Capital Flows and Exchange Rates

A Quantitative Assessment of the Dilemma Hypothesis*

Ambrogio Cesa-Bianchi
Bank of England, CEPR, and CfM

Andrea Ferrero
University of Oxford

Shangshang Li
University of Liverpool

Emerging Markets Workshop - Pretoria
26 January 2024

***The views expressed in this paper are those of the authors and do not necessarily represent the views of the Bank of England or its committees.**

Question and Motivation

- **Monetary policy tightening cycle in advanced economies**
  - Renewed interest on cross-country transmission of monetary policy (shocks)

Question and Motivation

- Monetary policy tightening cycle in advanced economies
  - Renewed interest on cross-country transmission of monetary policy (shocks)
- **Global Financial Cycle** [Rey, 2013] → From Trilemma to Dilemma?
  - Does a flexible exchange rate regime provide enough insulation?
  - Are additional instruments necessary for domestic monetary policy independence?

Question and Motivation

- Monetary policy tightening cycle in advanced economies
  - Renewed interest on cross-country transmission of monetary policy (shocks)
- Global Financial Cycle [Rey, 2013] → From Trilemma to Dilemma?
  - Does a flexible exchange rate regime provide enough insulation?
  - Are additional instruments necessary for domestic monetary policy independence?
- **Our contribution** → Revisit these questions in an estimated open economy DSGE model
  - Dominant currency paradigm in finance and trade
  - Consistent with Global Financial Cycle (GFC) evidence

What We Do and What We Find

1. **Panel VAR** $\rightarrow$ Response of financial and macro variables to US monetary policy shock
   * Typical (small) open economy with flexible exchange rates
   * Demand/financial channel dominates over expenditure-switching effect

What We Do and What We Find

1. **Panel VAR** $\rightarrow$ Response of financial and macro variables to US monetary policy shock
   * Typical (small) open economy with flexible exchange rates
   * Demand/financial channel dominates over expenditure-switching effect

2. **Two-country DSGE model** $\rightarrow$ Estimated to match VAR impulse responses
   * Frictions in international financial intermediation and trade pricing frictions
   * Necessary to replicate empirical evidence

What We Do and What We Find

1. **Panel VAR** → Response of financial and macro variables to US monetary policy shock
   - Typical (small) open economy with flexible exchange rates
   - Demand/financial channel dominates over expenditure-switching effect

2. **Two-country DSGE model** → Estimated to match VAR impulse responses
   - Frictions in international financial intermediation and trade pricing frictions
   - Necessary to replicate empirical evidence

3. **Policy analysis** → Counterfactuals
   - Exchange rate targeting increases domestic macroeconomic volatility
   - Additional instruments (tax on capital flows / total credit) mitigate consequences of GFC
   - Taxes can limit volatility of economic activity under peg but with disinflationary side effect

Related Literature

- Empirical studies of global financial cycle and its drivers

  Rey (2013); Dedola, Rivolta and Stracca (2017); Cesa-Bianchi, Ferrero and Rebucci (2018); Cerutti, Claessens and Rose (2019); Corman and Lloyd (2019); Obstfeld, Ostry and Qureshi (2019); Miranda-Agrippino and Rey (2020); Degasperi, Hong and Ricco (2021); Ilzetzki and Jin (2021); Georgiadis, Muller, Schumann (2023a,b), Georgiadis and Jarocinski (2023)

- Financial frictions in open economy

  Farhi and Werning (2014); Gabaix and Maggiori (2015); Aoki, Benigno and Kiyotaki (2020); Gourinchas (2020); Adrian et al. (2020); Casas et al. (2020); Corsetti, Dedola, and Leduc (2020); Itskhoki and Mukhin (2021); Akinci and Queralto (2022)

- LCP and dominant currency paradigm

  Devereux and Engel (2003); Cook and Devereux (2006); Corsetti, Dedola and Leduc (2010); Engel (2011); Fujiwara and Wang (2017); Gopinath et al. (2020); Chen et al. (2021); Gopinath and Stein (2021)

Panel VAR

Data

- **Panel** of macro-financial variables for 15 countries with flexible exchange rate
  - Australia, Canada, Chile, Germany, Japan, Korea, Mexico, New Zealand, Norway, Singapore, South Africa, Sweden, Switzerland, Thailand, United Kingdom
  - Robustness with a larger set of countries (24)

Data

- **Panel** of macro-financial variables for 15 countries with flexible exchange rate
  - Australia, Canada, Chile, Germany, Japan, Korea, Mexico, New Zealand, Norway, Singapore, South Africa, Sweden, Switzerland, Thailand, United Kingdom
  - Robustness with a larger set of countries (24)

- **Variables**
  - US: Monetary policy surprise, excess bond premium, real GDP
  - Domestic: Real GDP, CPI, exports, policy rate, nominal exch. rate (LC/USD), corporate bond spreads

Data

- **Panel** of macro-financial variables for 15 countries with flexible exchange rate
  - Australia, Canada, Chile, Germany, Japan, Korea, Mexico, New Zealand, Norway, Singapore, South Africa, Sweden, Switzerland, Thailand, United Kingdom
  - Robustness with a larger set of countries (24)

- **Variables**
  - US: Monetary policy surprise, excess bond premium, real GDP
  - Domestic: Real GDP, CPI, exports, policy rate, nominal exch. rate (LC/USD), corporate bond spreads

- **Monthly frequency** $\rightarrow$ 1997:M1–2019:M12 (subject to availability)
  - Corporate spreads constrain earlier starting date (robustness from 1985 without spreads)
  - Macro series interpolated from quarterly to monthly frequency [Miranda-Agrippino and Rey, 2020]

Panel VAR

- High frequency monetary policy surprises [Jarocinski and Karadi, 2020]
- Internal instrument [Plagborg-Moeller and Wolf, 2021]

$$x_{it} = a_i + b_i t + \sum_{p=1}^{P} F_{i,p} x_{i,t-p} + u_{it}$$

where

$$x_{it} = \begin{bmatrix} \epsilon_t^m & EBP_t^{US} & Y_t^{US} & Y_{it} & CPI_{it} & EX_{it} & i_{it} & FX_{it} & CS_{it} \end{bmatrix}$$

Panel VAR

- High frequency monetary policy surprises [Jarocinski and Karadi, 2020]
- Internal instrument [Plagborg-Moeller and Wolf, 2021]

$$x_{it} = a_i + b_i t + \sum_{p=1}^{P} F_{i,p} x_{i,t-p} + u_{it}$$

where

$$x_{it} = \Big[\underbrace{\epsilon_t^m \quad EBP_t^{US} \quad Y_t^{US}}_{US} \quad \underbrace{Y_{it} \quad CPI_{it} \quad EX_{it} \quad i_{it} \quad FX_{it} \quad CS_{it}}_{SOE} \Big]$$

Panel VAR

- High frequency monetary policy surprises [Jarocinski and Karadi, 2020]
- Internal instrument [Plagborg-Moeller and Wolf, 2021]

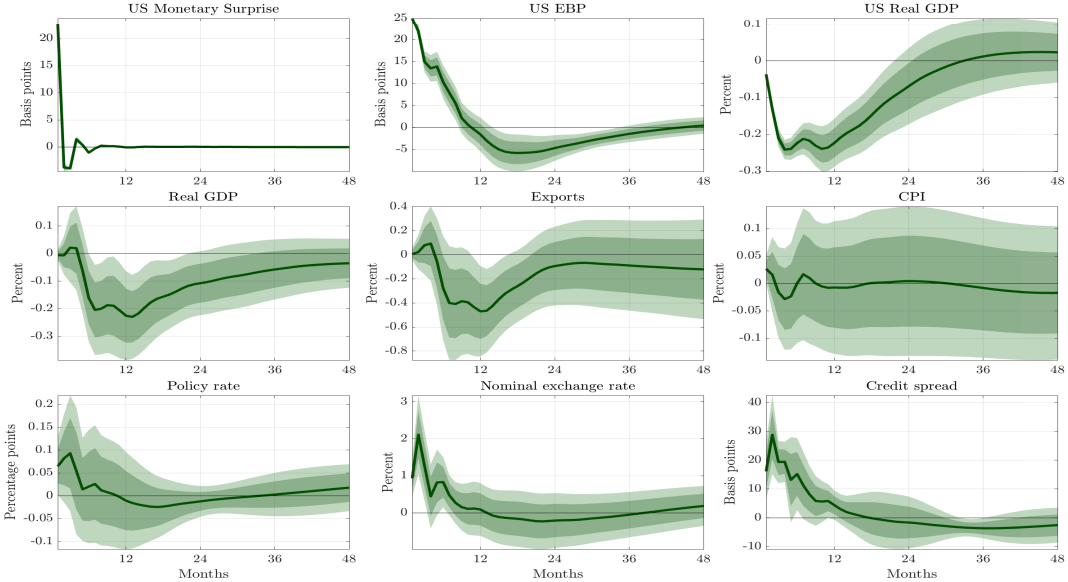
$$x_{it} = a_i + b_i t + \sum_{p=1}^{P} F_{i,p} x_{i,t-p} + u_{it}$$

