Savings and consumption responses to persistent income shocks

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Introduction

- **Question:**
  How does consumption react to persistent income shocks?
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- **Today:**
  1. **Data:** micro data on bank accounts and mortgage from Ireland
     a. Identify unexpected persistent shock to mortgage payments (=income shock)
     b. Estimate response of bank balances to shock
     b. Use budget constraint to back out consumption response to shock
     d. Explore heterogeneity by balances in bank account and shock length
  2. **Model:** Can standard consumption-savings explain the estimated responses?
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  2. **Model:** Can standard consumption-savings explain the estimated responses?

- **Main findings:**
  1. Average MPC $\frac{\partial c_t}{\partial \tau_t}$ is high: 0.91
  2. By bank balance: 1.006 for lowest and 0.82 for highest balance quartiles
  3. By shock length: 0.84 for 6-10 year shock; 0.63 for $\leq$5 year shock
  4. Model matches average MPC with 62 quarter shock
Literature: MPCs

- **Covariance restrictions.** Hall & Mishkin (1982), Blundell, Pistaferri & Preston (2008)
- **Subjective expectations.** Hayashi (1985), Pistaferri (2001)
- **Quasi-experimental.**
  - **Unexpected one-time shock.** Bodkin (1959), Agarwal & Qian (2014), Fagereng, Holm & Natvik (2020)
- **Model comparison.** Kaplan & Violante (2014)
- **Identification strategy.** Byrne, Kelly & O’Toole (2021)
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- **Our contribution**
  1. Estimate MPC using a quasi-experimental persistent income shock
  2. Heterogeneity by initial bank balance and by length of the shock
  3. Evaluate performance of standard consumption-savings model with persistent shocks
Message from the today

- **Data**: Average MPC $\frac{\partial c_t}{\partial \tau_t}$ is high: **0.91**
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- **Model**: exactly matches average MPC with a 62 quarter income shock
  - By bank balance: matches covariance, errors $\leq$ 0.08
  - By shock length: matches covariance, errors $>0.27$

Comparison to literature:
- Higher MPC than literature (di Maggio et. al., MPC for cars=0.4; Baker elasticity = 0.33)
- Literature: Data MPC (0.5) $>>$ Model MPC (0.05) for transitory shocks
- This paper: Data MPC $\approx$ Model MPC for persistent shocks
  $\rightarrow$ Standard model performs comparatively well for persistent shocks
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  - **This paper**: Data MPC $\approx$ Model MPC for persistent shocks
  → Standard model performs comparatively well for persistent shocks
1. Data and consumption response

2. Model of consumption-savings
Payment shock: variable and tracker mortgage interest rates

(a) Share of new mortgages issued by interest rate

- Overlap in variable/tracker samples
  - distributions
Payment shock: variable and tracker mortgage interest rates

(a) Share of new mortgages issued by interest rate

(b) Divergence in ECB Tracker and Standard Variable

- Overlap in variable/tracker samples

[Graphs of share of new mortgages by interest rate and divergence in interest rates over time]
Data: mortgage and bank account data in Ireland

1 Mortgage data
   - At origination: age, income, county, house price, mortgage size, interest rate
   - Over time: outstanding balance, interest rate, days past due
   - Six monthly, 2000-2016 for origination data; 2012-2016 for over time
   - Estimate: current LTV w/ post code price index

2 Bank account data
   - Average balance over quarter (quarterly), balance at end date (6 monthly).
   - Checking and savings accounts
   - Quarterly, Q3 2011 - Q4 2014
   - Do not see accounts in multiple banks, or non-bank savings

3 Cleaning
   - Household view: Link all mortgages, bank accounts for household
   - Restrict to active (non-constant/zero) checking accounts (when using savings data)
   - Mortgages originated 2000-2008
   - Quarterly panel: Q3 2011 - Q4 2014
   - $N \approx 10,000$ households $\times 14$ quarters $\approx 140,000$
Household finances in Ireland

How much of household savings are captured in our data:

1. How much of non-housing assets are in deposit savings
   - **Macro data**: 91% Quarterly Financial Accounts
   - **Micro data**: 55% HFCS, evidence of large (≈ 66%) under reporting of deposits (Cussen, Lydon & O’Sullivan, 2018)

2. How much of deposit savings are in bank accounts
   - Bank deposits: 66%
   - Non-bank deposits (e.g. credit unions, Post Office):

