The International Spillovers of Synchronous Monetary Tightening

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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 (GFI).
   - 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: $\varepsilon_{i,t}^{MP}$

$$R_{i,t} = \alpha_i + \beta_i Z_{i,t} + \varepsilon_{i,t}^{MP},$$

$Z_{i,t}$: 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.

\[ \Delta GDP_{i,t+8} = \beta_D D_{i,t} + \beta_F F_{i,t} + \beta_H DF_{i,t} \times YH_{i,t} + \beta_L DF_{i,t} \times YL_{i,t} + u_{i,t} \]

<table>
<thead>
<tr>
<th>Dummy: Own Tightening</th>
<th>(1) ( \Delta GDP(t + 8) )</th>
<th>(2) ( \Delta GDP(t + 8) )</th>
<th>(3) ( \Delta GDP(t + 8) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 1 { \varepsilon_{i,t}^{MP} &gt; 0 } )</td>
<td>-1.09*** (-6.16)</td>
<td>-0.77*** (-3.61)</td>
<td>-0.80*** (-3.72)</td>
</tr>
<tr>
<td>Dummy: Foreign Tightening</td>
<td>-0.87*** (-3.39)</td>
<td>-0.55** (-2.23)</td>
<td>-0.56** (-2.18)</td>
</tr>
<tr>
<td>( 1 { \sum_{j \neq i} w_{jt} \varepsilon_{jt}^{MP} &gt; 0 } )</td>
<td>-0.65* (-1.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy: Own \times Foreign Tightening, Hi Growth</td>
<td>-0.07 (-0.24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 1 { \varepsilon_{i,t}^{MP} &gt; 0 \text{ and } \sum_{j \neq i} w_{jt} \varepsilon_{jt}^{MP} &gt; 0 \text{ and GDP Q4/Q4 &gt; median} } )</td>
<td>-1.53*** (-4.95)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy: Own \times Foreign Tightening, Lo Growth</td>
<td>-1.53*** (-4.95)</td>
<td></td>
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</tr>
<tr>
<td>( 1 { \varepsilon_{i,t}^{MP} &gt; 0 \text{ and } \sum_{j \neq i} w_{jt} \varepsilon_{jt}^{MP} &gt; 0 \text{ and GDP Q4/Q4 &lt; median} } )</td>
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</table>

| 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:

$$R^*_t - R^*_{t-4} > 0.25 \text{ and } R^*_t > R^*_{t+6}$$

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

**Synchronous**: $DS_{i,t} = 1$ if $\varepsilon_{i,t}^{MP} > 0.25 \text{ and } t \in \text{ global window}$

**Asynchronous**: $DA_{i,t} = 1$ if $\varepsilon_{i,t}^{MP} > 0.25 \text{ and } t \notin \text{ global window}$
Global Tightening Windows

Global Interest Rates

Share of Countries with Rising Interest Rates
State-dependent responses to contractionary shocks

**Synchronous vs Asynchronous**

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

---

### Components

- **Interest Rate**
- **GDP**
- **Unemployment**
- **Inflation**
- **Corporate Spreads**
- **Banks Equity Prices**
- **Consumption**
- **Investment**
- **Net Exports/GDP**
- **Real Exchange Rate**
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 $\epsilon_{i,t}^m$; Global markup shock $\epsilon_t^\mu$.
- 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, or (2) save through global intermediaries (GFIs).

- GFIs combine home and foreign deposits and net worth to finance investment at home and abroad.

- 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

U.S. Capital
\[ K_H = K_H^b + K_H^h \]

Foreign Capital
\[ K_F = K_F^b + K_F^h \]

U.S. Households

Foreign Households

Global Financial Intermediary (GFI)

Balance Sheet

US Assets
\[ S_H^b \]

Deposits

Net Worth

Foreign Assets
\[ S_F^b \]

Equity
\[ S_F^b K_F^b = S_F^b + B_F \]

Risky Lending
\[ S_H^b = Q_H K_H^b \]

Costly Direct Finance
\[ K_H^h \]

Costly Direct Finance
\[ K_F^h \]

Riskly Lending
\[ K_F^b \]
Model: International Financial Flows

U.S. Capital

\[ K_H = K_H^b + K_H^h \]

U.S. Households

Costly Direct Finance

\[ K_H^h \]

Risky Lending

\[ S_H^b = Q_H K_H^b \]

Global Financial Intermediary (GFI)

