Home Equity Extraction and the Boom-Bust Cycle in Consumption and Residential Investment

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Disclaimer: The views in this presentation are solely the responsibility of the author and should not be interpreted as reflecting the views of the Bank of Canada.
U.S. Consumption and Home Equity-Based Borrowing

- Consumption (detrended)
- Home equity cashed out (billions 2009 $)

Quarter:
- 2000q1
- 2005q1
- 2010q1
- 2015q1

Graph showing home equity cashed out and consumption over quarters from 2000q1 to 2015q1.
U.S. Consumption Cycle in the 2000s

- The conventional view:
  - The spending of homeowners created large fluctuations in aggregate consumption.
  - Their spending was financed by increased mortgage debt, through cash-out refinancing, second mortgages, HELOCs, home sales, etc.

- Focus of this paper
  - Requires data that match borrowing and spending.

Focus of the previous empirical work

Focus of this paper

Requires data that match borrowing and spending
The conventional view:

- The **spending of homeowners** created large fluctuations in aggregate consumption.
- Their spending was financed by increased mortgage debt, through cash-out refinancing, second mortgages, HELOCs, home sales, etc.

Focus of the previous empirical work

Focus of this paper

- Requires data that match borrowing and spending...
U.S. Consumption Cycle in the 2000s

- The conventional view:
  - The **spending of homeowners** created large fluctuations in aggregate consumption.
  - Their spending was financed by increased mortgage debt, through cash-out refinancing, second mortgages, HELOCs, home sales, etc.

- Focus of the previous empirical work
- Focus of this paper
  - Requires data that match borrowing and spending
Question # 1

Did homeowners really spend most of their home equity on consumption?

- Micro data show that they did not.
- Increased mortgage debt was mainly used for housing investment
  (i) Purchasing a larger home
  (ii) Making home improvements
  (iii) Buying a second home or investing in real estate
- Young homeowners spent disproportionately more of their borrowed funds on housing investment.
Question # 2

Can a structural model help us explain why homeowners spent a substantial fraction of their borrowed funds on housing investment?

- The model needs to account for the rich heterogeneity in the micro data
  - across household borrowing status
  - across different spending types
  - across household age

- A heterogeneous-agent life-cycle model

- Structural interpretation of the evidence
  - Key mechanism: Interaction of life-cycle demand for housing with borrowing frictions
  - Housing investment is lumpy, is mainly made by young homeowners, and is debt-financed.
Question # 3

Can this model also capture the boom-bust cycles in aggregate consumption and housing investment?

- No presumption that a model calibrated based on micro data can also match macro data.
- If the model can, it is useful for policy analysis.
Outline of the Paper

1. Provide new empirical evidence
   ▶ Intensive margin: spending out of increased mortgage debt
   ▶ Extensive margin: response of borrowing propensity to shocks
   ▶ Heterogeneity: spending and borrowing across household age

2. Calibrate a quantitative life-cycle model and evaluate the model fit
   ▶ Life-cycle profiles: income, wealth, consumption and housing investment
   ▶ Cross-sectional patterns: micro-level evidence
   ▶ Time-series evidence: boom-bust cycles in aggregate data

3. Conduct two policy experiments
   ▶ Remove the housing collateral channel
   ▶ Set the mortgage rate constant over the 2000s
- Nationally representative household sample with a long panel structure
- Detailed information on income, wealth, expenditures, and mortgages
- Link households’ borrowing to their spending

Sample selection
- Homeowners
- Households of working age (the head’s age: 26-65)
- Not owning business or farm
- Income ≥ 0, and home value ≥ $5,000

Define home equity extraction as an *increase in mortgage debt*
- Total mortgage balance increases by at least 5%, and the increase exceeds $1,000.
Fact # 1. Increased mortgage debt tends to finance housing investment

- **Investment types**
  1. Home upgrading
  2. Home improvement
  3. Buying a second home/Investing in real estate

