The Cross-Section of Household Preferences

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Arrow Lecture 2
Stanford University
April 19, 2017
Yesterday’s Arrow Lecture considered a problem where preferences play almost no role.

Today I will consider the canonical problem of saving and risktaking, where attitudes towards time and uncertainty are central.

I will present an ongoing project with Laurent Calvet, Francisco Gomes, and Paolo Sodini using administrative data from Sweden.

The project has features that illustrate the practice of household finance:

- Administrative data on an entire population
- A strong theoretical benchmark
- Randomness generated by risky asset returns.
Questions About Preferences

- We work with the three-parameter Epstein-Zin model:
  - Attitude towards risk (relative risk aversion RRA).
  - Impatience (time discount factor TDF or time preference rate TPR).
  - Intertemporal smoothing (elasticity of intertemporal substitution EIS).

- How can all these parameters be identified?
- How heterogeneous are they?
- How are they correlated with one another?
- Power utility imposes the restriction that $EIS = 1/RRA$. Does this restriction fit the data?
- How are preference parameters related to observables such as career choice, education, and cohort?
- What are the implications of preference heterogeneity for macro models that assume a representative agent?
Approach to the Problem

- We specify a life-cycle model of consumption and portfolio choice with Epstein-Zin preferences and many realistic features:
  - Borrowing constraints
  - Transitory and permanent labor income risk
  - Retirement
  - Risky assets (defined to include real estate) and safe assets

- We estimate/calibrate the model using administrative data on all Swedish households.

- We estimate preference parameters that best match the data on
  - Risky portfolio shares
  - Wealth-income ratios
Cut 1.1

- The results I will present today are a first cut.
  - Not literally the first draft (cut 1.0), but still highly preliminary.
- I will highlight areas where we plan to improve the analysis, particularly
  - Treatment of housing and defined-contribution (DC) retirement savings.
  - Simulation of aggregate shocks.
  - Moments included in the estimation procedure.
Lecture Outline

- Basic facts about household risktaking (from my 2016 Ely Lecture).
  - Limited participation and DC retirement savings.
  - More risktaking among the wealthy.
  - Implications for wealth inequality.

- Epstein-Zin preferences.
  - The debate about the EIS.

- Swedish data.

- Identification of Epstein-Zin preferences in a lifecycle model.
  - A suggested new approach to identification.

- Preliminary empirical results.
Who Takes Risk? Variation Across and Within Countries

- Households’ willingness to take risks varies across countries.
  - And much of this is driven by cross-country variation in the participation rate (holding any risky assets).

- DC retirement systems make a big difference to both participation and the risky share of participants.

- Within countries, richer people tend to take more risk.
  - Again, much of this is driven by a higher participation rate among the wealthy.
Risktaking Across Countries

Source: Campbell (2016 Ely Lecture)
Risktaking Within Countries

Panel A. All households

Panel B. Risky market participants

Source: Campbell (2016 Ely Lecture)
Implications for the Evolution of Wealth Inequality

- Differences in financial strategies are large enough to impact the evolution of wealth inequality as suggested by Piketty (2014, Ch. 12).
- In a stylized model without saving,

$$W_{i,t+1} = W_{it}(1 + R_{i,t+1}),$$

where \((1 + R_{i,t+1})\) is the gross return on household \(i\)’s portfolio. Taking logs,

$$w_{i,t+1} = w_{it} + r_{i,t+1}$$

$$= w_{it} + E_t r_{i,t+1} + \tilde{r}_{i,t+1},$$

where \(E_t r_{i,t+1}\) is the rational (econometrician’s) expectation of the log portfolio return for household \(i\), and \(\tilde{r}_{i,t+1} = r_{i,t+1} - E_t r_{i,t+1}\) is the unexpected component of the log portfolio return.

- Now consider cross-sectional variances \(\text{Var}^*\) and covariances \(\text{Cov}^*\) at a point in time.
Evolution of Wealth Inequality

\[ E[\text{Var}^* w_{i,t+1} - \text{Var}^* (w_{it})] = E[\text{Var}^* (E_t r_{i,t+1})] + E[\text{Var}^* (\tilde{r}_{i,t+1})] + 2E[\text{Cov}^* (w_{it}, E_t r_{i,t+1})]. \]

- The average growth in wealth inequality depends on:
  - the cross-sectional variance of expected log returns (negligible empirically)
  - the cross-sectional variance of unexpected log returns
  - the covariance between log wealth and expected log returns.

