A Policy Model for Analyzing Macroprudential and Monetary Policies

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Motivation

- 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

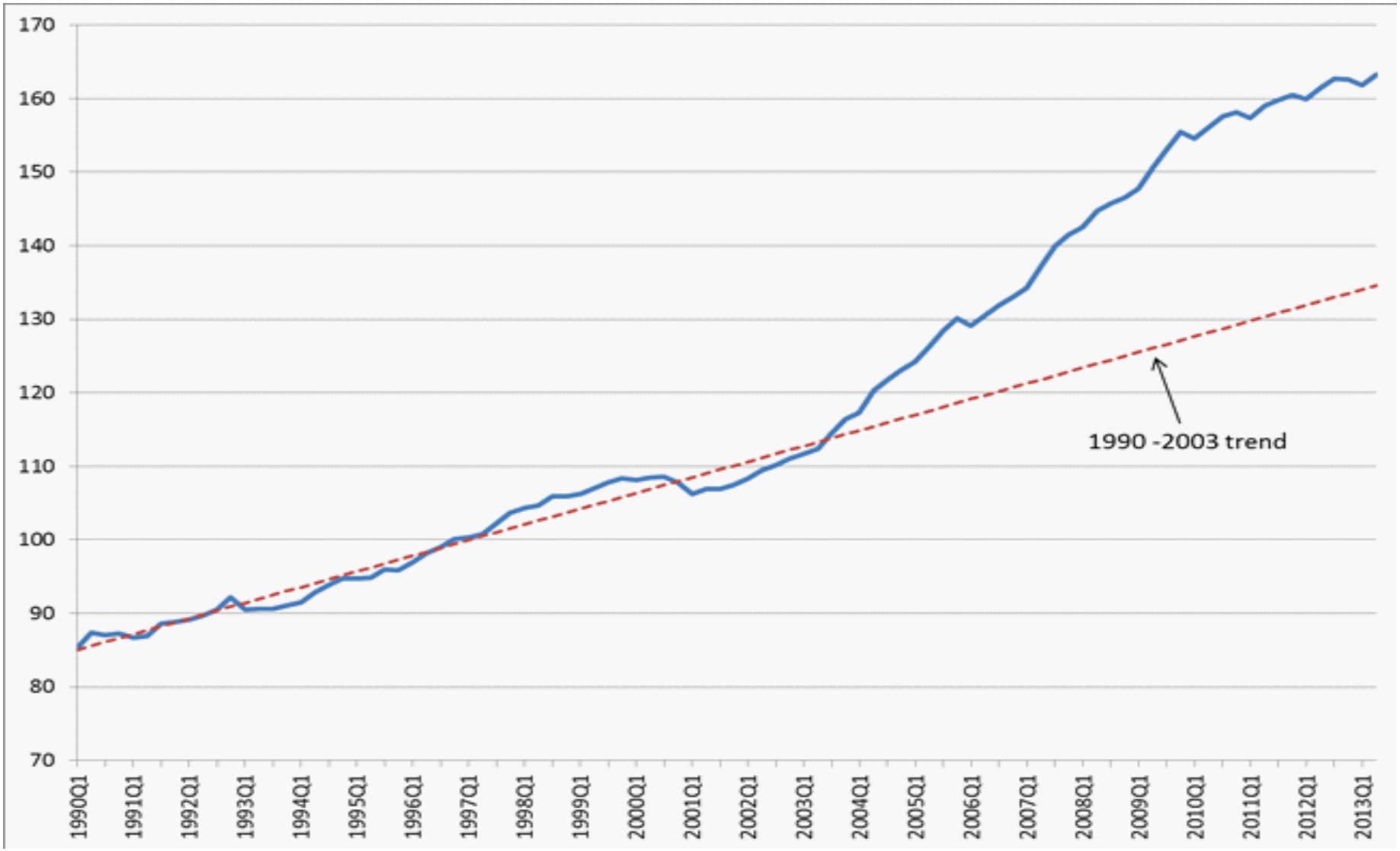
- **Theoretical front:** renewed interest in incorporating real-financial linkages into DSGE models

- **Policy front:** new emphasis on the role of macroprudential regulations and coordination with monetary policy

Canadian context

- 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
  - $q_k \uparrow \Longrightarrow n_E \uparrow,\ q_k k_E / n_E \downarrow \Longrightarrow$ spread $\downarrow \Longrightarrow b_E \uparrow \Longrightarrow q_k \uparrow$

