Houses as ATMs?
Mortgage Refinancing and Macroeconomic Uncertainty

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The Question

What is the role of housing collateral in financing consumption?

- Mortgages in U.S. household liabilities, 2012: over 70%
- Home equity extraction over 1993 - 2010: $1.7 trillion
What is the role of housing collateral in financing consumption?

- Mortgages in U.S. household liabilities, 2012: over 70%
- Home equity extraction over 1993 - 2010: $1.7 trillion
- “Great Moderation” (Campbell and Hercowitz 2004)
- Home-equity based borrowing – the main force behind run-up in household leverage from 2002 to 2006 (Mian and Sufi 2010)
- Subsequent decline in consumption stronger in high leverage areas (Mian, Rao, Sufi 2013)
Cash-out Refinancing and Consumption

The very low level of interest rates ... encouraged household spending through a variety of channels. ... The lowest home mortgage rates in decades were a major contributor ... engendering a large extraction of cash from home equity. A significant part of that cash supported personal consumption expenditures and home improvement. In addition, many households took out cash in the process of refinancing, often using the proceeds to substitute for higher-cost consumer debt.

- Alan Greenspan, Congressional Testimony, February 11, 2004
Refinancing Comoves with Interest Rates

Refinancing and Mortgage Rate Changes

Regressions
Refinancing Comoves with the Business Cycle

Refinancing and Industrial Production

Regressions
Cash-out and Rate Ratios over the Business Cycle

A. Components of refinesances

B. Ratio of new to old loan rates

Regressions
Overview of Results

- Develop and estimate a rational model of home-equity based borrowing by liquidity-constrained households:
  - counter-cyclical idiosyncratic labor income uncertainty
  - long-term mortgages + borrowing constraints
  - targeting assets, debt, and refinancing behavior
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  - absent ex ante heterogeneity, wide dispersion in refi behaviors
  - heterogeneous consumption paths for households with different boom-time leverage
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• Cross section:
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  • heterogeneous consumption paths for households with different boom-time leverage

• Policy implications: refi sensitivity to monetary policy
Preview: Leverage Run-up

- Housing price growth, relative to 2001
- Total debt growth, relative to 2001
- Change in debt-to-income ratio, relative to 2001


Consumption smoothing and cash-out: Hurst and Stafford (2004)
Household States: Homeownership, Default, and Renting

- Post-Default Renter
  - Default on mortgage
  - Leave autarky with prob $\omega$

- Homeowner (refi, repay)
- Purchase house
- Sell house

- Renter
Exogenous shocks

- Real aggregate income growth: $Z_{t+1} = Y_{t+1}/Y_t$
Exogenous shocks

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Exogenous shocks

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- Short-term (nominal) interest rate: $r_t$
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- House price: $P^H_t = \overline{H} \ P_t \ Y_t \ p^H_t$
Exogenous shocks

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- House price: \( P_t^H = \bar{H} P_t Y_t p_t^H \)
- Aggregate state: \( S = (Z, r, p^H) \)

\[
\log S_{t+1} = \mu_S + \phi_S \log S_t + \Sigma_S \epsilon_{S,t+1}^S
\]
Exogenous shocks

- Real aggregate income growth: $Z_{t+1} = Y_{t+1}/Y_t$
- Short-term (nominal) interest rate: $r_t$
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  \[
  \log S_{t+1} = \mu_S + \phi_S \log S_t + \Sigma_S \epsilon_S^{t+1}
  \]
- Individual labor income: $y_{i,t} = P_t Y_t \ \tilde{y}_{i,t}$
Exogenous shocks

- Real aggregate income growth: \( Z_{t+1} = Y_{t+1} / Y_t \)
- Short-term (nominal) interest rate: \( r_t \)
- Inflation: \( \pi = P_{t+1} / P_t \)
- House price: \( P^H_t = H \cdot P_t Y_t \cdot p^H_t \)
- Aggregate state: \( S = (Z, r, p^H) \)

\[
\log S_{t+1} = \mu_S + \phi_S \log S_t + \sum S \epsilon^S_{t+1}
\]

