6 Billion (3% of Total Income)
Annuity Choices of TIAA-CREF Participants, 1989-2001
A LOT OF GOOD THOSE ANNUITIES ARE DOING ME NOW
Payout Options in Large Defined Contribution Plans, 2000 NCS

- 38% of 401(k) Plans, 33% of All Defined Contribution Plans Offer an Annuity Option
- Lump-Sum Distribution is the ONLY Option in 28% of 401(k) Plans, 30% of All DC Plans
Explaining Small Private Annuity Markets

“DEMAND:” Precautionary Demand for Liquid Wealth, Bequest Motives, Informal Longevity Insurance Provided within Families

“SUPPLY:” Unattractive Annuity Prices Because of Adverse Selection or Limited Competition
The Role of Annuity Markets in Optimal Social Security Policy

- Eckstein / Eichenbaum / Peled, Diamond, Many Others Cite Absence of Large Private Annuity Market as a Key Potential Justification for Public Retirement Income Program
- Insurance Markets are Key for Many Public Policy Issues (Golosov / Tsyvinski)
Expected Present Discounted Value (EPDV) of Annuity Payouts per Premium Dollar

\[ \text{EPDV}_{\text{NOM}} = \sum_{t=1,T} S_t A_{\text{NOM}} \left/ \prod_{j=1,t} (1+i_j) \right. \]

- Survival Rates – Population Life Table or Annuitant Life Table, Projected Forward
- Choice of Bonds for Discount Rates – Riskless Treasuries vs. Risky Corporates
- EPDV Does Not Recognize Insurance Value of Annuity to Individual
## Adverse Selection: Comparing Mortality Rates for Annuitants & Population at Large, 2007

<table>
<thead>
<tr>
<th></th>
<th>Annuitant Mortality</th>
<th>Population Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>65</td>
<td>1.02%</td>
<td>0.57%</td>
</tr>
<tr>
<td>75</td>
<td>2.98</td>
<td>1.61</td>
</tr>
<tr>
<td>85</td>
<td>8.06</td>
<td>5.08</td>
</tr>
</tbody>
</table>
## Money’s Worth of Individual Annuities, December 2007

<table>
<thead>
<tr>
<th>Interest Rate:</th>
<th>Annuitant Mortality Table</th>
<th>Population Mortality Table</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate</td>
<td>Treasury</td>
</tr>
<tr>
<td><strong>Men Age 65</strong></td>
<td>0.894</td>
<td>1.009</td>
</tr>
<tr>
<td><strong>Women Age 65</strong></td>
<td>0.918</td>
<td>1.049</td>
</tr>
</tbody>
</table>
## Share of Annuity EPDV Associated with Payouts in First Five Years

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>Annuitant</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate</td>
<td>Treasury Corporate</td>
</tr>
<tr>
<td>Men, 65</td>
<td>0.383</td>
<td>0.350</td>
</tr>
<tr>
<td>Men, 75</td>
<td>0.487</td>
<td>0.460</td>
</tr>
<tr>
<td>Women, 65</td>
<td>0.350</td>
<td>0.317</td>
</tr>
<tr>
<td>Women, 75</td>
<td>0.439</td>
<td>0.410</td>
</tr>
</tbody>
</table>
Why Are EPDV Values < 1?

- Insurance Company Administrative Costs or Profits
- Adverse Selection: Annuitant Population is Longer-Lived Than Population at Large
- Risk Premium to Cover Cost of Future Mortality Improvement
Testing for Adverse Selection: Choice of Annuity Policy in UK

- Compulsory Retirement Annuity Market is Much Larger than U.S. Market
- Different Policies Offer Different Features and Individuals can Choose
- Large Insurance Company Shared Data on Ex Post Mortality Experience by Annuity Type
Is Adverse Selection Quantitatively Important? Evidence from the UK Compulsory Annuity Market

- Nominal Annuity
- Inflation-Indexed Annuity
- “Escalating” Annuity (3% per year)

Nominal Annuity: For 65 year old males, 41% of EPDV is in First Five Years, 6% Beyond Age 85; Contrast with 34% (9%) for a Policy with 3%/Year Escalation (US 2008 Corporate Discounting)
## Five-Year Survival Probability, 61-65 Year Old Male Annuitant (Finkelstein-Poterba)

<table>
<thead>
<tr>
<th>Type</th>
<th>Compulsory Annuity</th>
<th>Voluntary Annuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
<td>0.913</td>
<td>0.951</td>
</tr>
<tr>
<td>Escalating</td>
<td>0.970</td>
<td>0.989</td>
</tr>
<tr>
<td>Guaranteed</td>
<td>0.911</td>
<td>0.940</td>
</tr>
<tr>
<td>Index-Linked</td>
<td>0.962</td>
<td>0.980</td>
</tr>
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</table>
Consequences of Adverse Selection in Private Annuity Markets

- Competitive Equilibrium May Not Exist, May Not Be Pareto Optimal
- Possibility of Welfare Gain from Public Action
- Government Policy Actions:
  - Compel Market Participation
  - Regulate Structure of Contracts
Can Insurers Design Contracts to Induce Self-Selection?