- What matters here are \textbf{log} returns, which are lowered by poor diversification even if simple returns are the same.
Wealth Inequality Decomposition in Sweden

<table>
<thead>
<tr>
<th></th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Var}^* (w_{it}) )</td>
<td>2.71</td>
</tr>
<tr>
<td>( \mathbb{E} [\Delta \text{Var}^* w_{i,t+1}] )</td>
<td>0.039</td>
</tr>
<tr>
<td>Sum of investment effects</td>
<td>0.062</td>
</tr>
<tr>
<td>( \mathbb{E} [\text{Var}^* (E_{t}r_{i,t+1})] )</td>
<td>2%</td>
</tr>
<tr>
<td>( \mathbb{E} [\text{Var}^* (\bar{r}_{i,t+1})] )</td>
<td>22%</td>
</tr>
<tr>
<td>( 2\mathbb{E} [\text{Cov}^* (w_{it}, E_{t}r_{i,t+1})] )</td>
<td>76%</td>
</tr>
</tbody>
</table>

- Swedish results from Bach, Calvet, and Sodini (2015) based on financial assets outside DC retirement accounts.
  - Important effect is greater financial risktaking and more efficient diversification by the wealthy.
  - This is greater than the total measured increase in wealth inequality in their data.
The Epstein-Zin Parameter Space
Why Epstein-Zin Preferences?

- EZ preferences relax the restriction that EIS = 1/RRA.
- This is appealing for both theoretical and empirical reasons:
  - Theoretically, these parameters play different roles, e.g. unit EIS implies constant consumption-wealth ratio while unit RRA implies myopic portfolio choice.
  - Empirically, the equity premium puzzle pushes towards high RRA, but very low EIS leads to the “riskfree rate puzzle” (Weil 1989): there is wild variation in the riskfree rate if there is any time-variation in expected consumption growth.
The Debate About the EIS (1)

- The EIS governs the response of the planned consumption path to changes in investment opportunities:

\[ E_t \Delta c_{t+1} = \text{time preference} + \text{EIS} \ E_t r_{t+1} + \text{variance terms}. \]  

- When expected returns are constant, EIS cannot be separately identified from time preference (Kocherlakota 1990, Svensson 1989).

- When expected returns are time-varying, EIS can be identified in principle but comovement of variance terms and expected returns is a pitfall.

- Estimation of equation (1) using aggregate data suggests very low EIS 0.1 – 0.2 (Hall 1988, Yogo 2004 et al.)

- Higher estimates, close to 1, are obtained from micro data on stockholders (Vissing-Jørgensen 2002).
The Debate About the EIS (2)

- In the finance literature, the “long-run risk model” of Bansal and Yaron (2004) proposes an EIS well above 1, e.g. 1.5.
  - This implies high prices of consumption claims when consumption growth is expected to be rapid, and low prices when consumption is expected to be volatile.
  - There is a debate over the empirical fit of this model, e.g. Bansal, Kiku and Yaron (2012) vs. Beeler and Campbell (2012).

- A theoretical difficulty with a high RRA and high EIS is that it implies a very strong preference for early resolution of uncertainty (Epstein, Farhi, and Strzalecki 2014).
The State of the Literature

![Graph showing the relationship between Coefficient of Relative Risk Aversion ($\gamma$) and Elasticity of Intertemporal Substitution ($\psi$). The graph illustrates Constant consumption-wealth ratio, Log utility, Myopic portfolio choice, and Power utility with $\psi = \frac{1}{\gamma}$.]
Nature of the Data

- Disaggregated wealth (excluding DC retirement accounts) and income over time.
- We focus on households with heads aged 40 to 60, who have accumulated retirement wealth and whose behavior is better fit by a standard life-cycle model.
- We study stock market participants to avoid modeling the participation decision.
- 5.9 million household-years.
Household Groups

- We don’t analyze the data at the household level.
- Instead we consider moderately large groups of households with similar characteristics, to diversify idiosyncratic events.
  - We treat each group as a large household with uniform preferences.
- We first group households based on education (3), sector of employment (12) and birth cohort (13), for a total of 468 groups.
- Within each of these 468 groups we further sort households in 4 wealth-to-income buckets and 3 portfolio share buckets:
  - This gives us $5616 = 468 \times 12$ groups.
  - We drop a few groups with insufficient household coverage and end up with 5547 groups.
Wealth Measurement

- We consider three broad forms of wealth: liquid financial wealth, real estate equity, and illiquid retirement savings.

\[ W_{h,t} = LW_{h,t} + RE_{h,t} + RW_{h,t}, \]

- Liquid financial wealth includes:
  - Bank accounts and money market funds (safe asset).
  - Mutual funds, stocks, insurance products, derivatives and bonds (risky asset).

