Housing Prices and Consumer Spending: The Bank Balance-Sheet Channel

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Bank of Canada

Housing, Credit and Heterogeneity: New Challenges for Stabilization Policies

Stockholm, September 2018
Main Idea

- Housing Prices
- Consumption
Main Idea

Housing Prices → Wealth and Collateral Effects → Consumption
Main Idea

Housing Prices → Banking Sector → Consumption

Wealth and Collateral Effects
Main Idea

- Housing Prices
- Wealth and Collateral Effects
- Banking Sector
- Credit Supply
- Consumption
Main Idea

Housing Prices

Wealth and Collateral Effects

Bank Losses

Banking Sector

Credit Supply

Bank Balance Sheet Channel

Consumption
Contributions and Findings

- **Theoretical Contribution**
  - Introduce a *Banking Sector* with Balance Sheet Frictions in a model of collateralized debt with default
  - Credit supply depends on the capitalization of the entire banking sector.
  - Mortgage spreads and endogenous down payments increase in periods when banks are poorly capitalized
  - Quantify the Bank Balance Sheet Channel
    - Bank Balance Sheet explains 13% of the change in house prices, 9% change in foreclosures and 22% change in consumption

- **Empirical Contribution**
  - Document the Bank Balance Sheet Channel using an instrumental variable approach
    - Banks located in areas exposed to higher house price drop faced larger declines in their capital ratio
    - An 1p.p. decrease in the capital ratio induced by exogenous variation in housing prices leads to a decrease of supply of Home Purchase loans by 10.5% and Refinance by 15.2%
Related Work

- **Consumption response to Housing Price Shocks**
  - Mian et al. (2013), Kaplan et al. (2016), Mian and Sufi (2011, 2014)
  - Berger et al. (2016), Carrol and Dunn (1998)

- **Lending Channel**
  - Chakraborty et al. (2016), Greenstone and Alexandre (2012), Chodow-Reich (2014)

- **Credit Crunch and Financial Crisis**
MODEL
Model Overview

- Time is discrete and infinite

- **Households**
  - Agents live forever
  - Homeowners or Renters
  - Long-term mortgages

- **Banks**
  - Issue and price individual mortgages
  - Bank balance sheet frictions
  - Credit supply depends on the banks’ capitalization

- **Housing Sector**
  - Determine housing prices and rental rates
  - **Endogenous** House Prices
Households

- Income endowment ($y$) subject to temporary uninsured shocks

$$y_{it} = w \cdot \exp(z_{it}), \quad z_{it} = \rho z_{it-1} + \epsilon_{it}, \quad \epsilon_{it} \sim \mathcal{N}(0, \sigma_z)$$

- Utility over non-durable goods ($c$) and housing services ($s$)
  - Rented: $s = h$
  - Owned: $s = vh, \quad v > 1$

- **Housing** ($h$):
  - Rental Housing - $p_t^r$
  - Owned Housing - $p_t$
    - Transaction Costs
    - Random maintenance costs
Long-Term Mortgages

- **Long Term Collateralized Mortgages**
  - Mortgage face value (principal) originated at time $\tau$: $m_\tau = m$
  - Borrower receives $q_\tau (y, a, h, m, r_\tau^m) m$

- **Payments**
  - **Contract terminates** (house sold or refinance): $X^s_t = m_{t-1}$
  - **Default** (Bank takes the house): $X^d_t = \min \{(1 - \chi_d) p_t h_t, m_{t-1}\}$
  - **Mortgage payment:**
    - $X_t = \frac{\mu + r^m_t}{1 + r^m_t} m_{t-1}$
    - $\mu$ amortization term, $r^m_t$ the coupon (or interest) part
    - $m_t = (1 - \mu) m_{t-1} = (1 - \mu)^t m$
Households Decisions

- **Homeowners** \( \Lambda_h = (y, a, h, \delta_h, m, r^m_T) \)
  - Stays Home-owner: Pays Mortgage, Refinances or Changes House
  - Default - becomes a renter with no access to credit market
  - Sells house and becomes a Renter