where

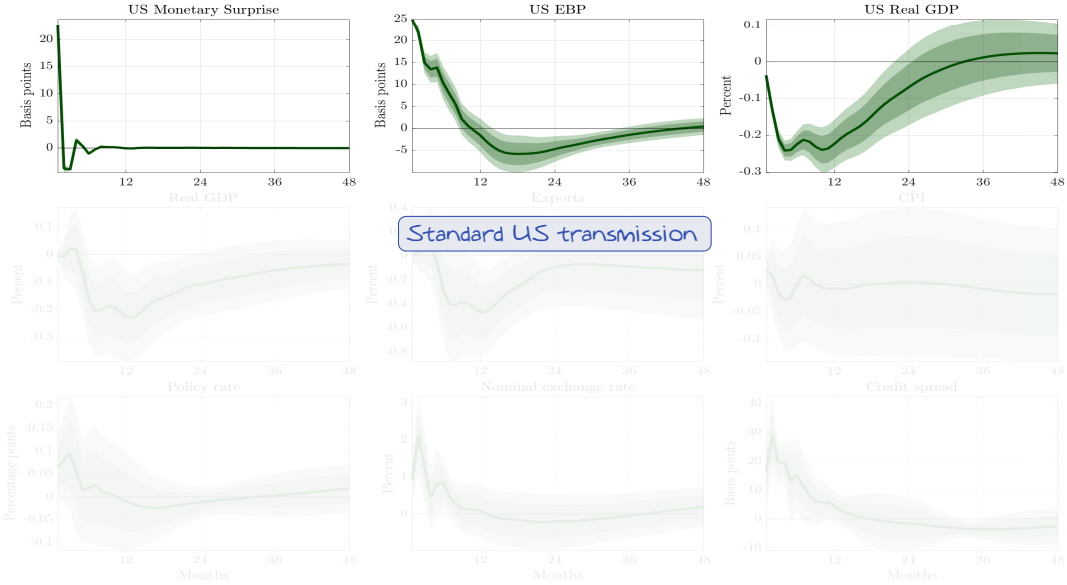
$$x_{it} = \Big[\underbrace{\epsilon_t^m \quad EBP_t^{US} \quad Y_t^{US}}_{\text{US}} \quad \underbrace{Y_{it} \quad CPI_{it} \quad EX_{it} \quad i_{it} \quad FX_{it} \quad CS_{it}}_{\text{SOE}} \Big]$$

- Mean group estimator [Pesaran and Smith, 1995]
  - Dynamic panel with heterogeneous slope coefficients
  - Estimate country-by-country VARs with OLS
  - Take average IRFs across countries $\rightarrow$ Response of typical country

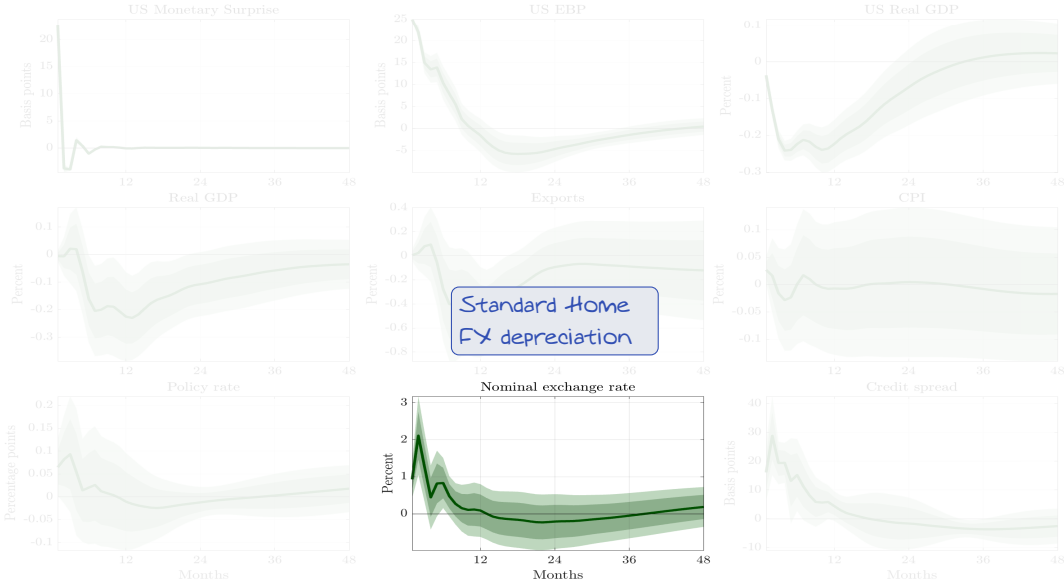
IRFs to a US Monetary Policy Tightening



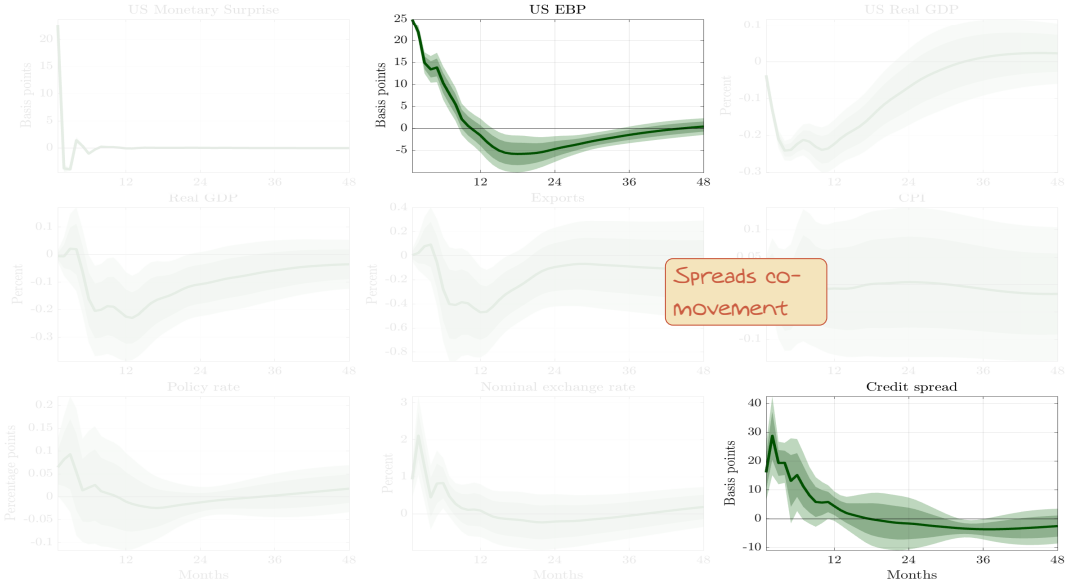
IRFs to a US Monetary Policy Tightening



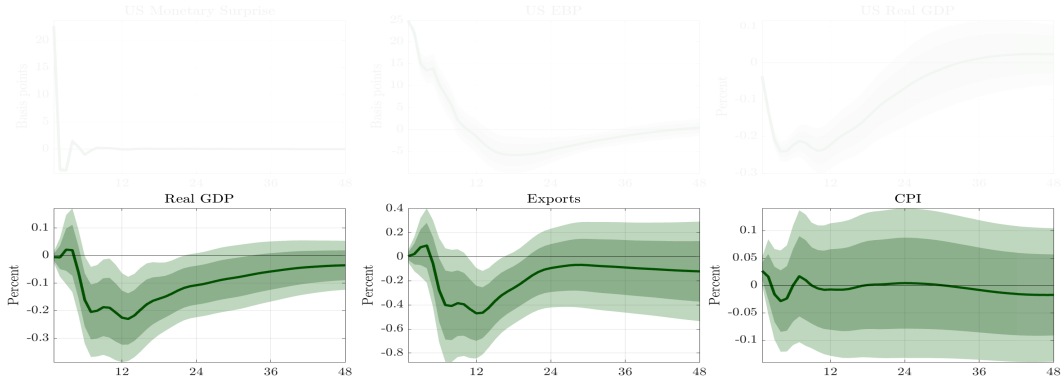
IRFs to a US Monetary Policy Tightening



IRFs to a US Monetary Policy Tightening

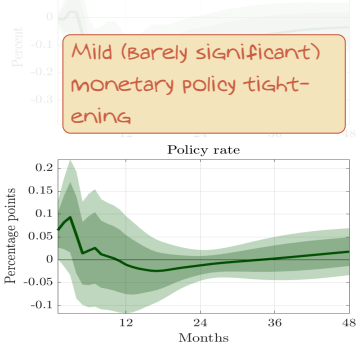


IRFs to a US Monetary Policy Tightening



Expenditure-switching effect does not dominate

IRFs to a US Monetary Policy Tightening



Mild (barely significant) monetary policy tightening

Summary of the VAR Evidence & Robustness

- Evidence consistent with Global Financial Cycle hypothesis
  - Demand/financial channel dominates over expenditure-switching

