# Global Liquidity, Leverage, House Prices and Exchange Rates

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## Motivation

▶ Push shocks to capital inflows can lead to large increase in asset prices

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▶ This can amplify the expansionary effects of capital inflows by inflating the value of collateral and expanding the borrowing capacity of the economy

▶ Policy response may differ depending on which asset price is responsible for the collateral expansion

  • **House prices**: leverage caps, loan-to-income, capital requirements, reserve requirements,...
  • **Exchange rate**: official reserve accumulation, sterilized intervention, capital controls,...

## Contribution

▶ Investigate and document the country heterogeneity of consumption and house price responses to an international credit supply shock (ie, a "push" shock)

▶ Develop a model of housing and macroeconomic dynamics with both domestic and international financial frictions

- Borrowing constraint on households (collateral valuation depends on both exchange rates and house prices)
- Leverage constraint on a global bank

▶ Run a horse race between competing transmission mechanisms

# Related Literature

- ▶ Consumption sensitivity to asset price changes/credit shock
  - Domestic: Calza, Monacelli, Stracca (2014); Lorenzoni et al (2016); Svensson (2016); Primiceri and Justiniano and Tambalotti
  - International: Almeida, Campello, and Liu (2006); Favilukis et al. (2012, 2014); Mian, Su, and Verner (2016);

- ▶ Capital flows, house prices, and exchange rates
  - Aizenman and Jinjarak (2009); Gete (2009); Cesa-Bianchi, Cespedes, and Rebucci (2015)

- ▶ Model of international financial intermediation
  - Bruno and Shin (2014); Gabaix and Maggiori (2014), Ferrero (2015)

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   - Causal effects of international credit supply shock are consistent with the unconditional associations

3. **Inspecting the heterogeneity of the transmission mechanism**
   - Country-specific characteristics of the housing finance system and monetary regime explain heterogeneity

4. **A general equilibrium open economy model with housing**
   - In line with empirical results

# Boom and bust cycles in cross-border credit

- ▶ Cross-border credit data is from BIS Locational Banking Statistics
  - Foreign banks' claims to country $i$'s non-bank sector

$$KF_{it} = \sum_{j=1}^{N} KF_{ij,t}$$

- ▶ Combine with novel quarterly data set for house prices and macro-financial variables
  - 57 countries from 1970

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- ▶ Identify boom-bust episodes in cross-border credit [Mendoza and Terrones, 2008]
  - • 134 booms, 81 busts and 50 boom-busts episodes
  - • Observe the behavior of the economy around the peak of those boom-bust cycles

# Boom and bust cycles in cross-border credit: asset prices increase, current account deteriorates, economy expands
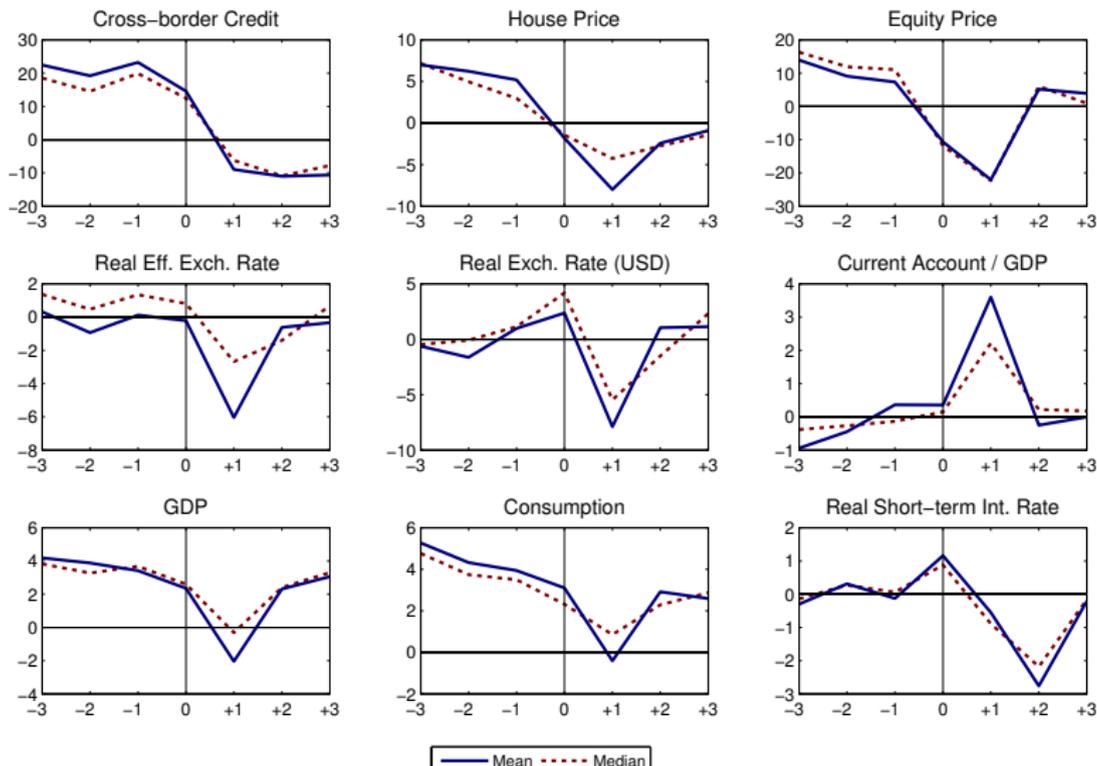
# Global liquidity – A push factor of capital flows

