Monetary and Exchange Rate Policies in a Global Economy

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August 27, 2024

EEA Annual Conference, Rotterdam

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Introduction

- **Question:** How should central banks assign different objectives to monetary and exchange rate policies?
- Classical view: (Mundell'68; Fleming'62)
  - MP targets the domestic inflation + let the exchange rate float
- Modern view: financial globalization, international spillover (Rey, 2015)
  - Unconventional policies to limit capital mobility
  - Foreign exchange intervention (FXI) is a popular tool
    - Buy local currency and sell $ reserves $\Rightarrow$ Local currency appreciates
    - Used by $>$ 120 countries (Adler/etal'23)
  - The interaction and trade-off of MP and FXI was less studied
    - MP and FXI are often considered to have two separate targets
    - MP targets the inflation, FXI targets the exchange rate

What I Do

- In practice, policymakers combine MP and FXI to target inflation
  - Example: COVID-19, Russian-Ukraine war ⇒ worldwide inflation
  - Central banks responded by selling $ using FXI without a large increase in monetary policy rate
- I build a general macro-framework with both monetary and exchange rate policies and study optimality, interaction, and trade-offs
- Data and central banks' and currency officials' statements suggest:
  1. Large countries use FXI on a massive scale
  2. Countries cooperate to achieve exchange rate stability
     - Excessive intervention can cause disagreements across countries
  3. Countries combine MP and FXI to stabilize inflation
  4. In countries with FXI, exports and imports are mainly in dollars, but assets and liabilities are not necessarily in dollars

What I Do

Intuition (summary)

- 2-country (local, US), 2-policy (MP, FXI), 2-friction (nominal, financial)
  - Price is costly to adjust ⇒ MP affects the output (Rotemberg'82)
  - Limits to arbitrage ⇒ FXI affects the exchange rate (Gabaix/Maggiori'15) [1]

- Optimal MP and FXI under cooperation & commitment
  1. When MP can achieve both first-best inflation and output,
     - FXI achieves the first-best exchange rate
     - Number of inefficiencies = policies → two separate objectives
  2. When MP cannot achieve the first-best & faces inflation-output trade-off:
     - **FXI improves the MP trade-off** by stabilizing inflation but **distorts the exchange rate** by strengthening the local currency and improving the local demand (purchasing power) over the US.
     - Number of inefficiencies > policies → no longer separate objectives
     - MP and FXI should be combined to stabilize the inflation

[1] Empirically, limits to arbitrage are reflected in the excess carry trade return (deviation from uncovered interest rate parity).

Data

What I Do

- Dollar pricing: both exports and imports in dollars
    - Optimal FXI is large under dollar pricing
    - Transmission is asymmetric
        - FXI stabilizes the local inflation without causing large US inflation
        - Incomplete exchange-rate pass-through on the US import prices
    - Capital flow management in international finance can be driven by dollar dominance in international trade
- TBD: Non-cooperative (Nash) equilibrium, gains from cooperation (Bodenstein et al., 2019, 2023)

Literature

▸ Table ▸ Relationship with Literature ▸ FXI volume ▸ FXI over GDP share

- Theory on foreign exchange intervention
  - Gabaix/Maggiori'15, Fanelli/Straub'21: FXI independently of MP
  - Cavallino'19, Amador/etal'20, Basu/etal'21, Itskhoki/Mukhin'23: MP and FXI in a small open economy

$\Rightarrow$ Cooperative MP and FXI in a large two-country model, New trade-off between internal and external objectives

- Empirical evidence on the effectiveness of FXI
  - Fatum/Hutchison'10, Kuesteiner/Phillips/Villamizar-Villegas'18, Fratzscher/etal'19, Adler/Mano'21, Rodnyansky/Timmer/Yago'24, Dao/Gourinchas/Mano/Yago'24

$\Rightarrow$ Normative implication of FXI

- Exchange rate disconnect from macro fundamentals
  - Itskhoki/Mukhin'21, Jiang/Krishnamurthy/Lustig'21,23, Devereux/Engel/Wu'23, Engel/Wu'22, Kekre/Lenel'23, Fukui/Nakamura/Steinsson'23

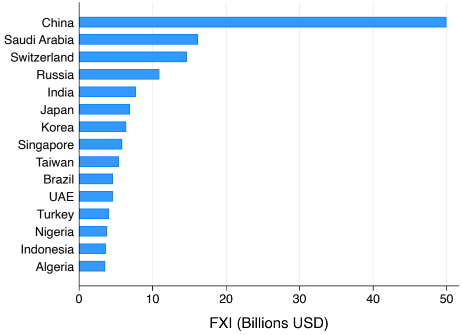
$\Rightarrow$ Role of FXI in stabilizing capital flows and exchange rate

FXI Volume by Countries

GDP share

- *Fact 1.* Large emerging and advanced economies conduct FXI on massive scales (1.2% of GDP on average).