- Individual labor income: \( y_{i,t} = P_t Y_t \tilde{y}_{i,t} \)
  - \( \tilde{y}_i \) – idiosyncratic labor income

\[
\log \tilde{y}_{i,t+1} = \log \mu_y(Z_t) + \rho_y \log \tilde{y}_{i,t} + \sigma(Z_t) \epsilon^y_{i,t+1}
\]
Preferences

Epstein-Zin Preferences:

\[ U_t = \left( (1 - \delta) X_t^{\frac{1-\gamma}{\theta}} + \delta E_t \left[ U_{t+1}^{1-\gamma} \right]^{\frac{1}{\theta}} \right)^{1-\gamma} \]

\[ \theta = \frac{1 - \gamma}{1 - \frac{1}{\psi}} \]

- \( X_t \): Cobb-Douglas aggregator of nonhousing consumption and housing services

\[ X_t = (h_t Y_t)^{\nu} \left( \frac{c_t}{P_t} \right)^{1-\nu} \]
Households

- Taxes: labor income and interest income taxed at rate $\tau$
- Liquid assets: $a_{i,t}$, earning interest at rate $r_t$
- House:
  - House size: $h_{i,t}$
  - Transaction cost: proportional cost $\phi_h$
- Homeowners:
  - Short-term secured borrowing (HELOC): at rate $r_{t}^{HL} = r_t + \vartheta$
  - Long-term (and illiquid) mortgage: $b_{i,t}$, with mortgage rate $k_{i,t}$
- Renters: aggregate rent-to-income ratio $\varpi$
Long-term mortgages

- Interest-only mortgage:
  - Fixed-rate
  - Interest payments $k_{i,t}b_{i,t}$ are tax deductible

- Refinancing:
  - Option to refinance: reset $k_{i,t}$ to market rate $R_t = R(S_t)$
  - Transaction cost: $\phi(b) = P_t Y_t \phi_0 + \phi_1 b$

- (P)repayment:
  - Option to reduce mortgage balance costlessly

- Option to default (on mortgage and HELOC jointly):
  - Lose house and portion $1 - \zeta$ of liquid assets
  - Temporarily excluded from housing market; rate of re-entry $\omega$

Bellman equations
Borrowing constraints

• Collateral (LTV) constraints:
  \[ b_{i,t+1} + \text{HELOC}_{i,t+1} \leq \xi_{LTV} P_t^H h_{i,t} \]

• Debt service (LTI) constraints:
  \[ b_{i,t+1} + \text{HELOC}_{i,t+1} \leq \xi_{LTI} y_{i,t} \]

• HELOC limit:
  \[ \text{HELOC}_{i,t+1} \leq a P_t Y_t \]

• Long vs. short-term debt: LTV and LTI imposed on HELOC every period; only at refinancing and origination for mortgage
Preemptive refinancing

- Households with no immediate liquidity needs might preemptively refinance before the constraints become binding.

- LTI: cash-out when aggregate labor income growth drops, and when idiosyncratic labor income uncertainty rises.

- LTV: cash-out when house prices are sufficiently high.
Simulated moments estimation

Three-step estimation procedure:

1. Estimate/calibrate exogenous state variable dynamics

2. Calibrate pre-set institutional parameters

3. Estimate structural parameters of interest by targeting auxiliary statistics of simulated data
   - moments of assets, debt, and consumption
   - dynamics of refinancing and cash-out
Calibration and Estimation

- Household state vector:
  \[ a_i, h_i, b_i, k_i, \underbrace{y_i, Z, r, p^H}_{\text{exogenous}} \]
  \[ \underbrace{a_i, h_i, b_i, k_i,}_{\text{endogenous}} \]

- Aggregate state \( S = (Z, r, p^H) \): restricted VAR(1) in logs; estimated using GDP, 1-year T-bill rate, and S&P Case-Shiller HPI

- Idiosyncratic labor income process: AR(1) process in logs, with heteroscedasticity (Storesletten, Telmer, Yaron, 2004)

- Mortgage rate \( R \): function of aggregate states
  \[ \log R(S) = \kappa_0 + \kappa_1 \log S + \kappa_2 (\log p^H_t)^2 \]