- Real estate equity consists of properties (residential, rental and commercial) and land, net of mortgage debt
  - Assumed risky.

- Illiquid retirement wealth consists of wealth in defined contribution accounts.
  - Assumed risky (for now).
Imputing Retirement Wealth

- Retirement wealth includes the contributions to DC retirement accounts and the investment returns on these contributions.
- We input contributions using a detailed reconstruction of the administrative rules governing DC retirement plans for different groups of households and the history of “pension-qualified income” (PQI)
  - PQI directly measured 1983-2007, imputed before that using historical GDP per capita and inflation and the 1983-2007 relationship between PQI and these variables.
- We calculate investment returns by assuming that all DC retirement wealth is invested in a global equity index.
- After-tax retirement wealth is obtained by multiplying pre-tax retirement wealth by $1 - \tau$, where $\tau$ is the tax rate on withdrawals.
Data: Risky Shares and W/Y Ratios

- When we sort by education and sector we see some variation in W/Y but not much variation in risky share.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and quarrying, electricity, gas and water supply</td>
<td>Risky share</td>
<td>96.25%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Risky share</td>
<td>88.76%</td>
</tr>
<tr>
<td>Construction</td>
<td>Risky share</td>
<td>86.45%</td>
</tr>
<tr>
<td>Wholesale and retail trade</td>
<td>Risky share</td>
<td>86.78%</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>Risky share</td>
<td>86.14%</td>
</tr>
<tr>
<td>Transport, storage and communication</td>
<td>Risky share</td>
<td>84.40%</td>
</tr>
<tr>
<td>Financial intermediation</td>
<td>Risky share</td>
<td>86.00%</td>
</tr>
<tr>
<td>Real estate activities</td>
<td>Risky share</td>
<td>81.85%</td>
</tr>
<tr>
<td>Public sector</td>
<td>Risky share</td>
<td>64.11%</td>
</tr>
<tr>
<td>Education and social work</td>
<td>Risky share</td>
<td>78.53%</td>
</tr>
<tr>
<td>Health care and veterinary services</td>
<td>Risky share</td>
<td>80.77%</td>
</tr>
<tr>
<td>Other services and activities</td>
<td>Risky share</td>
<td>81.92%</td>
</tr>
</tbody>
</table>

Table 1 - Means and Standard Deviations of Initial Risky Shares and Wealth-Income Ratios

Mean initial observed risky share and wealth-to-income ratio (equally weighted)
Data: Risky Shares and W/Y Ratios

- But this conceals substantial variation across groups by cohort, initial W/Y, and initial risky share.

<table>
<thead>
<tr>
<th>Standard deviations of initial observed risky share and wealth-to-income ratio (equally weighted)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No high school degree</strong></td>
</tr>
<tr>
<td><strong>Risky share</strong></td>
</tr>
<tr>
<td>Mining and quarrying, electricity, gas and water supply</td>
</tr>
<tr>
<td>Manufacturing</td>
</tr>
<tr>
<td>Construction</td>
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<tr>
<td>Wholesale and retail trade</td>
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<tr>
<td>Hotels and restaurants</td>
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<tr>
<td>Transport, storage and communication</td>
</tr>
<tr>
<td>Financial intermediation</td>
</tr>
<tr>
<td>Real estate activities</td>
</tr>
<tr>
<td>Public sector</td>
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<tr>
<td>Education and social work</td>
</tr>
<tr>
<td>Health care and veterinary services</td>
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<tr>
<td>Other services and activities</td>
</tr>
</tbody>
</table>
Data: Risky Shares and W/Y Ratios
Data: Risky Shares and W/Y Ratios

- Some of this heterogeneity is related to education, income risk, and cohort.