Balance Sheet

US Assets

\[ S_H^b \]

Foreign Assets

\[ S_F^b \]

Deposits

Net Worth

Net Worth

Foreign GFI Subsidiary

\[ Q_F K_F^b = S_F^b + B_F \]

Deposits

Equity

\[ S_F^b \]

Foreign Capital

\[ K_F = K_F^b + K_F^h \]

Foreign Households

Costly Direct Finance

\[ K_F^h \]

Risky Lending

\[ K_F^b \]
Model: International Financial Flows

U.S. Capital

\[ K_H = K_H^b + K_H^h \]

Costly Direct Finance

\[ K_H^h \]

U.S. Households

Foreign Households

Costly Direct Finance

\[ K_F^h \]

Foreign Capital

\[ K_F = K_F^b + K_F^h \]

Global Financial Intermediary (GFI)

Balance Sheet

US Assets

\[ S_H^b \]

Deposits

Equity

\[ S_F^b \]

Foreign GFI Subsidiary

Risky Lending

\[ K_F^b \]

Deposits

Foreign Assets

\[ S_F^b \]

Net Worth

Risky Lending

\[ S_H = Q_H K_H^b \]
GFIs Problem

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

$$R_{Ht+1}^s = \frac{1}{Q_{Ht}}(z_{Ht+1} + (1 - \delta)Q_{Ht+1})$$

$$R_{Ft+1}^s = \frac{X_{t+1}}{X_t} \left( \frac{1}{1 - \lambda} (R_{Ft+1}^k - R_{Ft}^d) + R_{Ft}^d \right)$$

- If excess returns positive, GFI raises leverage until:

$$\mathbb{E}_t \Lambda_{t+1} \left( R_{Ht+1}^s - R_{Ht}^d \right) = \mathbb{E}_t \Lambda_{t+1} \left( R_{Ft+1}^s - R_{Ht}^d \right) = 0$$

- **Agency Problem**: GFI can divert fraction $\theta_H$ of home and $\theta_F$ 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:
  \[
  N_t = R_{Ht}^{s} S_{Ht-1} + R_{Ft}^{s} S_{Ft-1} - R_{Ht-1}^d D_{t-1}
  \]

- If \( N_t \downarrow \) small, GFIs leverage up, no change in spreads:
  \[
  \mathbb{E}_t \Lambda_{t+1} \left( R_{Ht+1}^s - R_{Ht}^d \right) = \mathbb{E}_t \Lambda_{t+1} \left( R_{Ft+1}^s - R_{Ht}^d \right) = 0
  \]

- If \( N_t \downarrow \) large, leverage constraint binds, credit spreads up globally:
  \[
  \mathbb{E}_t \Lambda_{t+1} \left( R_{Ht+1}^s - R_{Ht}^d \right) = \frac{\theta_H}{\theta_F} \mathbb{E}_t \Lambda_{t+1} \left( R_{Ft+1}^s - R_{Ht}^d \right) > 0
  \]
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).
Model Simulations
Simulations: Asynchronous Tightening

- **US Policy Rate**
  - BPS

- **US GDP**
  - Percent

- **US Inflation**
  - P.P.

- **Foreign Policy Rate**
  - BPS

- **Foreign GDP**
  - Percent

- **Foreign Inflation**
  - P.P.

- **GFI’s Net Worth**
  - Percent

- **US Credit Spread**
  - BPS

- **Foreign Credit Spread**
  - BPS

The graphs illustrate the impacts of US and foreign policy rate changes on various economic indicators, including GDP, inflation, and credit spreads.
Simulations: Asynchronous Tightening

- **US Policy Rate**
- **US GDP**
- **US Inflation**
- **Foreign Policy Rate**
- **Foreign GDP**
- **Foreign Inflation**
- **GFI Net Worth**
- **US Credit Spread**
- **Foreign Credit Spread**

Legend: 
- **US Tightening**
- **Foreign Tightening**
Synchronous vs Asynchronous Tightening

US Policy Rate

Foreign Policy Rate

GFI's Net Worth

US GDP

Foreign GDP

US Credit Spread

Foreign Credit Spread

U.S. tightening  Foreign Tightening  Nonlinear Effect
Synchronous vs Asynchronous Tightening

US Policy Rate

Foreign Policy Rate

GFIs Net Worth

US GDP

Foreign GDP

US Credit Spread

Foreign Credit Spread

U.S. tightening
Foreign Tightening
Nonlinear Effect
Synchronous vs Asynchronous Tightening