- Global liquidity (GL) is a vector of factors affecting provision of cross-border credit to country $i$ by global banks [BIS; Cerutti, Claessens, and Ravnostki, 2014]

- GL shock can be thought as a shifter of the international supply of credit ("push" shock)

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▶ Focus on the US

- Monetary policy $\implies$ US Interest rates, US M2
- Funding conditions of global banks $\implies$ US TED spread, US Leverage, US Yield curve slope
- Measures of risk appetite and uncertainty $\implies$ VIX

# Model – Panel VAR

- VAR model for country $i$

$$x_{it} = a_i + b_i t + c_i t^2 + F_{1i} x_{i,t-1} + u_{it},$$

- Endogenous variables $x_{it}$ include

$$x_{it} = \left[ \underbrace{KF_t}_{\substack{\text{Cross-border} \\ \text{credit}}} \quad \underbrace{C_{it}}_{\text{Consumption}} \quad \underbrace{HP_{it}}_{\substack{\text{House} \\ \text{Price}}} \quad \underbrace{RIR_{it}}_{\substack{\text{Real Int.} \\ \text{Rate}}} \quad \underbrace{RER_{it}}_{\substack{\text{Real Exch.} \\ \text{Rate}}} \right]$$

where $KF_t$ is a global aggregate (more on this later)

- Mean group estimator $\implies$ Dynamic panel data models with heterogenous slope coefficients
  - Estimate country by country with OLS
  - Take average IRFs across countries
  - Deals with potential inconsistency issues [Pesaran and Smith, 1995]

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  - Single SOE cannot affect the global supply of credit $KF_t = \sum_{i=1}^{N} KF_{it}$
  - Idiosyncratic "pull" shocks wash away for large $N$

# Identification – International credit supply shock

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  - Idiosyncratic "pull" shocks wash away for large $N$

- ► **External instruments** [Stock and Watson, 2012; Mertens and Ravn, 2013]
  - Use the drivers of GL as instruments for $KF$
  - Isolate the variation of the $KF$ reduced-form residuals that are due only to supply "push" factors
  - As instruments are US variables, drop US from sample