- Backloading Payouts Can Induce High-Mortality Households to Select Other Products
- Contract Menu Has Not Included Policies with Strong Age-Related Slope
- Equilibrium Depends on Ancillary Assumptions Such as Saving Technology
- Research Challenge: Calibrating Models with Endogenous Contracts
The Risk of Aggregate Mortality Shocks: Are Insurers Charging a Risk Premium?

- Forecasting Mortality is Difficult
- Risk of Medical Breakthrough Could Change Experience
- Life Insurers are Affected by Illness Shocks (1918 Influenza, AIDS)
Projecting Mortality Improvement: Beyond Simple Extrapolation

- Lee-Carter (1992 JASA) Model
- Robust and Widely Used
- One Factor Model – No Differences Across Ages, No Cohort Effects

\[ m_{a,t} = \text{crude death rate at age } a \text{ in year } t \]

\[ \ln m_{a,t} = \alpha_a + \beta_a \cdot k_t + \epsilon_{a,t} \]

\[ q_{a,t} = \text{mortality rate at age } a \text{ in year } t \]

\[ q_{a,t} = 1 - \exp[-m_{a,t}] \]
Estimation of Lee-Carter Mortality Model

\[ \ln m_{a,t} = \alpha_a + \beta_a \cdot k_t + \varepsilon_{a,t} \]

- Normalize \( \sum_a \beta_a = 1, \sum_t k_t = 0 \)
- Aggregate Mortality Factor \( k_t \) Follows a Random Walk with Drift
- Estimate for \( \{\alpha_a, \beta_a, k_t\} \) for Men, Women over 1950-2007 Period (\( a = 65, \ldots, 110 \))
- Stochastic Simulation of Future Paths of Mortality Rates Can be Used to Compute EPDV of Annuities
Estimates of $\beta_a$ – Age Specific Loading Factor

B(a) - Age Specific Coefficient

- Males
- Females
Estimates of \( \{k_t\} \): Year-Specific Mortality Improvement

\[ k(t) - \text{Time Trend} \]

- **Males**
- **Females**

Potential Variation in EPDV of Annuity for 65-Year-Old Male, Treasury Discount Rates

<table>
<thead>
<tr>
<th>Valuation Percentile</th>
<th>Annuitant Mortality Table</th>
<th>Population Mortality Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>5\textsuperscript{th}</td>
<td>0.966</td>
<td>0.829</td>
</tr>
<tr>
<td>25\textsuperscript{th}</td>
<td>0.992</td>
<td>0.859</td>
</tr>
<tr>
<td>Median</td>
<td>1.010</td>
<td>0.878</td>
</tr>
<tr>
<td>75\textsuperscript{th}</td>
<td>1.028</td>
<td>0.897</td>
</tr>
<tr>
<td>95\textsuperscript{th}</td>
<td>1.053</td>
<td>0.924</td>
</tr>
</tbody>
</table>
Dispersion of Life Expectancy at Future Dates in Lee-Carter Projections

- Life Expectancy at Age 75 for a Current 65 Year Old Male
  - Median: 87.8 years
  - 5-95 spread: 86.5 years, 89.0 years
  - 25-75 spread: 87.3 years, 88.3 years
Future Directions in Projecting Mortality Rates

- Disaggregating Mortality by Source: Focus on Cancer, Heart Disease, Alzheimer's...
- Some Demographers Project More Rapid Future than Past Improvements
- Attempt at Explicit Modeling of Rare Events (1918 Flu, AIDS)
Hedging Mortality Risks: Survivor Bonds and Mortality Swaps

- Emerging Financial Markets for Mortality Risks
- Pension Funds, Companies that Offer Life Annuities are Long Mortality Risk (Profit from High Mortality Rates)
- Total Mortality Swap Market: < $3 Billion
Examples of Mortality-Linked Derivative Instruments

- **2003 Swiss Re Mortality Bond**: $400M Issue, Three-Year Maturity, Payout Depends on Index of Mortality Rates Across Five OECD Nations (“Flu Insurance”)

- **BNP Paribus Long-Term Mortality Bond**, 2004: Payment at \( t = 50M \times (\text{Percentage of Cohort Aged 65 in England & Wales in 2004 that is Still Alive at } t) \)
Should Governments Offer “Survivor Bonds” to Absorb Long-Term Mortality Improvement Risk?

- Governments Are Already Long Mortality Risk – Why Buy More?
- Risk-Sharing through Markets vs. Government
Conclusions

- Exploring Institutions Such as Private Annuity Markets Can Inform Modeling Exercises About Optimal Consumption Planning and Policy Design
- Mortality Risks are Central for Old-Age Consumption Planning
- Dynamic Lifecycle Models Can Inform Security Design: Lifecycle Funds, Survivor Bonds
References