The International Spillovers of Synchronous Monetary Tightening

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Motivation

- Central banks are tightening aggressively to reduce inflation.
- Risk (Obstfeld, 2022):
  - Larger spillovers due to synchronized tightening.
  - Global policy coordination needed to avoid severe global slowdown.
- Questions:
  - Are effects of synchronous tightening "larger than sum of the parts"?
  - If so, are there gains from coordinating monetary policies?

Our Contribution

- Synchronous tightening → large spillovers by straining global financial intermediaries' balance sheets.
- Strains on global intermediaries → worse monetary policy trade-offs, more scope for policy coordination.

1. Empirical Analysis:
   - Effects of contractionary monetary shocks larger during global tightening cycles.
   - Ampification larger for output than for inflation.
2. Model:
   - Leverage-constrained global financial intermediaries (GFIs).
   - Nonlinear effects of synchronous tightening through GFIs' balance sheet.
   - Financial amplification large for output, small for inflation.
3. Motives for monetary coordination in a global inflation surge:
   - Both countries' monetary policy affects GFIs' balance sheet.
   - Stronger GFIs' balance sheets improve trade-offs globally.

Empirical Analysis

Empirical Background

Data: interest rates, GDP, inflation, credit spreads, bank equity prices, unemployment for 21 advanced economies 1980q1-2019q4.

Monetary policy shocks: $\varepsilon_{i,t}^{MP}$

$$R_{i,t} = \alpha_i + \boldsymbol{\beta}_i \mathbf{Z}_{i,t} + \varepsilon_{i,t}^{MP},$$

$\mathbf{Z}_{i,t}$: two lags of of interest rates, inflation, unemployment, exchange rate.

Two questions :

1. Are the GDP effects of synchronous contractionary shocks larger than the sum of their parts?
2. Are the effects of a sizeable contractionary shock larger during historical episodes of global tightening?

Spillovers, in Isolation and Combined

1. GDP effects of synchronous contractionary shocks are larger than the sum of their parts.

$$\Delta GDP_{i,t+8} = \beta_D \mathbb{D}_{i,t} + \beta_F \mathbb{F}_{i,t} + \beta_H \mathbb{DF}_{i,t} \times \mathbb{YH}_{i,t} + \beta_L \mathbb{DF}_{i,t} \times \mathbb{YL}_{i,t} + u_{i,t}$$

	(1) $\Delta GDP(t+8)$	(2) $\Delta GDP(t+8)$	(3) $\Delta GDP(t+8)$
Dummy: Own Tightening	-1.09***	-0.77***	-0.80***
$\mathbb{1}\{\varepsilon^{MP}_{i,t} > 0\}$	(-6.16)	(-3.61)	(-3.72)
Dummy: Foreign Tightening	-0.87***	-0.55**	-0.56**
$\mathbb{1}\left\{\sum_{j\neq i} w_{jt}\varepsilon^{MP}_{jt} > 0\right\}$	(-3.39)	(-2.23)	(-2.18)
Dummy: Own × Foreign Tightening		-0.65*	
$\mathbb{1}\left\{\varepsilon^{MP}_{i,t} > 0 \text{ and } \sum_{j\neq i} w_{jt}\varepsilon^{MP}_{jt} > 0\right\}$		(-1.93)	
Dummy: Own × Foreign Tightening, Hi Growth			-0.07
$\mathbb{1}\left\{\varepsilon^{MP}_{i,t} > 0 \text{ and } \sum_{j\neq i} w_{jt}\varepsilon^{MP}_{jt} > 0 \text{ and GDP Q4/Q4} > \text{median}\right\}$			(-0.24)
Dummy: Own × Foreign Tightening, Lo Growth			-1.53***
$\mathbb{1}\left\{\varepsilon^{MP}_{i,t} > 0 \text{ and } \sum_{j\neq i} w_{jt}\varepsilon^{MP}_{jt} > 0 \text{ and GDP Q4/Q4} < \text{median}\right\}$			(-4.95)
Observations	2,986	2,986	2,958
Fixed Effects	yes	yes	yes

State-dependent responses to contractionary shocks

2. Large contractionary monetary shocks are amplified during a global tightening cycle (synchronous)

A global tightening window lasts two years and starts in quarter t when global interest rate R^* satisfies:

$$R_t^* - R_{t-4}^* > 0.25 \text{ and } \quad R_t^* > R_{t+6}^*$$

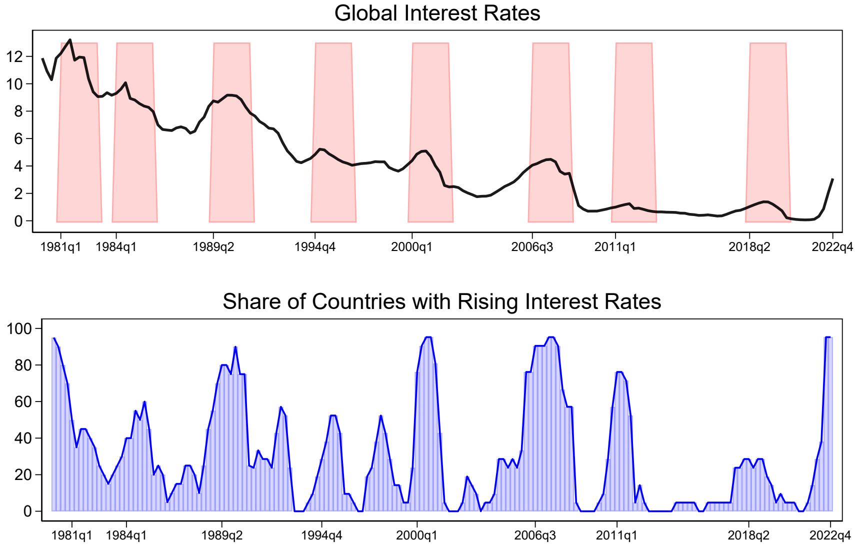
Define dummies for contractionary monetary shocks during and outside of global tightening windows:

$$\text{Synchronous} : \mathbb{DS}_{i,t} = 1 \quad \text{if } \varepsilon_{i,t}^{MP} > 0.25 \text{ and } t \in \text{ global window}$$

$$\text{Asynchronous} : \mathbb{DA}_{i,t} = 1 \quad \text{if } \varepsilon_{i,t}^{MP} > 0.25 \text{ and } t \notin \text{ global window}$$

distributions

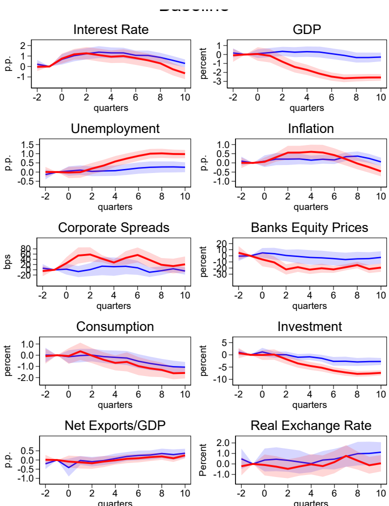
Global Tightening Windows



State-dependent responses to contractionary shocks

Synchronous vs Asynchronous

$$y_{i,t} = \gamma_i + \sum_{\tau=-2}^{10} \sigma_\tau \mathbb{DS}_{i,t-\tau} + \sum_{\tau=-2}^{10} \alpha_\tau \mathbb{DA}_{i,t-\tau} + \varepsilon_{i,t},$$



Empirical Background: Takeaways

- Synchronous contractionary monetary shocks have large non-linear effects on GDP.

