A Policy Model for Analyzing Macroprudential and Monetary Policies

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Recent global financial crisis was a reminder that the real economy and the financial system are closely linked

- financial system can be a source of shocks
- and can amplify/propagate shocks originating elsewhere

**Theoretical front:** renewed interest in incorporating real-financial linkages into DSGE models

**Policy front:** new emphasis on the role of macroprudential regulations and coordination with monetary policy
Since the crisis, monetary policy in Canada has faced important challenges/tradeoffs:

- external headwinds necessitated policy rate to remain low
- low interest rates and safe-haven flows have led to a rise in HH debt

Flexible inflation targeting framework already allows consideration of financial stability issues in setting monetary policy.

Macroprudential regulations can provide more targeted tools to achieve financial stability:

- increase in capital requirements (Basel III); lowering regulatory LTV
- important to assess effectiveness of these policies in reducing household debt and their macroeconomic costs
HH debt-to-income ratio increased rapidly since mid-2000s
In this paper

- We build a medium scale, small-open-economy DSGE model with
  - **real-financial linkages:** balance sheet positions of banks, households, and firms affect funding/lending conditions and the real economy
  - **macroprudential policies:** capital requirements; LTV
  - **nominal and real frictions:** monetary policy and propagation

- We use the model to analyze
  - effects of macroprudential policies on real and financial variables
  - transmission of financial shocks (e.g. exuberance, risk premium)
Related literature: Balance sheet channel

- Asset prices and borrowers’ balance sheet positions are key determinants of borrowing conditions (spreads; quantity constraints)
  - *agency-cost*: Carlstrom and Fuerst (1997); Bernanke et al. (1997); Aoki et al. (2004)
  - *collateral constraint*: Kiyotaki and Moore (1997); Iacoviello (2005)

- **Financial accelerator**: shocks are amplified through their effects on asset prices/borrowing conditions

\[
q_k \uparrow \implies n_E \uparrow, \quad q_k k_E / n_E \downarrow \implies \text{spread} \downarrow \implies b_E \uparrow \implies q_k \uparrow
\]

<table>
<thead>
<tr>
<th>Entrepreneurs</th>
<th>Assets</th>
<th>Liabilities</th>
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<tbody>
<tr>
<td></td>
<td>$q_k k_E$</td>
<td>$b_E$</td>
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<tr>
<th>Households</th>
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<td>$q_h h_I$</td>
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Related literature: Bank capital channel

- Balance sheet/capital position of financial intermediaries is key for their funding (and lending) conditions
  - *moral hazard*: Holmstrom and Tirole (1997); Meh and Moran (2010); Gertler and Karadi (2010)
  - *bank default*: Davis (2010); *regulation*: Gerali et al. (2010)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
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<tr>
<td>Loans (HHs, firms)</td>
<td>Retail deposits</td>
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<tr>
<td>Securities</td>
<td>Wholesale funding</td>
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<td>Equity (bank capital)</td>
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- **Adverse feedback loop:** deterioration in borrower balance sheets reduce bank capital and cause further adverse effects on lending

- **Banks’ "trading book":** marked-to-market accounting; quicker pass-through of asset price fluctuations to bank capital
Wholesale funding, new "bank-runs", and **fire-sale externalities**
- Diamond and Rajan (2005); Kiyotaki and Moore (2012); Woodford (2012)

Funding liquidity, search-for-yield, govt. guarantees and risk-taking
- Brunnermeier and Pederson (2008); Rajan (2006); Farhi and Tirole (2009); Adrian and Shin (2010)
- **risk-taking channel:** during low interest rate episodes, banks can build up risks on both asset and liability sides of their balance sheet

**Irrational exuberance** and asset prices
- Shiller (2000); Bernanke and Gertler (1999); Basant Roi and Mendes (2007); Granziera and Kozicki (2012)
Model

- Small-open-economy DSGE model with **financial frictions**
  - HH lending to banks, and bank lending to HHs/firms involve **monitoring costs** (Curdia and Woodford, 2011)
  - **spreads** in funding/lending rates depend on bank and borrower leverage (Bernanke et al., 1999; Davis, 2010)
  - **macroprudential policies** feed into spreads
  - **financial shocks** (e.g. capital quality; spreads; exuberance)