- **Renter** \( \Lambda_r = (y, a) \)
  - Rents
  - Buys a house
    - If have Defaulted before may be restricted of mortgage market

- All decide Consumption \( (c) \) and Savings \( (a) \)
Banking Sector

- Representative Bank that behaves competitively

\[ Q_t M_t = B_t + N_t \]
\[ Q_t M_t = \int q_{it}(m_{it})m_{it} \, di \]
Banking Sector

- Representative Bank that behaves competitively
  \[ Q_t M_t = B_t + N_t \]
  \[ Q_t M_t = \int q_{it}(m_{it})m_{it}di \]

- Frictions:
  - Low Capital ratio is costly
    \[ \Phi\left(\frac{N}{QM}\right) = \begin{cases} 
      \kappa_0 + \kappa_1 \left(\tilde{K} - \frac{N}{QM}\right)^2 & \text{if } \frac{N}{QM} < \tilde{K} \\
      0 & \text{otherwise}
    \end{cases} \]

- Net worth is accumulated through retained earnings
  \[ N_{t+1} = (1 - \omega) [N_t + \Pi_{t+1}] \]
Banking Sector

- Representative Bank that behaves competitively

\[ Q_t M_t = B_t + N_t \]
\[ Q_t M_t = \int q_{it} (m_{it}) m_{it} di \]

- Frictions:
  - Low Capital ratio is costly

\[ \Phi \left( \frac{N}{QM} \right) = \begin{cases} 
  \kappa_0 + \kappa_1 \left( \tilde{K} - \frac{N}{QM} \right)^2 & \text{if } \frac{N}{QM} < \tilde{K} \\
  0 & \text{otherwise}
\end{cases} \]

- Net worth is accumulated through retained earnings

\[ N_{t+1} = (1 - \omega) [N_t + \Pi_{t+1}] \]

\[ \Pi_{t+1} = r_{t+1}^m Q_t M_t - rB_t - \Phi \left( \frac{N_t}{Q_t M_t} \right) \]
Banking Sector

- Maximize the present discounted value of future dividends
  - Given $N_t$, decides $M_t$ and $B_t$

Bank’s Problem
Banking Sector

- Maximize the present discounted value of future dividends
  - Given $N_t$, decides $M_t$ and $B_t$

- If No frictions
  \[ r_{t+1}^m - r = 0 \]

- With Frictions
  \[
  \left\{ r_{t+1}^m - r - \Phi \left( \frac{N_t}{Q_t M_t} \right) - \Phi' \left( \frac{N_t}{Q_t M_t} \right) \frac{N_t}{Q_t M_t} \right\} = 0
  \]

- High Leverage
  - Cost of funding increases $r_{t+1}^c$↑
Individual Mortgage

- Competition: zero expected discounted profit

\[ q_t(y, a', h', m', r^m_t) m' = \frac{1}{(1 + r_{t+1}^c)} E_t \left\{ z_{t+1} m' + \right. \]
\[ \left. (1 - d_{it+1} - s_{it+1}) q_{t+1}(y', a'', h', (1 - \mu) m', r^m_t)(1 - \mu) m' \right\} \]

- Mortgages price decrease when banks are constraint (higher leverage ratio)
  - Cost of funding increases \( r^c_{t+1} \uparrow \)
Mechanism

Housing Prices
Mechanism

Housing Prices → Household Net Worth → Consumption

Housing Equity → Riskier Households → Credit Supply → Consumption
Mechanism

Housing Prices → Household Net Worth → Consumption

Housing Equity → Riskier Households → Defaults

Bank Losses → Credit Supply

 Defaults
Mechanism

Housing Prices

Housing Equity

Bank Losses

Credit Supply

Riskier Households

Defaults

Household Net Worth

Frictions

New Home Purchases

Refinance

Consumption
Mechanism

- Housing Prices
- Housing Equity
- Bank Losses
- Credit Supply
- Refinance
- New Home Purchases
- Consumption
- Household Net Worth
- Riskier Households
- Defaults
- Frictions