Entrepreneurs

Assets	**Liabilities**
$q_k k_E$	b_E
	n_E

Households

Assets	**Liabilities**
$q_h h_I$	b_I
	n_I

Related literature: Bank capital channel

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

Assets	**Liabilities**
Loans (HHs, firms)	Retail deposits
Securities	Wholesale funding
	Equity (bank capital)

- **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

Related literature: Liquidity, risk-taking and exuberance

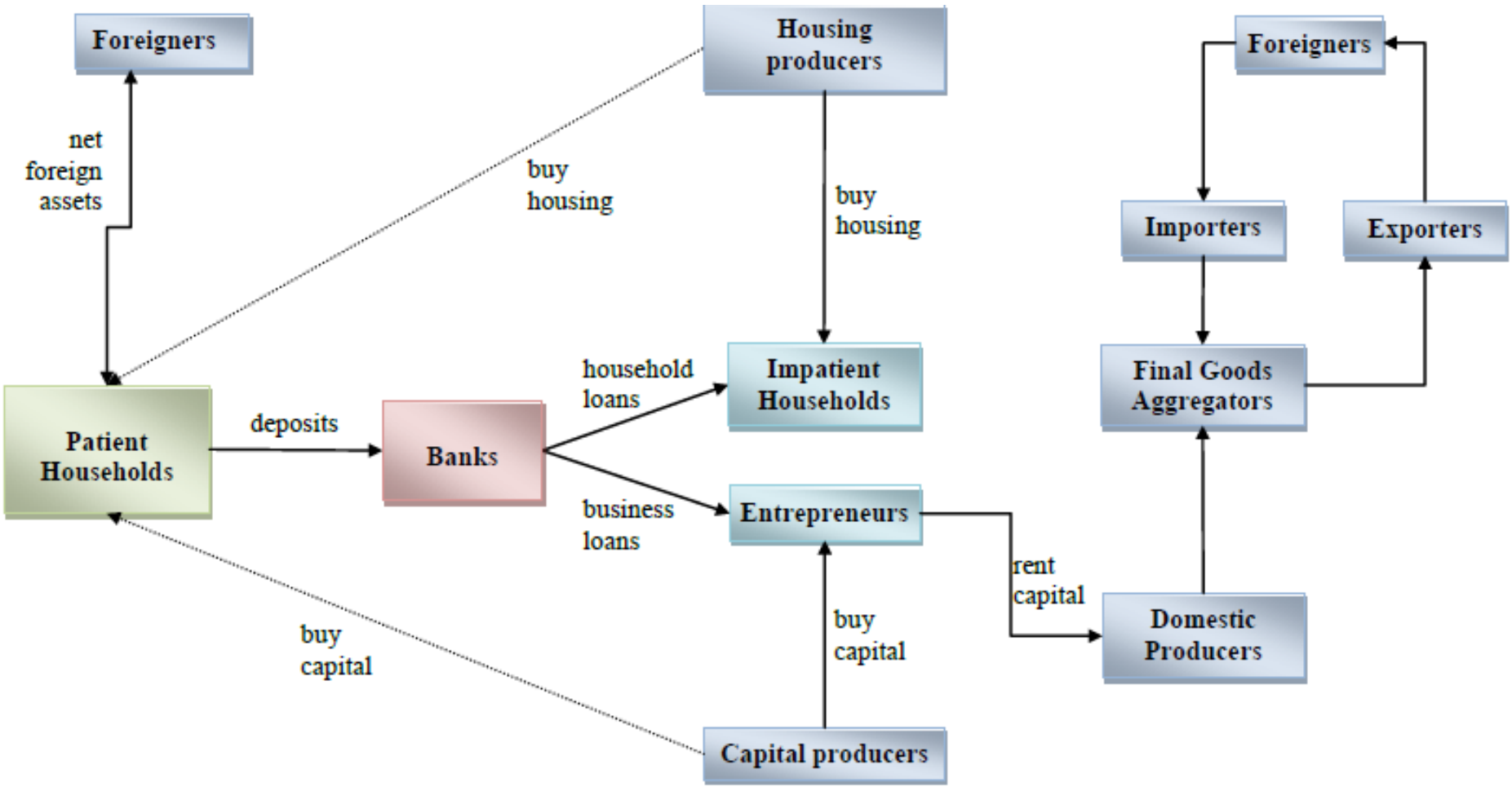
- Wholesale funding, new "bank-runs", and **fire-sale externalities**
  - Diamond and Rajan (2005); Kiyotaki and Moore (2012); Woodford (2012)
- Funding liquidity, search-for-yield, govt. guarantees and risk-taking
  - Brunnermeier and Pederson (2008); Rajan (2006); Farhi and Tirole (2009); Adrian and 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