<table>
<thead>
<tr>
<th>Table 4 - Drivers of Risky Share and Wealth-to-income ratio</th>
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</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>Risky Share</td>
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<tr>
<td>Education dummies</td>
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<tr>
<td>High school</td>
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<tr>
<td>Post-High School</td>
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<tr>
<td>Labour income volatility</td>
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<td>Total volatility of labour income</td>
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<tr>
<td>Volatility of permanent income shocks</td>
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<tr>
<td>Volatility of temporary income shocks</td>
</tr>
<tr>
<td>Cohort dummies</td>
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<tr>
<td>Cohort 11</td>
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<tr>
<td>Cohort 12</td>
</tr>
<tr>
<td>Cohort 13</td>
</tr>
<tr>
<td>Constant</td>
</tr>
</tbody>
</table>
Maximization Problem

- We use a standard life-cycle consumption and portfolio choice model

\[
\begin{align*}
\max_{\{C_{h,t}, \alpha_{h,t}\}_{t^*}} V_{t^*} & = \left\{ (1 - \beta) C_t^{1-1/\psi} + \beta E_t \left[ p_{t,t+1} V_{t+1}^{1-\gamma} \right]^{1-1/\psi} \right\}^{1/(1-1/\psi)}, \\
\text{s.t.} & \\
W_{h,t+1} & = (R^f_t + \alpha_{h,t} R^e_{t+1})(W_{h,t} + L_{h,t} - C_{h,t}), \\
R^e_{t+1} & = \mu + \eta_{t+1}, \\
0 & \leq \alpha_{h,t} \leq 1.
\end{align*}
\]

- We set \( t^* \) equal to the first age at which we observe the household in our data set (we will restrict the sample to households between ages 40 and 60).

- Initial wealth \( (W_{h,t^*}) \) is calibrated from the data.
Income Process

- We model labor income as:

\[
\log(L_{h,t}) = a_h + b'x_{h,t} + \nu_{h,t} + \varepsilon_{h,t},
\]

\[
\nu_{h,t} = \nu_{h,t-1} + \zeta_{h,t},
\]

\[
\zeta_{h,t} = \kappa_{g,t} + \omega_{h,t}.
\]

- \(x_{h,t}\) captures deterministic components of income (age profile, retirement).

- \(\nu_{h,t}\) is permanent random income, \(\varepsilon_{h,t}\) is transitory income shock.

- Permanent income has a group-level shock \(\kappa_{g,t}\) (can be correlated with risky assets) and an idiosyncratic shock \(\omega_{h,t}\).
Age-Income Profile (Figure 1)

- Age-income profile and DB replacement ratios vary with education.
Estimated Volatilities of Permanent and Transitory Income Shocks

- Labor income estimation: over 36m household-years 1984-2007, over 29m with information on sector of employment.

Table 3 - Permanent and Transitory Components of Income Risk

<table>
<thead>
<tr>
<th>Industry</th>
<th>No High School Degree</th>
<th>High School Degree</th>
<th>Post-High School Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permanent Transitory</td>
<td>Permanent Transitory</td>
<td>Permanent Transitory</td>
</tr>
<tr>
<td>Mining and quarrying, electricity, gas and water supply</td>
<td>7.88% 7.24%</td>
<td>7.35% 6.35%</td>
<td>6.75% 7.00%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>7.97% 7.64%</td>
<td>7.58% 7.92%</td>
<td>7.39% 9.65%</td>
</tr>
<tr>
<td>Construction</td>
<td>10.25% 9.74%</td>
<td>9.42% 9.18%</td>
<td>9.52% 9.09%</td>
</tr>
<tr>
<td>Wholesale and retail trade</td>
<td>9.18% 11.07%</td>
<td>9.35% 9.91%</td>
<td>8.28% 11.51%</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>11.53% 14.57%</td>
<td>10.42% 14.28%</td>
<td>11.35% 14.72%</td>
</tr>
<tr>
<td>Transport, storage and communication</td>
<td>9.48% 10.05%</td>
<td>7.90% 9.58%</td>
<td>7.06% 11.15%</td>
</tr>
<tr>
<td>Financial intermediation</td>
<td>7.20% 10.33%</td>
<td>7.24% 10.18%</td>
<td>6.56% 11.59%</td>
</tr>
<tr>
<td>Real estate activities</td>
<td>8.59% 11.07%</td>
<td>8.48% 11.30%</td>
<td>8.02% 13.04%</td>
</tr>
<tr>
<td>Public administration and defense, compulsory social security activities</td>
<td>7.83% 8.06%</td>
<td>8.03% 7.56%</td>
<td>7.30% 8.82%</td>
</tr>
<tr>
<td>Education and social work</td>
<td>9.26% 9.82%</td>
<td>9.62% 8.75%</td>
<td>8.35% 9.29%</td>
</tr>
<tr>
<td>Health care and veterinary services</td>
<td>9.21% 9.69%</td>
<td>9.20% 9.00%</td>
<td>8.50% 9.87%</td>
</tr>
<tr>
<td>Other services and activities</td>
<td>9.70% 10.81%</td>
<td>9.53% 11.41%</td>
<td>7.60% 10.68%</td>
</tr>
</tbody>
</table>
Interpreting Income Volatilities