- Housing Prices → Household Net Worth → Consumption
- Housing Equity → Riskier Households → Refinance
- Bank Losses → Defaults → Credit Supply
- Credit Supply → New Home Purchases
Mechanism

- Housing Prices
  - Housing Equity
  - Defaults → Bank Losses
  - Refinance

- Household Net Worth
  - Riskier Households
  - Frictions → Credit Supply

- Consumption

Bank Balance Sheet Channel
## Calibration - Target Moments

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data</th>
<th>Model</th>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeownership</td>
<td>68%</td>
<td>68.1%</td>
<td>Own-house add utility</td>
<td>$v = 1.06$</td>
</tr>
<tr>
<td>LTV $\geq$ 90%</td>
<td>7.02%</td>
<td>7.51%</td>
<td>Discount Factor</td>
<td>$\beta = 0.945$</td>
</tr>
<tr>
<td>Average Equity</td>
<td>62%</td>
<td>63.7%</td>
<td>Mortgage amortization</td>
<td>$\mu = 0.018$</td>
</tr>
<tr>
<td>Default Rate</td>
<td>1.5%</td>
<td>1.45%</td>
<td>High Depreciation shock</td>
<td>$\delta = 0.22$</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>1.06%</td>
<td>1.06%</td>
<td>Prob High Maintenance</td>
<td>$p_\delta = 0.048$</td>
</tr>
<tr>
<td>Refinance Rate</td>
<td>24%</td>
<td>25.7%</td>
<td>Refinance Cost</td>
<td>$\chi_r = 5.1%$</td>
</tr>
<tr>
<td>Mortgage Spread</td>
<td>165b.p.</td>
<td>160b.p.</td>
<td>Capital ratio target</td>
<td>$\tilde{K} = 15%$</td>
</tr>
<tr>
<td>Increase in spread</td>
<td>128b.p.</td>
<td></td>
<td>Leverage Cost Param.</td>
<td>$\kappa_0 = 0.0103, \kappa_1 = 3.37$</td>
</tr>
</tbody>
</table>

Exogenous Calibration
Calibration

Mortgage Spreads

Capital to Assets Ratio

Unweighted Mean (left axis)  Weighted Mean (right axis)
## Non Target Moments

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortgage Holder Rate</td>
<td>66%</td>
<td>67%</td>
</tr>
<tr>
<td>Avg. Income Homeowners / renters</td>
<td>2.05</td>
<td>3.34</td>
</tr>
<tr>
<td>Avg. Housing Wealth / Avg. Income</td>
<td>1.69</td>
<td>2.54</td>
</tr>
<tr>
<td>Cash Buyers</td>
<td>19</td>
<td>19.41</td>
</tr>
<tr>
<td>% Homeowners with 0% equity</td>
<td>1.81</td>
<td>0.39</td>
</tr>
<tr>
<td>% Homeowners with ≤ 10% equity</td>
<td>7.02</td>
<td>6.5</td>
</tr>
<tr>
<td>% Homeowners with ≤ 20% equity</td>
<td>14.07</td>
<td>13.04</td>
</tr>
<tr>
<td>% Homeowners with ≤ 30% equity</td>
<td>22.4</td>
<td>21.05</td>
</tr>
<tr>
<td>% Homeowners with 100% equity</td>
<td>28.75</td>
<td>34.05</td>
</tr>
</tbody>
</table>
Home Equity

CDF

All Homeowners
New Homeowners

Home Equity

CDF

All Homeowners
New Homeowners
Quantification of Bank Balance Sheet

- Unanticipated Decrease in Demand for Housing
- Negative Productivity shock (4.7% cumulative over 3 periods)
- Delays in foreclosure process