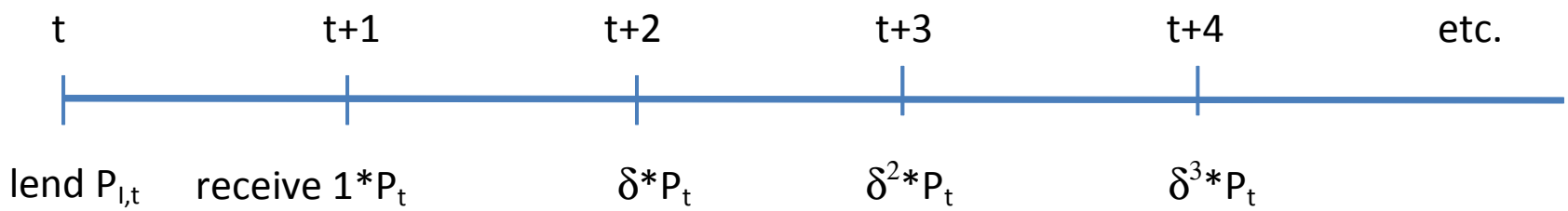


Banks

- Use deposits and bank capital to fund lending to impatient households and entrepreneurs

$$P_{I,t} b_{I,t} + P_{E,t} b_{E,t} = D_t + A_t$$

- 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 $(\delta/\pi_t) * P_{l,t}$; allows recursive formulation for banks' cash-flow

$$D_{B,t} + R_{d,t-1} D_{t-1} + (1 + \Upsilon_{l,t}) P_{l,t} b_{l,t} + (1 + \Upsilon_{E,t}) P_{E,t} b_{E,t}$$
$$\leq \left(P_{t-1} + \frac{\delta_l P_{l,t}}{\pi_t} \right) b_{l,t-1} + \left(P_{t-1} + \frac{\delta_E P_{E,t}}{\pi_t} \right) b_{E,t-1} + D_t - \text{adj.}$$

- 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

$$R_{l,t} = \frac{P_t}{P_{l,t}} + \delta_l \quad \text{and} \quad R_{E,t} = \frac{P_t}{P_{E,t}} + \delta_E$$

Monitoring costs and spreads on lending rates

- 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:

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

$$\frac{1 + \Upsilon_{I,t}}{R_{I,t} - \delta_I} = E_t \left[\left(\beta_B \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \frac{\lambda_{B,t+1}}{\lambda_{B,t}} \right) \frac{R_{I,t+1}}{\pi_{t+1} \left(R_{I,t+1} - \delta_I \right)} \right]$$

- Lending rate (in log-linearized form):

$$\widehat{R}_{I,t} = \left(1 - \frac{\delta_I}{R_I} \right) \sum_{s=0}^{\infty} \left(\frac{\delta_I}{R_I} \right)^s E_t \left[\widehat{R}_{d,t+s} + \widehat{\Upsilon}_{I,t+1} \right]$$

  - 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

$$\Upsilon_{d,t} = f\left(\frac{\omega_l P_{l,t} b_{l,t} + \omega_E P_{E,t} b_{E,t}}{A_t}, \varepsilon_{d,t}\right)$$

  - monitoring costs increase with bank leverage where bank assets are "risk-weighted" by ω_l and ω_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)

$$\widehat{R}_{d,t} = \widehat{R}_t + \widehat{\Upsilon}_{d,t}$$

- 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

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

- 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)

$$p_{I,t} b_{I,t} \leq m_t q_{h,t} h_{I,t} \Longrightarrow (1 - m_t) q_{h,t} h_{I,t} \leq n_{I,t}$$

  - 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, $\gamma_t \left[\omega_I P_{I,t} b_{I,t} + \omega_E P_{E,t} b_{E,t}\right] \leq A_t$, is translated into funding spread

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

  - 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, $\varkappa_{k,t}$:

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

- Similar set-up for housing

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

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:

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

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

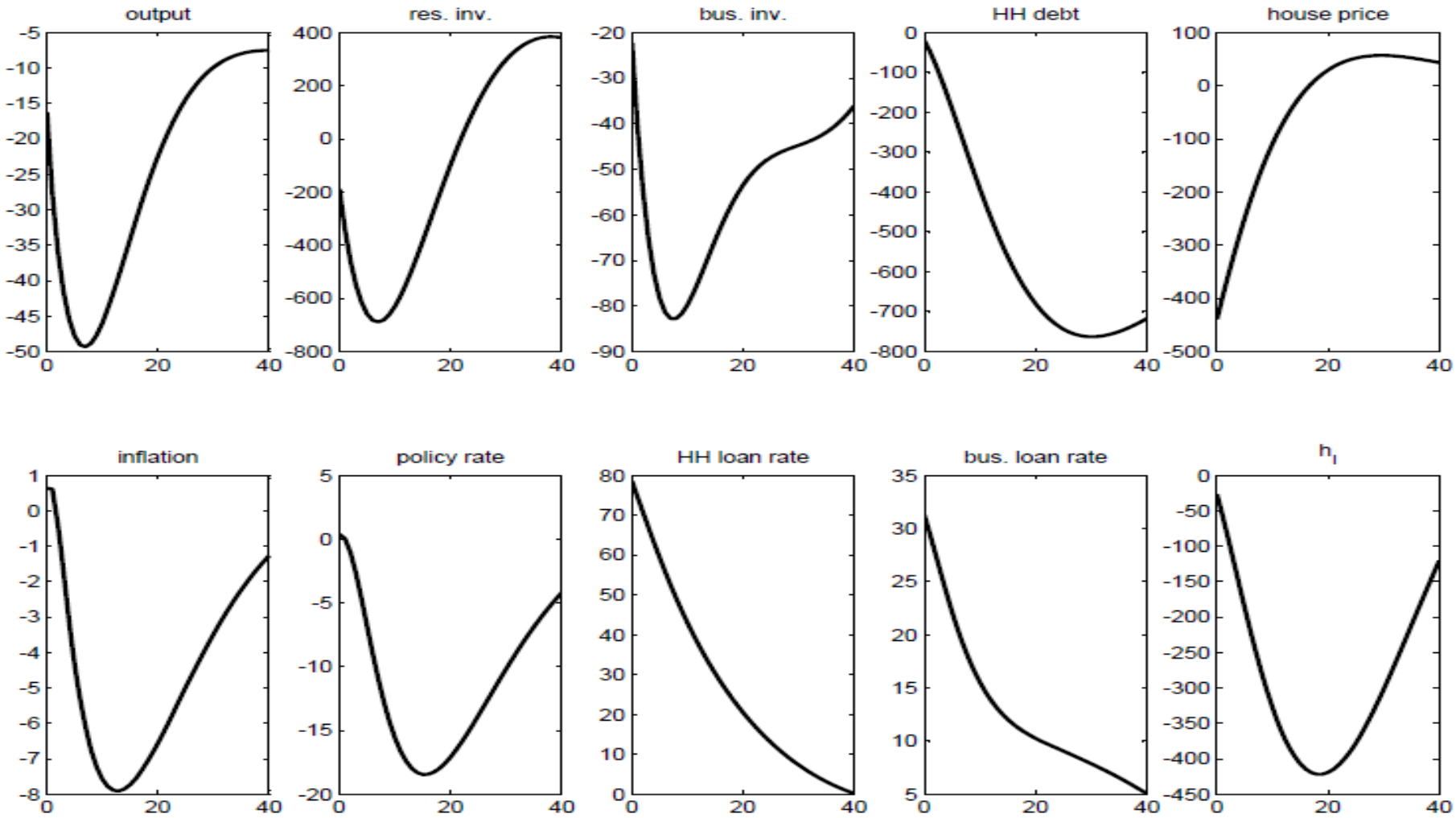
$$c_{d,t} + i_{kd,t} + i_{hd,t} + g_{d,t} + y_{xd,t} = y_{d,t}$$