- During historical episodes of global tightening, contractionary monetary shocks
  1. have larger GDP effects;
  2. are associated with tightening of financial conditions;
  3. affect activity relatively more than inflation.

A Model of Global Spillovers

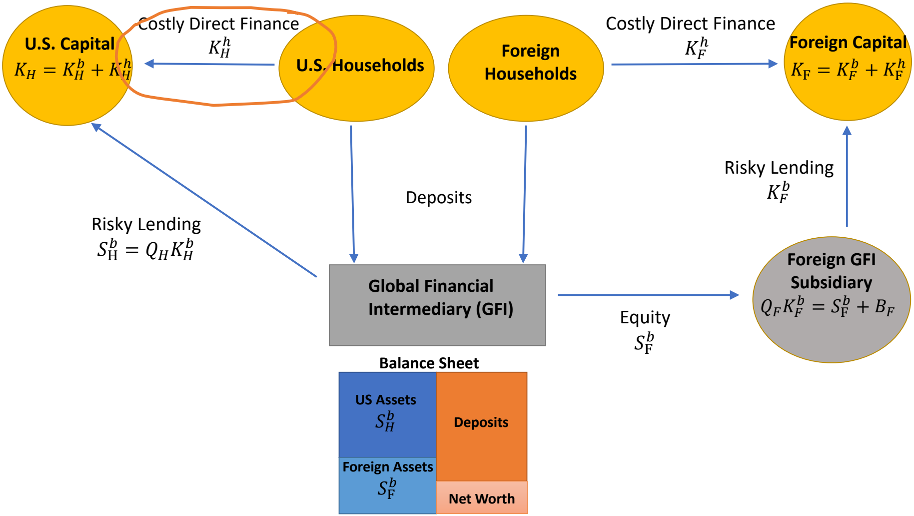
Model: Elements

- Two-country new-Keynesian DSGE model: U.S. (H) and ROW (F).
- Consumption habits and investment adjustment costs.
- Sticky prices for domestic and exported goods (LCP).
- Monetary policy follows Taylor rule that responds to inflation.
- **Shocks**: Country specific monetary shocks $\varepsilon^{m}_{i,t}$; Global markup shock ϵ^{μ}_{t}.
- Global financial institutions (GFIs) intermediate financing of firms by households
  - High net worth. GFIs adjust debt issuance and assets so that K is efficiently allocated. Small trade spillovers.
  - Low net worth. GFIs fire-sale assets to households, credit spreads rise. Large trade and financial spillovers.

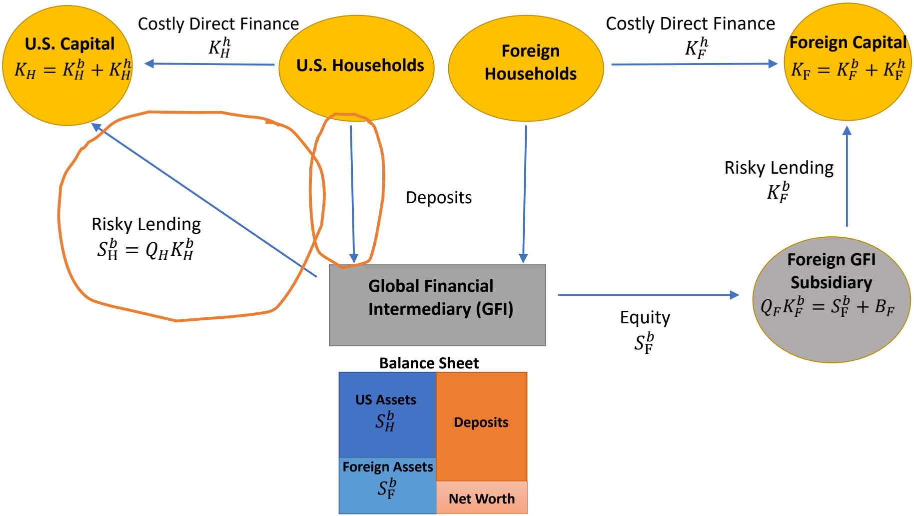
Global Financial Flows

- Households can (1) directly and inefficiently finance firms' investment 1, or (2) save through global intermediaries (GFIs) 2
- GFIs combine home and foreign deposits and net worth to finance investment at home and abroad 3
- GFIs face occasionally binding leverage constraint which affects transmission of adverse shocks.
  - GFIs operate abroad through leveraged subsidiaries. This amplifies sensitivity of balance sheet to fluctuations in foreign returns.

Model: International Financial Flows



Model: International Financial Flows



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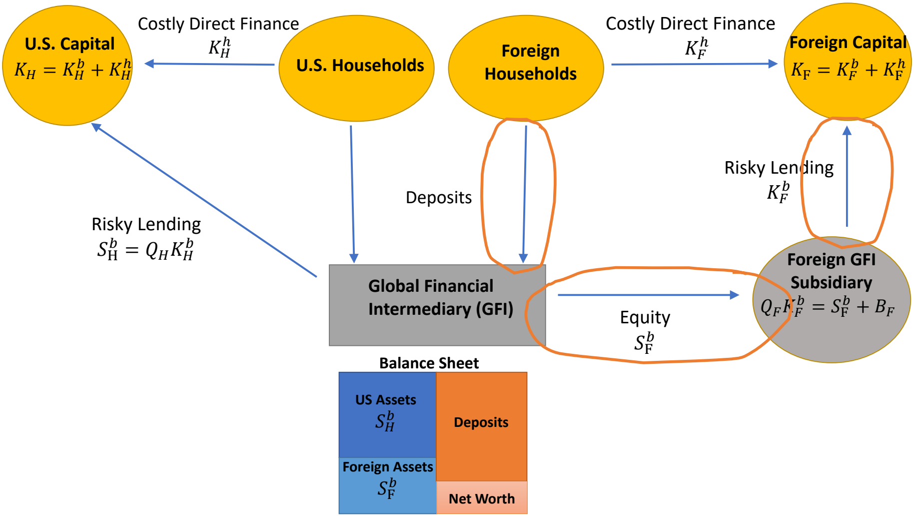
Model: International Financial Flows



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GFIs Problem

- GFI borrows at R^d_{Ht}, invests in home and foreign assets, returns (in \$):

$$R^s_{Ht+1} = \frac{1}{Q_{Ht}}(z_{Ht+1} + (1-\delta)Q_{Ht+1})$$
$$R^s_{Ft+1} = \frac{X_{t+1}}{X_t}\left(\frac{1}{1-\lambda}(R^k_{Ft+1} - R^d_{Ft}) + R^d_{Ft}\right)$$

- If excess returns positive, GFI raises leverage until:

$$\mathbb{E}_t\Lambda_{t+1}\left(R^s_{Ht+1} - R^d_{Ht}\right) = \mathbb{E}_t\Lambda_{t+1}\left(R^s_{Ft+1} - R^d_{Ht}\right) = 0$$

- **Agency Problem**: GFI can divert fraction θ_H of home and θ_F of foreign assets

$\implies$ Leverage constraint which limits arbitrage.