<table>
<thead>
<tr>
<th>△Cumulative</th>
<th>Data</th>
<th>Model (a)</th>
<th>No Fric (b)</th>
<th>(a-b)/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>House prices</td>
<td>-18%</td>
<td>-18%</td>
<td>-16.6%</td>
<td>13%</td>
</tr>
<tr>
<td>Default Rate</td>
<td>13p.p.</td>
<td>11.2p.p.</td>
<td>10.2p.p.</td>
<td>9%</td>
</tr>
<tr>
<td>Consumption</td>
<td>-11.5%</td>
<td>-10.6%</td>
<td>-8.2 %</td>
<td>22%</td>
</tr>
<tr>
<td>Refinancing</td>
<td>-43%</td>
<td>-38.5%</td>
<td>-24.9%</td>
<td>35%</td>
</tr>
<tr>
<td>Bank Capital</td>
<td>-1.4p.p.</td>
<td>-1.15p.p.</td>
<td>-0.72p.p.</td>
<td>38%</td>
</tr>
<tr>
<td>Mortgage spread</td>
<td>133b.p.</td>
<td>109b.p.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Results

House Prices

Foreclosures

Consumption

Refinancing

Capital Ratio

Mortgage Spreads
Heterogeneity

**Consumption**

- **LTV**
  - >90
  - 80-90
  - <80
- **Bank Frictions**
  - No Bank Frictions

**Refinance**

- **LTV**
  - >90
  - 80-90
  - <80
- **Bank Frictions**
  - No Bank Frictions
EMPIRICAL EVIDENCE
Empirical Evidence

- **Goal:** Estimate how changes in Housing Prices affect **Mortgage Supply** through **Banks’ Balance Sheets**

- **Part I:** Impact of decline in house prices on Capital Ratio

  \[ \Delta K_{k,t} = \beta_1 + \beta_2 RES_{k,t} + \beta_3 X_{k,05} + \epsilon_{k,t} \]

  - **Challenge:** Reverse Causality
  - **Solutions:**
    - Exploit variation in banks’ exposure to different housing markets
    - Instrumental variable approach - structural breaks in house prices evolution 2000-2006 (Charles, Hurst and Notowidigdo (2017))

- **Part II:** Impact of decline in Capital Ratio (induced by house price drop) on Credit Supply

  - Control for Demand characteristics at county level

  \[ \Delta VolOrig_{j,t} = \beta_1 + \beta_2 \Delta Y_{j,t} + \beta_3 \Delta H_{j,t} + \beta_4 X_{j,05} + \epsilon_{j,t} \]

  \[ \Delta Y_{j,t} = \sum_k \alpha_{k,j} \Delta K_{k,t,-j} \]
Results - Part I:  \( \Delta K_{k,t} = \beta_1 + \beta_2 RES_{k,t} + \beta_3 X_{k,05} + \epsilon_{k,t} \)

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>IV</th>
<th>OLS</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>RES(t)</td>
<td>0.088***</td>
<td>0.091***</td>
<td>0.061***</td>
<td>0.082**</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.022)</td>
<td>(0.009)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Observations</td>
<td>4908</td>
<td>4908</td>
<td>4888</td>
<td>4888</td>
</tr>
<tr>
<td>Adjusted ( R^2 )</td>
<td>0.031</td>
<td>0.031</td>
<td>0.117</td>
<td>0.116</td>
</tr>
<tr>
<td>SD</td>
<td>robust</td>
<td>robust</td>
<td>robust</td>
<td>robust</td>
</tr>
<tr>
<td>Bank controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- If a bank faces an average shock (-4.6p.p. per year), capital decreases by -0.38p.p. 
- From 90th to 10th percentile of change in RES implies that Capital Ratio decreases 0.85p.p. more
Results - Part II: $\Delta VolOrig_{j,t} = \beta_1 + \beta_2 \Delta Y_{j,t} + \beta_3 \Delta H_{j,t} + \beta_4 X_{j,05} + \epsilon_{j,t}$