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

Calibration

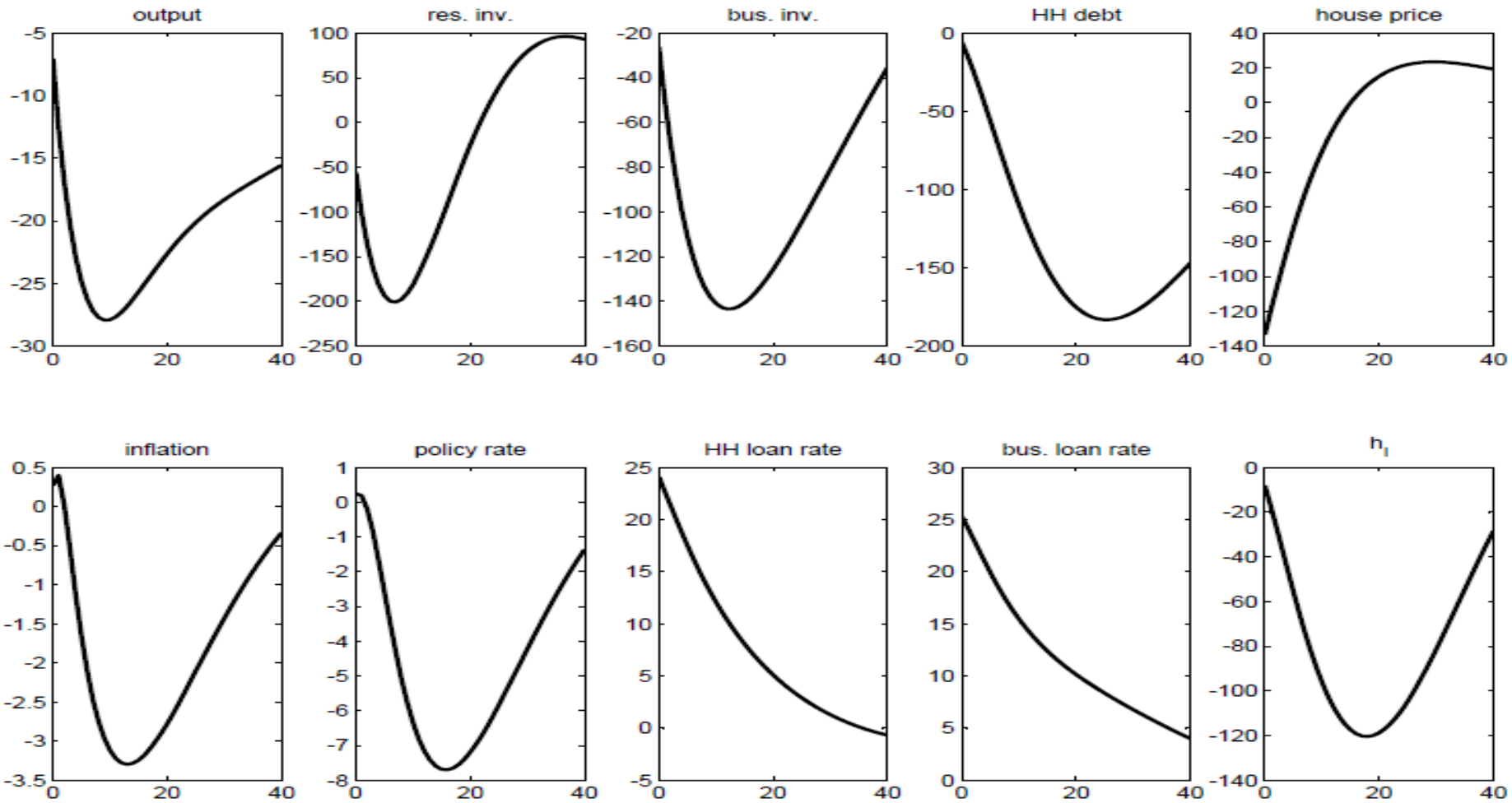
- Main targets for steady-state:
  - 3% risk-free rate; 14 bps. funding spread
  - 240 and 200 bps. overall spread on HH and business loans
  - mortgage debt / impatient HH housing = 95% (b_I / h_I)
  - mortgage debt / total housing = 30% (b_I / h)
  - business debt / entrep. capital = 0.5 (b_E / k_E)
  - 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)

Reducing LTV by 5 p.p.