3. How much of bank deposits are in a single bank
   - Bank accounts per household in Ireland: 5.2
   - Bank accounts per household in our data: 4
   - We can check results for households with both checking and savings accounts
     - Checking account MPC = 0.93; Savings account MPC = 0.95
     - Results are similar
Household finances in Ireland

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   - **Non-bank deposits (e.g. credit unions, Post Office)**: 34%
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Size of payment savings

Payment savings:

\[ m_t^{\text{flow}} = \begin{cases} 
\text{pay}_t^{\text{variable}} - \text{pay}_t^{\text{tracker}} & \text{if tracker} \\
0 & \text{if variable}
\end{cases} \]

\[ m_t^{\text{stock}} = \sum_{j=0}^{t} m_j^{\text{flow}} \]

Median: 5% of income; 20% of payments
Size of payment savings

Payment savings:

\[ m_t^{\text{flow}} = \begin{cases} \text{pay}_t^{\text{variable}} - \text{pay}_t^{\text{tracker}} > 0 & \text{if tracker} \\ 0 & \text{if variable} \end{cases} \]

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Median: 5% of income; 20% of payments
Comparing variable and tracker mortgage borrowers (ex-ante)

(a) Income at origination

(b) Age at origination

(c) Mortgage balance at origination
Q. Were trackers more likely to get income shocks?  
- Use survey of mortgage holders 2012Q2 — 2013Q1 (Byrne, Kelly, O’Toole, 2021)

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<td>(2)</td>
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<td>(0.0774)</td>
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<td>0.044</td>
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<td>Yes</td>
</tr>
<tr>
<td>Controls</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Regression: savings response

\[ \Delta b_{i,t+k} = \beta_0 + \beta_k \Delta m_{i,t+k}^{\text{stock}} + \eta X_{it} + \gamma_{t+k} + u_{i,t+k} \quad \text{for } k=1, \ldots, 12 \]

- \( \Delta b_{i,t+k} \) is the change in bank balance of household \( i \) between quarter \( t \) and \( t + k \)
- \( \Delta m_{i,t+k}^{\text{stock}} \) is change in stock payment savings between \( t \) and \( t + k \)
  - \( \Delta m_{i,t+k}^{\text{stock}} > 0 \) if tracker mortgage
  - \( \Delta m_{i,t+k}^{\text{stock}} = 0 \) if variable mortgage
- \( X_{it} \) is a vector of observable controls
- \( \gamma_{t+k} \) are time fixed effects
- Variations:
  - logs and levels
  - pooled and different time horizons
Result: Savings response at many horizons

- 12 quarter estimate
  - $MPS_{t+12} = 0.074$;
  - Implied MPC = 0.93

- $MPS_{t+h} = \sum_{s=0}^{h}(1 + r)^{h-s}(1 - MPC)$

- Average pooled estimate
  - MPS = 0.087;
  - Implied MPC = 0.913
MPC heterogeneity

1. **Average** MPC = 0.913 (MPS= 0.087).

2. **Split samples**
   - **Savings balances at 2011Q3:**
     - Lowest balance quartile: 1.006
     - Highest balance quartile: 0.82
   - **Mortage maturity at 2010Q1:**
     - $\leq$ 5 year to maturity: 0.46 (imprecise)
     - 6-10 year to maturity: 0.84
     - $>10$ year to maturity: 0.93
1. Data & consumption response

2. Model of consumption-savings
Consumption-savings problem by households

Households solve infinite horizon problem

$$\max_{c,a} \sum_{t=0}^{\infty} E_0 \left[ \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right]$$

$$c_t + a_t = (1 + r)a_{t-1} + e_t + \tau_t$$

$$a \geq 0$$

$$\ln e_t = \rho_e \ln e_{t-1} + \epsilon_t \quad \epsilon_t \sim \mathcal{N}(0, \sigma_e^2)$$

Perfect foresight for path $\{\tau_s\}_{s \geq 0}$.

Compare to stationary distribution with $\tau_{ss} = 0$
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Compare to stationary distribution with $$\tau_{ss} = 0$$

Policies $$c_t^*(e_t, a_{t-1}; \tau)$$ and $$a_t^*(e_t, a_{t-1}; \tau)$$

Distribution's law of motion

$$D_{t+1}(e_{t+1}, a_t) = \sum_{e_t} D_t(e_t, a_t^{*-1}(e_t, a_t; \tau)) \mathcal{P}(e_t, e_{t+1})$$
Consumption-savings problem by households

Households solve infinite horizon problem

\[
\max_{c,a} \sum_{t=0}^{\infty} E_0 \left[ \beta t \frac{c_t^{1-\sigma}}{1-\sigma} \right]
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Distribution's law of motion \(D_{t+1}(e_{t+1}, a_t) = \sum_{e_t} D_t(e_t, a_t^{*-1}(e_t, a_t; \tau)) P(e_t, e_{t+1})\)

Calibration: \(\sigma = 2, r = 0.01, \beta = 0.98, \rho_e = 0.966, \sigma_e = 0.5\) (Auclert, et. al.)