- Other key features
  - **nominal frictions**: price/wage stickiness; indexation
  - **real frictions**: habit formation; utilization and investment adj. costs
  - **open economy**: extended UIP condition; partial pass-through
  - **monetary policy**: Taylor rule
Brief overview of the model
Banks

- Use deposits and bank capital to fund lending to impatient households and entrepreneurs
  \[ P_{l,t} b_{l,t} + P_{E,t} b_{E,t} = D_t + A_t \]

- Pay dividends to patient HHs; dividend smoothing based on adj. costs (Jermann and Quadrini, 2012)

- Bank loans are modeled as perpetuities with exponentially decaying coupon payments (Woodford, 2001)
Banks’ cash-flow

- Bank loan issued in \( t - 1 \) would be priced in period \( t \) as 
  \[ \left( \frac{\delta}{\pi_t} \right) \cdot P_{l,t} \]; allows recursive formulation for banks’ cash-flow
  \[
  D_{B,t} + R_{d,t-1} D_{t-1} + (1 + \gamma_{l,t}) P_{l,t} b_{l,t} + (1 + \gamma_{E,t}) P_{E,t} b_{E,t} \\
  \leq \left( P_{t-1} + \frac{\delta_{l} P_{l,t}}{\pi_t} \right) b_{l,t-1} + \left( P_{t-1} + \frac{\delta_{E} P_{E,t}}{\pi_t} \right) b_{E,t-1} + D_t - \text{adj.}
  \]

- Bank assets can also be thought as asset-backed securities (ABS), backed by a portfolio of bank loans
  - inverse relation between relative price of loan and its gross nominal yield
    \[
    R_{l,t} = \frac{P_{t}}{P_{l,t}} + \delta_{l} \quad \text{and} \quad R_{E,t} = \frac{P_{t}}{P_{E,t}} + \delta_{E}
    \]
Banks incur monitoring costs on the value of their outstanding lending (Curdia and Woodford, 2011) captures "bad loans"/default; cost of purchasing default insurance

Monitoring costs increase with borrower leverage

$$\Upsilon_{E,t} = f \left( \frac{q_{k,t} k_{E,t}}{n_{E,t}}, \varepsilon_{E,t} \right)$$

generate lending spread similar to financial accelerator model of BGG

Monitoring costs for bank lending to HHs and bank funding are modeled similarly

modeling choice captures main themes in literature while avoiding technical issues (long-term borrowing; risk-averse borrowers)
Key equilibrium conditions

- Bank funding and lending to impatient HHs:

\[
1 = E_t \left[ \left( \beta_B \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \frac{\lambda_{B,t+1}}{\lambda_{B,t}} \right) \frac{R_{d,t}}{\pi_{t+1}} \right] \\
\frac{1 + Y_{l,t}}{R_{l,t} - \delta_l} = E_t \left[ \left( \beta_B \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \frac{\lambda_{B,t+1}}{\lambda_{B,t}} \right) \frac{R_{l,t+1}}{\pi_{t+1} (R_{l,t+1} - \delta_l)} \right]
\]

- Lending rate (in log-linearized form):

\[
\hat{R}_{l,t} = \left( 1 - \frac{\delta_l}{R_l} \right) \sum_{s=0}^{\infty} \left( \frac{\delta_l}{R_l} \right)^s E_t \left[ \hat{R}_{d,t+s} + \hat{Y}_{l,t+1} \right]
\]

- depends on current and expected future deposit rates and monitoring costs (based on future borrower leverage)
Patient households

- Max. PV of expected utility (consumption with external habits, housing, and labor) s.t. budget constraint
  - **expenditure**: consumption, investment in housing and capital, bank deposits, domestic and foreign gov. bonds
  - **income**: wage, rental income, interest on deposits and gov. bonds, gov. transfers from gov., dividends and profits