**US Policy Rate**
-bps vs Time (0-8)

**US GDP**
-Percent vs Time (0-8)

**US Inflation**
P.P. vs Time (0-8)

**Foreign Policy Rate**
-bps vs Time (0-8)

**Foreign GDP**
-Percent vs Time (0-8)

**Foreign Inflation**
P.P. vs Time (0-8)

**GFI's Net Worth**
-Percent vs Time (0-8)

**US Credit Spread**
-bps vs Time (0-8)

**Foreign Credit Spread**
-bps vs Time (0-8)

-Graphs show comparison between U.S. tightening, foreign tightening, and nonlinear effect.
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...

\[ \downarrow y_t = c_t + \downarrow \downarrow i_t + nx_t \]

... while the associated drop in inflation \( \pi \) is smaller:

\[
\pi_{it} = s [(1 - \alpha) w_{it} + \alpha z_{it} - p_{iit}] + \beta \mathbb{E}_{t} \pi_{it+1} + \mu_t
\]

- 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
... and Abroad

Foreign GDP

Foreign inflation

Foreign credit spread

Baseline
Unconstrained global banks

Foreign fundamental inflation

Foreign capital cost ($k_{ct}$)

Foreign labor cost ($l_{ct}$)
Optimal Policy
Central banks in $H, F$ observe one-time global markup shock $\epsilon^{\mu}$ and chooses inflation response coefficient $\varphi_i \in (1, 10]$ in the Taylor rule.

Loss function for country $i$ given shock $\epsilon^{\mu}$:

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

with high weight on inflation $\lambda_\pi$.

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 $\varphi$, response to inflation
- Large shock: policy actions are substitutes: “small” $\varphi$; $\varphi_H > \varphi_F$
Nash Equilibrium and Interdependence

![Diagram](image)

- Better Average Outcomes
- $\mathcal{P}$ set: Better Outcomes Both U.S. and Foreign
- Nash Equilibrium
- Cooperative Optimum
- Optimal Pareto improvement
Cooperative policies

- Global loss:
  \[
  \tilde{L}(\varphi_H, \varphi_F) = \sigma_H \mathcal{L}_H(\varphi_H, \varphi_F) + (1 - \sigma_H) \mathcal{L}_F(\varphi_H, \varphi_F)
  \]
  with U.S. weight \( \sigma_H = 1/4 \)

- **Two Cooperative Solutions:**
  1: **Cooperative Optimum**
  policies minimize world loss
  \[
  \{ \varphi_H^{coop}, \varphi_F^{coop} \} = \arg \min_{\varphi_H, \varphi_F} \tilde{L}(\varphi_H, \varphi_F)
  \]
  2: **Optimal Pareto Improvement**
  policies minimize world loss, s.t. improving relative to Nash
  \[
  \left\{ \varphi_H^{pi}, \varphi_F^{pi} \right\} = \arg \min_{(\varphi_H, \varphi_F) \in P} \tilde{L}(\varphi_H, \varphi_F)
  \]
  where \( P = \left\{ (\varphi_H, \varphi_F) \mid \mathcal{L}_i(\varphi_H, \varphi_F) \leq \mathcal{L}_i^{NASH} \text{ for } i = H, F \right\} \)
Cooperative policies

- Large set of policies with better avg outcomes relative to Nash
- These policies feature less aggressive U.S. response $\varphi_H$
Cooperative optimum features small $\phi_H$ relative to $\phi_F$.
Small $\phi_H$ eases financial conditions allowing large $\phi_F$, but the home country is worse off!
Policies that improve over Nash feature smaller $\varphi_H$ and $\varphi_F$

Under these policies, both countries forgo inflation stabilization
Outcomes under Nash and Cooperative policies

**US Policy Rate**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**US Inflation**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**US GDP**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**US Credit Spreads**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**Foreign Policy Rate**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**Foreign Inflation**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**Foreign GDP**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line

**Foreign Credit Spreads**
- Nash: Blue line
- Cooperative: Red line
- Cooperative Pareto Improvement: Black line
Takeaways

- With constrained GFIs, less-aggressive policy at home eases trade-offs abroad, and vice versa.