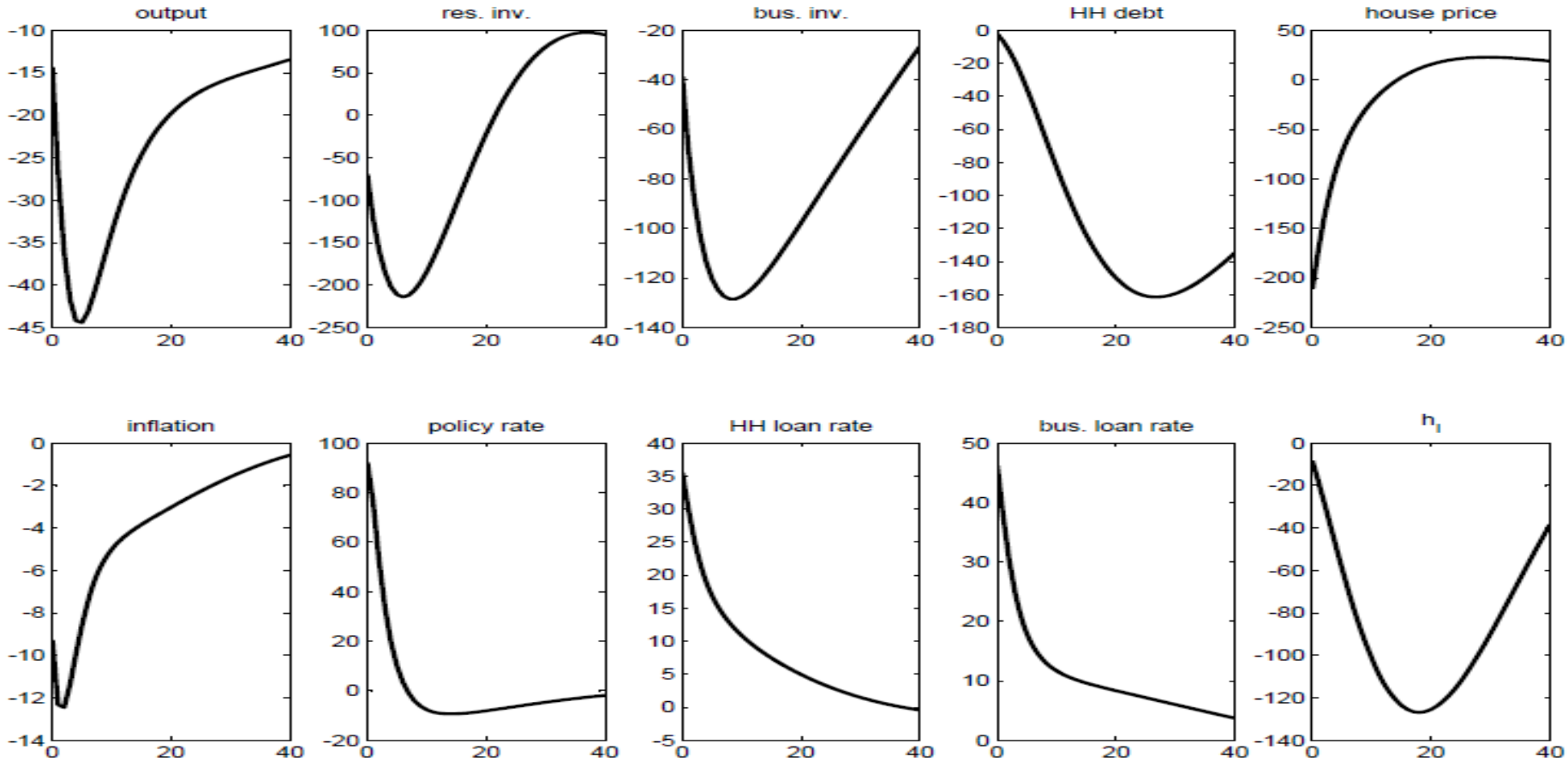
- $R_l \uparrow \Longrightarrow q_h \downarrow \Longrightarrow$ net worth of borrowers and banks $\downarrow \Longrightarrow R_d, R_E \uparrow$
- $R \downarrow$; c_P, $h_P \uparrow$; currency depreciation are moderating factors

Increasing capital requirements by 1 p.p.