  Estimated using 30-year FRM rate
Discretized aggregate state variables

A. Aggregate income growth

B. Transitory component in house price

C. Short-term interest rate

D. Long-term mortgage rate
## Exogenous Institutional Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau$</td>
<td>0.25</td>
<td>Income tax rate</td>
</tr>
<tr>
<td>$\bar{H}$</td>
<td>4</td>
<td>Average house price to income ratio</td>
</tr>
<tr>
<td>$\xi_{LTV}$</td>
<td>0.8</td>
<td>Collateral constraint</td>
</tr>
<tr>
<td>$\xi_{LTI}$</td>
<td>3.5</td>
<td>Debt service constraint</td>
</tr>
<tr>
<td>$-a$</td>
<td>30%</td>
<td>Max HELOC balance as fraction of avg. income</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.15</td>
<td>Probability of return to credit market after default</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>1</td>
<td>Retention of liquid assets upon default</td>
</tr>
<tr>
<td>$\vartheta$</td>
<td>0.04</td>
<td>Interest rate premium on HELOC</td>
</tr>
</tbody>
</table>
Estimation Approach: 8 parameters/14 moments

Simulated Method of Moments:
Estimate the vector of model parameters $\Theta \equiv (\delta, \gamma, \psi, \eta, \phi_0, \phi_1, \phi_h)$ such that

$$\hat{\Theta} = \arg \min_{\Theta} (M - m(\Theta))^\prime W (M - m(\Theta))$$

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Preferences</td>
<td></td>
</tr>
<tr>
<td>$\delta$</td>
<td>Subjective discount rate</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Risk aversion</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Intertemporal elasticity of substitution</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Utility share of housing</td>
</tr>
<tr>
<td>$\bar{\eta}$</td>
<td>Indirect (dis)utility of renting (vs home-ownership)</td>
</tr>
<tr>
<td>Transaction Costs</td>
<td>$\phi_0$</td>
</tr>
<tr>
<td>$\phi_1$</td>
<td>Proportional cost of issuing new mortgage</td>
</tr>
<tr>
<td>$\phi_h$</td>
<td>Proportional cost of buying/selling a house</td>
</tr>
</tbody>
</table>

Use pre-specified weighting matrix $W$; simulation-based inference
Estimation Approach: 8 parameters/14 moments

<table>
<thead>
<tr>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption/Income, average</td>
<td>$c/pY$</td>
</tr>
<tr>
<td>Consumption growth volatility, average</td>
<td>$\sigma(\Delta \log c_{t+1})$</td>
</tr>
<tr>
<td>Homeownership rate</td>
<td>$E[I^h]$</td>
</tr>
<tr>
<td>Liquid Asset Holdings/Income (homeowners)</td>
<td>$a/pY$</td>
</tr>
<tr>
<td>Mortgage Balance/Income</td>
<td>$b/pY$</td>
</tr>
<tr>
<td>Refinancing rate</td>
<td>$REFI$</td>
</tr>
<tr>
<td>HELOC Balance/Income</td>
<td>$-a^-/pY$</td>
</tr>
<tr>
<td>Refinancing Loan/Income</td>
<td>$b'/pY$</td>
</tr>
<tr>
<td>Dollar Cash-out (as a share of Refi)</td>
<td>$(b' - b)^+/b'$</td>
</tr>
<tr>
<td>Liquid Asset Holdings/Income (renters)</td>
<td>$a/pY$</td>
</tr>
</tbody>
</table>

Refinancing Regression: Details

| Coefficient on $Z$                  | $\beta_{Z}^{REFI}$ | -0.25 |
| Coefficient on $\Delta \log H$     | $\beta_{H}^{REFI}$ | 0.15 |

Cashout Regression: Details

| Coefficient on $Z$                  | $\beta_Z$ | -0.13 |
| Coefficient on $\Delta \log H$     | $\beta_H$ | 0.06 |
# Estimated parameters