- Pareto-improving cooperation exploits this, leading to easier policy globally → 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.
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.
Related Literature

- Foreign spillovers of monetary policy shocks. 
  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. 
  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 
  Our contribution: Gains from cooperation are larger when adverse shocks are severe and financial intermediation is impaired
Empirical Specification

- Event study panel regression:
  \[ y_{i,t} = \gamma_i + \sum_{\tau=-2}^{10} \sigma_{\tau} DS_{i,t+\tau} + \sum_{\tau=-2}^{10} \alpha_{\tau} DA_{i,t+\tau} + \epsilon_{i,t}, \]

  \( DS_{i,t} \): 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.
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**

Distribution trimmed at the 99th percentile
Household Problem

Households in country $i = h, f$ solve

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

subject to

$$C_{i,t} + X_{Hi,t}D_{i,t} + g_{i,t} + Q_{i,t}K_{i,t}^h + \eta_i \left( K_{i,t}^h, K_{i,t} \right) =$$

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

where

$$\eta_i \left( K_{i,t}^h, K_{i,t} \right) = \frac{\chi}{2} \left( \frac{K_{i,t}^h}{K_{i,t}^h} - \gamma_i \right)^2 K_{i,t}$$
Household Problem (cont.)

Optimality conditions are given by

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

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

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

where

$$U_{ci,t} = (C_{i,t} - \iota C_{i,t-1})^{-\rho} - \beta I E_t (C_{i,t+1} - \iota C_{i,t})^{-\rho}$$

and

$$\Lambda_{i,t+1} = \frac{U_{ci,t+1}}{U_{ci,t}} .$$
Nominal Rigidities

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

Phillips curve for domestic goods:

\[
(p_{ii,t} - 1) p_{ii,t} = s_t [MC_{it} \mu_t - p_{ii,t}] + \beta E_t \Lambda_{t+1} (p_{iit+1} - 1) p_{iit+1} \frac{Y_{iit+1}}{Y_{ii,t}}
\]

Phillips curve for exported goods:

\[
(p_{ij,t} - 1) p_{ij,t} = s_t [MC_{it} \mu_t - X_{ji,t} X_{ij,t}] + \beta E_t \Lambda_{t+1} (p_{ijt+1} - 1) p_{ijt+1} \frac{Y_{ijt+1}}{Y_{ij,t}}
\]
Capital Goods Production

Capital producers create new investment goods subject to adjustment costs

$$\max E_t \Lambda_{t+1} \left[ Q_{i,t}^k l_{i,t} - l_{i,t} - \frac{\gamma k}{2} \left( \frac{l_t}{l_{t-1}} - 1 \right)^2 l_t \right]$$

which implies the following first order condition

$$Q_{i,t}^k = 1 + \frac{\gamma k}{2} \left( \frac{l_{i,t}}{l_{i,t-1}} - 1 \right)^2 + \gamma_k \frac{l_{i,t}}{l_{i,t-1}} \left( \frac{l_{i,t}}{l_{i,t-1}} - 1 \right) - \beta \Lambda_{it+1} \gamma_k \left( \frac{l_{it+1}}{l_{i,t}} \right)^2 \left( \frac{l_{it+1}}{l_{i,t}} - 1 \right)$$
Foreign Subsidiaries

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

\[
Q_{F_t}^k K_{F_t}^b = B_{i,t} + S_{F_t} \quad (1)
\]

subject to a (binding) leverage constraint

\[
B_{F_t} \leq \lambda Q_{F_t}^k K_{F_t}^b \quad (2)
\]

Market clearing implies

\[
R_{F_t}^s = \frac{1}{(1 - \lambda)} R_{F_t}^k - \frac{\lambda}{(1 - \lambda)} R_{Ft-1} \quad (3)
\]

\[
S_{i,t} = (1 - \lambda) Q_{F_t} K_{F_t}^b \frac{N_F}{N_H} \quad (4)
\]
Market Clearing

Market clearing in the goods market

\[ \bar{Y}_{i,t} = C_{ii,t} + l_{ii,t} + \frac{N_j}{N_i} Y_{ij,t} \left( C_{ij,t} + l_{ij,t} \right) = Y_{ii,t} + \frac{N_j}{N_i} Y_{ij,t} \quad \text{for } i \in \{H, F\} \quad (5) \]

Market clearing for capital

\[ K_{i,t} = K_{i,t}^h + K_{i,t}^b \quad \text{for } i \in \{h, f\} \quad (6) \]

Market clearing for bank deposits

\[ D_t = D_{H,t} + D_{F,t} \quad (7) \]