- Bank funding and lending rates $\uparrow \Longrightarrow$ 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 $\Longrightarrow$ loans $\downarrow$
- $c_P \downarrow$ and appreciation $\Longrightarrow$ "broad tool" to reduce HH debt

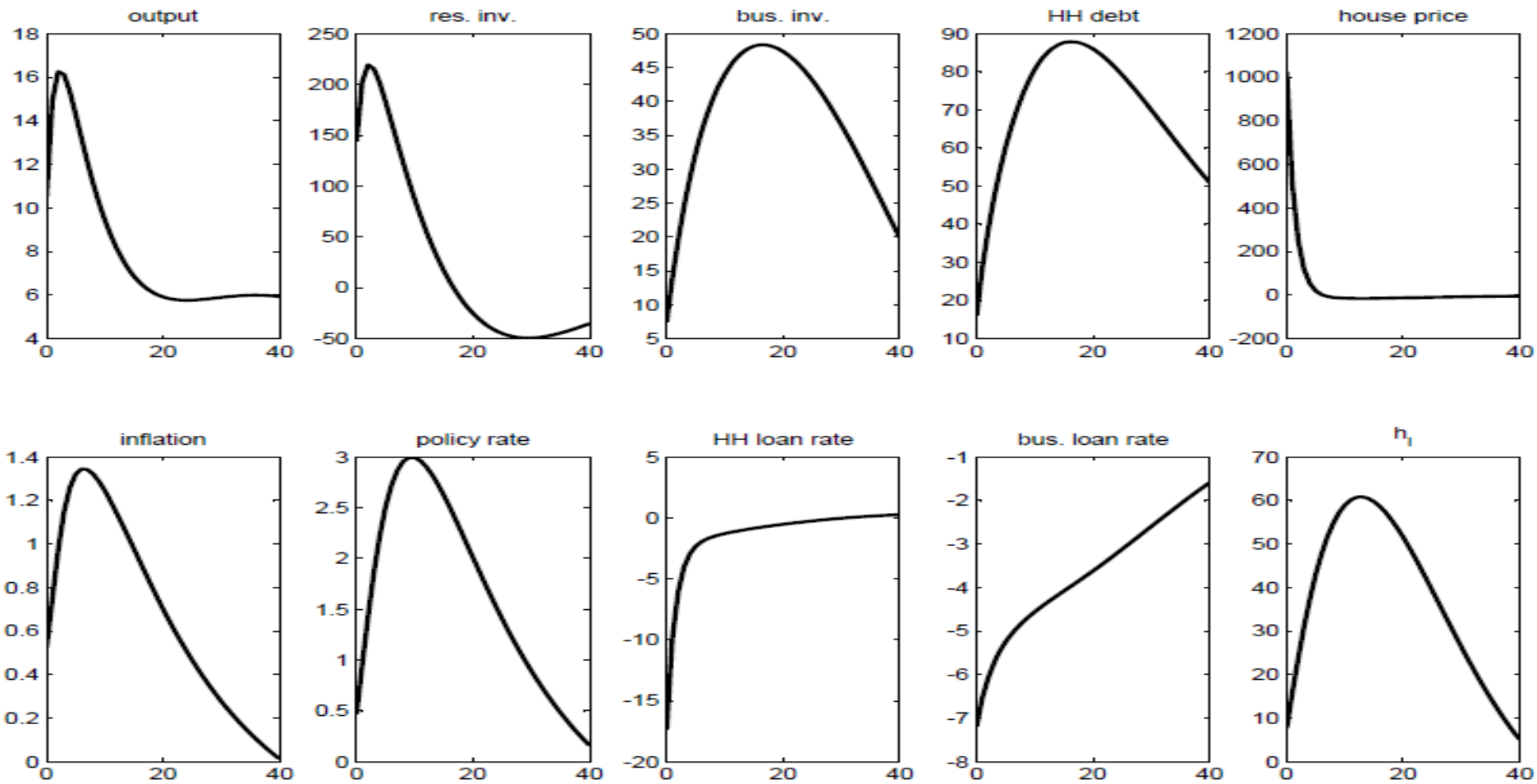
Comparing effects of different policies

Table 3. Comparing effects of macroprudential and monetary policies

peak effect in p.p.	5 p.p. $\downarrow$ LTV	1 p.p. $\uparrow$ cap. req.	100 bps. $\uparrow$ policy
Output	-0.5	-0.3	-0.5
Consumption	-0.5	-0.1	-0.2
Business inv.	-0.8	-1.4	-1.4
Residential inv.	-6.9	-2.0	-2.4
Inflation	-0.08	-0.03	-0.14
House price	-4.4	-1.3	-2.4
HH debt	-7.6	-1.8	-1.8

- 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



- $q_h \uparrow \Longrightarrow$ net worth of borrowers and banks $\uparrow \Longrightarrow R_d, R_l, R_E \downarrow$
- 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