Summary of the VAR Evidence & Robustness

- Evidence consistent with Global Financial Cycle hypothesis
  - Demand/financial channel dominates over expenditure-switching
- Robustness
  - Larger sample of countries
  - Longer sample period (no spreads)
  - Alternative lag length criteria, drop linear trend
  - Additional variables (US variables, oil price, SOE equity prices)

Go to robustness

Two-Country DSGE Model

Overview

- Similar to Aoki, Benigno and Kiyotaki (2020) and Akinci and Queralto (2022)

Overview

- Similar to Aoki, Benigno and Kiyotaki (2020) and Akinci and Queralto (2022)
- Standard household sector symmetric across two countries (*H* small and *F* large)

Overview

- Similar to Aoki, Benigno and Kiyotaki (2020) and Akinci and Queralto (2022)
- Standard household sector symmetric across two countries (*H* small and *F* large)
- Asymmetric international financial structure
  - **Foreign banks** raise funds domestically, lend both domestically and internationally
  - **Home banks** raise funds domestically and internationally, lend only domestically

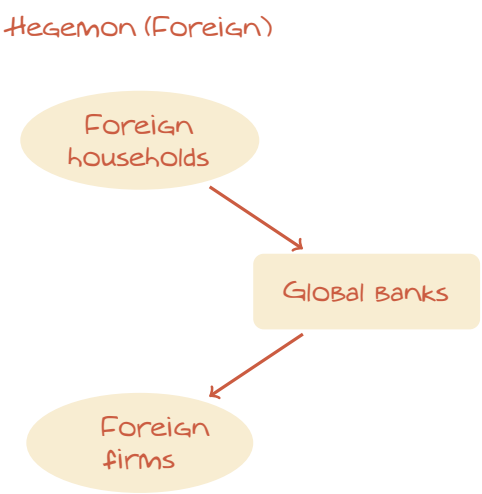
Overview

- Similar to Aoki, Benigno and Kiyotaki (2020) and Akinci and Queralto (2022)
- Standard household sector symmetric across two countries (*H* small and *F* large)
- Asymmetric international financial structure
  - Foreign banks raise funds domestically, lend both domestically and internationally
  - Home banks raise funds domestically and internationally, lend only domestically
- Multi-layer production (capital producers, importers, wholesale producers, retailers)
  - **Local currency pricing**: Home exporters price in Foreign currency
  - **Imperfect pass-through**: Law of one price for Home imported goods holds at the dock

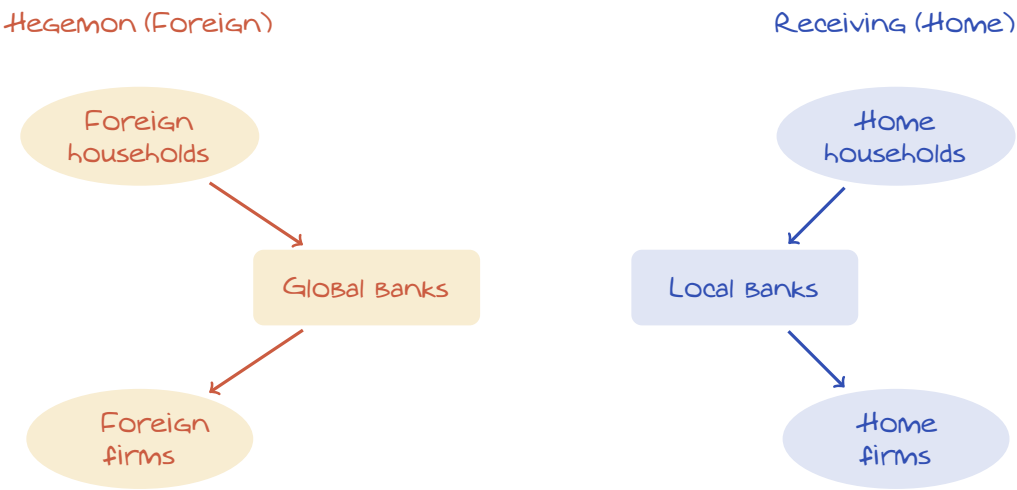
Overview

- Similar to Aoki, Benigno and Kiyotaki (2020) and Akinci and Queralto (2022)
- Standard household sector symmetric across two countries (*H* small and *F* large)
- Asymmetric international financial structure
  - Foreign banks raise funds domestically, lend both domestically and internationally
  - Home banks raise funds domestically and internationally, lend only domestically
- Multi-layer production (capital producers, importers, wholesale producers, retailers)
  - Local currency pricing: Home exporters price in Foreign currency
  - Imperfect pass-through: Law of one price for Home imported goods holds at the dock
- **Dominant currency paradigm** in international goods and financial markets

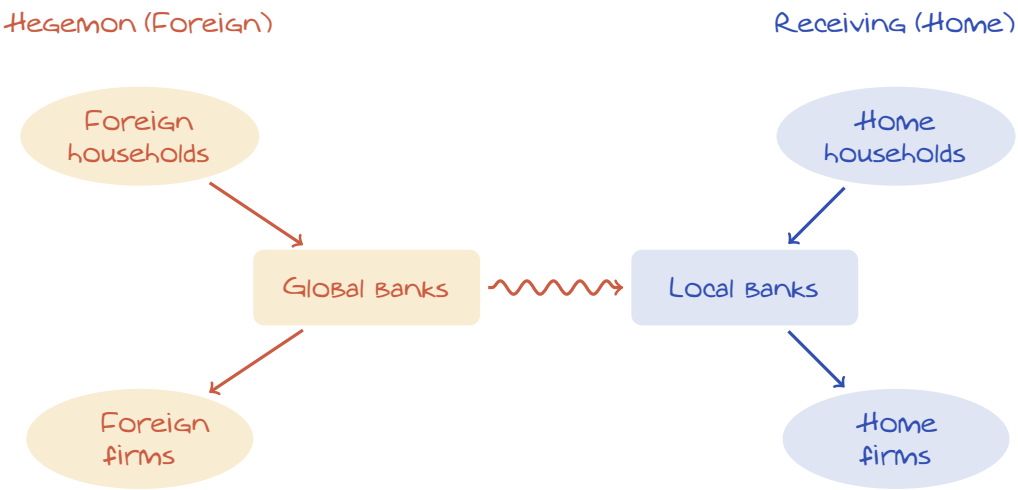
Financial Flows



Financial Flows



Financial Flows



Financial Frictions

- **Foreign banks**
  - Standard Gertler and Karadi (2011), balance sheet fully in USD
  - Issue deposits to F households, lend to F firms and H banks

Financial Frictions

- **Foreign banks**
  - Standard Gertler and Karadi (2011), balance sheet fully in USD
  - Issue deposits to F households, lend to F firms and H banks

- **Home banks**
  - Balance sheet currency mis-match

$$\underbrace{q_t z_t}_{\text{Assets}} = \underbrace{d_t + s_t b_t^* + n_t}_{\text{Liabilities}}$$

  - Moral hazard: Banker can divert fraction of assets

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)$$

with $\gamma > 0$, where $x_t = s_t b_t^* / (q_t z_t)$ (foreign funds harder to recover than domestic funds)

Financial Frictions

- **Foreign banks**
  - Standard Gertler and Karadi (2011), balance sheet fully in USD
  - Issue deposits to F households, lend to F firms and H banks

- **Home banks**
  - Balance sheet currency mis-match

$$\underbrace{q_t z_t}_{\text{Assets}} = \underbrace{d_t + s_t b_t^* + n_t}_{\text{Liabilities}}$$