<table>
<thead>
<tr>
<th></th>
<th>Banks in sample</th>
<th>All Originations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1a)</td>
<td>(2a)</td>
</tr>
<tr>
<td><strong>Home Purchase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta Y_{j,t}$</td>
<td>141.031***</td>
<td>47.090**</td>
</tr>
<tr>
<td></td>
<td>(21.241)</td>
<td>(17.293)</td>
</tr>
<tr>
<td><strong>Refinance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta Y_{j,t}$</td>
<td>60.902***</td>
<td>78.385***</td>
</tr>
<tr>
<td></td>
<td>(13.507)</td>
<td>(12.809)</td>
</tr>
<tr>
<td>Observations</td>
<td>2850</td>
<td>2850</td>
</tr>
<tr>
<td>cluster</td>
<td>State</td>
<td>State</td>
</tr>
<tr>
<td>Year FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>State FE</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Going from the 90th to the 10th percentile of change in capital ratio induced by a real estate shock distribution (-0.57p.p.) in the cross-section implies a decrease in **Refinance of 8.55% and Home Purchases of 5.98%**.
Conclusion

- Model of long-term collateralized debt with risk of default with a *Banking Sector* with balance sheet frictions
  - Endogenous Credit Supply

- Bank Balance Sheet Channel is important to explain changes in house prices, foreclosures and consumption between 2006-2009

- Empirical Evidence that Bank’s balance sheet are affected by change in house prices
  - More constrained banks contracted credit supply by more
Related Work

- **Consumption response to Housing Price Shocks**
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- **Credit Crunch and Financial Crisis**
Long-Term Mortgages

- **Long Term Collateralized Mortgages**
  - Mortgage face value (principal) originated at time $\tau$: $m_\tau = m$
  - Borrower receives $q_\tau(y,a,h,m,r_\tau m) m$

- **Payments**
  - **Contract terminates** (house sold or refinance): $X_t^s = m_{t-1}$
  - **Default** (Bank takes the house): $X_t^d = \min\{(1 - \chi_d)p_t h_t, (1 + x)m_{t-1}\}$
  - **Mortgage payment**: $X_t = \frac{\mu + r_t^m}{1 + r_t^m} m_{t-1}$
    - $\mu$ amortization term, $r_t^m$ the coupon (or interest) part
    - $m_t = (1 - \mu)m_{t-1} = (1 - \mu)^t m$
Homeowners

- Keeps House (Refinance or not)

\[
\begin{align*}
V^{HH}(\Lambda_h, \Lambda_{at}) &= \max\{c, a', h', m'\} U(c, h') + \beta E_{(y', \delta'_{h})|y} \left[ V^{H}(\Lambda'_{h}, \Lambda_{at+1}) \right] \\
\end{align*}
\]

\[
\begin{align*}
c + a' + \delta_h p_t h &= w \cdot y + a(1 + r) + \left[ q_t(y, a', m', h', \Lambda_{at}) m' - m - \chi m \right]_{m' \neq (1 - \mu)m, h' = h} \\
&+ \left[(1 - \chi_s) p_t h - (1 + \chi_b) p_t h' + q_t(y, a', m', h', \Lambda_{at}) m' - m - \chi m\right]_{h' \neq h} \\
&- \left[x_{\tau m}\right]_{m' = (1 - \mu)m, h' = h} - T(y, h', m, r^m_{\tau})
\end{align*}
\]

- Defaults

\[
\begin{align*}
V^{D}(\Lambda_h, \Lambda_{at}) &= \max\{c, h', a'\} U(c, h') + \beta E_{y'|y} \left[ (1 - \theta) V^{M}(\Lambda'_{r}, \Lambda_{at+1}) + \theta V^{NM}(\Lambda'_{r}, \Lambda_{at+1}) \right] \\
\end{align*}
\]

\[
\begin{align*}
s.t. \quad c + p^r_{\tau} h' + a' &= y + a(1 + r) + \max \{(1 - \chi_d - \tau_h) p_t h - m, 0\} - T(y, 0, 0, 0)
\end{align*}
\]