- **Logit specification**

\[
Invest_{i,t}^j = \alpha_0 + \alpha_1 Extract_{i,t} + X_{i,t} \alpha + \gamma_t + e_{i,t}
\]

- $j$: investment type; $i$: household; $t$: time
- $Invest_{i,t}^j = 1$, if household $i$ makes a type $j$ investment
- $Extract_{i,t} = 1$, if household $i$ increases mortgage borrowing
<table>
<thead>
<tr>
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<td>0.137** (0.011)</td>
<td>0.089** (0.010)</td>
<td>0.082** (0.013)</td>
</tr>
<tr>
<td><strong>ii. Propensity to upgrade home</strong></td>
<td></td>
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</tr>
<tr>
<td>Extract = 1</td>
<td>0.085** (0.004)</td>
<td>0.202** (0.014)</td>
<td>0.112** (0.009)</td>
<td>0.048** (0.006)</td>
<td>0.028** (0.005)</td>
</tr>
<tr>
<td><strong>iii. Propensity to make home improvements</strong></td>
<td></td>
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<tr>
<td>Extract = 1</td>
<td>0.051** (0.005)</td>
<td>0.064** (0.012)</td>
<td>0.045** (0.010)</td>
<td>0.042** (0.009)</td>
<td>0.060** (0.012)</td>
</tr>
<tr>
<td><strong>iv. Propensity to invest in real estate</strong></td>
<td></td>
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<tr>
<td>Extract = 1</td>
<td>0.012** (0.003)</td>
<td>0.012 (0.007)</td>
<td>0.016** (0.005)</td>
<td>0.013* (0.005)</td>
<td>0.008 (0.006)</td>
</tr>
</tbody>
</table>
Fact # 2. Housing investment expenditures grow the most when homeowners extract home equity

- **Expenditures**
  - **Consumption**
    - nondurable
    - durables
    - services
  - **Housing investment**
    - home upgrading
    - home improvement
    - investment in real estate

- **Linear specification**

\[
\frac{\Delta Exp^k_{i,t}}{Total Exp^k_{i,t-1}} = \beta_0 + \beta_1 Extract_{i,t} + X_{i,t} \beta + \gamma_t + e_{i,t}
\]

\( k \): expenditure category \( k \)
Dependent Variable: $\frac{\Delta Exp_k^t}{TotalExp_{t-1}}$, where $k$ denotes the type of expenditures

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Consumption</th>
<th>Housing</th>
<th>Consumption Non-durable</th>
<th>Durable</th>
<th>Services</th>
<th>Services mortgage</th>
<th>Others</th>
<th>Move-up</th>
<th>Housing Improvement</th>
<th>Real estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Extract = 1$</td>
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<td></td>
<td>0.193**</td>
<td>0.079**</td>
<td>0.115*</td>
<td>-0.011</td>
<td>-0.006</td>
<td>0.096**</td>
<td>0.089**</td>
<td>0.007</td>
<td>0.131**</td>
<td>0.011</td>
<td>-0.027</td>
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<td></td>
<td>(0.057)</td>
<td>(0.016)</td>
<td>(0.053)</td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.011)</td>
<td>(0.007)</td>
<td>(0.008)</td>
<td>(0.042)</td>
<td>(0.007)</td>
<td>(0.018)</td>
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<tr>
<td>Demographics</td>
<td>Y Y Y Y</td>
<td></td>
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<td>Y Y Y Y</td>
<td>Y Y Y</td>
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<td>Y Y Y</td>
<td>Y Y Y</td>
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<tr>
<td>Other Controls</td>
<td>Y Y Y Y</td>
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<td>Year Dummies</td>
<td>Y Y Y Y</td>
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<tr>
<td># Obs.</td>
<td>15,994</td>
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</tr>
<tr>
<td>Expenditure share (%)</td>
<td>100</td>
<td>91.0</td>
<td>9.0</td>
<td>24.9</td>
<td>6.5</td>
<td>59.6</td>
<td>20.7</td>
<td>38.9</td>
<td>4.2</td>
<td>3.3</td>
<td>1.5</td>
</tr>
</tbody>
</table>

- **Heterogeneity**: the difference in housing expenditure growth decreases with age.
Fact # 3. For a $1 increase in mortgage debt, housing investment expenditures increase by about 40 cents.