Financial spillovers of Tighter Monetary Policy

- Leverage constraint on GFIs:

$$\theta_H Q_{Ht} S_{Ht} + \theta_F Q_{Ft} S_{Ft} \leq N_t$$

- Joint tightening at home & abroad causes net worth losses:

$$\underbrace{N_t}_{\uparrow i_{Ht}, i_{Ft} \rightarrow N_t \downarrow} = \underbrace{R^s_{Ht} S_{Ht-1}}_{\uparrow i_{Ht} \rightarrow R^s_{Ht} \downarrow} + \underbrace{R^s_{Ft} S_{Ft-1}}_{\uparrow i_{Ft} \rightarrow R^s_{Ft} \downarrow} - R^d_{Ht-1} D_{t-1}$$

- If $N_t \downarrow$ small, GFIs leverage up, no change in spreads:

$$\mathbb{E}_t \Lambda_{t+1} \left(R^s_{Ht+1} - R^d_{Ht} \right) = \mathbb{E}_t \Lambda_{t+1} \left(R^s_{Ft+1} - R^d_{Ht} \right) = 0$$

- If $N_t \downarrow$ large, leverage constraint binds, credit spreads up globally:

$$\mathbb{E}_t \Lambda_{t+1} \left(R^s_{Ht+1} - R^d_{Ht} \right) = \frac{\theta_H}{\theta_F} \mathbb{E}_t \Lambda_{t+1} \left(R^s_{Ft+1} - R^d_{Ht} \right) > 0$$

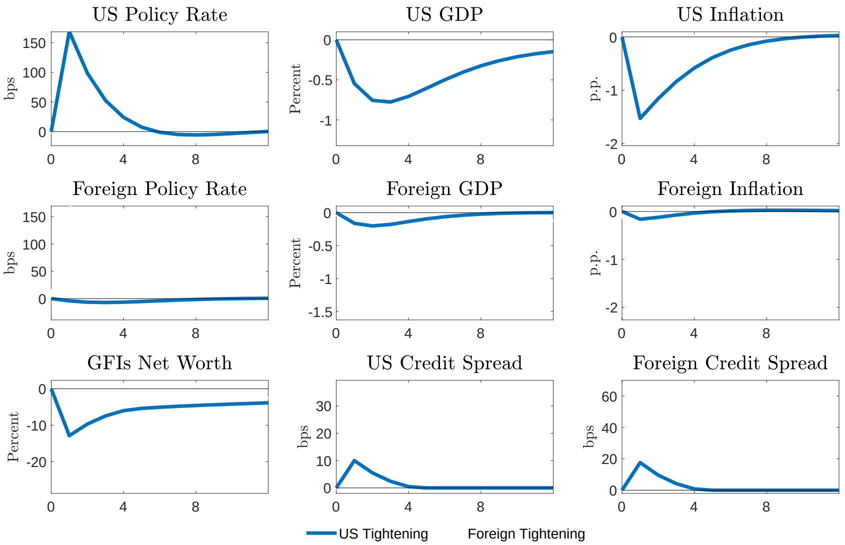
Calibration & Solution Method

- Key calibration targets:
  - Regions size: United States 1/4; Foreign 3/4.
  - GFI asset exposure: United States 3/4; Foreign 1/4. (BIS data)
  - Leverage of GFIs = 4.75. (Ottonello and Winberry (2018))
  - Global spreads rise 60bps with synchronous tightening. (Event Study Analysis)
- Leverage constraint not binding in steady state.
- Model solution: piece-wise linear with occasionally binding constraint (OccBin).