<table>
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<tr>
<td>Preferences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.920</td>
<td>Subjective discount rate</td>
</tr>
<tr>
<td>($0.007$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$</td>
<td>3.036</td>
<td>Risk aversion</td>
</tr>
<tr>
<td>($0.347$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\psi$</td>
<td>0.301</td>
<td>Intertemporal elasticity of substitution</td>
</tr>
<tr>
<td>($0.020$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.134</td>
<td>Housing utility share</td>
</tr>
<tr>
<td>($0.004$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{\eta}$</td>
<td>0.750</td>
<td>Disutility of renting versus home-ownership</td>
</tr>
<tr>
<td>($0.006$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_0$</td>
<td>0.154</td>
<td>Fixed cost of issuing new mortgage</td>
</tr>
<tr>
<td>($0.020$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_1$</td>
<td>0.014</td>
<td>Proportional cost of issuing new mortgage</td>
</tr>
<tr>
<td>($0.008$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_h$</td>
<td>0.135</td>
<td>Proportional cost of buying/selling a house</td>
</tr>
<tr>
<td>($0.017$)</td>
<td></td>
<td></td>
</tr>
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</table>
Estimation results: targeted moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Variable</th>
<th>Data</th>
<th>Model</th>
<th>s.e.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Households:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Consumption/Income</td>
<td>$c_i/y_i$</td>
<td>0.66</td>
<td>0.71</td>
<td>0.01</td>
</tr>
<tr>
<td>2. Consumption growth volatility, %</td>
<td>$\sigma(\Delta \log c_{i,t+1})$</td>
<td>9(18)</td>
<td>16.4</td>
<td>0.01</td>
</tr>
<tr>
<td>3. Homeownership rate, %</td>
<td>$E[l^h]$</td>
<td>66.0</td>
<td>67.5</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Homeowners:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Liquid assets/Income</td>
<td>$a_i^+/y_i$</td>
<td>0.28</td>
<td>0.24</td>
<td>0.04</td>
</tr>
<tr>
<td>5. Mortgage/Income</td>
<td>$b_i/y_i$</td>
<td>0.98</td>
<td>0.96</td>
<td>0.08</td>
</tr>
<tr>
<td>6. HELOC/Income</td>
<td>$-a_i^-/y_i$</td>
<td>0.07</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td>7. Refinancing rate, % of homeowners</td>
<td>$REFI$</td>
<td>8.0</td>
<td>11.3</td>
<td>0.02</td>
</tr>
<tr>
<td>8. Refi loan/Income</td>
<td>$b_i'/y_i$</td>
<td>1.41</td>
<td>2.74</td>
<td>0.14</td>
</tr>
<tr>
<td>9. Dollar cash-out/Refi loan</td>
<td>$(b_i' - b_i)^+/b_i'$</td>
<td>0.12</td>
<td>0.51</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Renters:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Liquid assets/Income</td>
<td>$a_i^+/y_i$</td>
<td>0.18</td>
<td>0.15</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Refinancing Regression:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Coefficient on $Z$</td>
<td>$\beta_{REFI}^Z$</td>
<td>-0.25</td>
<td>-0.24</td>
<td>0.41</td>
</tr>
<tr>
<td>12. Coefficient on $\Delta \log H$</td>
<td>$\beta_{REFI}^H$</td>
<td>0.15</td>
<td>0.08</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Cashout Regression:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Coefficient on $Z$</td>
<td>$\beta_Z$</td>
<td>-0.12</td>
<td>-0.23</td>
<td>0.43</td>
</tr>
<tr>
<td>14. Coefficient on $\Delta \log H$</td>
<td>$\beta_H$</td>
<td>0.06</td>
<td>0.11</td>
<td>0.15</td>
</tr>
</tbody>
</table>
### Estimation results: additional moments

<table>
<thead>
<tr>
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<th>Model</th>
<th>s.e.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatility of agg. consumption growth, %</td>
<td>$\sigma(\Delta \log C_{t+1})$</td>
<td>2.7</td>
<td>3.9</td>
<td>0.01</td>
</tr>
<tr>
<td>Sensitivity of consumption to Z shocks</td>
<td>$\beta^C_Z$</td>
<td>0.46</td>
<td>1.30</td>
<td>0.20</td>
</tr>
<tr>
<td>Sensitivity of consumption to H shocks</td>
<td>$\beta^C_H$</td>
<td>0.06</td>
<td>0.09</td>
<td>0.05</td>
</tr>
<tr>
<td>Sensitivity of consumption to lagged $r$</td>
<td>$\beta^C_r$</td>
<td>0.07</td>
<td>0.09</td>
<td>0.43</td>
</tr>
<tr>
<td>Sensitivity of consumption to lagged $R$</td>
<td>$\beta^C_R$</td>
<td>0.09</td>
<td>0.10</td>
<td>0.65</td>
</tr>
<tr>
<td>Refinancing regression coefficient on $R$</td>
<td>$\beta^{REFI}_R$</td>
<td>-1.91</td>
<td>-1.09</td>
<td>0.67</td>
</tr>
<tr>
<td>Cashout regression coefficient on $R$</td>
<td>$\beta_R$</td>
<td>-0.43</td>
<td>-0.83</td>
<td>0.73</td>
</tr>
</tbody>
</table>
Quintiles sorted on income and debt/income