- Bank deposits best viewed as wholesale funding (not covered by deposit insurance); patient HHs as "institutional investors"
  - investors incur monitoring costs when lending to banks

\[
\gamma_{d,t} = f \left( \frac{\omega_l P_{I,t} b_{I,t} + \omega_E P_{E,t} b_{E,t}}{A_t}, \varepsilon_{d,t} \right)
\]

- monitoring costs increase with bank leverage where bank assets are "risk-weighted" by \( \omega_I \) and \( \omega_E \)
Combining bank funding and lending spreads

- Short-term bank funding rate equal to interest rate on short-term gov. bonds plus a funding spread (similar to Davis, 2010)
  \[ \hat{R}_{d,t} = \hat{R}_t + \hat{Y}_{d,t} \]

- Long-term rates faced by borrowers depend on
  - long-term gov. bond interest rate (based on expectations hypothesis)
  - current and future bank leverage
  - current and future borrower leverage
  \[ \hat{R}_{l,t} = \left(1 - \frac{\delta_l}{R_l}\right) \sum_{s=0}^{\infty} \left(\frac{\delta_l}{R_l}\right)^s E_t \left[\hat{R}_{t+s} + \hat{Y}_{d,t+s} + \hat{Y}_{l,t+1}\right] \]

- Comovement in funding and lending spreads
  - adverse shocks that reduce asset prices and increase lending premia, also reduce the market value of bank assets ("adverse feedback loop")
Macroprudential policy and spreads

- Our formulation is based on the borrowing constraint framework of Kiyotaki and Moore (1997) and Iacoviello (2005)

\[ p_{I,t} b_{I,t} \leq m_t q_{h,t} h_{I,t} \implies (1 - m_t) q_{h,t} h_{I,t} \leq n_{I,t} \]

- but, translates the impact of LTV policy into lending spread:

\[ \Upsilon_{I,t} = f \left( \frac{(1 - m_t) q_{h,t} h_{I,t}}{n_{I,t}} \right) \]

- Similarly, the impact of bank capital regulations in borrowing constraint framework, \( \gamma_t [\omega_I P_{I,t} b_{I,t} + \omega_E P_{E,t} b_{E,t}] \leq A_t \), is translated into funding spread

\[ \Upsilon_{d,t} = f \left( \frac{\gamma_t [\omega_I P_{I,t} b_{I,t} + \omega_E P_{E,t} b_{E,t}]}{A_t} \right) \]

- regulations do not necessarily bind in the short-run
Asset quality and exuberance shocks

- Beginning-of-period capital stock is given by \((1 - \delta_k) \psi_{k,t} k_{t-1}\), where \(\psi_{k,t}\) is capital-quality/depreciation shock (Gertler and Karadi, 2010)

\[
k_t = (1 - \delta_k) \psi_{k,t} k_{t-1} + \left[ 1 - \frac{\kappa_k}{2} \left( \frac{i_{k,t}}{i_{k,t-1}} - 1 \right)^2 \right] i_{k,t}
\]

- Expected returns also affected by "exuberance" shock, \(\kappa_{k,t}\):

\[
q_{k,t} = E_t \left[ \left( \beta_P \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) \left(1 - \delta_k\right) q_{k,t+1} + r_{kP,t+1} \right] \psi_{k,t+1} \kappa_{k,t}
\]

- Similar set-up for housing

\[
q_{h,t} = \frac{MU_{h,t}}{MU_{c,t}} + E_t \left[ \left( \beta_P \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) (1 - \delta_h) \psi_{h,t+1} \kappa_{h,t} q_{h,t+1} \right]
\]
Borrowers

- Impatient HHs maximize PV of expected utility; $\beta_I < \beta_B$ to facilitate borrowing from banks

- Budget constraint:

  \[ c_{I,t} + q_{h,t} \left[ h_{I,t} - (1 - \delta_h) \psi_{h,t} h_{I,t-1} \right] + \frac{P_{t-1} + \frac{\delta_I}{\pi_t} P_{I,t}}{P_t} b_{I,t-1} \]

  \[ \leq (1 - \tau_I) \frac{W_{I,t}}{P_t} l_{I,t} + \frac{P_{I,t}}{P_t} b_{I,t} + \frac{TR_{I,t}}{P_t} - \text{adj.} \]