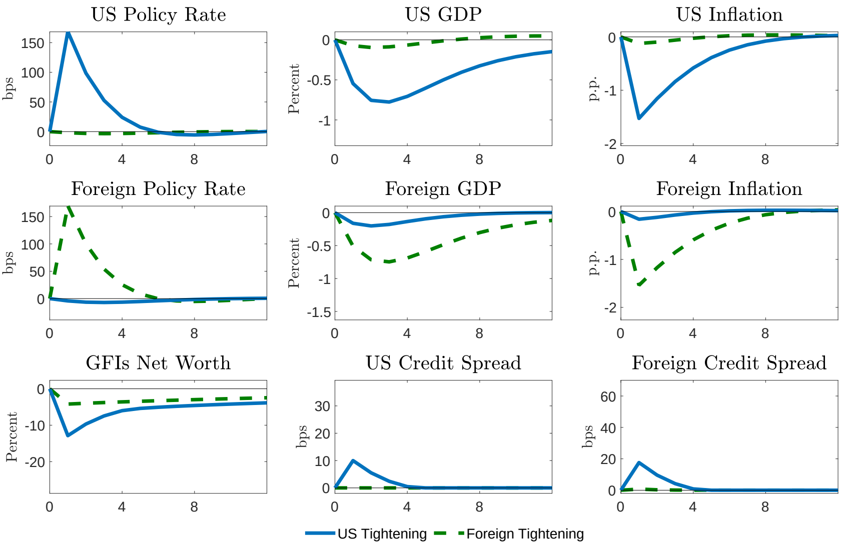
Details

Model Simulations

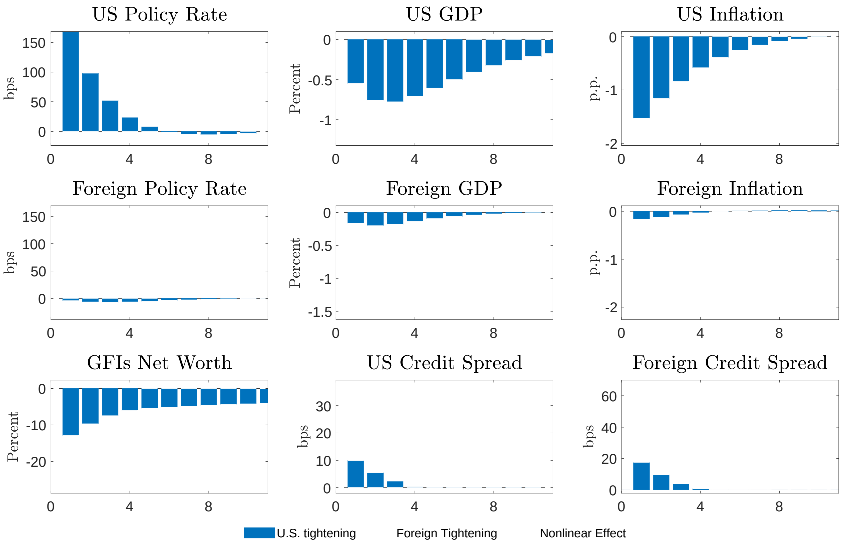
Simulations: Asynchronous Tightening



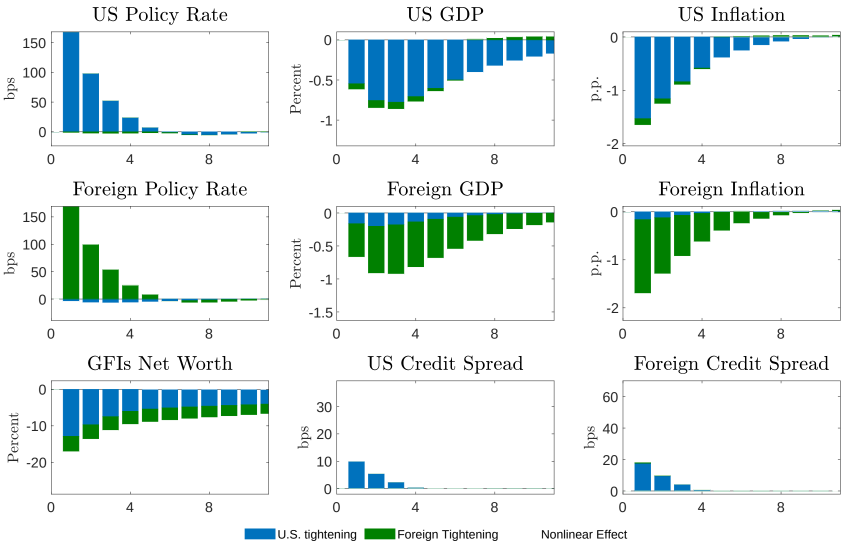
Simulations: Asynchronous Tightening



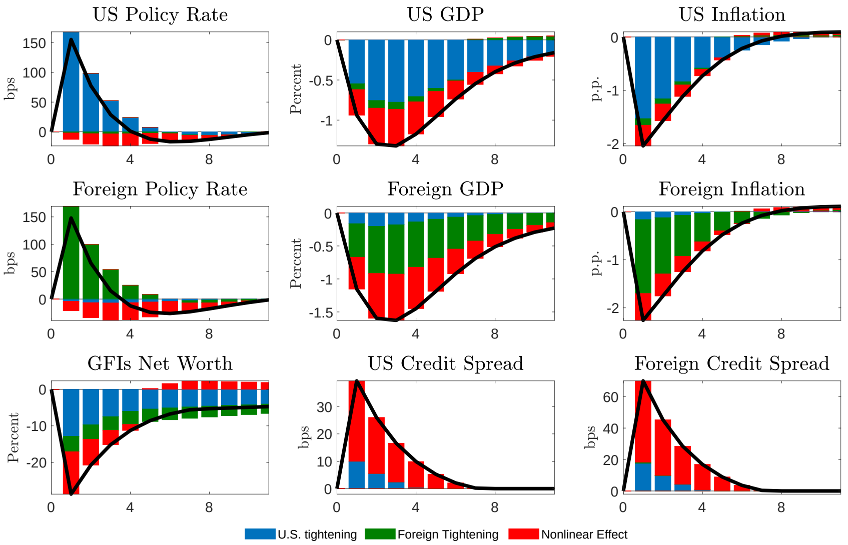
Synchronous vs Asynchronous Tightening



Synchronous vs Asynchronous Tightening



Synchronous vs Asynchronous Tightening



Policy Trade-offs

- Financial amplification larger on output than on inflation.
  (Christiano et al. (2015), Gilchrist et al. (2017))

- Intuition: Financial amplification affects mainly investment... EventStudy

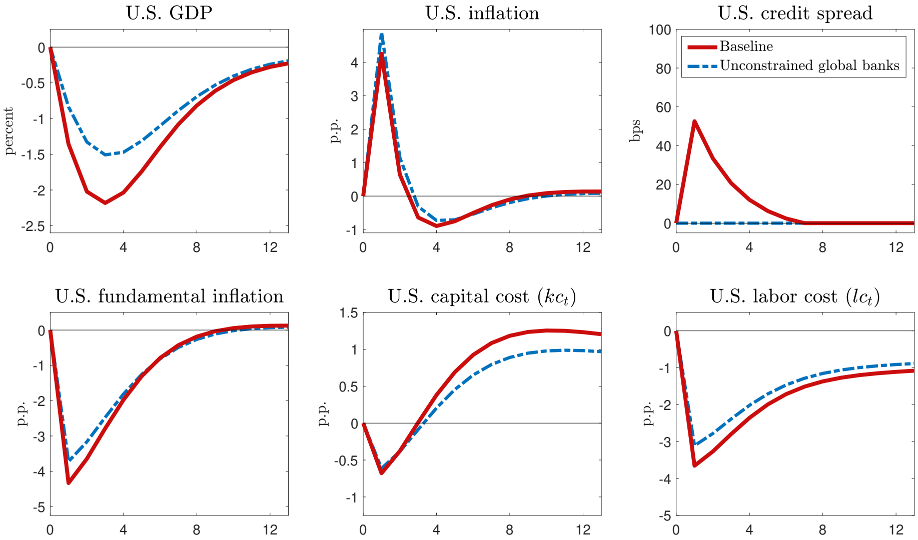
$$\downarrow y_t = c_t + \downarrow\downarrow i_t + nx_t$$

... while the associated drop in inflation π is smaller:

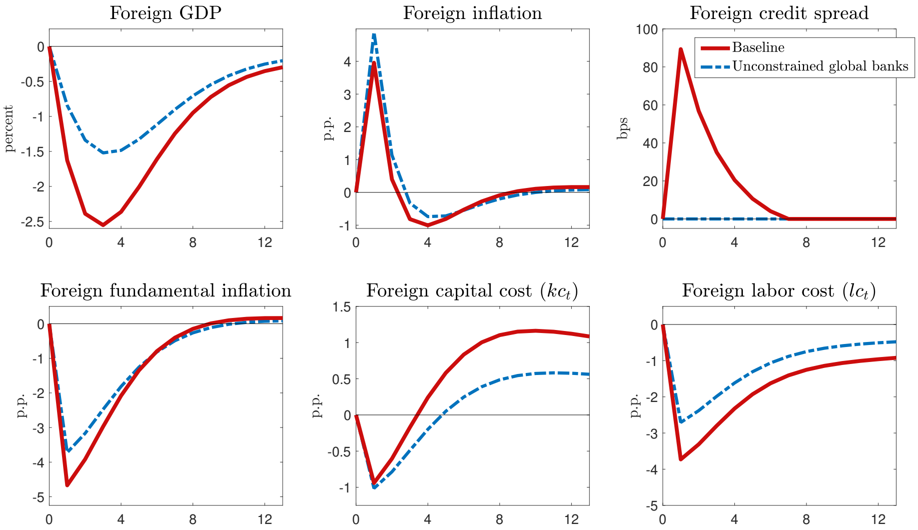
$$\pi_{it} = s\left[(1-\alpha)\, w_{it} + \alpha z_{it} - p_{iit}\right] + \beta \mathbb{E}_t \pi_{it+1} + \mu_t$$

  - lower future capital dampens drop in rental rate z.
  - smaller consumption drop dampens drop in w through smaller wealth effects on labor supply.