- Linear specification

\[ \triangle \text{Exp}_i,t = \delta_0 + \delta_1 \triangle \text{MortgageBalance}_i,t + X_{i,t} \delta + \gamma_t + e_{i,t} \]

<table>
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<tr>
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PSID 1999 - 2015:
Change in expenditures for a $1 increase in mortgage debt

▶ Consumption (excl. mortgage payments) increases by no more than 5 cents.
▶ Housing investment increases by 40 cents on average.
Shock # 1. House price shocks

- Logit specification

\[
Extract_{i,t} = \theta_0 + \theta_1 \Delta p_{i,t} + \theta_2 \Delta p_{i,t} \times LTV_{i,t-1} + \theta_3 LTV_{i,t-1} + X_{i,t} \theta + \gamma_t + e_{i,t}
\]

\(\Delta p_{i,t}\): household-level house price growth rate

\(LTV_{i,t-1}\): loan-to-value ratio in the previous period (standardized)

\begin{tabular}{lcccccc}
\hline
 & All homeowners & 26-35 & 36-45 & 46-55 & 56-65 \\
\hline
\(\Delta p_{i,t}\) & 0.310** & 0.461** & 0.372** & 0.225** & 0.139** \\
 & (0.014) & (0.025) & (0.027) & (0.025) & (0.021) \\
\(\Delta p_{i,t} \times LTV_{i,t-1}\) & 0.128** & 0.219** & 0.166** & 0.095** & 0.001 \\
 & (0.014) & (0.029) & (0.029) & (0.023) & (0.014) \\
\hline
\end{tabular}
Shock # 2. Mortgage rate shocks

- In the PSID, homeowners who have a mortgage report their mortgage rate.
- I use household-level variation in mortgage rate in the previous period.

\[ Extract_{i,t} = \eta_0 + \eta_1 r^b_{i,t-1} + \eta_2 r^b_{i,t-1} \times LTV_{i,t-1} + \eta_3 \Delta p_{i,t} + \eta_3 \Delta p_{i,t} \times LTV_{i,t-1} + \eta_5 LTV_{i,t-1} + X_{i,t} \theta + \gamma_t + e_{i,t} \]

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<td>( r^b_{i,t-1} )</td>
<td>0.884**</td>
<td>0.271</td>
<td>1.259**</td>
<td>1.161*</td>
<td>0.271</td>
</tr>
<tr>
<td></td>
<td>(0.266)</td>
<td>(0.602)</td>
<td>(0.421)</td>
<td>(0.471)</td>
<td>(0.480)</td>
</tr>
<tr>
<td>( r^b_{i,t-1} \times LTV_{i,t-1} )</td>
<td>0.150</td>
<td>0.754</td>
<td>0.527</td>
<td>-0.368</td>
<td>0.566</td>
</tr>
<tr>
<td></td>
<td>(0.205)</td>
<td>(0.574)</td>
<td>(0.389)</td>
<td>(0.399)</td>
<td>(0.323)</td>
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General features
- A partial-equilibrium life-cycle model adapted from Berger et al.(2017)
- The main sources of heterogeneity are uninsurable labor income shocks.
- At birth, households are endowed with a small house and a mortgage.
- Life-cycle choices: consumption, liquid savings, whether to adjust mortgage debt and by how much, and how much to invest in housing.

Mortgage markets
- Long-term debt: amortized over the rest of the borrower’s life
- The LTV requirement has to be satisfied (only) at mortgage origination.
- Adjustment of the mortgage debt level is subject to fixed costs.
- Adjustment of the mortgage rate is costless.