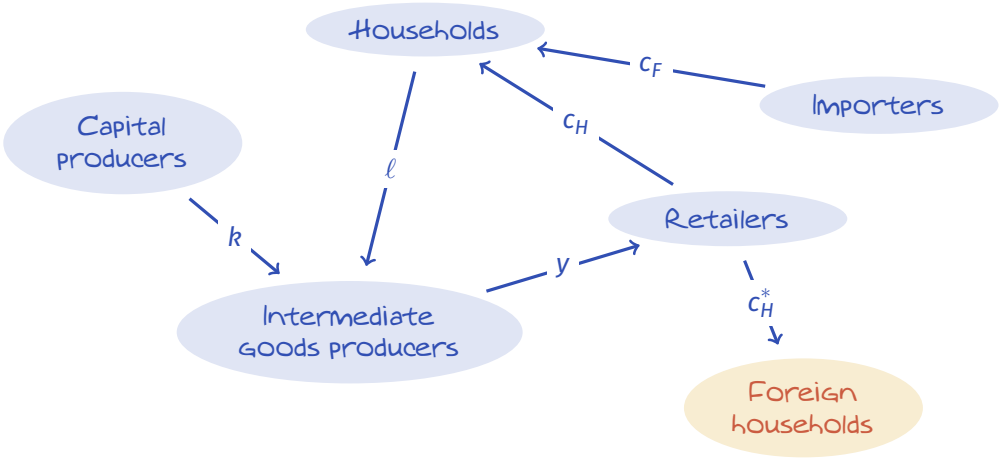
  - Moral hazard: Banker can divert fraction of assets

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)$$

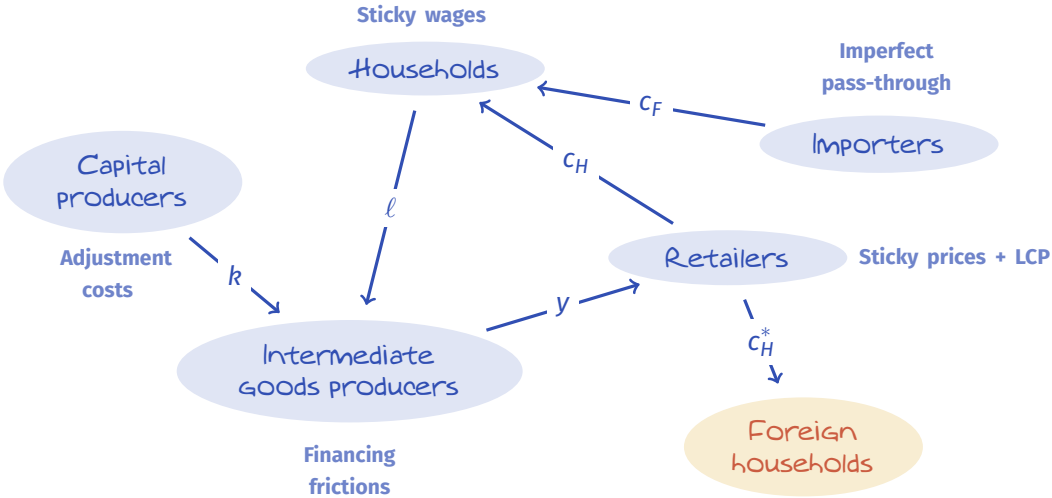
    with $\gamma > 0$, where $x_t = s_t b_t^* / (q_t z_t)$ (foreign funds harder to recover than domestic funds)

  - Financial friction $\rightarrow$ Endogenous UIP wedge

Production Structure (Home)



Production Structure (Home)



Policy

- **Monetary policy rule**

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)^{\phi_\mathcal{E}}\right]^{1-\rho_R}$$

  - Foreign $\phi_\mathcal{E} = 0 \rightarrow$ Flexible exchange rate
  - Home $\phi_\mathcal{E} \geq 0 \rightarrow$ From fully flexible, to managed float, to peg (i.e. $\phi_\mathcal{E} \rightarrow \infty$)

Policy

- **Monetary policy rule**

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)^{\phi_\mathcal{E}}\right]^{1-\rho_R}$$

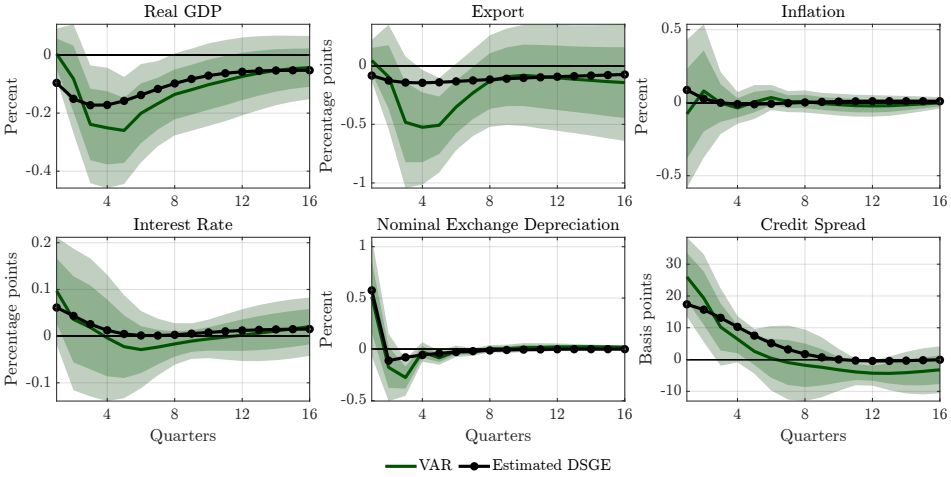
  - Foreign $\phi_\mathcal{E} = 0 \rightarrow$ Flexible exchange rate
  - Home $\phi_\mathcal{E} \geq 0 \rightarrow$ From fully flexible, to managed float, to peg (i.e. $\phi_\mathcal{E} \rightarrow \infty$)

- **Additional instruments** (in Home country only)
  - Tax on foreign liabilities (capital flows management tool)
  - Tax on total credit (domestic macro-prudential tool)

Calibrated Parameters

Parameter	Description	Home	Foreign
n	Relative size of country H	0.1	0.9
β	Individual discount factor	0.9926	0.9975
h	Habits in consumption	–	0.71
σ	Relative risk aversion	–	1.38
χ	Relative weight on disutility of labor	28	49
ζ	Inverse Frisch elasticity	1	1
ϱ	Elasticity of substitution among goods varieties	6	6
a	Home bias in consumption	0.66	0.96
ϵ	Elasticity of substitution between H and F goods	1.5	1.5
ν	Elasticity of substitution among labor varieties	6	6
ξ_w	Wage rigidity	0.66	0.66
ξ_p	Price rigidity	–	0.66
α	Capital share	0.33	0.33
δ	Depreciation rate	0.025	0.025
φ_i	Investment adjustment cost	–	5.74
ω	Bank survival rate	0.97	0.97
θ	Proportion of divertible funds	–	0.51
ξ_b	Bank transfer rate	–	0.002