- Becomes a Renter

\[
\begin{align*}
V^{HS}(\Lambda_h, \Lambda_{at}) &= \max\{c, h', a'\} U(c, h') + \beta E_{y'|y} V^{GR}(\Lambda'_{r}, \Lambda_{at+1}) \\
\end{align*}
\]

\[
\begin{align*}
s.t. \quad c + p^r_{\tau} h' + a' &= y + a(1 + r) + (1 - \delta_h - \chi_s) p_t h - m
\end{align*}
\]

\[
\begin{align*}
V^{H}(\Lambda_h, \Lambda_{at}) &= \max \left\{ V^{HH}(\Lambda_h, \Lambda_{at}), V^{HD}(\Lambda_h, \Lambda_{at}), V^{HS}(\Lambda_h, \Lambda_{at}) \right\}
\end{align*}
\]
Renters ($m' = 0$ if $w = NM$)

- **Buys a House**

\[
V^{RHw}(\Lambda_r, \Lambda_{at}) = \max\{c, a', h', m'\} U(c, h') + \beta E_{y'|y} \left[ V^{HH}(\Lambda'_h, \Lambda_{at+1}) \right]
\]

subject to

\[
c + a' + (1 + \chi_b) p_t h' = y + a(1 + r) + q(y, a', h', m', r_t^m) m' - T(y, 0, h', 0)
\]

\[
m' = 0 \text{ if } w = NM
\]

- **Rents**

\[
V^{RRw}(\Lambda_r, \Lambda_{at}) = \max\{c, h', a'\} U(c, h') + \beta E_{y'|y} \left[ V^{Rw}(\Lambda'_r, \Lambda_{at+1}) \right]
\]

\[
c + p_t^r h' + a' = y + a(1 + r)
\]

where $V^{RM}(\Lambda_r, \Lambda_{at}) = \max \left\{ V^{RHM}(\Lambda_r, \Lambda_{at}), V^{RRM}(\Lambda_r, \Lambda_{at}) \right\}$ and

$V^{RNM}(\Lambda_r, \Lambda_{at}) = \max \left\{ V^{RHNM}(\Lambda_r, \Lambda_{at}), V^{RRNM}(\Lambda_r, \Lambda_{at}) \right\}$
Housing Sector

- **Composite Consumption**

\[ Y_c = AN_c \quad w = A \]

- **Construction sector**

\[ Y_h = Y_c^{\alpha_h} L^{1-\alpha_h} \quad S_t^h = (\alpha_h p_t)^{\frac{\alpha_h}{1-\alpha_h}} L_t \]

- **Rental Sector:**
  - Every period faces a maintenance cost \( \delta_r \cdot p_t^h \)
  - Can buy/sell housing at the equilibrium price
  - No transaction cost: Arbitrage Condition determines equilibrium rents \( (p_r^t) \)

\[
p_t^r - (\delta_r + \tau_h) p_t^h + E_t \left[ \frac{p_t^h+1}{1+r} \right] = p_t^h
\]
## Calibration - Exogenous Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing share</td>
<td>$\alpha = 0.15$</td>
</tr>
<tr>
<td>Elasticity substitution c and h</td>
<td>$\frac{1}{\gamma} = 1.25$</td>
</tr>
<tr>
<td>Intertemporal elasticity</td>
<td>$\sigma = 2$</td>
</tr>
<tr>
<td>House sizes</td>
<td>$\mathcal{H}^h = {1.43, 1.79, 2.3, 2.9, 3.6, 4.2}$</td>
</tr>
<tr>
<td>Rental sizes</td>
<td>$\mathcal{H}^r = {1.1, 1.43, 1.79}$</td>
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<td>Autocorrelation earning shocks</td>
<td>$\rho_z = 0.97$</td>
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<td>S.D. of earning shocks</td>
<td>$\sigma_z = 0.2$</td>
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<td>Buying Costs</td>
<td>$\chi_b = 0.01$</td>
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<td>Selling Costs</td>
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<td>Liquidation cost</td>
<td>$\chi_d = 0.25$</td>
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<td>Rental Maintenance cost</td>
<td>$\delta_r = 0.0165$</td>
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<td>World Interest Rate</td>
<td>$r = 0.03$</td>
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<tr>
<td>Probability of reentering credit mkt</td>
<td>$\theta = 0.25$</td>
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<tr>
<td>Dividend</td>
<td>$\omega = 0.115$</td>
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Empirical Evidence