Key differences from Berger et al.
- Distinction between long-term mortgage debt and liquid assets
- Empirical evaluation of the model

Calibration
- 6 parameters for preferences/demographics; 5 for income process;
  3 parameters for housing/mortgage markets;
  7 parameters for initial states/steady state aggregate prices
Model Evaluation: Life-cycle profiles

- **Income**
  - Model (black lines)
  - PSID data (red asterisks)

- **Total wealth**
  - Model (black lines)
  - PSID data (red asterisks)

- **Liquid savings**
  - Model (black lines)
  - PSID data (red asterisks)

- **Housing investment**
  - Model (black lines)
  - PSID data (red asterisks)

- **Consumption**
  - Model (black lines)
  - PSID data (red asterisks)
  - CE data (blue asterisks)
Fact # 1. Increased mortgage debt tends to finance housing investment

- Logit specification

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<td>(.006)</td>
<td>(.013)</td>
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<td>(.010)</td>
<td>(.013)</td>
</tr>
<tr>
<td>Model</td>
<td>0.132**</td>
<td>0.191**</td>
<td>0.138**</td>
<td>-0.001</td>
<td>-0.417**</td>
</tr>
<tr>
<td></td>
<td>(.004)</td>
<td>(.008)</td>
<td>(.008)</td>
<td>(.013)</td>
<td>(.049)</td>
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Fact # 2. Housing investment expenditures grow the most when homeowners extract home equity

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<td>(.057)</td>
<td>(.016)</td>
<td>(.053)</td>
<td>(.073)</td>
<td>(.160)</td>
<td>(.026)</td>
<td>(.086)</td>
</tr>
<tr>
<td>Model</td>
<td>0.142**</td>
<td>0.021**</td>
<td>0.122**</td>
<td>0.169**</td>
<td>0.129**</td>
<td>0.077**</td>
<td>0.014**</td>
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<tr>
<td></td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.002)</td>
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<td>(.002)</td>
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Fact # 3. For a $1 increase in mortgage debt, housing investment expenditures increase by about 40 cents.

▶ Linear specification

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<td>0.500**</td>
<td>0.121**</td>
<td>0.379**</td>
<td>0.630**</td>
<td>0.524**</td>
<td>0.251**</td>
<td>0.127</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.013)</td>
<td>(0.036)</td>
<td>(0.063)</td>
<td>(0.065)</td>
<td>(0.053)</td>
<td>(0.080)</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>0.506**</td>
<td>0.057**</td>
<td>0.449**</td>
<td>0.777**</td>
<td>0.607**</td>
<td>0.376**</td>
<td>0.183**</td>
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<tr>
<td></td>
<td>(0.006)</td>
<td>(0.001)</td>
<td>(0.005)</td>
<td>(0.007)</td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.010)</td>
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Responses of borrowing propensity to

- Response to $p$ shock: monotonically decreasing (as in the data)
- Response to $r^b$ shock: not monotonic (as in the data)
Approach: Feed the U.S. historical data for the relevant prices into the model

Expectation: Prices in the future equal the current price
(Robust to alternative assumptions)
Policy Experiments: The Role of the Housing Collateral Channel in Explaining Consumption Volatility in the 2000s

- **Experiment # 1.** Remove the housing collateral channel
  - Houses provide services, but have no collateral value.
  - Consumption and housing investment are financed by liquid savings.
  - Consumption volatility in the 2000s would have been reduced by 88%.

- **Experiment # 2.** Set the mortgage rate at the year 2000 level
  - Remove the effect of a changing mortgage rate, and any interaction between the mortgage rate and house prices
  - Consumption volatility in the 2000s would have been reduced by 75%.
The conventional view has been that extracted home equity was mostly spent on consumption, which led to the consumption boom-bust cycle.

Quantitative models hence focus on the role of home equity-based borrowing in explaining consumption fluctuations.

Using micro data, I show that most of the borrowed funds was used for housing investment, not consumption.

Why does this distinction matter?

- Housing investment changes the distribution of housing stock and debt
- Consumption responses to shocks depend on the endogenous distribution of housing stock and debt (Berger et al. 2017)

A life-cycle model rationalizes the micro-level findings and can capture the boom-bust cycles in the aggregate data.