Figure 1: Top-15 Largest FXI Volumes by Country (Billions of US Dollars)



Note: Quarterly FXI data in 122 countries, 2000-24 (Adler et al., 2022). Excludes countries that mainly intervene against the euro.

Cooperation on Exchange Rate Stabilization

- *Fact 2.* Countries cooperate to promote exchange rate stability.

We will continue to cooperate to promote sustainable economic growth, financial stability, as well as orderly and well-functioning financial markets. We will also continue to consult closely on foreign exchange market developments in line with our existing G20 commitments, while acknowledging serious concerns of Japan and the Republic of Korea about the recent sharp depreciation of the Japanese yen and the Korean won.

— Japan - Korea - United States Trilateral Ministerial Joint Press Statement, 2024/04/17

- Excessive intervention can cause disagreements across countries.

The Treasury chief said China's yuan is among the currencies that she monitors, along with the euro and yen. Yellen continued to register her discomfort with government intervention in currency markets — especially among Group of Seven countries. "It's possible for countries to intervene... but we believe that it should happen very rarely and be communicated to trade partners if it does." (Bloomberg)

— Janet Yellen, Secretary of the Treasury, United States, 2024/05/13

Combination of MP and FXI

- *Fact 3.* FXI is combined with MP to stabilize inflation.

South Korea's central bank is ready to take steps, including intervention to stabilize the won against the dollar. "This depreciation pressure due to the dollar strength is a bad factor for our inflation, because our imported prices increase a lot." (Reuters)

— Rhee Chang-yong, Governer of the Bank of Korea, 2024/04/28

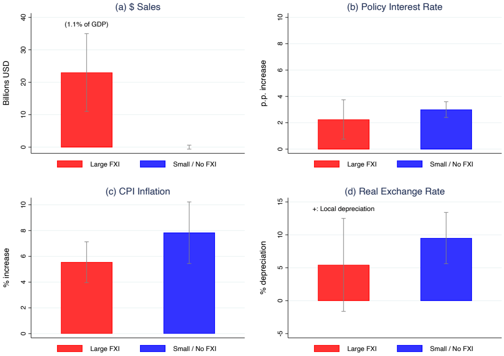
"The combination of rising interest rates and foreign currency sales was effective in quickly bringing inflation back into the range of price stability. Without the use of foreign currency sales, the SNB would have had to raise the policy rate to a higher level." (ICMB Public Lecture)

— Martin Schlegel, Vice Chairman of the Governing Board, Swiss National Bank, 2024/04/09

FXI around 2022 Russian-Ukraine War

Raw data: FXI, MP Inflation, RER

- Divide major AEs & EMEs into Large FXI and Small / No FXI groups
- Large FXI $\Rightarrow$ less inflation and currency depreciation without a large monetary tightening

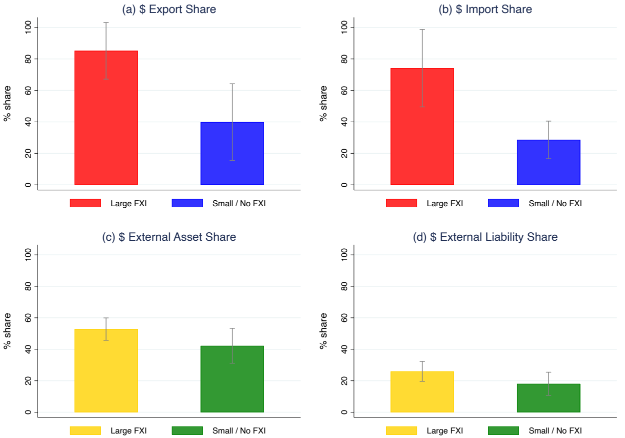


Note: (a) $ sales in 2022Q3-Q4, (b)-(d) changes in 2021Q4-2022Q4 (median).
Large FXI = above median ($3.6B / 0.14% of GDP). Exclude small countries (annual GDP < $500B).