\(\tau = 0.04, \tau/e = [0.15, 0.1, 0.07, 0.05, 0.03, 0.02, 0.01]\) interquartile range \(\approx 3-7%\) income

- Bellman
Computing MPCs

Individual MPCs

\[ MPC_t(e_t, a_{t-1}; \tau) = \frac{c^*_t(e_t, a_{t-1}; \tau) - c^*_{ss}(e_t, a_{t-1}, 0)}{\tau} \]
Computing MPCs

Individual MPCs

\[ MPC_t(e_t, a_{t-1}; \tau) = \left[ c_t^*(e_t, a_{t-1}; \tau) - c_{ss}^*(e_t, a_{t-1}, 0) \right] / \tau \]

Average \( C_t(\tau) = \sum_e \int_a c_t^*(e_t, a_{t-1}; \tau) D_t(e_t, a_{t-1}) \)

Average MPC

\[ MPC_t(\tau) = \left[ C_t(\tau) - C_{ss}(0) \right] / \tau \]
The model experiment

![Graph of Transfer Shock](attachment:image1.png)

![Graph of Cumulative Transfer Shock](attachment:image2.png)
Comparing model and data

- **MPC errors (data-model)** = [-0.004, -0.021, 0.084, 0.071]
- Close quantitatively relative to 1 time shock

  ▶ One period shock at quarter 0  ▶ One period shock at quarter 40  ▶ Savings response  ▶ Permanent income hypothesis
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- Close quantitatively relative to 1 time shock

- One period shock at quarter 0
- One period shock at quarter 40
- Savings response
- Permanent income hypothesis
Comparing length of the shock

- Smaller MPC for less persistent shocks in both model and data
- Data > model errors increase with less persistent shocks
Conclusions

- Compared savings responses in model and data with persistent shocks

1 Data: Average MPC is high 0.92
  - By bank balance: Lower MPC (0.82) for high bank balance consumers
  - By shock length: Lower MPC (0.84) for shorter (6-10 year) shocks

2 Model: matches average MPC with 62 quarter shock
  - By bank balance: matches covariance, error ≤ 0.08
  - By shock length: matches covariance, error > 0.27

3 Takeaway:
  - Literature: Data MPC >> Model MPC for transitory shocks
  - This paper: Data MPC ≈ Model MPC for persistent shocks
  → Standard model performs comparatively well for persistent shocks

- Bonus:
  - How do defaults depend on balances?
Thank you
The value function at time $t$ is

$$V_t(e, a) = \max_{c, a} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \beta \sum_{e'} V_{t+1}(e', a) P(e, e') \right\}$$

$$c + a = (1 + r) a - e + \tau$$

$$a \geq 0$$

$$\ln e_t = \rho e \ln e_{t-1} + \epsilon_t \quad \epsilon_t \sim \mathcal{N}(0, \sigma^2_e)$$

Perfect foresight for aggregate path $\{\tau_s\}_{s \geq 0}$.

Compare against stationary dist with $\tau_{ss} = 0$

Policies $c_t^*(e, a; \tau)$ and $a_t^*(e, a; \tau)$

Distribution’s law of motion $D_{t+1}(e', a) = \sum_{e'} D_t(e', a_t^{*-1}(e, a; \tau)) P(e, e')$
Warm up: one period shock

- Here: $MPC_{t=0} = \frac{r}{1+r}$, when $\beta = 1/R$
  $MPC_{t=0}$ at impact 0.043 with risk and $\beta < 1/R$;
- Kaplan Violante (2014) One-asset: $MPC_{t=0} \approx 0.03$ (non-HtM), 0.15(HtM)
- Data: $MPC_{t=0} \approx 0.5$ Fagereng, Holm and Natvik (2020)
Warm up: one period shock

- Transfer shock, $\tau$
- Savings
- Consumption

Back
Asset distribution in steady state
Other model experiments

- Responses are larger to negative shocks, though not by much for this shock size
Positive versus negative shocks