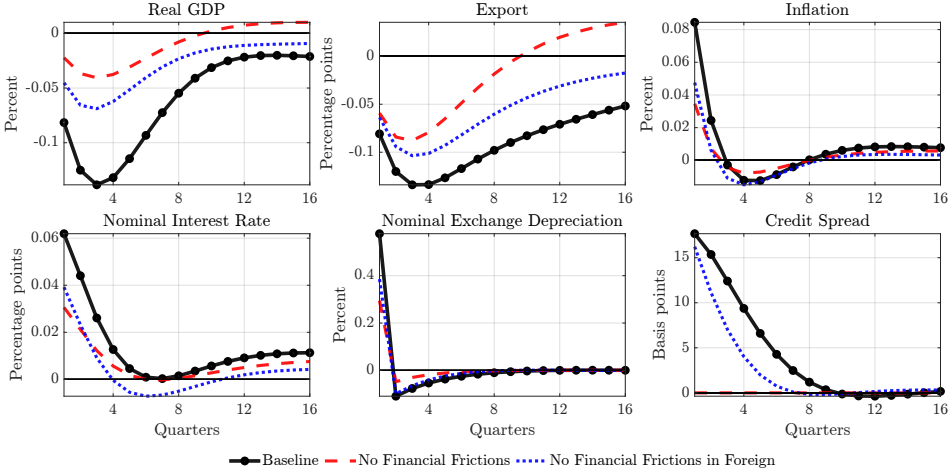
Impulse Response Matching



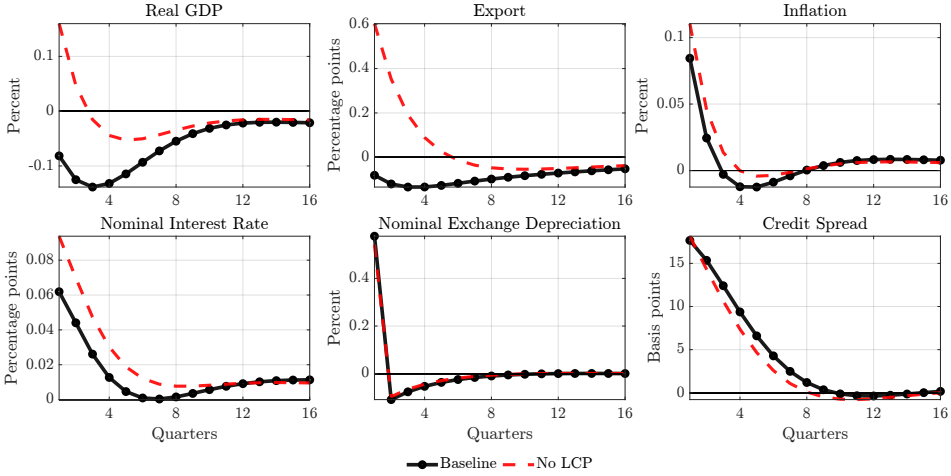
Estimated Parameters

Parameter	Prior			Posterior			
	Distribution	Mean	SD	Mode	Median	5%	95%
h	Beta	0.650	0.1	0.715	0.709	0.558	0.841
σ	Gamma	1	0.375	1.126	1.260	0.765	1.811
λ	Gamma	5	1	4.727	4.831	3.429	6.293
x	Beta	0.240	0.15	0.110	0.168	0.022	0.323
φ_i	Gamma	2.850	2	0.589	0.726	0.167	1.596
ξ_p	Beta	0.660	0.15	0.833	0.777	0.544	0.957
ξ_{im}	Beta	0.660	0.15	0.697	0.665	0.410	0.873
ρ_R	Beta	0.750	0.1	0.769	0.769	0.603	0.913
ϕ_π	Gamma	1.500	0.25	1.485	1.518	1.158	1.881
ϕ_y	Gamma	0.125	0.05	0.110	0.120	0.047	0.202
ϕ_ε	Gamma	0.100	0.05	0.074	0.093	0.022	0.168
ρ_R^*	Beta	0.750	0.1	0.798	0.742	0.613	0.853
ϕ_π^*	Gamma	1.500	0.25	1.466	1.518	1.162	1.900
ϕ_y^*	Gamma	0.125	0.05	0.107	0.119	0.044	0.204

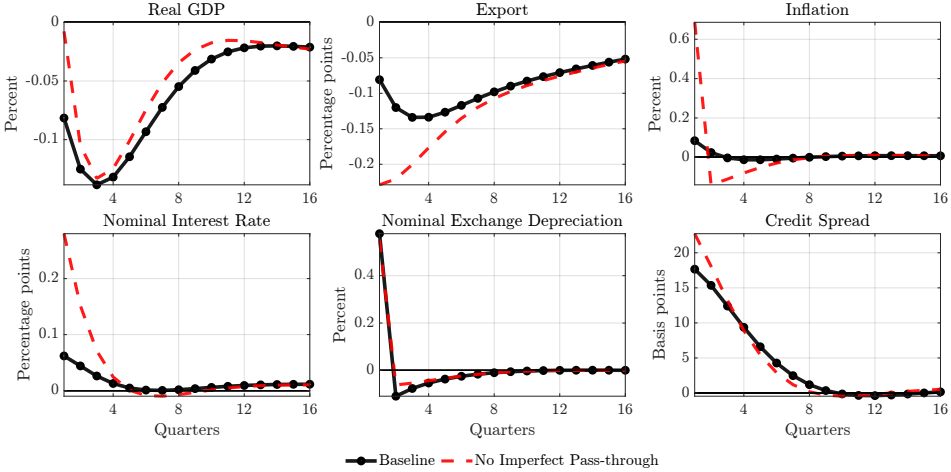
The Role of Financial Frictions



The Role of LCP



The Role of Imperfect Pass-Through



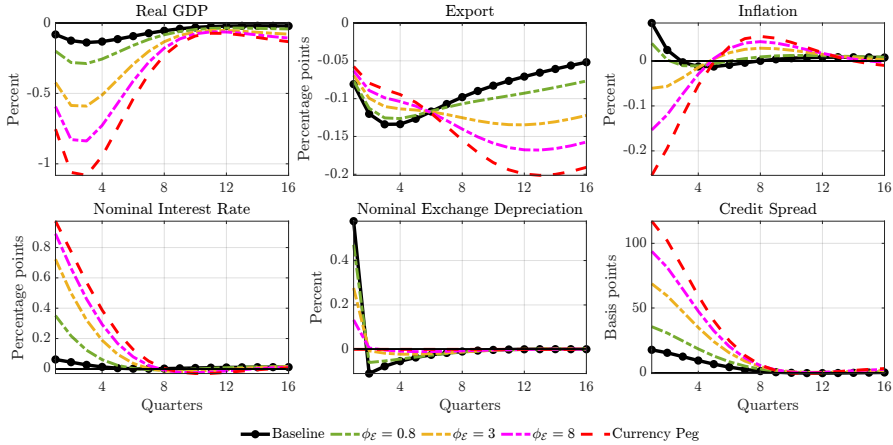
Summary of DSGE Results

- Estimated DSGE model can match VAR evidence
- Three key frictions
  - Financial $\rightarrow$ Amplification
  - Dominant currency paradigm $\rightarrow$ Sign of exports response
  - Imperfect pass-through $\rightarrow$ Inflation and interest rate response

Policy Analysis

Monetary Policy Response to the Exchange Rate

- **Exchange rate regime not irrelevant**
  - Macroeconomic volatility increasing with weight on exchange rate in monetary policy rule



Additional Instruments

- **Tax on total credit**

$$n_t = (1 - \tau^k_{t-1}) r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1} d_{t-1}}{\Pi_t} - (1 + \tau^b_{t-1}) \frac{R^*_{bt-1}}{\Pi^*_t} s_t b^*_{t-1}$$

  - Directly impacts credit spreads

$$\mu_{kt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[(1 - \tau^k_{t+1}) r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right] \right\}$$

Additional Instruments

- **Tax on foreign borrowing**

$$n_t = (1 - \tau^k_{t-1}) r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1} d_{t-1}}{\Pi_t} - (1 + \tau^b_{t-1}) \frac{R^*_{bt-1}}{\Pi^*_t} s_t b^*_{t-1}$$

  - Directly impacts UIP wedge

$$\mu_{bt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[\frac{R_{t+1}}{\Pi_{t+1}} - (1 + \tau^b_{t+1}) \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right] \right\}$$

Additional Instruments

- Tax on foreign borrowing

$$n_t = (1 - \tau^k_{t-1}) r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1} d_{t-1}}{\Pi_t} - (1 + \tau^b_{t-1}) \frac{R^*_{bt-1}}{\Pi^*_t} s_t b^*_{t-1}$$

  - Directly impacts UIP wedge

$$\mu_{bt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[\frac{R_{t+1}}{\Pi_{t+1}} - (1 + \tau^b_{t+1}) \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right] \right\}$$

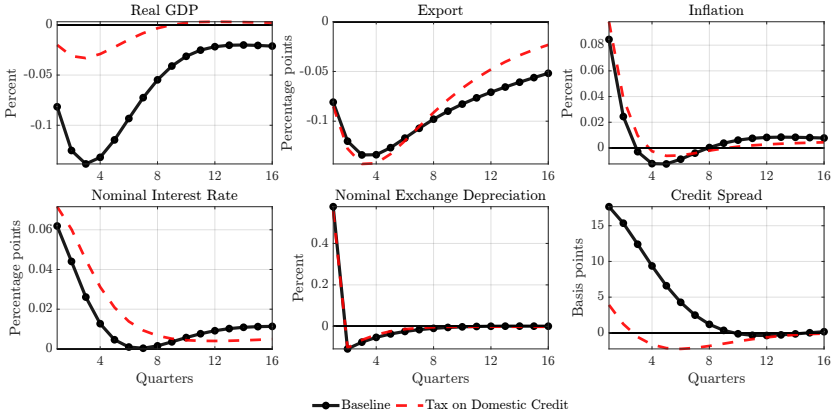
- **Policy rule** for both taxes is

$$\tau^j_t = \phi_j \ln \left(\frac{q_t z_t}{qz} \right)$$

for $j = \{b, k\}$ [Borio and Lowe (2002)]