A. Cash-out for refi loans

\[ (b' - b^+) / y \]

B. Cash-out for refi loans

\[ (b' - b^+) / y \]

C. Asset holding

\[ a / y \]

D. Asset holding

\[ a / y \]

E. Rate ratio

\[ k' / k \]

F. Rate ratio

\[ k' / k \]

Low income  High income  Low debt/income  High debt/income
Model vs. Data (sorted on income/house value and debt/income, SCF)

A. Loan-to-income ratio

B. Loan-to-income ratio

C. Loan-to-value ratio

D. Loan-to-value ratio

E. Annual refinancing rate, %

F. Annual refinancing rate, %

Low income

High income

Low debt/income

High debt/income
Aggregate time series

A. Real consumption growth

B. Rate ratio
Experiment: replicating Mian-Sufi evidence

- Feed in alternative time series
- “Inelastic MSAs”: model with $2 \times$ volatility of $p^H$ shocks
- “Elastic MSAs”: $p^H = 1$ (house prices comove with income)
Mian-Sufi experiment: Leverage Run-up

- Housing price growth, relative to 2001
  - Inelastic MSAs
  - Elastic MSAs

- Total debt growth, relative to 2001
  - Inelastic MSAs
  - Elastic MSAs

- Change in debt-to-income ratio, relative to 2001
Leverage-sorted groups during crisis (model)

A. Consumption vs. 2006

B. Liquid assets/Income

C. Debt/Income

D. Refinancing rate

\[ \ln\left(\frac{C_t}{C_{2006}}\right) \]

\[ \frac{a^+}{y} \]

\[ \frac{b}{y} \]

\[ \text{REFI} \]
Conclusion

- “Standard” model able to account for the dynamics of household leverage and consumption over the “boom” and the “bust” periods

- Financing frictions have quantitatively large effects on household finance and consumption
  - Long vs. short-term debt: deleveraging effect substantial even with long-maturity debt
  - Precautionary savings in liquid assets vs. illiquid home equity

- Substantial heterogeneity in refi and consumption behavior in response to monetary shocks and government programs (e.g., HARP and FHA loans)
Aggregate-level regression: REFI

- Regression:

\[ REFI_t = b_0 + b_{IP} \Delta IP_t + b_{r30} R_{t}^{30Y} + b_{HPI} \Delta HPI_t \]

\[ + b_{r} R_{t}^{3M} + b_{\Delta r30} \Delta R_{t}^{30Y} + \epsilon_t \]

- MBA REFI Index (# of loans, refinancing only)