Invoicing Currency

Raw data: export, import | Asset, liability | Debt asset and liability

- *Fact 4.* Export and import are more dollarized in large FXI countries (but small difference for asset and liability)



Roadmap

Step-by-step construction of a two-country model

1. Optimal MP, nominal friction
   $\Rightarrow$ First-best allocation

2. Optimal MP & FXI, nominal & financial frictions
   $\Rightarrow$ First-best allocation

3. Optimal MP & FXI, nominal & financial frictions, cost-push shock
   $\Rightarrow$ FXI improves the MP trade-off between inflation and output

4. Dollar pricing
   $\Rightarrow$ Larger FXI, asymmetric transmission

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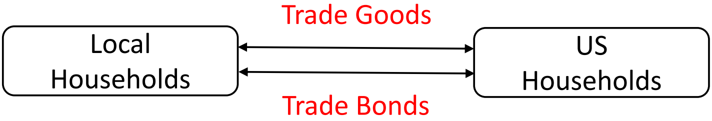
Monetary Policy in a Simple Two-Country Model



- **Households:** ▸ Details
  - Consume local and US goods

$$U(C_t) = \log(C_t), \qquad C_t = C_{Lt}^{a} C_{Ut}^{1-a} \qquad (a : \text{home bias of consumption})$$

  - Supply labor, trade goods & bonds internationally
- **Firms:** ▸ Details
  - Produce goods & set prices subject to adjustment cost (Rotemberg '82)
    - Producer currency pricing (PCP): price is sticky in exporter's currency
  - Productivity $\sim$ AR(1) with shocks
- **Central banks** use MP to set the nominal interest rate

Optimal Monetary Policy

Lagrangian | Local Currency Pricing loss function

- Cooperation = maximize the sum of welfare in the two countries = minimize the loss function:[2][3]

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[\frac{\theta}{\kappa} \underbrace{\left(\pi_{Lt}^2 + \pi_{Ut}^{*2}\right)}_{\text{Inflation}} + \underbrace{\tilde{Y}_{Lt}^2 + \tilde{Y}_{Ut}^2}_{\text{Output gap}} \right] + a(1-a) \underbrace{\tilde{\mathcal{D}}_t^2}_{\text{Demand gap}}$$

- $\tilde{\mathcal{D}}_t \equiv \tilde{C}_t - \tilde{C}_t^* - \tilde{\mathcal{Q}}_t$: demand gap = relative marginal utility
  - $\tilde{\mathcal{D}}_t = 0$: consumption smoothing across countries (risk-sharing)
  - $\tilde{\mathcal{D}}_t > 0$: Local economy has excess demand (purchasing power) over US[4]

[2] κ: slope of NKPC, θ: CES between differentiated goods, a: home bias, $\mathcal{Q}_t$: real exchange rate ($\mathcal{Q}_t \Uparrow$ = local depreciation)

[3] π_{Lt}, π_{Ut}^*: inflation of local (US) goods consumed by local (US) households. I assume producer currency pricing (law of one price).

[4] $\mathcal{D}_t \equiv (U'(C_t^*)/U'(C_t))/\mathcal{Q}_t = (C_t/C_t^*)/\mathcal{Q}_t$ with log and Cobb-Douglas preference

Optimal Monetary Policy

Lemma 1 (Optimal Monetary Policy)

With log and Cobb-Douglas utility and without cost-push shocks, optimal monetary policy closes all gaps: $\pi_{Lt} = \pi^*_{Ut} = \tilde{Y}_{Lt} = \tilde{Y}_{Ut} = \tilde{\mathcal{D}}_t = 0$.

- MP sets the nominal interest rate at natural (flexible-price) level
  $\Rightarrow$ No inflation and output gap
- Output rises $\Rightarrow$ Price falls (exchange rate depreciates) proportionally
  $\Rightarrow$ Relative wealth is unchanged ($P_{Lt}Y_{Lt} = P_{Ut}Y_{Ut}$), No demand gap
  (Corsetti/Dedola/Leduc'10)

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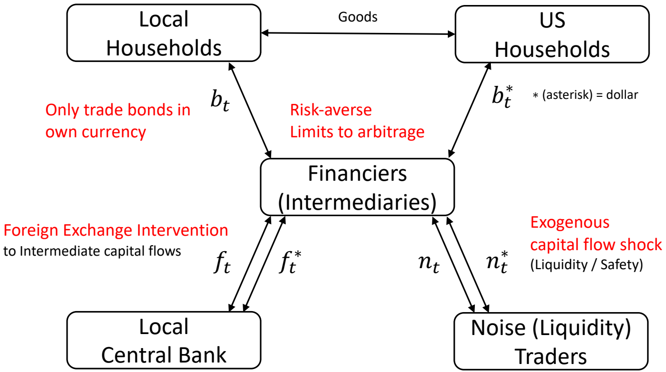
   $\Rightarrow$ Larger FXI, asymmetric transmission