# Consistent with associations in the event study, "push" shock increases house prices, the exchange rate, consumption, and real interest rate over time
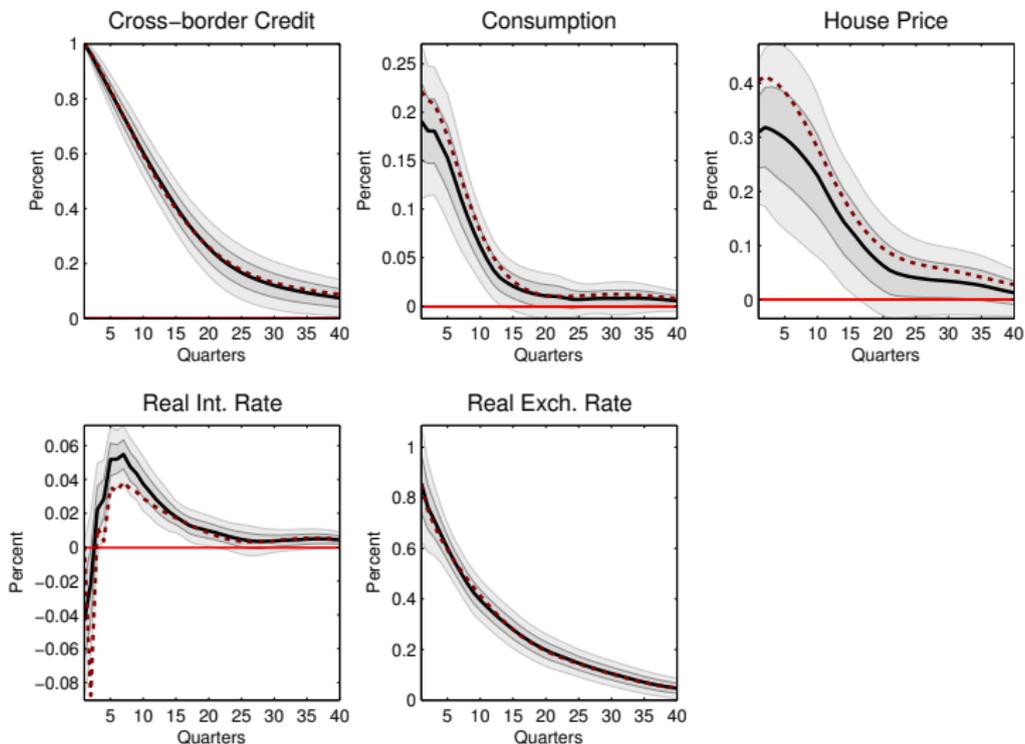
# Heterogeneity of the transmission mechanism

▶ Error bands of the VAR reveal heterogeneity across countries
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  • Conjecture: shock relaxes borrowing constraints differently in different
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▶ Error bands of the VAR reveal heterogeneity across countries
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  - Conjecture: shock relaxes borrowing constraints differently in different countries

▶ Two relevant asset prices: house price and the exchange rate

$$d_t \leq \theta \frac{q_t h_t}{s_t}$$

▶ Determinants of cross-country differences
  - **Housing finance system**: financial development, leverage, and transaction costs
  - **Monetary policy regime**: exch. rate flexibility, foreign currency exposure, capital controls

## Country characteristics & Responses to push shock

- Cross-sectional regressions

$$Y_i = X_i \boldsymbol{\beta} + \epsilon_i$$

- $Y_i = N \times 1$ vector including response of country $i$ to GL shock
  - Consider peak impact of house price & consumption
  - Robust to impact and average over first 4 quarters

- $X_i = N \times k$ matrix including $k$ structural characteristics for each country $i$

- Data sources: Warnock and Warnock (2008); Cerutti, Dell'Arriccia, Dagher (2014); WB WDI

# Consumption responses stronger the less developed financial system (HLP), the higher the leverage (LTV), the lower transaction costs (CRP), the less flexible the exchange rate regime (ERF)

|  | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| HLP | -0.37 |  |  | -0.41 |  |  |  |  | -0.34 |
|  | [-2.91] |  |  | [-4.15] |  |  |  |  | [-2.58] |
| LTVavg |  | 0.11 |  | 0.28 |  |  |  |  | 0.23 |
|  |  | [0.73] |  | [2.19] |  |  |  |  | [1.73] |
| CRP |  |  | -0.29 | -0.26 |  |  |  |  | -0.17 |
|  |  |  | [-1.63] | [-2.67] |  |  |  |  | [-1.53] |
| FCL |  |  |  |  | 0.65 |  |  | 0.52 | 0.088 |
|  |  |  |  |  | [4.69] |  |  | [2.50] | [0.60] |
| ERF |  |  |  |  |  | -0.33 |  | -0.10 | -0.20 |
|  |  |  |  |  |  | [-1.94] |  | [-0.61] | [-1.64] |
| KAI |  |  |  |  |  |  | 0.30 | -0.082 | -0.093 |
|  |  |  |  |  |  |  | [1.56] | [-0.40] | [-0.64] |
| Constant | 0.048 | -0.27 | 0.014 | -0.031 | 0.11 | 0.024 | -0.026 | -0.0019 | -0.050 |
|  | [0.34] | [-2.45] | [0.081] | [-0.28] | [0.81] | [0.14] | [-0.15] | [-0.013] | [-0.47] |
| Observations | 29 | 29 | 31 | 25 | 33 | 32 | 30 | 30 | 25 |
| R-squared | 0.24 | 0.02 | 0.08 | 0.50 | 0.42 | 0.11 | 0.08 | 0.36 | 0.61 |