- Intuitive sectoral effects
  - Low income risk in the public sector and in mining/quarrying/electricity/gas/water supply
  - High income risk in wholesale and retail trade, hotels and restaurants, and real estate.

- Educated workers face somewhat higher income volatility on average.
  - Consistent with Low, Meghir, and Pistaferri (2010).
  - Reflects relatively low unemployment and good unemployment benefits in Sweden, while educated workers face higher income losses from unemployment.
Calibrating a Composite Risky Asset

- In the life-cycle model, we assume that households invest in a single composite risky asset, or the safe asset.
- The return on the composite risky asset is a weighted average of its three constituents (risky financial assets, real estate and retirement wealth):
  \[
  R^e_{t+1} = (1 - \phi - \psi) R^S_{t+1} + \phi R^{RE}_{t+1} + \psi R^{RW}_{t+1}.
  \]
- The return on risky real estate takes into account embedded leverage via mortgage debt:
  \[
  R^{RE}_{t+1} = \frac{R^H_{t+1} - \lambda R^M_{t+1}}{1 - \lambda} + \epsilon^{RE}_{h,t+1},
  \]
  where \( R^H_{t+1} \) is the excess return on housing, \( R^M_{t+1} \) is the mortgage spread, \( \lambda_t \) is the LTV ratio and \( \epsilon^{RE}_{h,t+1} \) is an idiosyncratic shock (Bach et al 2015).
- We assume that retirement wealth is well diversified but risky financial assets have idiosyncratic risk (Calvet et al 2007).
Calibrating the Composite Risky Asset Return

- The components of the composite are:
  - Liquid financial wealth: 22.23% average share, 3.69% excess return (MSCI world index adjusted for fund fees)
  - Housing equity: 47.07%, 1.84% excess return (assumes equal Sharpe ratio on housing and stocks, adjusts for mortgage spread)
  - Retirement wealth: 30.70%, 4.03% excess return (higher because of lower fund fees)

- Implied average excess return on composite risky asset is 2.92%, volatility 12.68%, Sharpe ratio 0.23.

- Estimated correlation between composite risky asset return and labor income shocks: 35.12% (because of housing component, not stocks).

- We are exploring the effects of varying these assumptions (which seem modest so far).
The Euler Equation

- The Euler equation for the return on the optimal portfolio is given by

\[ 1 = E_t \left[ \delta p_{t,t+1} \left( \frac{C_{t+1}}{C_t} \right)^{-\frac{1}{\psi}} \left( \frac{V_{t+1}}{\mu(V_{t+1})} \right)^{\frac{1}{\psi} - \gamma} R_{t+1}^P \right] \]

where \( R_{t+1}^P = \alpha R_{t+1}^e + (1 - \alpha) R_f \), and \( \mu(V_{t+1}) \) denotes the certainty equivalent of \( V_{t+1} \).

- Taking logs of both sides and making the usual assumption of joint conditional log-normality we obtain

\[ E_t \log\left( \frac{C_{t+1}}{C_t} \right) = \psi (E_t r_{t+1}^P + \log(\delta p_{t,t+1})) + \text{extra terms} \]

- Campbell and Viceira (1999) and Gomes and Michaelides (2005) show that the additional terms have a negligible effect on \( E_t \log\left( \frac{C_{t+1}}{C_t} \right) \) for “middle-aged households” that have accumulated retirement savings.
The Identification Challenge

- This equation highlights the identification problem, since $\delta$ and $\psi$ appear multiplicatively in that first term:

$$E_t \log(C_{t+1}/C_t) = \psi(E_{t+1}^P + \log(\delta p_{t,t+1})) + \text{extra terms}$$

- A low $\delta$ and a high $\psi$ or a high $\delta$ and a low $\psi$, could deliver the same wealth accumulation within the model.