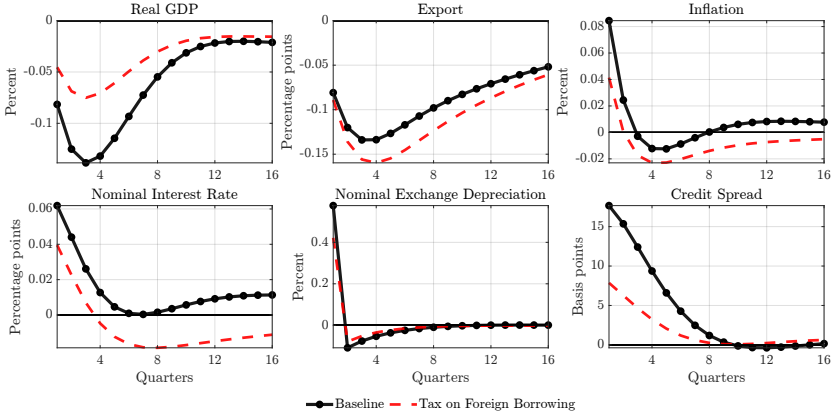
Macroprudential policy

- **Tax on total credit reduces macroeconomic volatility**
  - Subsidize total credit → Reduce credit spread → Smaller GDP contraction → Slightly higher inflation



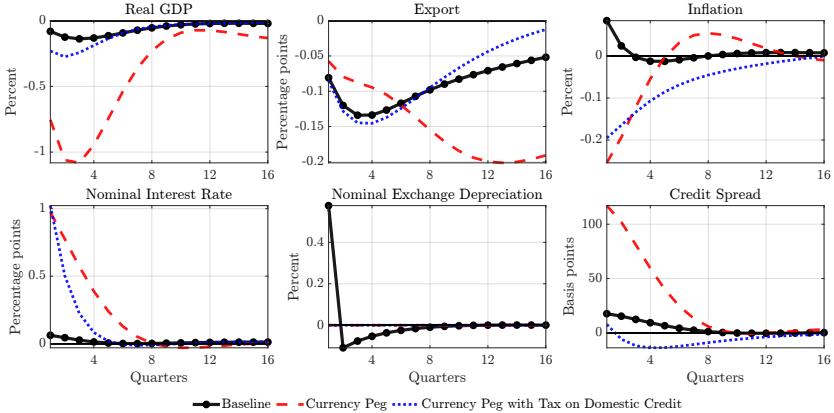
Capital Flows Managament

- **Tax on foreign borrowing has very similar effects to those of tax on total credit**
  - Subsidize USD borrowing → Reduce UIP → Smaller ER depreciation → Smaller increase in inflation



Peg + Macroprudential Policy

- **Tax on total credit alleviates negative consequences of peg**
  - Can partly substitute for lack of monetary policy stabilization



Conclusions

Conclusions

- **Panel VAR** $\rightarrow$ Consistent with idea of Global Financial Cycle
  - Contractionary US monetary policy shock leads to a domestic recession
  - Despite domestic currency depreciation

Conclusions

- **Panel VAR** $\rightarrow$ Consistent with idea of Global Financial Cycle
  - Contractionary US monetary policy shock leads to a domestic recession
  - Despite domestic currency depreciation
- **Estimated two-country DSGE** $\rightarrow$ Can match empirical evidence
  - Key role of financial frictions in banking sector and pricing frictions in international trade

Conclusions

- **Panel VAR** $\rightarrow$ Consistent with idea of Global Financial Cycle
  - Contractionary US monetary policy shock leads to a domestic recession
  - Despite domestic currency depreciation
- **Estimated two-country DSGE** $\rightarrow$ Can match empirical evidence
  - Key role of financial frictions in banking sector and pricing frictions in international trade
- **Policy analysis**
  - Peg exacerbates macroeconomic volatility (exchange rate regime not irrelevant)
  - Tax on foreign borrowing decreases macroeconomic volatility
  - Tax on domestic credit can achieve similar result
  - Both taxes can substitute for lack of monetary policy stabilization under a peg

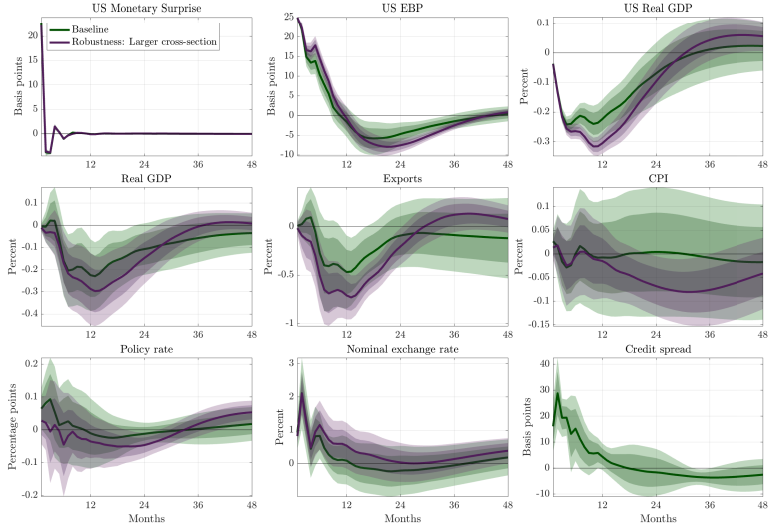
Appendix

A1: VAR Robustness

VAR Robustness

Back

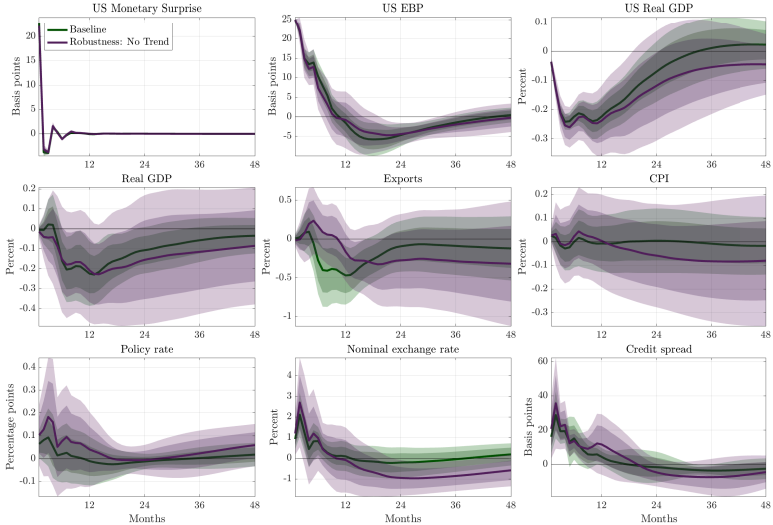
Larger sample of 24 countries



VAR Robustness

Back

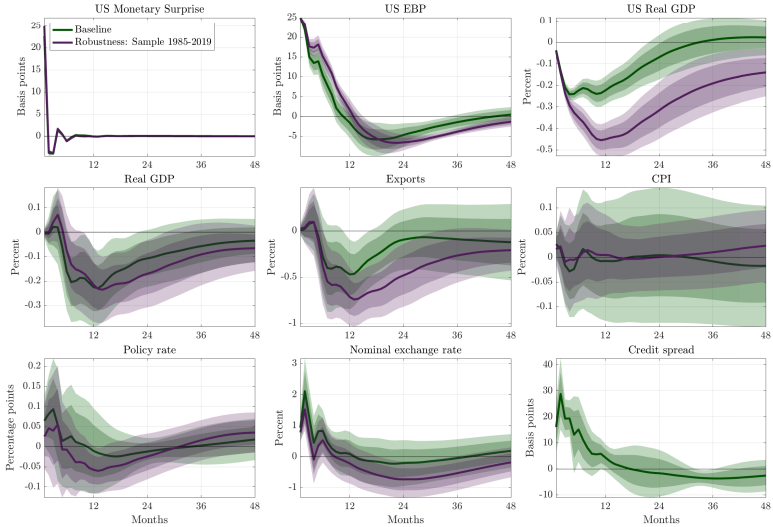
No trend



VAR Robustness

Back

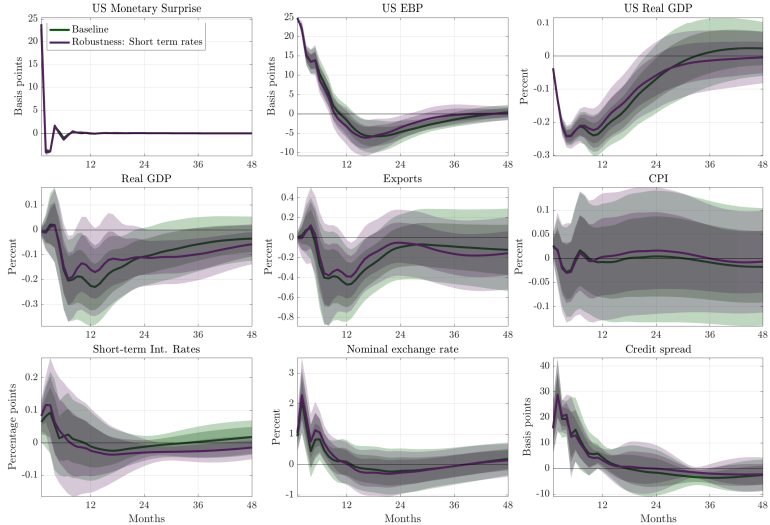
Longer sample (1985-2019, no data on credit spreads)