*Note.* t-Stats in errors in square brackets. HLP is Housing Loan Penetration; LTVavg is the average LTV; CRP is Cost of Registering Property; FCL is foreign currency liability; ERF is exchange rate flexibility; KAI is capital controls on inflows.

# A simple model

► Two countries ($H$ and $F$), two goods, no aggregate uncertainty

► Home households
  - Impatient
  - Want to buy housing
  - Subject to collateral constraint: $d_t \leq \theta \frac{q_t h_t}{s_t}$

► Foreign households
  - More patient than Home households: $\beta^* > \beta$
  - Save via deposits and equity in financial intermediaries

► Global financial intermediaries
  - Channel funds internationally from lenders to borrowers
  - Subject to leverage constraint $\frac{d_t}{e_t} \leq \chi$

# Goods Market

- ▶ Each country endowed with one good, households consume both

$$c_t \equiv \frac{(c_{Ht})^\alpha (c_{Ft})^{1-\alpha}}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \qquad \text{with} \qquad \alpha \in (n, 1]$$

- ▶ Price indexes (LOOP holds)

$$P_t = (P_{Ht})^\alpha (P_{Ft})^{1-\alpha}$$

- ▶ Relative prices and real exchange rate $\propto$ terms of trade ($\tau_t \equiv P_{Ft}/P_{Ht}$)

$$p_{Ht} \equiv P_{Ht}/P_t = \tau_t^{\alpha-1}$$
$$s_t \equiv P_t^*/P_t = \tau_t^{\alpha-\alpha^*}$$

## Households - Home country

▶ Utility function defined over consumption goods and housing services

$$\max_{\{c_t, h_t, d_t\}} \mathbb{U}_t = \sum_{t=0}^{\infty} \beta^t \left[ u(c_t) + v(h_t) \right]$$

▶ Subject to

$$c_t + q_t h_t - s_t(d_t - R_{t-1} d_{t-1}) = p_{Ht} y_t + q_t h_{t-1}$$
$$s_t d_t \leq \theta q_t h_t$$

▶ Debt is denominated in foreign currency
  • Appreciation of the real exchange rate ($s_t$) can relax the borrowing constraint

## Households - Foreign country

▶ Utility function defined over consumption goods

$$\max_{\{c_t^*, d_t^*\}} \mathbb{U}_t^* = \sum_{t=0}^{\infty} \beta^{*t} u(c_t^*)$$

▶ Subject to

$$c_t^* + d_t^* + e_t + \psi(e_t) = p_{Ft} y_t^* + R_{t-1}^d d_{t-1}^* + R_{t-1}^e e_{t-1} + \pi_t,$$

▶ More patient than Home households $\beta^* > \beta$

▶ Foreign households own financial intermediaries
  • Cost of adjusting equity

## Global Financial Intermediaries

► Balance sheet at time $t$ (after borrowers and lenders decisions)

| Assets | | Liabilities | |
|--------|------|-------------|-------------|
| Loans | $nd_t$ | Deposits | $(1-n)d_t^*$ |
| | | Equity | $(1-n)e_t$ |

► Maximize profits subject to leverage constraint (capital requirement)

$$nd_t \leq \chi(1-n)e_t$$

► We introduce a credit supply shock (a "leverage shock")

$$\chi_t = \chi(1-\rho) + \rho\chi_{t-1} + \varepsilon^\chi$$

# Simplified version of the model – Analytical results

- ▶ Simplified version of the model
  - Symmetric ($n = 0.5$), one-good only ($s_t = \tau_t = 1$) world economy
  - Risk-neutrality ($u'(c_t) = \bar{u}$)