# Aggregate Refinancing Activity

<table>
<thead>
<tr>
<th></th>
<th>$\Delta IP_t$</th>
<th>$\Delta HPI_t$</th>
<th>$R_{t}^{M30}$</th>
<th>$R_{t}^{M30} - R_{t-12}^{M30}$</th>
<th>$R_{t}^{M30} - R_{avg,t}^{M30}$</th>
<th>$r_t^{1Y}$</th>
<th>Adj. $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.422</td>
<td>0.148</td>
<td>-1.914</td>
<td>-1.464</td>
<td>-2.609</td>
<td>-1.156</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>(0.161)</td>
<td>(0.098)</td>
<td>(0.667)</td>
<td>(0.845)</td>
<td></td>
<td>(0.611)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.253</td>
<td>0.156</td>
<td>-1.982</td>
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<td>-0.986</td>
<td>0.654</td>
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<tr>
<td></td>
<td>(0.087)</td>
<td>(0.095)</td>
<td>(0.675)</td>
<td></td>
<td></td>
<td>(0.566)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.196</td>
<td>0.155</td>
<td>-2.700</td>
<td>-1.464</td>
<td></td>
<td>-0.278</td>
<td>0.673</td>
</tr>
<tr>
<td></td>
<td>(0.097)</td>
<td>(0.095)</td>
<td>(0.601)</td>
<td>(0.845)</td>
<td></td>
<td>(0.496)</td>
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</tr>
<tr>
<td></td>
<td>-0.268</td>
<td>0.155</td>
<td>-2.700</td>
<td>-1.464</td>
<td></td>
<td>-0.278</td>
<td>0.687</td>
</tr>
<tr>
<td></td>
<td>(0.091)</td>
<td>(0.095)</td>
<td>(0.601)</td>
<td>(0.845)</td>
<td></td>
<td>(0.496)</td>
<td></td>
</tr>
</tbody>
</table>
Aggregate-level regression: $ Home Equity Withdrawal

- **Regression:**

  \[
  HEW^j_t = \beta_0^j + \beta_Z^j \Delta PI_t + \beta_H^j \Delta HPI_t + \beta_R^j R_{t}^{M30} + \beta_{rl}^j \Delta R_{t}^{M30} + \beta_{r1}^j r_{t}^{1Y} + \epsilon_t.
  \]

  where \( j \in \{ \text{Cash-out, HELOC} \}\)

- **Freddie Mac, $ Cash-out (over year-ago personal income)**

- **Fed Flow of Funds Accounts, $ Home equity loans and lines of credit (over year-ago personal income)**

- **Quarterly data, Q1 1993 - Q1 2011**
# Home Equity Withdrawal

<table>
<thead>
<tr>
<th></th>
<th>Prime, first-lien mortgage</th>
<th>HEL(OC)s</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta PI_t$</td>
<td>-0.003</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>(0.051)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>$\Delta HPI_t$</td>
<td>0.061</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>$R_{t}^{M30}$</td>
<td>-0.430</td>
<td>-0.038</td>
</tr>
<tr>
<td></td>
<td>(0.146)</td>
<td>(0.112)</td>
</tr>
<tr>
<td>$R_{t}^{M30} - R_{t-1}^{M30}$</td>
<td>0.207</td>
<td>0.185</td>
</tr>
<tr>
<td></td>
<td>(0.084)</td>
<td>(0.063)</td>
</tr>
<tr>
<td>$r_{t}^{1Y}$</td>
<td>0.279</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.076)</td>
</tr>
<tr>
<td>$Adj. , R^2$</td>
<td>-0.055</td>
<td>0.111</td>
</tr>
<tr>
<td></td>
<td>0.487</td>
<td>0.611</td>
</tr>
<tr>
<td></td>
<td>0.545</td>
<td>0.679</td>
</tr>
</tbody>
</table>
Exploiting State-Level Variation

- At the state level, macroeconomic conditions are less likely to comove with interest rates

- Variation in the ability to use housing collateral (prices vary)
  - Caplin, Freeman and Tracy (1997)
  - Lustig and Van Nieuwerburgh (2010)
  - Mian and Sufi (2010)
  - Case, Quigley and Shiller (2011)
  - Midrigan and Philippon (2011)

- Use state-level aggregations of HMDA data
  - all originated loans
Business Cycle and Refinancing: State Level Variation

- Quarterly refi loans (scaled by population):

\[ REFI_{t}^{State} = b_{Cycle} Cycle_{t}^{State} + b_{HPI} \Delta HPI_{t}^{State} + b_{CH} Cycle_{t}^{State} \times HPI_{t}^{State} + b_{R} R_{t}^{State} + b_{w} WAC_{t}^{State} + b_{3M} R_{t}^{3M} + b_{30Y} R_{t}^{30Y} + b_{30Y} \Delta R_{t}^{30Y} + b_{t} + b_{State} + \epsilon_{t}, \]

- \( BC \) = Payroll, Coincident Economic Activity Index or Personal Income Growth