Balance of payment equation

\[ C_{H,t} + I_{H,t} = p_{HH,t} \bar{Y}_{H,t} + \left( D_{F,t} - D_{F,t-1} R_t^d \right) + \left( R_{F,t}^s S_{F,t-1}^b - S_{F,t}^b \right) \quad (8) \]
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Target/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country Size</td>
<td>$N_H, N_F$</td>
<td>1,3</td>
<td>Relative GDP share of United States</td>
</tr>
<tr>
<td>Discount Factor</td>
<td>$\beta$</td>
<td>0.9975</td>
<td>World Interest Rate =1%</td>
</tr>
<tr>
<td>CRRA coefficient</td>
<td>$\rho$</td>
<td>1</td>
<td>Standard</td>
</tr>
<tr>
<td>Inverse Frisch Elasticity</td>
<td>$\varphi$</td>
<td>1</td>
<td>Standard</td>
</tr>
<tr>
<td>Habit parameter</td>
<td>$\iota$</td>
<td>0.8</td>
<td>Justiniano et al. (2010)</td>
</tr>
<tr>
<td>Disutility of Labor</td>
<td>$\psi$</td>
<td>0.85</td>
<td>$L_H = L_F = 1$</td>
</tr>
<tr>
<td>Home Bias</td>
<td>$\omega_H, \omega_F$</td>
<td>0.85, 0.90</td>
<td>U.S. import share =15 % and $X_{hf} = 1$</td>
</tr>
<tr>
<td>Foreign deposits</td>
<td>$D_F$</td>
<td>9</td>
<td>Balanced trade in steady state</td>
</tr>
<tr>
<td>Trade Elasticity</td>
<td>$\theta$</td>
<td>1</td>
<td>Standard</td>
</tr>
<tr>
<td>Capital Depreciation Rate</td>
<td>$\delta$</td>
<td>0.025</td>
<td>Standard</td>
</tr>
<tr>
<td>Capital Share</td>
<td>$\alpha$</td>
<td>0.33</td>
<td>Standard</td>
</tr>
<tr>
<td>Markup</td>
<td>$\mu$</td>
<td>1.1</td>
<td>10% steady-state markup</td>
</tr>
<tr>
<td>Rotemberg costs</td>
<td>$\kappa$</td>
<td>300</td>
<td>Phillips Curve slope=0.03</td>
</tr>
<tr>
<td>Investment adjustment cost</td>
<td>$\gamma_k$</td>
<td>2</td>
<td>Justiniano et al. (2010)</td>
</tr>
<tr>
<td>Taylor rule coefficient on inflation</td>
<td>$\varphi_\pi$</td>
<td>1.5</td>
<td>Standard</td>
</tr>
<tr>
<td>Taylor rule inertia</td>
<td>$\rho_r$</td>
<td>0.8</td>
<td>Standard</td>
</tr>
<tr>
<td>Share of capital held by households</td>
<td>$\gamma_H, \gamma_F$</td>
<td>0.67, 0.90</td>
<td>GFIs hold 33% of US capital, GFIs foreign asset share=0.25</td>
</tr>
<tr>
<td>GFIs survival rate</td>
<td>$\sigma_b$</td>
<td>0.95</td>
<td>Gertler and Kiyotaki (2015)</td>
</tr>
<tr>
<td>GFIs Subsidiary Leverage Constraint</td>
<td>$\lambda$</td>
<td>0.66</td>
<td>Leverage of GFIs subsidiaries =3</td>
</tr>
<tr>
<td>Households capital holding costs</td>
<td>$\chi$</td>
<td>100</td>
<td>Global spreads rise 60bps with synchronous tightening</td>
</tr>
<tr>
<td>Agency problem parameters</td>
<td>$\theta_H, \theta_F$</td>
<td>0.1, 0.5</td>
<td>Ratio of foreign to home spread=1.5; Steady-state leverage=4.75</td>
</tr>
<tr>
<td>GFIs endowment</td>
<td>$\zeta$</td>
<td>0.013</td>
<td>Equity 5% above constraint</td>
</tr>
</tbody>
</table>
Nonlinear amplification of US monetary shocks
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

U.S. GDP

U.S. inflation

U.S. credit spread

Baseline
Unconstrained global banks

U.S. fundamental inflation

U.S. capital cost ($k_c$)

U.S. labor cost ($l_c$)