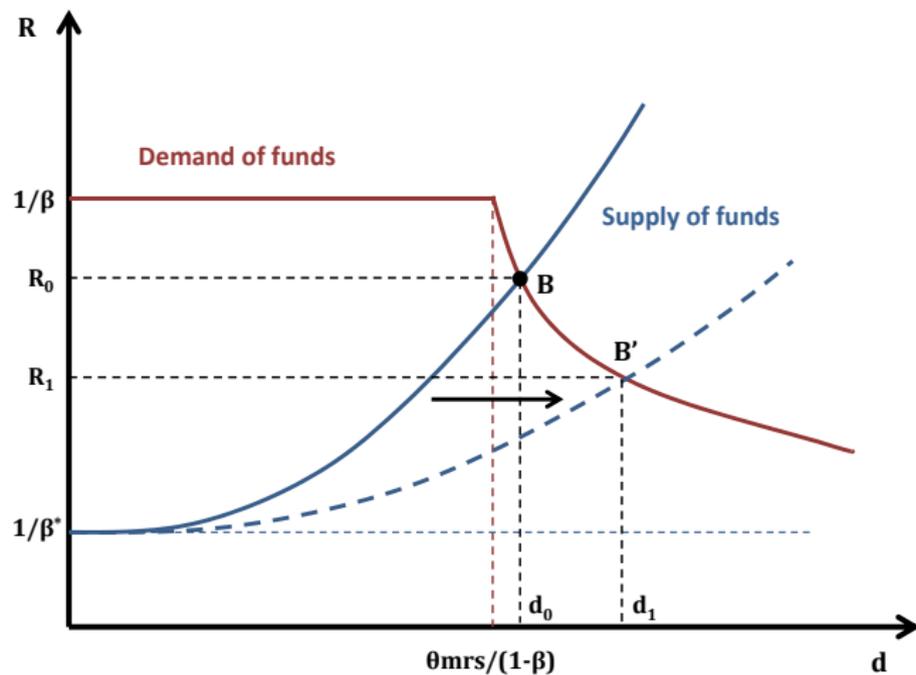- ▶ Derive credit demand and supply schedules and characterize the credit market equilibrium

- ▶ Supply

$$R = \frac{1}{\beta^*} \left[ 1 + \Theta \left( \frac{d}{\chi} \right)^{\gamma - 1} \right]$$

- ▶ Demand

$$R = \begin{cases} 1/\beta & \text{if } d < \theta p \\ \frac{\theta - (1 - \beta)}{\beta \theta} - \frac{mrs}{\beta d} & \text{if } d = \theta p \end{cases}$$

# A leverage shock in the model

## Full model – Parameter values

- ▶ Two-good world economy, countries can differ in size, risk aversion

- ▶ Parametrization

| Parameter | Description | Value |
|-----------|-------------|-------|
| $\alpha$ | Weight of H good in H consumption | 0.6 |
| $n$ | Size of H economy | 0.01 |
| $\alpha^*$ | Weight of H good in F consumption | $1 - \alpha$ |
| $\nu$ | Relative risk aversion | 1.5 |
| $vh$ | Marginal utility of housing | 0.0006 |
| $\beta$ | H discount factor | 0.985 |
| $\beta^*$ | F discount factor | 0.992 |
| $\theta$ | LTV ratio | 0.75 |
| $y$ | H endowment | 1 |
| $y^*$ | F endowment | 1 |
| $\rho_\chi$ | Persistence of leverage shock | 0.25 |
| $\chi$ | Steady state leverage | 5 |
| $\gamma$ | Equity adj. cost (1) | 1.5 |
| $\eta$ | Equity adj. cost (2) | 0.005 |

- ▶ Leverage shock

$$\chi_t = \chi^{(1-\rho_\chi)} \chi_{t-1}^{\rho_\chi} \exp\left(\varepsilon_{\chi,t}\right),$$