- Quarterly data, March 1993 - December 2007
## Refi Loan Originations

<table>
<thead>
<tr>
<th>BC</th>
<th>$\Delta HPI_t$</th>
<th>$BC \times HPI_t$</th>
<th>$WAC_t$</th>
<th>$R_t$</th>
<th>$R_{30Y}^t$</th>
<th>$R_{3M}^t$</th>
<th>$\Delta R_{30Y}^t$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payroll</td>
<td>-0.29</td>
<td>0.17</td>
<td>-1.85</td>
<td>0.62</td>
<td>1.50</td>
<td>-1.70</td>
<td>-0.75</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.39)</td>
<td>(0.05)</td>
<td>(0.22)</td>
<td>(0.12)</td>
<td>(0.06)</td>
<td>(0.12)</td>
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<tr>
<td>CEAI</td>
<td>-0.24</td>
<td>0.10</td>
<td>-0.64</td>
<td>-2.74</td>
<td>0.32</td>
<td></td>
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<td>0.89</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.01)</td>
<td>(0.20)</td>
<td>(0.67)</td>
<td>(0.37)</td>
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<tr>
<td>Personal Income</td>
<td>0.01</td>
<td>0.15</td>
<td>-1.89</td>
<td>0.61</td>
<td>1.84</td>
<td>-1.89</td>
<td>-1.00</td>
<td>-0.32</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.01)</td>
<td>(0.37)</td>
<td>(0.05)</td>
<td>(0.26)</td>
<td>(0.13)</td>
<td>(0.07)</td>
<td>(0.13)</td>
</tr>
<tr>
<td></td>
<td>-0.10</td>
<td>0.09</td>
<td>-0.36</td>
<td>-2.63</td>
<td>0.18</td>
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<td></td>
<td>0.89</td>
</tr>
<tr>
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<td>(0.22)</td>
<td>(0.70)</td>
<td>(0.39)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Household Problem: Home-owner

\[ U_i^h(a_i, b_i, k_i, s_i) = \max_{a_i', b_i', I_i^{RF}} \left[ (1 - \delta)(c_i/p)^{1-\gamma} + \delta \mathbb{E} \left[ \max \left( U_i^{h'}, U_i^{hr'}, U_i^{hd'} \right)^{1-\gamma} \right] \right]^{1/\gamma} \]

subject to

\[ c_i + \frac{a_i'^+}{1 + (1 - \tau)r} + \frac{a_i'^-}{1 + r^{HL}} + b_i = (1 - \tau)(y_i - k_i b_i) + a_i + b'_i - \phi(b'_i) I_i^{RF}, \]

\[ (b'_i - b_i) (1 - I_i^{RF}) \leq 0, \]

\[ c_i, b_i \geq 0, \]

and the borrowing constraints
Household Problem: Renter

Renters:

- Incur a rental expense: share $\frac{\eta}{1+\eta}$ of per period income

$$U_i^r(a_i, s_i) = \max_{a_i'} \left[ (1 - \delta)(c_i/p)^{\frac{1-\gamma}{\theta}} + \delta \mathbb{E} \left[ \max \left( U_i^{rh'}, U_i^{r'} \right)^{1-\gamma} \right]^{\frac{1}{\theta}} \right]^{\frac{\theta}{1-\gamma}}$$

subject to,

$$c_i = (1 - \tau) \frac{y_i}{1+\eta} + a_i - \frac{a_i'}{1 + (1 - \tau)r} \quad \text{After-Tax Income}$$

$$a_i', c_i \geq 0 \quad \text{Change in Savings}$$
Household Problem: Default State

Households in Default State:

- Become renters and stay in that state (w.p. $1 - \omega$)
- Are not allowed to buy a house

$$U^d_i = \max_{a_i'} \left[ (1-\delta)(c_i/p)^{1-\gamma} + \delta \mathbb{E} \left[ (1 - \omega) \left( U^{d'}_i \right)^{1-\gamma} + \omega \max \left( U^{rh'}_i, U^{r'}_i \right)^{1-\gamma} \right] \right]^{\frac{\theta}{1-\gamma}}$$

subject to,

$$c_i = \left(1 - \tau\right) \frac{y_i}{1 + \eta} + a_i - \frac{a_i'}{1 + (1 - \tau)r}$$

$$a_i', c_i \geq 0$$