Global markup shock: Financial stress worsens trade-offs Home



... and Abroad


Foreign GDP
percent
Foreign inflation
p.p.
Foreign credit spread
bps
Baseline
Unconstrained global banks
Foreign fundamental inflation
p.p.
Foreign capital cost (kc_t)
p.p.
Foreign labor cost (lc_t)
p.p.

Optimal Policy

Policy coordination in a global inflation surge

- Central banks in H, F observe one-time global markup shock ϵ^{μ} and chooses inflation response coefficient $\varphi_i \in (1, 10]$ in the Taylor rule.
- Loss function for country i given shock ϵ^{μ}:

$$\mathcal{L}_i(\varphi_H, \varphi_F) = \sum_{t=0}^{T} \beta^t (\lambda_\pi \pi_{it}^2 + y_{it}^2),$$

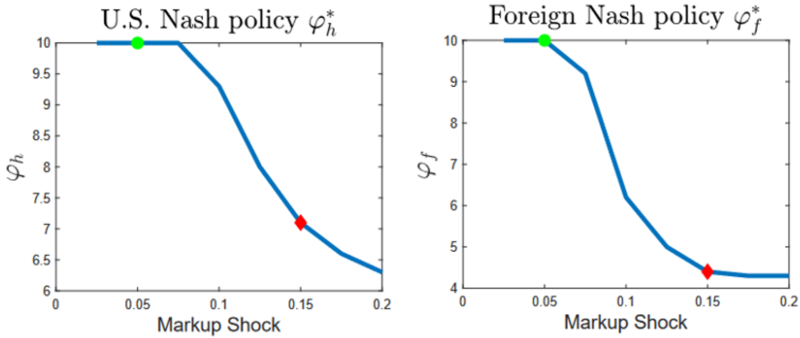
  with high weight on inflation λ_π.

- Best response functions:

$$\varphi_i^{br}(\varphi_j) = \arg\min_{\varphi_i} \mathcal{L}_i(\varphi_i, \varphi_j).$$

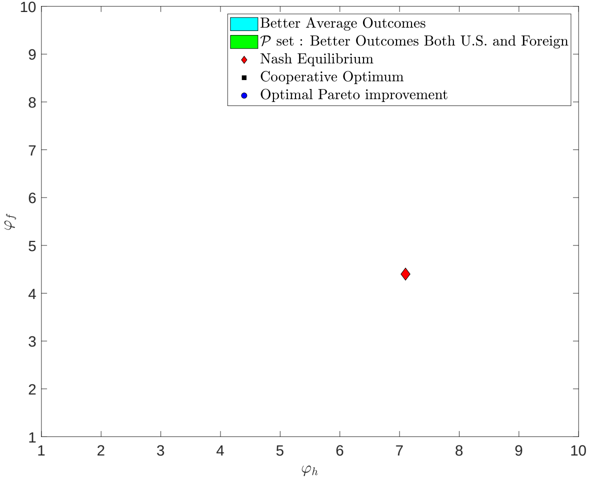
- **Nash Equilibrium**: strategies are best responses to each other.

Nash Equilibrium and Interdependence



- Small shock: large φ, response to inflation
- Large shock: policy actions are substitutes: "small" φ; $\varphi_H > \varphi_F$

Nash Equilibrium and Interdependence



Cooperative policies

- Global loss:

$$\bar{\mathcal{L}}\left(\varphi_H, \varphi_F\right) = \sigma_H \mathcal{L}_H\left(\varphi_H, \varphi_F\right) + (1 - \sigma_H)\mathcal{L}_F\left(\varphi_H, \varphi_F\right)$$

with U.S. weight $\sigma_H = 1/4$

- **Two Cooperative Solutions**:

1: Cooperative Optimum
policies minimize world loss

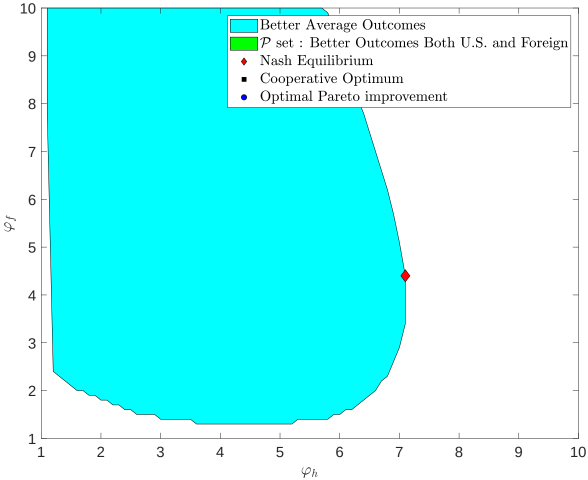
$$\{\varphi_H^{coop}, \varphi_F^{coop}\} = \arg\min_{\varphi_H, \varphi_F} \quad \bar{\mathcal{L}}\left(\varphi_H, \varphi_F\right)$$

2: Optimal Pareto Improvement
policies minimize world loss, s.t. improving relative to Nash

$$\left\{\varphi_H^{pi}, \varphi_F^{pi}\right\} = \arg\min_{(\varphi_H, \varphi_F) \in \boldsymbol{P}} \bar{\mathcal{L}}\left(\varphi_H, \varphi_F\right)$$

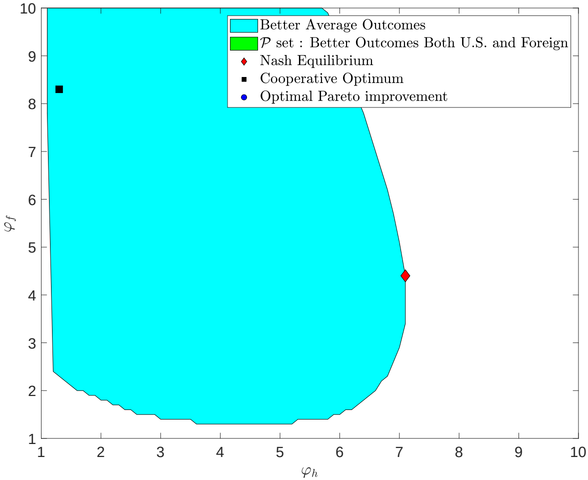
where $P = \left\{(\varphi_H, \varphi_F) \;\middle|\; \mathcal{L}_i\left(\varphi_H, \varphi_F\right) \leq \mathcal{L}_i^{NASH} \text{ for } i = H, F\right\}$.