- back
Policy functions

- Policy function lowest e state

- No risk, $\beta = 1/R$
- Risk, $\text{beta}=1/R$
- Risk, $\text{beta}<1/R$

![Policy function graph with lines representing different scenarios.](image)
Average savings responses

- back
Average consumption responses

- One period shock at quarter 0
- One period shock at quarter 40
- Savings response
- Permanent income hypothesis
Average responses

- One period shock at quarter 0
- One period shock at quarter 40
Tracing out the default threshold: LTI-balance space

(a) Default propensity

(b) Defaults
Distribution of observations

(a) Distribution of observations
Distribution of variable and tracker mortgage borrowers

- Income
- Age
- Mortgage balance
- Annual interest rate

Note: All variables are at origination for new mortgages for house purchases originated in 2006 and 2007. Plots are truncated at ages below 60, incomes below 500,000 and mortgage balances below 1m for presentation.
Pooled Marginal Propensity to save (MPS)

\[ \Delta b_{i,t+1} = \beta_0 + \beta_1 m_{it} + \eta X_{it} + \gamma_t + u_{it} \]  

(1)

<table>
<thead>
<tr>
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<th>(1) Savings</th>
<th>(2) Log Savings</th>
<th>(3) Δ Savings</th>
<th>(4) Δ Log Savings</th>
<th>(5) Savings</th>
<th>(6) Log Savings</th>
<th>(7) Δ Savings</th>
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## MPS heterogeneity: by balance quartiles

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<td>Cumulative Payment Difference</td>
<td>-0.006 (0.0071)</td>
<td>0.043 (0.0204)</td>
<td>0.038 (0.0431)</td>
<td>0.176* (0.0660)</td>
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<td>Log Cumulative Payment Difference</td>
<td>0.039 (0.0441)</td>
<td>0.123* (0.0525)</td>
<td>0.161** (0.0510)</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Controls × Quarter FE</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Prob($\beta = 1$)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
MPS heterogeneity: by quarters to maturity

- Compute time to maturity when shock starts 2010Q1

<table>
<thead>
<tr>
<th></th>
<th>Δ Savings</th>
<th></th>
<th>Δ Log Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>≤ 5 years</td>
<td>0.394</td>
<td>0.161*</td>
<td>0.076*</td>
</tr>
<tr>
<td>(0.2059)</td>
<td>(0.0651)</td>
<td>(0.0268)</td>
<td></td>
</tr>
<tr>
<td>6 – 10 years</td>
<td>0.161*</td>
<td>0.076*</td>
<td></td>
</tr>
<tr>
<td>(0.0651)</td>
<td>(0.0268)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>0.076*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.0268)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                      | (4)       | (5)                  | (6)          |
| ≤ 5 years            | 0.130***  | 0.022                | 0.031        |
| (0.0206)             | (0.0332)  | (0.0313)             |              |
| 6-10 years           | 0.022     |                      |              |
| (0.0332)             |           |                      |              |
| > 10 years           | 0.031     |                      |              |
| (0.0313)             |           |                      |              |

Observations: 10634, 23153, 94835, 10632, 23149, 94826
Adjusted $R^2$: -0.004, 0.003, 0.003, -0.005, -0.006, 0.003
Individual FE: Yes, Yes, Yes, Yes, Yes, Yes
Quarter FE: Yes, Yes, Yes, Yes, Yes, Yes
Controls × Quarter FE: Yes, Yes, Yes, Yes, Yes, Yes
Prob(β = 1): 0.012, 0.000, 0.000, 0.000, 0.000, 0.000

Standard errors in parentheses.
Size of payment shock

**Figure**: Box plot of size of payment difference

(a) Euro value

(b) Percent difference (relative to variable payment)

**Note**: Percent is relative to the first lien only.
Tracing out the default threshold: LTV-balance space

- Stylized default decision: \( V_t(y, b, \frac{m}{p}) = \max \{ V_{t}^{\text{pay}}(y, b, \frac{m}{p}), V_{t}^{\text{default}}(y, b, \frac{m}{p}) \} \)

(a) Default propensity

- Many other dimensions of heterogeneity:
  - Balance-LTI-space
  - Distribution
  - Mean balances

- Do not observe income, but can use our “disposable income” shocks
Tracing out the default threshold: LTV-balance space