- **Part 1:** Fluctuations in housing prices impact banks’ balance sheets
- **Part 2:** banks react to losses induced by changes in housing prices by contracting mortgage loan supply

**Data**
- 2007-2010 period
- **Housing Prices:** Zillow Median Home Value Index for All Homes
- **Mortgages:** Home Mortgage Disclosure Act (HMDA)
- **Banks’ balance sheets:**
  - Report of Condition and Income (Call Reports)
  - Summary of Deposits (SOD)
- County level Unemployment (BLS) and Income (IRS)
Empirical Strategy - Part I

- Change in house prices and banks balance sheets

\[ \Delta K_{k,t} = \beta_1 + \beta_2 RES_{k,t} + \beta_3 X_{k,05} + \epsilon_{k,t} \]

\[ RES_{k,t} = \sum_j \omega_{kj05} \Delta P_{jt} \]

- \( \Delta K_{k,t} \): change of Capital Ratio of bank \( k \)
- \( RES_{kt} \): Real Estate Shock to bank \( k \) at time \( t \)

- Instrumental variable approach

  - Assumption: variation in housing prices during the boom and bust derived from a speculative âbubbleâ and not from changes in standard determinants of housing values.
  - Boom is strongly correlated with the size of its later housing bust, this structural breaks are strongly correlated with house demand in the bust period
Deposits as proxy

\[ RES_{k,t} = \sum_j \omega_{kj05} \Delta P_{jt} \]

- \( \Delta P_{jt} \): change in House Prices in county \( j \)
  - \( \omega_{kj05} \) share of bank \( k \) deposits in county \( j \) in 2005

- Two major concerns:
  1. Weights are based on deposits rather than loans.
  2. Rise of mortgage-backed securities may have allowed banks to diversify away from their physical locations.

- Section 109 of the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 prohibits a bank from establishing or acquiring branches outside of its home state primarily for the purpose of deposit production.

- Aguirregabiria et. al. (2016): evidence of a strong home bias for 1998-2010 period - local deposits are mostly used to fund local loans

- Chakraborty et. al. (2016):
  - when loans are sold, banks are likely to remain as servicers of the mortgage and maintain exposure to the local market.
  - MBS: often maintain a certain share of the security as a signal of its quality
### Real Estate Shock - Summary Statistics

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<th>Mean</th>
<th>SD</th>
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<th>Perc10</th>
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<tr>
<td><strong>Δ House Prices - Unweighted</strong></td>
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Source: Call Reports. Capital to Assets Ratio weighted by total assets in 2005

- The average Real Estate shock relevant for each bank is similar in size to the house price change in the US.
- Large variation across banks.
Strong 1st Stage: Breaks in House Price evolution explains a large portion of the real estate shocks faced by the banks

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<td>(0.012)</td>
<td>(0.011)</td>
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<td>Observations</td>
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<td>Adjusted $R^2$</td>
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Empirical Strategy - Part II

- Estimate the impact of predicted changes in banks’ capital ratio on Credit Supply

- Change in mortgages originations at the county level ($j$)

\[
\Delta VolOrig_{j,t} = \beta_1 + \beta_2 \Delta Y_{j,t} + \beta_3 \Delta H_{j,t} + \beta_4 X_{j,05} + \epsilon_{j,t}
\]

\[
\Delta Y_{j,t} = \sum_k \alpha_{k,j} \Delta K_{k,t,-j}
\]

- $\Delta \hat{Y}_{k,t}$ predicted change in Bank’s Capital Ratio (regression part I)
- $\Delta H_{j,t}$ change in House prices, Unemployment Rate and Income at county level
- $X_{j,06}$ bank’s controls at county level
Banking Sector

- $Q_t M_t$ can be seen as “representative” mortgage.