Cooperative policies



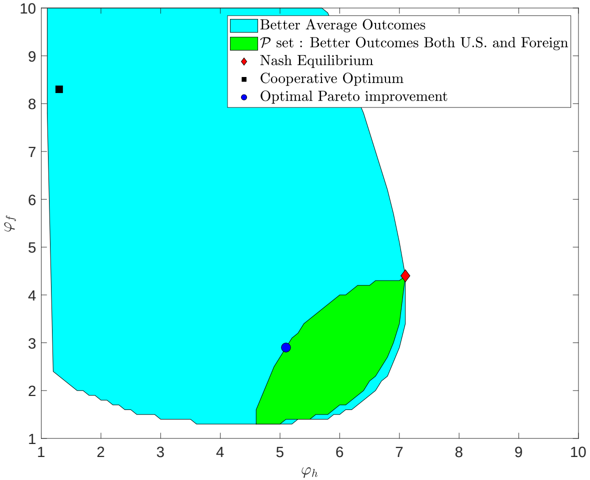
- Large set of policies with better avg outcomes relative to Nash
- These policies feature less aggressive U.S. response φ_H

Cooperative Optimum



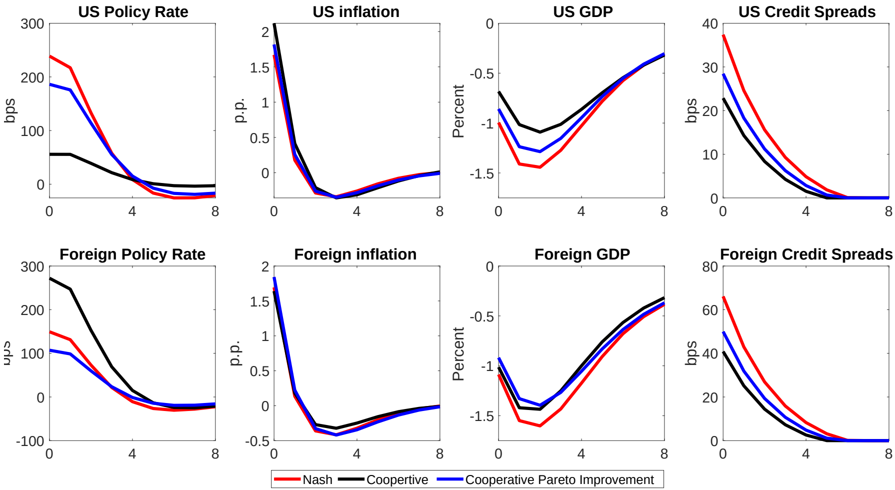
- Cooperative optimum features small φ_H relative to φ_F
- Small φ_H eases fin.conditions allowing large φ_F, but home worse off!

Optimal Pareto Improvement



- Policies that improve over Nash feature smaller φ_H and φ_F
- Under these policies, both countries forgo inflation stabilization

Outcomes under Nash and Cooperative policies



Takeaways

- With constrained GFIs, less-aggressive policy at home eases trade-offs abroad, and viceversa.
- Pareto-improving cooperation exploits this, leading to easier policy globally $\rightarrow$ smaller GDP declines with similar inflation.
- When not requiring a Pareto improvement, cooperation entails easier policy in the U.S. and more aggressive abroad.
    - U.S. has small weight in loss and large influence on GFI balance sheets.
    - RoW much better off (smaller output decline and smaller inflation increase), at expense of the U.S.

Conclusions

Conclusions

- Monetary policy actions can have large effects on asset valuations & funding capacity of global intermediaries.
- With interconnected financial network, financial turbulence can spread across countries.
- Large financial spillovers imply coordination matters.
- Next steps:
    - The role of commitment.
    - Liquidity tools.
    - Deposit pass-through.
    - Bank runs.
    - Fiscal policy effects on monetary policy and financial stability.

Appendix

Details on Data

- We use quarterly data since 1980 on interest rates, GDP, unemployment and inflation.
- Advanced economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, U.K., U.S.
- Emerging market countries: Chile, HK, Indonesia, Israel, Korea, Mexico, Philippines, South Africa, Taiwan.

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Details on Data (I)

- Corporate credit spreads available for:
  - Canada, France, Germany, Italy, Japan, Spain, Switzerland, United Kingdom, United States.
- Equity data of following global banks:
  - Canada: Royal Bank of Canada, Toronto Dominion.
  - France: BNP, SG.
  - Germany: Deutsche Bank.
  - Japan: Sumitomo Mitsui FG, Mitsubishi UFJ FG
  - Spain: Banco Santander, BBVA.
  - Switzerland: Credit Suisse.
  - United Kingdom: HSBC, Barclays, NatWest, Lloyd's.
  - United States: JPMorgan, Citi, WF, BofA, GS, MS.

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Related Literature

- Foreign spillovers of monetary policy shocks.
  Iacoviello and Navarro (2019), Dedola, Rivolta, and Stracca (2017), Degasperi, Hong, and Ricco (2020), di Giovanni and Shambaugh (2008).
  Our contribution: We study interaction between domestic and global monetary shocks and the nonlinear and state-dependent nature of their effects.
- Models with global financial intermediaries and international financial contagion.
  Gabaix and Maggiori (2015), Maggiori (2017), Morelli, Ottonello, and Perez (2022), Devereux and Yetman (2010), Cetorelli and Goldberg (2012), Bruno and Shin (2015)
  Our contribution: The stance of global monetary policy is key determinant of how financial intermediation matters for economic outcomes
- Literature on gains from policy coordination
  Obstfeld and Rogoff (2002), Corsetti and Pesenti (2005), Devereux and Engel (2003), Taylor (2013), Dedola, Karadi, and Lombardo (2013), Bodenstein, Corsetti, and Guerrieri (2020),
  Our contribution: Gains from cooperation are larger when adverse shocks are severe and financial intermediation is impaired

Empirical Specification

- Event study panel regression:

$$y_{i,t} = \gamma_i + \sum_{\tau=-2}^{10} \sigma_\tau DS_{i,t+\tau} + \sum_{\tau=-2}^{10} \alpha_\tau DA_{i,t+\tau} + \varepsilon_{i,t},$$

  $DS_{i,t}$: synchronous tightening dummy;

  $DA_{i,t}$: asynchronous tightening dummy.

- Dependent variables:
  - Interest rate, inflation.
  - Real GDP, unemployment.
  - Corporate credit spreads, bank equity.
- Normalize to 0 the response in $t-1$.
- Standard errors are clustered by country and quarter.