# Impulse response to a leverage shock consistent with Panel VAR response
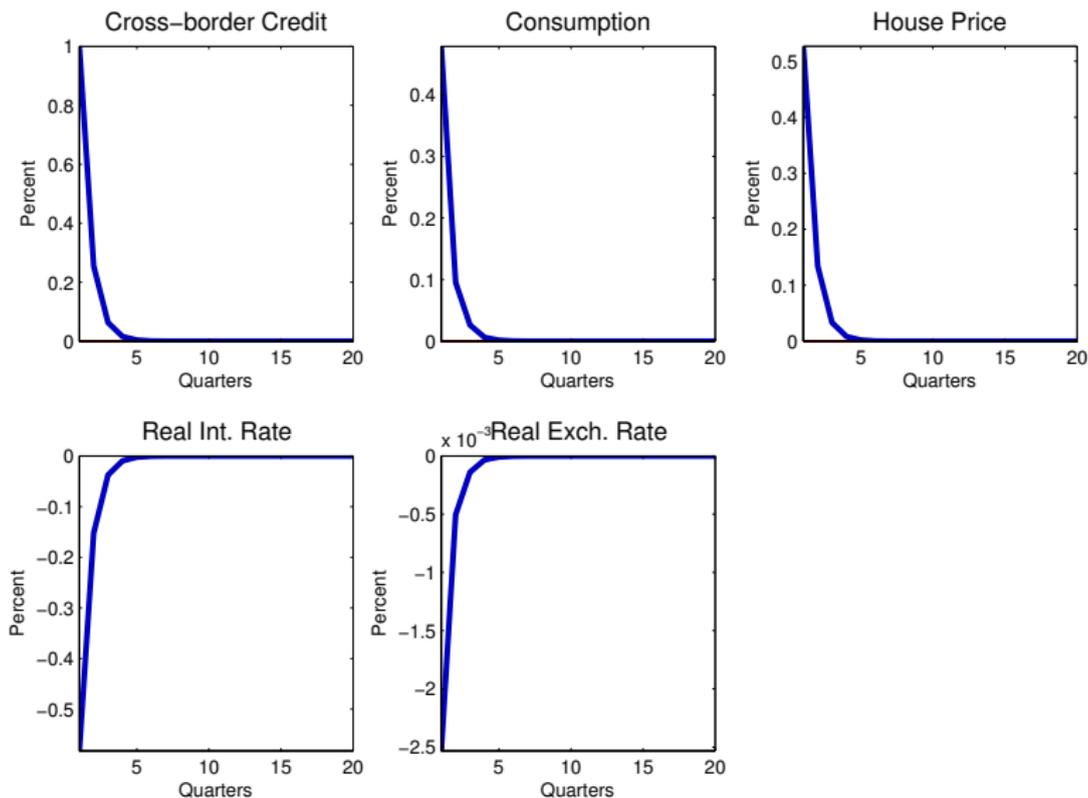
## Conclusions

▶ Consumption responds to international credit supply shocks in a heterogeneous fashion across countries

▶ Two main channels of transmission
  • Monetary policy regime (exchange rate)
  • Housing finance system (house price)

  Hard to disentangle empirically

▶ Set up DSGE model to interpret both time series and cross-section empirical evidence

▶ Next steps
  • Investigate cross-sectional factors within the model
  • Model estimation by matching VAR IRFs and horse race between alternative mechanisms

# Appendix

# GL - Data



International cross−border claims of BIS reporting banks vis−a−vis the banking sector
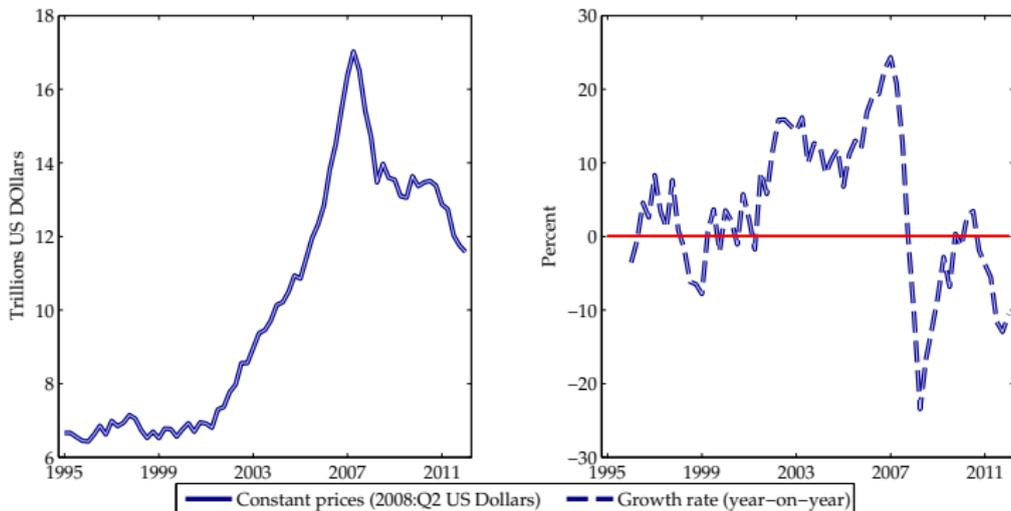
# First stage regressions