- **Principal Evolution:**

  $$\tilde{M}_{t+1} = (1 - d_{t+1} - s_{t+1}) (1 - \mu) M_t$$

  - $d_{t+1} M_t = \int 1_{\{d_{it+1}=1\}} m_{it} di$,  $s_{t+1} M_t = \int 1_{\{s_{it+1}=1\}} m_{it} di$

- **Earnings:**

  $$\Pi_{t+1} = \underbrace{Z_{t+1} M_t + (\tilde{Q}_{t+1} \tilde{M}_{t+1} - Q_t M_t)}_{r^m_{t+1} Q_t M_t} - rB_t - \Phi \left( \frac{Q_t M_t}{N_t} \right)$$

  $$Z_{t+1} M_t = (1 - d_{kt+1} - s_{kt+1}) (\mu + x) M_t + d_{t+1} x_{t+1}^d M_t + s_{t+1} (1 + x) M_t$$

  $$r^m_{t+1} = \frac{Z_{t+1} + \tilde{Q}_{t+1} (1 - d_{t+1} - s_{t+1}) (1 - \mu)}{Q_t} - 1$$

Bank’s Problem
Bank's Problem

\[ V_{t-1}(M_{t-1}, N_{t-1}) = \max_{\{M_{t+\tau}, B_{t+\tau}\}} E_t \sum_{\tau=0}^{\infty} \beta_b^{\tau+1} \omega \left[ N_{t-1+\tau} + \Pi_{t+\tau} \right] \]

\[ = \max_{\{M_t, B_t\}} E_t \left[ \omega \left[ N_{t-1} + \Pi_t \right] + V_t(M_t, N_t) \right] \]

s.t.

\[ Q_t M_t = B_t + N_t \]

\[ N_{t+1} = (1 - \omega) \left[ N_t + \Pi_{t+1} \right] \]

\[ \Pi_t = r_t^m Q_{t-1} M_{t-1} - r B_{t-1} - \Phi \left( \frac{Q_{t-1} M_{t-1}}{N_{t-1}} \right) \]

\[ r_t^m = \frac{Z_t + \tilde{Q}_t (1 - d_t - s_t) (1 - \mu)}{Q_{t-1}} - 1 \]

\[ Z_t = (1 - d_{kt} - s_{kt}) (\mu + x) + d_t x_t^d + s_t (1 + x) \]
Banking Sector

\[ N = (1 - \omega) \left[ (1 + r) N + (r^m - r - \Phi(L))QM \right] \]

\[ r^m - r - \Phi(L) - \Phi'(L)L = 0 \]

▶ Then

\[ 1 = (1 - \omega) \left[ 1 + r + \Phi'(L)L^2 \right] \]

▶ If \((1 - \omega)(1 + r) = 1\)

\[ L \leq \bar{L} \quad r^m - r = 0 \]

▶ If \((1 - \omega)(1 + r) > 1\)

\[ L > \bar{L} \quad r^m - r > 0 \]
Equilibrium

Given the **initial** distributions $\Gamma_H(\Lambda_h, 0)$, $\Gamma_M(\Lambda_r, 0)$ and $\Gamma_{NM}(\Lambda_r, 0)$ over $\Lambda_h = (y, a, h, m, \delta_h)$ and $\Lambda_r = (y, a)$; net worth $N_0$ and asset composition $Q_0M_0$; initial stock of own-occupied $H_O$ and rental $H_R$ houses and an exogenous $r$, the equilibrium is defined as

- sequence of house prices $\{p^h_t\}$, rents $\{p^r_t\}$, mortgage price function $\{q_t(y, a', m', h')\}$ and funding cost of banks $\{r^c_t\}$ for $t \geq 1$
- sequence of decision rules and distributions of homeowners $\Gamma_H(\Lambda_h, t)$, renters $\Gamma_j(\Lambda_r, t), j \in \{M, NM\}$ for $t \geq 1$
- Evolution of $N_t$ and asset composition $Q_tM_t$ for $t \geq 1$

such that:

- Decision rules are optimal given prices sequences
- Rents satisfy zero profit condition
- Cost of funding and individual mortgage prices satisfy the bank’s problem
- Demand for owner-occupied house equals supply
- Distributions are implied by the sequence of optimal decision rules and initial distributions