VAR Robustness

Back

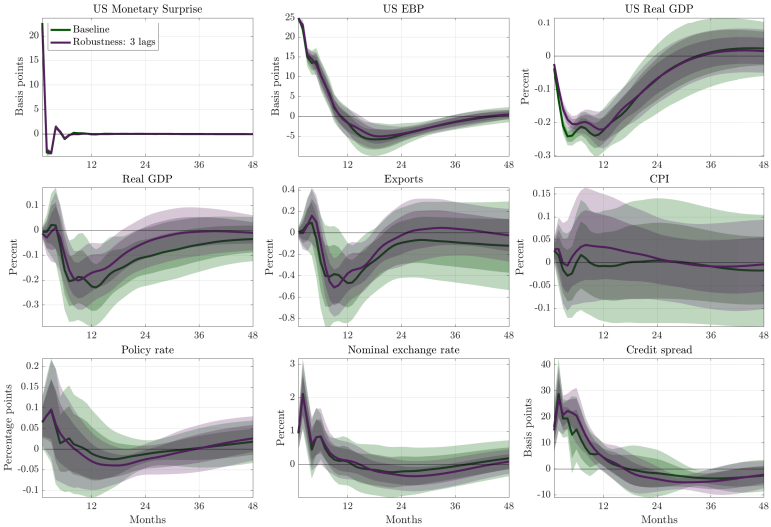
Short-term market interest rates



VAR Robustness

Back

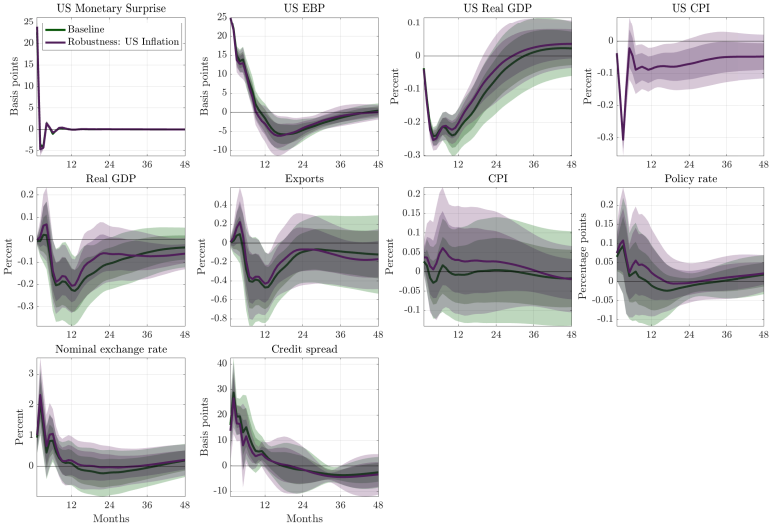
Alternative lag length (3 lags)



VAR Robustness

Back

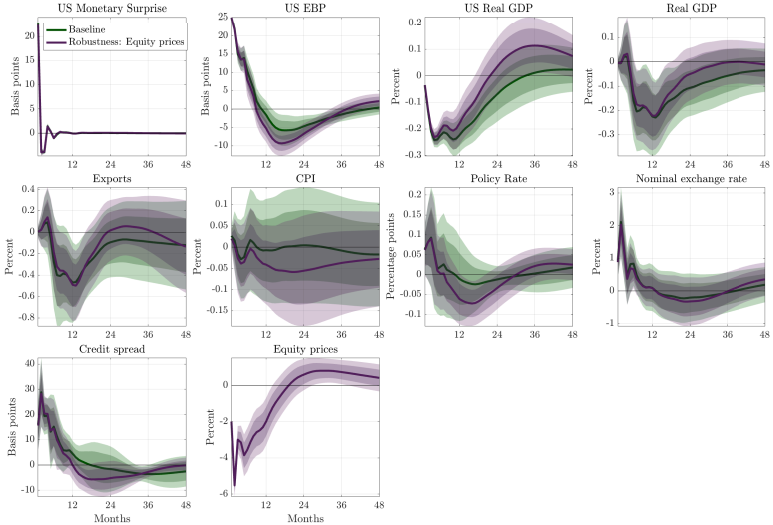
Adding US inflation



VAR Robustness

Back

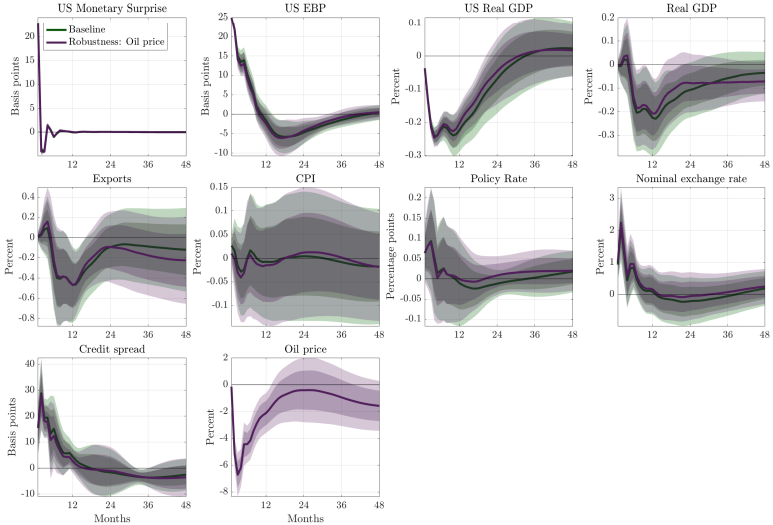
Controlling for Home equity prices



VAR Robustness

Back

Controlling for oil prices



A2: Model

Households

- Representative household in Home country keeps wage fixed with probability ξ_w

$$\max \ \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left[\ln(c_{t+j} - h\bar{c}_{t+j-1}) - \frac{\chi}{1+\zeta} \int_0^n \ell_{t+j}(i)^{1+\zeta} di \right]$$

subject to

$$P_t c_t + D_t = \int_0^n W_t(i) \ell_t(i) di + R_{t-1} D_{t-1} + T_t,$$

and

$$\ell_t(i) = \frac{1}{n} \left[\frac{W_t(i)}{W_t} \right]^{-\nu} \ell_t$$

where

$$c_t \equiv \left[a^{\frac{1}{\epsilon}} c_{Ht}^{\frac{\epsilon-1}{\epsilon}} + (1-a)^{\frac{1}{\epsilon}} c_{Ft}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$$

Home Banks

- Lend to H firms, issue deposits to H households, and **borrow from F banks**

Home Banks

- Lend to H firms, issue deposits to H households, and borrow from F banks
- **Balance sheet currency mismatch**

$$\underbrace{q_t z_t}_{\text{Assets}} = \underbrace{d_t + s_t b_t^* + n_t}_{\text{Liabilities}}$$

Home Banks

- Lend to H firms, issue deposits to H households, and borrow from F banks
- Balance sheet currency mismatch

$$\underbrace{q_t z_t}_{\text{Assets}} = \underbrace{d_t + s_t b_t^* + n_t}_{\text{Liabilities}}$$

- Can divert fraction of assets

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)$$

where $x_t = s_t b_t^* / (q_t z_t)$

  - **Foreign funds harder to recover than domestic funds**
  - Incentive compatibility constraint

$$V(n_t) \geq \Theta(x_t) q_t z_t$$

Home Banks' Problem

- Choose loans (z_t), deposits (d_t), and interbank borrowing (b_t^*) to solve

$$V(n_t) = \max \mathbb{E}_t \{\mathcal{M}_{t,t+1}[(1-\omega)n_{t+1} + \omega V(n_{t+1})]\}$$

subject to

$$\begin{aligned} q_t z_t &= d_t + s_t b_t^* + n_t \\ V(n_t) &\geq \Theta(x_t) q_t z_t \\ n_{t+1} &= r_{kt+1} q_t z_t - \frac{R_t}{\Pi_{t+1}} d_t - \frac{R_{bt}^*}{\Pi_{t+1}^*} s_{t+1} b_t^* \end{aligned}$$

where

$$\Theta(x_t) = \theta \left(1 + \frac{\gamma}{2} x_t^2\right)$$

and $x_t = s_t b_t^* / (q_t z_t)$

Solution of Local Banks' Problem

- All bankers choose same leverage and same ratio of foreign liabilities

Solution of Local Banks' Problem

- All bankers choose same leverage and same ratio of foreign liabilities
- Binding incentive compatibility constraint pins down **leverage**

$$\phi_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}$$

  - $\mu_{dt} \rightarrow$ Discounted return of domestic deposits
  - $\mu_{kt} \rightarrow$ Discounted excess return of capital over domestic deposits
  - $\mu_{bt} \rightarrow$ Discounted excess return of domestic deposits over international interbank borrowing