⇒ The model is useful for policy analysis.

- The housing collateral channel played an important role in driving the fluctuations in consumption and residential investment in the 2000s.
Additional Slides
Household Problem

- **Preference**
  \[ E_0 \left[ \sum_{j=0}^{J-1} \beta^j u(c_j, h_j) + \beta^J \Phi(w_J) \right] \]
  - Utility from bequest

- **Assets**
  - Liquid savings: \( a \)
  - Mortgage balance: \( b \)
  - Collateral asset: \( h \)

- **Idiosyncratic income shocks in the working ages; fixed income during retirement**
  \[ \log(y^i_j) = \chi_j + z^i_j \]
  - Total income
  - Deterministic
  - Idiosyncratic, AR(1)

- **Aggregate shocks**
  - House price: \( p \)
  - Mortgage rate: \( r^b \)
  - Cost of housing investment: \( p^I \)
At age $j$, value of adjusting mortgage debt

$$V_j^C(h, b, a, y; S) = \max_{h', b', a', c} \ u(c, h) + \beta E_j \left[ V_{j+1}(h', b', a', y'; S') \right]$$

s.t. \[ c + a' + p^I \left[ h' - h(1 - \delta) \right] = y + (1 + r^a)a - (1 + r^b)b + b' - F \]

- **LTV requirement** \[ 0 \leq b' \leq \gamma ph \]
- **Irreversible investment** \[ h' \geq (1 - \delta)h \]
- **Borrowing constraint** \[ a' \geq 0 \]

$F$: mortgage adjustment cost
At age $j$, value of not adjusting

$$V_j^N(h, b, a, y; S) = \max_{h', a', c} \left[ u(c, h) + \beta E_j \left[ V_{j+1}(h', b', a', y'; S') \right] \right]$$

s.t.  \[ c + a' + p^I \left[ h' - h(1 - \delta) \right] = y + (1 + r^a)a - M \]

\[ b' = (1 + r^b)b - M \]

\[ h' \geq (1 - \delta)h \]

\[ a' \geq 0 \]

$M$: scheduled payment

Value function at age $j$

$$V_j = \max\{V_j^C, V_j^N\}$$
Calibration

Preference
\[
\frac{(c^\alpha h^{1-\alpha})^{1-\sigma}}{1-\sigma}
\]
Cobb-Douglas utility
\[
\sigma
\]
Inverse of IES
\[
\alpha
\]
Exp. share of $c$
\[
\beta
\]
Discount factor

Housing and Mortgage
\[
F
\]
Adjustment cost
\[
\theta
\]
Down payment
\[
\delta
\]
Depreciation rate

Income process
\[
\chi_j
\]
Deterministic age profile
\[
\rho
\]
Persistence
\[
\sigma_{ez}
\]
Volatility

Estimated from PSID
FRB Consumer’s Guide
Berger et al. (2015)
BEA
Standard
Match life-cycle housing investment profile
Match life-cycle wealth profile

Back
Two-step procedure

1. Solve the value functions $V_j^C$ and $V_j^N$ over fixed grids
   
   (i) Discretize the state space $(h, b, a, y)$ using $20 \times 20 \times 10 \times 5$
   
   (ii) To obtain $V_j^C(h, b, a, y)$, construct a choice set
   
   \[ \{ h'_C(h, b, a, y), b'_C(h, b, a, y), a'_C(h, b, a, y) \} \]
   
   which takes all constraints into account. $V_j^C(h, b, a, y) = \max_{h'_C, b'_C, a'_C} V_j^C(h, b, a, y)$
   
   (iii) Multi-dimensional linear interpolation method is used to compute the continuation value.

   (iv) $V_j^N(h, b, a, y)$ is computed similarly, and $V_j = \max\{V_j^C, V_j^N\}$.

2. Solve the optimal choices over finer choice sets

   (i) Given $(h, b, a, y, j)$, solve the optimal choices similar to (ii) and (iii) above.

   (ii) Use 4 times more of the choices for each choice variable.