- Net worth:

  \[ n_{I,t} = q_{h,t} h_{I,t} - p_{I,t} b_{I,t} \]

- Similar set-up for entrepreneurs which accumulate capital, $k_E$
  - maximize PV of dividends paid to patient HHs; dividend smoothing
Domestic production

- Monopolistically-competitive domestic firms produce intermediate goods:

\[ y_{d,t} = z_t \left[ (u_{P,t} k_{P,t-1})^{\mu_k} (u_{E,t} k_{E,t-1})^{1-\mu_k} \right]^\alpha \left[ l_{P,t} l_{L,t} \right]^{1-\alpha} - f_d \]

- Domestic goods can be used as an input in final goods production for consumption goods, investment goods etc.:

\[ c_{d,t} + i_{kd,t} + i_{hd,t} + g_{d,t} + y_{xd,t} = y_{d,t} \]

- quadratic price adjustment costs (Rotemberg, 1982)
- utilization costs affect cash-flow of firms
- distribute profits to patient households
Calibration

Main targets for steady-state:

- 3% risk-free rate; 14 bps. funding spread
- 240 and 200 bps. overall spread on HH and business loans
- mortgage debt / impatient HH housing = 95% \( (b_I / h_I) \)
- mortgage debt / total housing = 30% \( (b_I / h) \)
- business debt / entrep. capital = 0.5 \( (b_E / k_E) \)
- business debt / total capital = 0.25 \( (b_E / k) \)
- bank capital ratio = 10%

Parameters determining dynamics:

- nominal and real frictions: ToTEM
- financial frictions: HRAM; MAG report (BIS)

- $R_l \uparrow \implies q_h \downarrow \implies$ net worth of borrowers and banks $\downarrow \implies R_d, R_E \uparrow$
- $R \downarrow; c_P, h_P \uparrow; $ currency depreciation are moderating factors.
Increasing capital requirements by 1 p.p.

- Bank funding and lending rates $\uparrow \implies$ loans $\downarrow$
- policy rate $\downarrow$; $c_p, h_P, k_P \uparrow$; depreciation are moderating factors
Increasing policy rate by 100 bps.

- Increase in bank funding and lending rates $\implies$ loans ↓
- $c_P \downarrow$ and appreciation $\implies$ "broad tool" to reduce HH debt
Comparing effects of different policies

Table 3. Comparing effects of macroprudential and monetary policies

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<tbody>
<tr>
<td>Output</td>
<td>-0.5</td>
<td>-0.3</td>
<td>-0.5</td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.5</td>
<td>-0.1</td>
<td>-0.2</td>
</tr>
<tr>
<td>Business inv.</td>
<td>-0.8</td>
<td>-1.4</td>
<td>-1.4</td>
</tr>
<tr>
<td>Residential inv.</td>
<td>-6.9</td>
<td>-2.0</td>
<td>-2.4</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.08</td>
<td>-0.03</td>
<td>-0.14</td>
</tr>
<tr>
<td>House price</td>
<td>-4.4</td>
<td>-1.3</td>
<td>-2.4</td>
</tr>
<tr>
<td>HH debt</td>
<td>-7.6</td>
<td>-1.8</td>
<td>-1.8</td>
</tr>
</tbody>
</table>

- LTV most effective in reducing HH debt with less output cost; relative to capital req. and monetary policy.
Exuberance shock to expected returns on housing

- $q_h \uparrow \implies \text{net worth of borrowers and banks} \uparrow \implies R_d, R_I, R_E \downarrow$
- Exuberance can generate a boom in economic activity.
Conclusion

- We build a medium-scale small-open-economy DSGE model with nominal, real and financial frictions
  - captures main themes in real-financial linkages literature while keeping model tractable
  - can be used to analyze effects of macroprudential policy

- Related work/possible extensions:
  - housing-related fiscal policy as a macroprudential tool
  - bank lending for working capital needs of firms
  - retail deposits vs. wholesale funding
  - modeling term-premium vs. credit risk (QE)
  - capital structure of firms and financial assets