Solution of Local Banks' Problem

- All bankers choose same leverage and same ratio of foreign liabilities
- Binding incentive compatibility constraint pins down leverage

$$\phi_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}$$

  - $\mu_{dt} \rightarrow$ Discounted return of domestic deposits
  - $\mu_{kt} \rightarrow$ Discounted excess return of capital over domestic deposits
  - $\mu_{bt} \rightarrow$ Discounted excess return of domestic deposits over international interbank borrowing
- Optimal portfolio allocation pins down **share of foreign liabilities**

$$\frac{\mu_{kt}}{\mu_{bt}} = \frac{\Theta(x_t)}{\Theta'(x_t)} - x_t$$

Endogenous UIP Wedge

- Without financial frictions, UIP would hold

$$1 = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right]$$

Endogenous UIP Wedge

- Without financial frictions, UIP would hold

$$1 = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right]$$

- Financial frictions create **endogenous wedge** between domestic and foreign interest rate

$$\mu_{bt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right]$$

  - Since Foreign funds harder to recover, domestic currency must pay a premium
  - Consistent with empirical evidence since Fama (1984)

Foreign Banks' Problem

- No currency mismatch on their balance sheet

- Choose loans (z_t^*), deposits (d_t^*), and interbank lending (b_t^*) to solve

$$V(n_t^*) = \max \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1}^* [(1-\omega) n_{t+1}^* + \omega V(n_{t+1}^*)] \right\}$$

subject to

$$\begin{aligned} q_t^* z_t^* + b_t^* &= d_t^* + n_t^* \\ V(n_t^*) &\geq \theta^* q_t^* z_t^* \\ n_{t+1}^* &= r_{kt+1}^* q_t^* z_t^* + \frac{R_{bt}^*}{\Pi_{t+1}^*} b_t^* - \frac{R_t^*}{\Pi_{t+1}^*} d_t \end{aligned}$$

Capital Producers

- **Capital producers** transform final goods into capital goods

$$\mathbb{E}_t \sum_{j=0}^{\infty} \mathcal{M}_{t,t+j} \left[q_{t+j} - 1 - \frac{\varphi_i}{2} \left(\frac{i_{t+j}}{i_{t+j-1}} - 1 \right)^2 \right] i_{t+j},$$

Capital Producers and Intermediate Goods Producers

- Capital producers transform final goods into capital goods

$$\mathbb{E}_t \sum_{j=0}^{\infty} \mathcal{M}_{t,t+j} \left[q_{t+j} - 1 - \frac{\varphi_i}{2} \left(\frac{i_{t+j}}{i_{t+j-1}} - 1 \right)^2 \right] i_{t+j},$$

- **Intermediate goods producers** use standard Cobb-Douglas technology

$$y_t = A_t k_{t-1}^{\alpha} \ell_t^{1-\alpha}$$

- Issue securities to acquire capital for production in subsequent period (balance sheet $\rightarrow q_t z_t = q_t k_t$)
  - Sell undepreciated capital on open market after production takes place

- Profits

$$\mathcal{P}_t = p_{mt} y_t - w_t \ell_t - r_{kt} q_{t-1} z_{t-1} + (1-\delta) q_t k_{t-1}$$

Retailers

- Firms in H set export prices in foreign currency (**local currency pricing**)

$$\max_{\widetilde{P}_t(h),\widetilde{P}^*_t(h)} \mathbb{E}_t \sum_{j=0}^{\infty} \xi_H^j \mathcal{M}_{t,t+j} \left\{ \left[\frac{\widetilde{P}_t(h)}{P_{t+j}} - p_{mt+j} \right] y_{t,t+j}(h) + \left[\frac{\mathcal{E}_t \widetilde{P}^*_t(h)}{P_{t+j}} - p_{mt+j} \right] y^*_{t,t+j}(h) \right\}$$

subject to

$$y_{t,t+j}(h) = \left[\frac{\widetilde{P}_t(h)}{P_{Ht+j}} \right]^{-\varrho} y_{Ht+j} \qquad \text{and} \qquad y^*_{t,t+j}(h) = \left[\frac{\widetilde{P}^*_t(h)}{P^*_{Ht+j}} \right]^{-\varrho} y^*_{Ht+j}$$

where

$$y_{Ht} = a \left(\frac{P_{Ht}}{P_t} \right)^{-\epsilon} \left[c_t + i_t + \frac{\varphi_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 i_t \right] \quad \text{and} \quad y^*_{Ht} = a^* \left(\frac{P^*_{Ht}}{P^*_t} \right)^{-\epsilon} \left[c^*_t + i^*_t + \frac{\varphi_i}{2} \left(\frac{i^*_t}{i^*_{t-1}} - 1 \right)^2 i^*_t \right]$$

Retailers

- Firms in H set export prices in foreign currency (local currency pricing)

$$\max_{\widetilde{P}_t(h),\widetilde{P}^*_t(h)} \mathbb{E}_t \sum_{j=0}^{\infty} \xi_H^j \mathcal{M}_{t,t+j} \left\{ \left[\frac{\widetilde{P}_t(h)}{P_{t+j}} - p_{mt+j} \right] y_{t,t+j}(h) + \left[\frac{\mathcal{E}_t \widetilde{P}^*_t(h)}{P_{t+j}} - p_{mt+j} \right] y^*_{t,t+j}(h) \right\}$$

subject to

$$y_{t,t+j}(h) = \left[\frac{\widetilde{P}_t(h)}{P_{Ht+j}} \right]^{-\varrho} y_{Ht+j} \qquad \text{and} \qquad y^*_{t,t+j}(h) = \left[\frac{\widetilde{P}^*_t(h)}{P^*_{Ht+j}} \right]^{-\varrho} y^*_{Ht+j}$$

where

$$y_{Ht} = a \left(\frac{P_{Ht}}{P_t} \right)^{-\epsilon} \left[c_t + i_t + \frac{\varphi_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 i_t \right] \quad \text{and} \quad y^*_{Ht} = a^* \left(\frac{P^*_{Ht}}{P^*_t} \right)^{-\epsilon} \left[c^*_t + i^*_t + \frac{\varphi_i}{2} \left(\frac{i^*_t}{i^*_{t-1}} - 1 \right)^2 i^*_t \right]$$

- Producer currency pricing in country F

Importers

- Law of One Price holds at the dock but not for consumers
- Importers reset price in local currency infrequently (**imperfect pass-through**)

$$\max_{\widetilde{P}_t(f)} \mathbb{E}_t \sum_{j=0}^{\infty} \xi_F^j \mathcal{M}_{t,t+j} \left[\frac{\widetilde{P}_t(f)}{P_{t+j}} - \frac{\mathcal{E}_t P_t^*(f)}{P_{t+j}} \right] y_{t,t+j}(f)$$

subject to

$$y_{t,t+j}(f) = \left[\frac{\widetilde{P}_t(f)}{P_{Ft+j}} \right]^{-\varrho} y_{Ft+j},$$

where

$$y_{Ft} = (1-a) \left(\frac{P_{Ft}}{P_t} \right)^{-\epsilon} \left[c_t + i_t + \frac{\varphi_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 i_t \right].$$

Welfare Analysis

Table Welfare and volatilities.

Regime	Welfare change	Std. of real GDP	Std. of inflation
Fully flexible exchange rate	-0.01	0.20	0.03
Baseline	0.00	0.25	0.02
Baseline + tax on domestic credit	0.69	0.01	0.03
Baseline + tax on foreign borrowing	0.27	0.08	0.01
Peg	-13.27	12.87	0.33
Peg + tax on domestic credit	1.14	0.66	0.29
Peg + tax on foreign borrowing	-0.02	1.00	0.15

NOTE: The second column of the table reports the consumption equivalent (in percent) of each policy regime (first column) relative to the baseline. The third and fourth columns report the standard deviation of real GDP and inflation (also in percent) under each policy regime.