- Our identification is based instead on exploiting variation in $E_t r_{t+1}^P + \log(\delta p_{t,t+1})$:
  - Even though we don’t have exogenous variation in expected returns, we have endogenous variation driven by the changes in the optimal portfolio over time.
  - Also, the effective discount factor is adjusted for survival probabilities $(p_{t,t+1})$ which are a function of age. (But this is a secondary effect for the ages we are considering.)
  - Conclusion: the age profile of W/Y is affected in different ways by the EIS and by the time discount factor.
Identification: Risk Aversion

- We motivate our identification strategy by running a series of regressions based on simulated data from the model.
- The first set of regressions is:
  \[ \alpha_{it} = k_0 + k_\gamma \gamma_i + k_\psi \psi_i + k_\delta \delta_i + e_{it}, \quad t = 1, \ldots, 9 \]
  with the results

<table>
<thead>
<tr>
<th>t</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>92%</td>
<td>90%</td>
<td>81%</td>
<td>75%</td>
<td>71%</td>
<td>69%</td>
<td>68%</td>
<td>66%</td>
<td>65%</td>
</tr>
</tbody>
</table>

- R-squared naturally falls with \( t \).
- We then restrict \( k_\psi = k_\delta = 0 \) and obtain

<table>
<thead>
<tr>
<th>t</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>90%</td>
<td>85%</td>
<td>58%</td>
<td>47%</td>
<td>44%</td>
<td>43%</td>
<td>43%</td>
<td>42%</td>
<td>40%</td>
</tr>
</tbody>
</table>

- Conclusion: \( \alpha_{i1} \) is an ideal moment to estimate \( \gamma \).
Identification: Impatience

- The second set of regressions is:

\[(W/Y)_{it} = k_0 + k_\gamma \gamma_i + k_\psi \psi_i + k_\delta \delta_i + e_{it}, \quad t = 1, \ldots, 9\]

with the results

<table>
<thead>
<tr>
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<tr>
<td>Unrestricted</td>
<td>88%</td>
<td>88%</td>
<td>87%</td>
<td>85%</td>
<td>82%</td>
<td>80%</td>
<td>78%</td>
<td>76%</td>
</tr>
<tr>
<td>RA only</td>
<td>2%</td>
<td>3%</td>
<td>6%</td>
<td>5%</td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
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<tr>
<td>EIS only</td>
<td>23%</td>
<td>21%</td>
<td>19%</td>
<td>17%</td>
<td>16%</td>
<td>15%</td>
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<tr>
<td>Disc. Fact. only</td>
<td>62%</td>
<td>64%</td>
<td>61%</td>
<td>62%</td>
<td>62%</td>
<td>62%</td>
<td>61%</td>
<td>60%</td>
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</table>

- All preference parameters are relevant, but the discount factor is clearly the most important: particularly as we increase $t$.

- Conclusion: $(W/Y)_9$ is a very good moment for estimating $\delta$. 
Identification: The EIS

- To identify $\psi$ we exploit the previous intuition: we consider how the wealth accumulation profile changes with age.
- More specifically, we study the degree of convexity conditional on having already identified $\gamma$ and $\psi$ (with the other two moments).
- The third set of regressions is then:

$$\frac{1}{2} \left[ \left( \frac{W}{Y} \right)_{i9} + \left( \frac{W}{Y} \right)_{i1} \right] - \left( \frac{W}{Y} \right)_{i5} = k_0 + k_\gamma \gamma_i + k_\psi \psi_i + k_\delta \delta_i + e_{it},$$

for $\gamma_i = 1, \ldots, N_\gamma$ and $\delta_i = 1, \ldots, N_\delta$.
- The $R^2$ statistics across the multiple regressions average to 90%.
- Conclusion: convexity of $W/Y$ is an ideal moment for estimating $\psi$. 
Illustration of Identification: Growth in W/Y
Illustration of Identification: Convexity of W/Y Profile

Convexity of the WY profile over time as a function of the EIS (and TPR)
SMM Estimation

- Our estimation is based on three moments
  - Initial risky share \( \alpha_{i1} \)
  - Cumulative growth in \( W/Y \), \( (W/Y)_{i9} / (W/Y)_{i1} \)
  - Convexity of \( W/Y \), \( 0.5((W/Y)_{i9} + (W/Y)_{i1}) - (W/Y)_{i5} \).