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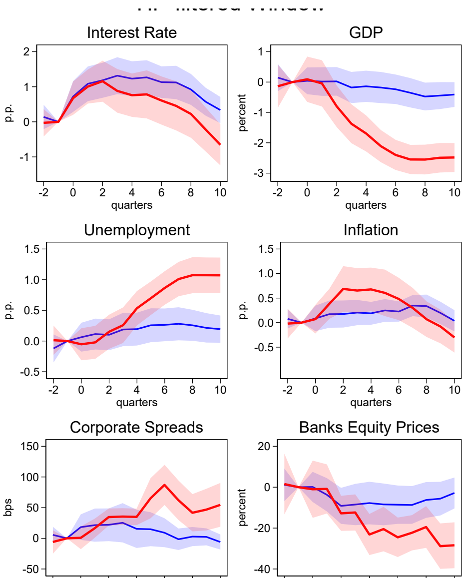
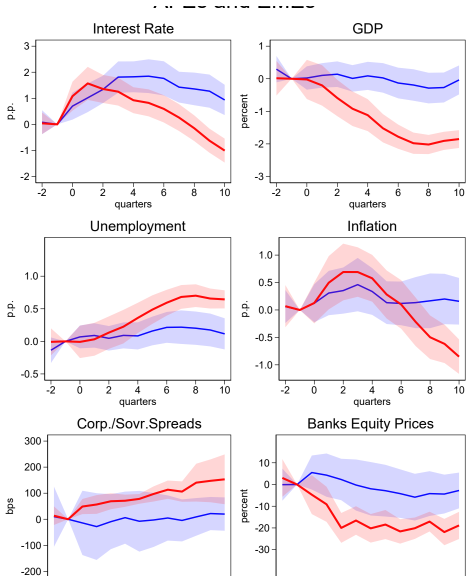
Responses to MP Tightening: Global Controls

Synchronous (red) vs Asynchronous (blue)



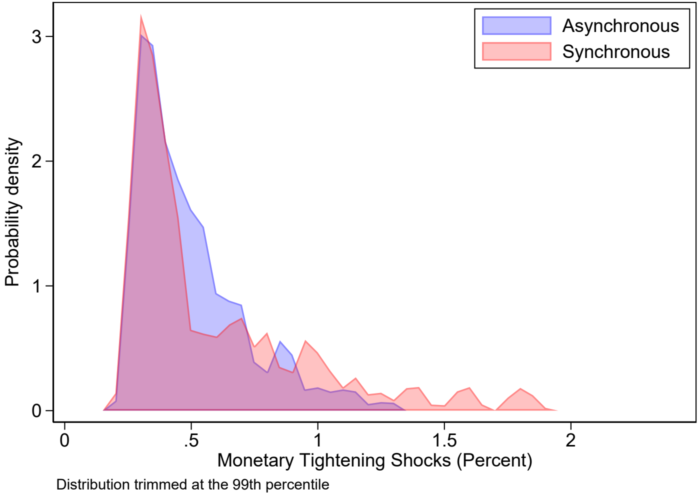
Responses to MP Tightening: Add EMs

Synchronous (red) vs Asynchronous (blue)



Distribution of Shocks

Synchronous vs Asynchronous



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Household Problem

Households in country $i = h, f$ solve

$$\max E_t \sum_{s \geq t} \beta^{s-t} \left[\frac{\left(C_{i,s} - \iota C_{i,s-1}\right)^{1-\rho}}{1-\rho} - \psi \frac{L_{i,s}^{1+\varphi}}{1+\varphi} \right]$$

subject to

$$C_{i,t} + X_{Hi,t} D_{i,t} + g_{i,t} + Q_{i,t} K_{i,t}^{h} + \zeta_i \left(K_{i,t}^{h}, K_{i,t} \right) =$$
$$w_{i,t} L_{i,t} + X_{Hi,t} D_{i,t-1} R_{t-1}^{d} + g_{i,t-1} \frac{R_{t-1}^{g}}{\pi_t} + K_{i,t-1}^{h} (z_{i,t} + (1-\delta) Q_{i,t}) + T_{i,t}$$

where

$$\zeta_i \left(K_{i,t}^{h}, K_{i,t} \right) = \frac{\chi}{2} \left(\frac{K_{i,t}^{h}}{K_{i,t}} - \gamma_i \right)^2 K_{i,t}$$

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Household Problem (cont.)

Optimality conditions are given by

$$\psi L_{i,t}^{\varphi} = U_{ci,t} w_{i,t},$$

$$1 = \beta E_t \Lambda_{i,t+1} \frac{X_{Hi,t+1}}{X_{Hi,t}} R_t^d = \beta E_t \Lambda_{i,t+1} \frac{R_{t+1}^g}{\pi_{t+1}},$$

$$1 + \frac{\partial \zeta_i}{\partial K_{i,t}^h} \frac{1}{Q_{i,t}} = E_t \Lambda_{i,t+1} \frac{(z_{i,t+1} + (1-\delta) Q_{i,t+1})}{Q_{i,t}} = E_t \Lambda_{i,t+1} R_{i,t+1}^k,$$

where $U_{ci,t} = (C_{i,t} - \iota C_{i,t-1})^{-\rho} - \beta \iota E_t (C_{i,t+1} - \iota C_{i,t})^{-\rho}$ and $\Lambda_{i,t+1} = \frac{U_{ci,t+1}}{U_{ci,t}}$.

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Nominal Rigidities

Local Currency Pricing: retailers set prices for domestic goods and for exports subject to Rotemberg adjustment costs.

Phillips curve for domestic goods:

$$\left(\pi_{ii,t}-1\right)\pi_{ii,t}=s_t\left[mc_{i,t}\mu_t-p_{ii,t}\right]+\beta E_t\Lambda_{H,t+1}\left(\pi_{iit+1}-1\right)\pi_{iit+1}\frac{Y_{iit+1}}{Y_{ii,t}}$$

Phillips curve for exported goods:

$$\left(\pi_{ij,t}-1\right)\pi_{ij,t}=s_t\left[mc_{i,t}\mu_t-X_{ji,t}p_{ij,t}\right]+\beta E_t\Lambda_{t,t+1}\left(\pi_{ijt+1}-1\right)\pi_{ijt+1}\frac{Y_{ijt+1}}{Y_{ij,t}}$$

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Capital Goods Production

Capital producers create new investment goods subject to adjustment costs

$$\max E_t \Lambda_{t+1} \left[Q^k_{i,t} I_{i,t} - I_{i,t} - \frac{\gamma_k}{2} (\frac{I_t}{I_{t-1}} - 1)^2 I_t \right]$$

which implies the following first order condition

$$Q^k_{i,t} = 1 + \frac{\gamma_k}{2} (\frac{I_{i,t}}{I_{it-1}} - 1)^2 + \gamma_k \frac{I_{i,t}}{I_{it-1}} (\frac{I_{i,t}}{I_{it-1}} - 1) - \beta \Lambda_{it+1} \gamma_k \left(\frac{I_{it+1}}{I_{i,t}} \right)^2 (\frac{I_{it+1}}{I_{i,t}} - 1)$$

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Foreign Subsidiaries

Foreign subsidiaries finance capital with risk free debt from households and with global banks' equity

$$Q^k_{Ft} K^b_{Ft} = B_{i,t} + S_{Ft} \tag{1}$$

subject to a (binding) leverage constraint

$$B_{Ft} \leq \lambda Q^k_{Ft} K^b_{Ft} \tag{2}$$

Market clearing implies

$$R^s_{Ft} = \frac{1}{(1-\lambda)} R^k_{Ft} - \frac{\lambda}{(1-\lambda)} R_{Ft-1} \tag{3}$$

$$S_{i,t} = (1-\lambda)\, Q_{Ft} K^b_{Ft} \frac{\mathcal{N}_F}{\mathcal{N}_H} \tag{4}$$