- Stylized default decision: \( V_t(y, b, \frac{m}{p}) = \max \{ V^\text{pay}_t(y, b, \frac{m}{p}), V^\text{default}_t(y, b, \frac{m}{p}) \} \)

(a) Default propensity

(b) Defaults

- Many other dimensions of heterogeneity:
  - Balance-LTV-space
  - Distribution
  - Mean balances

- Do not observe income, but can use our “disposable income” shocks
Comparing tracker and variable mortgages

<table>
<thead>
<tr>
<th>LTV at 2011Q3</th>
<th>Balance at 2011Q3 (Euro)</th>
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<tr>
<td>[0.0,0.2]</td>
<td>0</td>
</tr>
<tr>
<td>[0.2,0.4]</td>
<td>0.08 0.02 0 0 0</td>
</tr>
<tr>
<td>[0.4,0.6]</td>
<td>0.09 0.05 0.04 0.03 0.01</td>
</tr>
<tr>
<td>[0.6,0.8]</td>
<td>0.26 0.11 0.05 0.03 0.03</td>
</tr>
<tr>
<td>[0.8,1.0]</td>
<td>0.24 0.15 0.05 0.04 0.03</td>
</tr>
<tr>
<td>[1.0,1.2]</td>
<td>0.24 0.14 0.1 0.04 0.03</td>
</tr>
<tr>
<td>[1.2,1.4]</td>
<td>0.37 0.24 0.09 0.04 0.05</td>
</tr>
<tr>
<td>[1.4,1.6]</td>
<td>0.4 0.26 0.12 0.07 0.09</td>
</tr>
<tr>
<td>[1.6,1.8]</td>
<td>0.56 0.29 0.18 0.13 0</td>
</tr>
</tbody>
</table>

Default rate

- 0.5
- 0.4
- 0.3
- 0.2
- 0.1
- 0.0
Tracing out the default threshold: LTV-balance space

- Stylized default decision: \( V_t(y, b, \frac{m}{p}) = \max \{ V_{t}^{\text{pay}} (y, b, \frac{m}{p}), V_{t}^{\text{default}} (y, b, \frac{m}{p}) \} \)

(a) Default propensity

(b) Defaults
### Summary statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>P10</th>
<th>P25</th>
<th>P50</th>
<th>P75</th>
<th>P90</th>
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</thead>
<tbody>
<tr>
<td>No of liens</td>
<td>1.69</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>No of deposit accounts</td>
<td>3.97</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>6</td>
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<tr>
<td>Dublin (%)</td>
<td>51</td>
<td></td>
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<tr>
<td>Borrower Age</td>
<td>46.32</td>
<td>35</td>
<td>40</td>
<td>46</td>
<td>52</td>
<td>59</td>
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<tr>
<td>Total Account Balance</td>
<td>8346</td>
<td>42.25</td>
<td>565.17</td>
<td>2230.16</td>
<td>8531.59</td>
<td>25823.85</td>
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<tr>
<td>Total Quarterly Average Account Balance</td>
<td>8060</td>
<td>245.53</td>
<td>619.77</td>
<td>2093.94</td>
<td>8315.22</td>
<td>24498.02</td>
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<tr>
<td>Current Loan-to-Value</td>
<td>72</td>
<td>7</td>
<td>23</td>
<td>59</td>
<td>109</td>
<td>156</td>
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<td>Outstanding Balance</td>
<td>137508</td>
<td>16104</td>
<td>44148.76</td>
<td>109519.28</td>
<td>203884.44</td>
<td>300785.29</td>
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<tr>
<td>Quarterly Mortgage Payments</td>
<td>3050.06</td>
<td>973.3</td>
<td>1637.15</td>
<td>2642.15</td>
<td>3913.48</td>
<td>5656.83</td>
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<td>Current Interest Rate (%)</td>
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<td>2</td>
<td>5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Income at Origination</td>
<td>69796.72</td>
<td>31400</td>
<td>44632</td>
<td>62500</td>
<td>87562.18</td>
<td>120146.41</td>
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<td>Quarters to Maturity</td>
<td>56.95</td>
<td>13</td>
<td>27</td>
<td>54</td>
<td>85</td>
<td>105</td>
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<tr>
<td>Tracker Rate (%)</td>
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<td>SVR Rate (%)</td>
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<td>Primary Dwelling Home (%)</td>
<td>83</td>
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<td></td>
<td></td>
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</tbody>
</table>
Comparing across asset quartiles
- Split SS distribution by asset quartiles

\[
\text{Savings} \\
\text{Consumption}
\]