- Drop if VAR has unstable dynamics and/or less than 30 observations
- Leverage is selected as the single most relevant instrument in more than 90 percent of the cases

|  | F-Stat | R2 |  | F-Stat | R2 |
|---|---|---|---|---|---|
| Argentina | 6.20 | 0.06 | Indonesia | 6.13 | 0.06 |
| Australia | 10.80 | 0.10 | Ireland | 9.11 | 0.08 |
| Austria | 6.16 | 0.05 | Italy | 9.31 | 0.08 |
| Belgium | 7.94 | 0.07 | Japan | 7.70 | 0.07 |
| Bulgaria | 9.94 | 0.10 | Malaysia | 11.12 | 0.10 |
| Canada | 12.94 | 0.12 | Netherlands | 8.07 | 0.07 |
| Chile | 5.19 | 0.06 | New Zealand | 7.46 | 0.07 |
| Colombia | 11.53 | 0.12 | Norway | 10.08 | 0.09 |
| Croatia | 10.27 | 0.12 | Philippines | 8.45 | 0.09 |
| Denmark | 9.72 | 0.09 | Portugal | 11.67 | 0.12 |
| Estonia | 5.24 | 0.06 | Singapore | 7.63 | 0.07 |
| Finland | 10.48 | 0.10 | Sweden | 10.45 | 0.09 |
| France | 6.82 | 0.06 | Switzerland | 10.03 | 0.09 |
| Greece | 10.20 | 0.09 | Taiwan | 5.85 | 0.07 |
| Hong Kong | 11.75 | 0.12 | Thailand | 7.58 | 0.07 |
| Hungary | 5.22 | 0.07 | United Kingdom | 10.49 | 0.10 |
| Iceland | 8.32 | 0.13 |  |  |  |

*Note.* Dropped all countries where first-stage regressions has F-Stat<5.

# House price responses stronger the higher the share of FC liability (FCL), the less flexible the exchange rate regime (ERF), and the less extensive capital controls on inflows (KAI)

|  | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| HLP | -0.25 | | | -0.18 | | | | | -0.14 |
|  | [-1.35] | | | [-1.82] | | | | | [-1.24] |
| LTVavg | | 0.089 | | 0.19 | | | | | 0.16 |
|  | | [0.70] | | [1.55] | | | | | [1.46] |
| CRP | | | -0.30 | -0.12 | | | | | -0.048 |
|  | | | [-1.67] | [-1.21] | | | | | [-0.51] |
| FCL | | | | | 0.54 | | | 0.33 | 0.25 |
|  | | | | | [3.55] | | | [2.88] | [2.00] |
| ERF | | | | | | -0.26 | | -0.25 | -0.15 |
|  | | | | | | [-1.50] | | [-2.74] | [-1.52] |
| KAI | | | | | | | 0.10 | -0.21 | -0.28 |
|  | | | | | | | [0.76] | [-1.85] | [-2.32] |
| Constant | 0.062 | -0.25 | -0.019 | -0.19 | 0.093 | -0.010 | -0.15 | -0.15 | -0.19 |
|  | [0.31] | [-2.62] | [-0.11] | [-1.77] | [0.62] | [-0.059] | [-1.29] | [-1.83] | [-2.14] |
| Observations | 29 | 29 | 31 | 25 | 33 | 32 | 30 | 30 | 25 |
| R-squared | 0.06 | 0.02 | 0.09 | 0.19 | 0.29 | 0.07 | 0.02 | 0.57 | 0.55 |

*Note.* t-Stats in errors in square brackets. HLP is Housing Loan Penetration; LTVavg is the average LTV; CRP is Cost of Registering Property; FCL is foreign currency liability; ERF is exchange rate flexibility; KAI is capital controls on inflows