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Market Clearing

Market clearing in the goods market

$$\bar{Y}_{i,t} = C_{ii,t} + I_{ii,t} + \frac{\mathcal{N}_j}{\mathcal{N}_i} Y_{ij,t} \left(C_{ij,t} + I_{ij,t} \right) = Y_{ii,t} + \frac{\mathcal{N}_j}{\mathcal{N}_i} Y_{ij,t} \quad \text{for} \quad i \in \{H, F\} \tag{5}$$

Market clearing for capital

$$K_{i,t} = K^h_{i,t} + K^b_{i,t} \text{ for } \quad i \in \{h, f\} \tag{6}$$

Market clearing for bank deposits

$$D_t = D_{H,t} + D_{F,t} \tag{7}$$

Balance of payment equation

$$C_{H,t} + I_{H,t} = p_{HH,t} \bar{Y}_{H,t} + \left(D_{F,t} - D_{F,t-1} R^d_t \right) + \left(R^s_{F,t} S^b_{F,t-1} - S^b_{F,t} \right) \tag{8}$$

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Calibration

Parameter	Symbol	Value	Target/Source
Country Size	$\mathcal{N}_H, \mathcal{N}_F$	1,3	Relative GDP share of United States
Discount Factor	β	0.9975	World Interest Rate =1%
CRRA coefficient	ρ	1	Standard
Inverse Frisch Elasticity	φ	1	Standard
Habit parameter	ι	0.8	Justiniano et al. (2010)
Disutility of Labor	ψ	0.85	$L_H = L_F = 1$
Home Bias	$\omega_{H,}\omega_F$	0.85, 0.90	U.S. import share =15 % and $X_{hf} = 1$
Foreign deposits	D_F	9	Balanced trade in steady state
Trade Elasticity	θ	1	Standard
Capital Depreciation Rate	δ	0.025	Standard
Capital Share	α	0.33	Standard
Markup	μ	1.1	10% steady-state markup
Rotemberg costs	κ	300	Phillips Curve slope=0.03
Investment adjustment cost	γ_k	2	Justiniano et al. (2010)
Taylor rule coefficient on inflation	φ_π	1.5	Standard
Taylor rule inertia	ρ_r	0.8	Standard
Share of capital held by households	γ_H, γ_F	0.67, 0.90	GFIs hold 33% of US capital, GFIs foreign asset share=0.25
GFIs survival rate	σ_b	0.95	Gertler and Kiyotaki (2015)
GFIs Subsidiary Leverage Constraint	λ	0.66	Leverage of GFIs subsidiaries =3
Households capital holding costs	χ	100	Global spreads rise 60bps with synchronous tightening
Agency problem parameters	θ_H, θ_F	0.1, 0.5	Ratio of foreign to home spread=1.5; Steady-state leverage=4.75
GFIs endowment	ξ	0.013	Equity 5% above constraint

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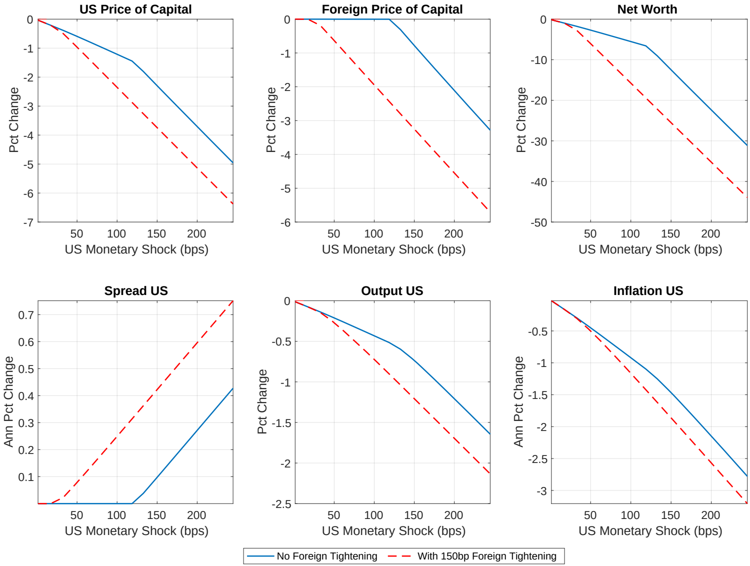
Nonlinear amplification of US monetary shocks



Inflation and financial frictions

- Linearized Phillips curve in country i can be written

$$\pi_{iit} = LC_{it} + KC_{it}$$

where LC_{it} and KC_{it} are the present discounted values of wages and rental rates

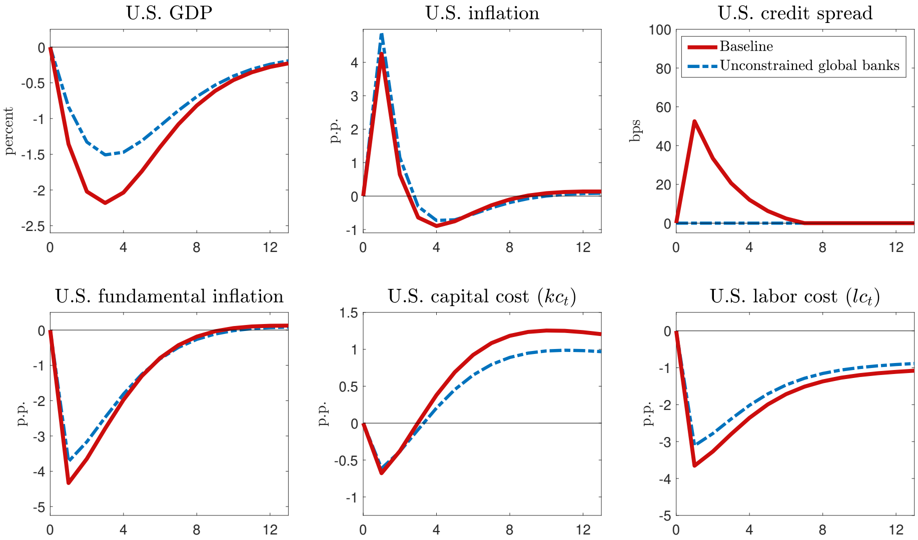
$$LC_{it} = \frac{\varepsilon}{\kappa}\left(\alpha w_{it} - \frac{p_{iit}}{(1+\mu)}\right) + \beta LC_{it+1}$$

$$KC_{it} = \frac{\varepsilon}{\kappa}(1-\alpha) z_{it} + \beta KC_{it+1}$$

- Financial frictions lower future capital pushing up KC_{it}

$$z_{it+i} = (1-\alpha)(l_{it+i} - k_{it+i})$$

Global Markup Shock



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