- We estimate the model using the Simulated Method of Moments: minimize the squared deviations between the moments implied by the model and those in the data.
  - Since we have three parameters and three moments, the model is just identified.

- For each group \( g \), we simulate average \( \{ \frac{W}{Y} \}_{t*}^{t*+9} \) and \( \{ \alpha \}_{t*}^{t*+9} \) from the model while setting:
  - \( \left( \frac{W}{Y} \right)_{t*} = \left( \frac{W}{Y} \right)_{1999} \) from the data.
  - \( \{ r_t \}_{t*}^{t*+9} \) equal to the actual returns from 1999 to 2007, plus a simulated idiosyncratic return shock.
Convergence of SMM Estimates

- We observe household decisions over nine years, so this is not a context where $T \to \infty$.
- Instead, we consider what happens as the number of households in the group $N \to \infty$.
- If we feed all aggregate (group-level) shocks into the simulation, randomness comes only from idiosyncratic (household-level) shocks that diversify away as $N \to \infty$.
- Currently we feed in aggregate stock returns, but not other group-level shocks.
  - Error arises from group-level income shocks.
  - Error can also arise from correlated underdiversification within a group (e.g. holding stocks in sector of employment as in Døskeland and Hvide 2011).
  - In principle we can fix both of these problems and hope to do so.
- Remaining obstacles to household-level analysis would be unobserved DC fund choice, and idiosyncratic household-level shocks not captured in the life-cycle model.
How Well Do We Fit the Moments?

- Essentially perfectly for risky share and growth in $W/Y$, but not all sample values of convexity can be fit.
Heterogeneous Preferences

- There is significant cross-sectional dispersion in the three parameters, particularly TPR and EIS.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>RA</td>
<td>5.80</td>
<td>1.27</td>
</tr>
<tr>
<td>EIS</td>
<td>1.20</td>
<td>0.78</td>
</tr>
<tr>
<td>TPR</td>
<td>0.04</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- EIS dispersion is large enough that
  - EIS is greater (less) than one for 58% (42%) of the cases
  - EIS is greater (less) than 1/RA for 80% (20%) of the cases
  - EIS hits the lower boundary in 17% of cases, and the upper boundary in 38% of cases (corresponds to cases where the model cannot perfectly fit convexity).
Heterogeneous Preferences

Histogram - RA

Histogram - TPR

Histogram - EIS
(First and Last bins Omitted)
Initial W/Y and Cohort Effects

- The initial wealth-income ratio is negatively correlated with RRA \((-0.84)\) and TPR \((-0.30)\). It is weakly positively correlated with the EIS \((0.06)\).
  - That is, initially richer groups are more risk-tolerant, more patient, and slightly more willing to substitute intertemporally.
  - This may explain lower estimates of risk aversion and higher estimates of EIS among stockholders and particularly large stockholders.
  - Equal-weighted and wealth-weighted preference parameters may look rather different.
- There are statistically significant cohort effects, but they explain very little cross-sectional variation in the parameter estimates.
  - Earlier cohorts have slightly lower RRA, lower EIS, and higher TPR.
Results

Risk Aversion and the EIS

- These two parameters are negatively correlated with one another, but the relation is fairly weak.
Time Preference and Risk Aversion

- There is a stronger pattern that impatient agents also tend to be more risk-averse.
Time Preference and the EIS