# Real exchange rate appreciation stronger the the higher the share of FC liability (FCL), the more flexible the exchange rate regime (ERF), and the less extensive capital controls on inflows (KAI)

|  | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| HLP | 0.13 |  |  | 0.12 |  |  |  |  | 0.36 |
|  | [0.83] |  |  | [0.56] |  |  |  |  | [1.30] |
| LTVavg |  | -0.047 |  | -0.072 |  |  |  |  | -0.20 |
|  |  | [-0.19] |  | [-0.27] |  |  |  |  | [-0.73] |
| CRP |  |  | 0.047 | 0.095 |  |  |  |  | 0.15 |
|  |  |  | [0.27] | [0.47] |  |  |  |  | [0.66] |
| FCL |  |  |  |  | 0.19 |  |  | 0.67 | 0.70 |
|  |  |  |  |  | [1.09] |  |  | [2.60] | [2.27] |
| ERF |  |  |  |  |  | 0.098 |  | 0.36 | 0.29 |
|  |  |  |  |  |  | [0.56] |  | [1.76] | [1.15] |
| KAI |  |  |  |  |  |  | -0.15 | -0.46 | -0.14 |
|  |  |  |  |  |  |  | [-0.67] | [-1.83] | [-0.45] |
| Constant | -0.071 | -0.057 | 0.088 | -0.026 | 0.033 | 0.038 | 0.0075 | 0.074 | 0.066 |
|  | [-0.40] | [-0.31] | [0.50] | [-0.11] | [0.19] | [0.22] | [0.038] | [0.40] | [0.30] |
| Observations | 29 | 29 | 31 | 25 | 33 | 32 | 30 | 30 | 25 |
| R-squared | 0.02 | 0.00 | 0.00 | 0.02 | 0.04 | 0.01 | 0.02 | 0.22 | 0.24 |

*Note.* t-Stats in errors in square brackets. HLP is Housing Loan Penetration; LTVavg is the average LTV; CRP is Cost of Registering Property; FCL is foreign currency liability; ERF is exchange rate flexibility; KAI is capital controls on inflows.

# Real interest rate response not insulated by exchange rate flexibility

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| HLP | -0.20 | | | 0.043 | | | | | 0.062 |
| | [-1.05] | | | [1.21] | | | | | [1.20] |
| LTVavg | | -0.042 | | -0.066 | | | | | -0.075 |
| | | [-1.00] | | [-1.44] | | | | | [-1.44] |
| CRP | | | -0.14 | -0.037 | | | | | -0.040 |
| | | | [-0.76] | [-1.06] | | | | | [-0.93] |
| FCL | | | | | 0.23 | | | 0.058 | 0.051 |
| | | | | | [1.32] | | | [0.22] | [0.89] |
| ERF | | | | | | -0.45 | | -0.47 | 0.050 |
| | | | | | | [-2.79] | | [-2.22] | [1.05] |
| KAI | | | | | | | 0.072 | -0.13 | 0.0097 |
| | | | | | | | [0.32] | [-0.52] | [0.17] |
| Constant | 0.079 | -0.18 | 0.015 | -0.19 | 0.040 | 0.022 | 0.041 | 0.011 | -0.18 |
| | [0.39] | [-5.80] | [0.079] | [-4.85] | [0.23] | [0.14] | [0.20] | [0.057] | [-4.31] |
| | | | | | | | | | |
| Observations | 29 | 29 | 31 | 25 | 33 | 32 | 30 | 30 | 25 |
| R-squared | 0.04 | 0.04 | 0.02 | 0.18 | 0.05 | 0.21 | 0.00 | 0.23 | 0.25 |

*Note.* t-Stats in errors in square brackets. HLP is Housing Loan Penetration; LTVavg is the average LTV; CRP is Cost of Registering Property; FCL is foreign currency liability; ERF is exchange rate flexibility; KAI is capital controls on inflows.

## Summary

1. Consumption response to credit supply shock affected more by access to finance and leverage

2. House price and exchange rate responses affected more by characteristics of monetary policy regime

3. Monetary regime characteristics could work indirectly via house prices and exchange rates

4. We need a model to better understand mechanisms with housing