- And impatient agents tend to have a lower EIS.
## The Effect of Income Risk

### Table 8 - Income risk and Education effects

<table>
<thead>
<tr>
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<td></td>
<td>Ln(RRA)</td>
<td>Estimate</td>
<td>t-stat</td>
<td>Ln(RRA)</td>
<td>Estimate</td>
<td>t-stat</td>
<td>Ln(EIS)</td>
<td>Estimate</td>
<td>t-stat</td>
<td>Ln(EIS)</td>
<td>Estimate</td>
<td>t-stat</td>
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<tr>
<td>Education dummies</td>
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<tr>
<td>High school</td>
<td>-0.016</td>
<td>-0.025</td>
<td>-2.790</td>
<td>0.133</td>
<td>2.845</td>
<td>0.142</td>
<td>3.028</td>
<td>-0.001</td>
<td>-0.657</td>
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<td>Post-High School</td>
<td>0.012</td>
<td>-0.050</td>
<td>-4.120</td>
<td>-0.128</td>
<td>-2.539</td>
<td>-0.086</td>
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<td>-0.009</td>
<td>-4.577</td>
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<td>Labour income volatility</td>
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<tr>
<td>Total volatility of labour income</td>
<td>-4.579</td>
<td>-16.306</td>
<td>1.087</td>
<td>0.762</td>
<td>0.055</td>
<td>1.158</td>
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<tr>
<td>Volatility of permanent income shocks</td>
<td>-8.029</td>
<td>-16.216</td>
<td>5.852</td>
<td>2.335</td>
<td>0.539</td>
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<tr>
<td>Volatility of temporary income shocks</td>
<td>-1.711</td>
<td>-5.680</td>
<td>-1.022</td>
<td>-0.887</td>
<td>-0.135</td>
<td>-2.502</td>
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<tr>
<td>Constant</td>
<td>2.395</td>
<td>59.821</td>
<td>2.673</td>
<td>60.396</td>
<td>-0.305</td>
<td>-1.471</td>
<td>-0.584</td>
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<td>0.026</td>
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<td>yes</td>
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<td>yes</td>
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<td>Adj. R-sq</td>
<td>11.50%</td>
<td>14.48%</td>
<td>2.04%</td>
<td>2.16%</td>
<td>3.99%</td>
<td>4.86%</td>
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</table>
The Effect of Income Risk

- The strongest effect is that (permanent) income risk is associated with lower estimated risk aversion.
- There are several possible interpretations of this finding:
  - Risk-tolerant individuals may self-select into risky occupations.
  - Households may fail to fully understand the importance of income risk for optimal investment strategies.
  - Households in risky occupations accumulate more wealth, as already discussed, and may fail to fully understand the need to invest more cautiously at higher $W/Y$ ratios.
- The ambiguity illustrates the general problem in finance that beliefs and preferences have observationally equivalent effects on portfolio choice and the stochastic discount factor.
Summary

- We estimate a life-cycle model of consumption and portfolio choice with Epstein-Zin preferences using a large cross-section of households in over 5,000 groups.
- We find important heterogeneity in all three preference parameters.
- We estimate EIS slightly greater than one on average but often less than one, and greater than 1/RRA in 80% of cases (contrary to power utility).
- We find a weak negative cross-sectional relationship between EIS and RRA (qualitatively consistent with power utility), and stronger relationships between TPR and RRA (positive) and EIS (negative).
- We estimate statistically significant but modest cohort effects.
- We find that initial wealth-income is negatively correlated with RRA and TPR.
- We find that RRA is negatively correlated with permanent income risk.
Some Broader Implications

- The heterogeneity we estimate implies that wealthier households are better able to exploit financial opportunities because they have lower TPR and RRA, and higher EIS.
- It has been suggested that heterogeneity provides a micro-foundation for time-varying risk aversion in representative agent models (Chan and Kogan 2002). Our estimates can discipline for such analysis.
- Covariances between risk aversion, other preference parameters, and \( \frac{W}{Y} \) complicate attempts to measure risk aversion from survey data and relate this parameter to observed behavior.
- Covariance between risk aversion and income risk complicates the attempt to relate income risk to observed behavior.
- Heterogeneity strengthens the argument that a range of financial products is needed to suit consumer tastes, contrary to a “one-size-fits-all” approach to financial regulation.
Next Steps

- Explore alternative treatments of DC retirement savings and housing:
  - Asset allocation of DC retirement saving.
  - Time-varying housing leverage.
  - Is housing a risky asset in the same sense as financial assets?

- Improve SMM estimation
  - Feed in group income shocks and possibly group-level returns estimated from group portfolio composition.
  - Consider additional moments, e.g. the change in the risky share over time.

- In the longer run, we can look at alternative models of constraints and preferences, e.g.
  - Endogenous labor supply and retirement.
  - Declining relative risk aversion.
  - Housing as a separate asset class, with an additional decision over housing.