Introducing FXI

Financiers' problem UIP condition

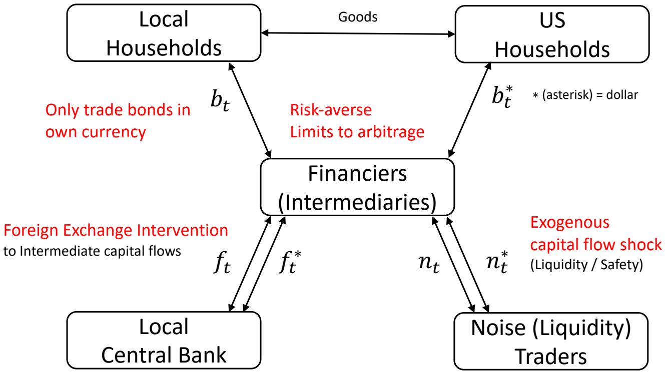


Example:

- Local investors buy \$ bonds ($n_t^* \Uparrow$) $\Rightarrow$ financiers short \$ and long LC
- Risk-averse financiers require risk premium (UIP deviation) for compensation
- Local CB buys local bonds ($f_t \Uparrow$) $\Rightarrow$ same return (UIP holds) when $f_t = n_t^*$

Introducing FXI

Financiers' problem UIP condition



Example:

- $f_t = n_t^*$ $\Rightarrow$ same bond return $\Rightarrow$ same consumption-savings decisions
- $\tilde{\mathcal{D}}_t = 0$ (no demand gap): consumption smoothing across countries

Optimal Monetary Policy and FXI

Lagrangian LCP loss function

Proposition 1 (Optimal MP and FXI: "Dichotomy" Case)

With log and Cobb-Douglas utility and without cost-push shocks, optimal monetary policy closes the inflation and output gap:

$$\pi_{Lt} = \pi^*_{Ut} = \tilde{Y}_{Lt} = \tilde{Y}_{Ut} = 0$$

and optimal FXI $(f_t = n^*_t)$ *closes the demand gap:*

$$\tilde{\mathcal{D}}_t = 0$$

- Conventional **Dichotomy** between monetary policy and FXI:
  - MP and FXI have separate targets
  - All gaps are closed = same allocation as the first-best

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Optimal Policies when Shocks are Inefficient

- Next, consider the case where the first-best cannot be achieved

1. Inefficient cost-push (markup) shock (μ_t^*) (example: pandemic, war)
   $\Rightarrow$ MP trades off inflation and output gap Details

2. General CRRA & CES preference[5] Details

$$U(C_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma}, \quad C_t = \left[a^{\frac{1}{\phi}} C_{Lt}^{1-\frac{1}{\phi}} + (1-a)^{\frac{1}{\phi}} C_{Ut}^{1-\frac{1}{\phi}}\right]^{\frac{\phi}{1-\phi}}$$

- $1/\sigma =$ substitution of consumption today and tomorrow (C_t, C_{t+1})
- $\phi =$ substitution of local and US goods (C_{Lt}, C_{Ut})
- $\sigma\phi > 1$: local and US goods are **substitutes**

[5] CO preference is the limiting case where $\sigma = \phi = 1$.

Optimal Monetary Policy without FXI

Lemma 2 (Optimal Monetary Policy)

When FXI is not available, optimal monetary policy rules are given by:

$$0 = \theta\pi_{Lt} + (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1}) + \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1}),$$
$$0 = \theta\pi^*_{Ut} + (\tilde{Y}_{Ut} - \tilde{Y}_{Ut-1}) - \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1}).$$

- Optimal MP trades off inflation with growth rates of output gap and demand gap.[6]
- Growth in local output $(\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1})$ or excess demand $(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1} > 0)$ $\Rightarrow$ monetary tightening to lower inflation $(\pi_{Lt} < 0)$
    - Same policy rules as in the incomplete asset market without costly intermediation (Corsetti/Dedola/Leduc '23)

[6] $\xi_D = \frac{2a(1-a)\phi}{\sigma+\eta\{4a(1-a)(\sigma\phi-1)+1\}} \frac{2a(\sigma\phi-1)+1-\sigma}{2a(\phi-1)+1} > 0$ where $\sigma = \frac{1}{\theta}$ is the relative risk aversion.

International Transmission of Cost-Push Shock (No FXI)

Lemma 3 (Transmission of shock: No FXI)

Suppose that the local and US goods are substitutes ($\sigma\phi > 1$), FXI is not available, and monetary policy follows the optimal rule.

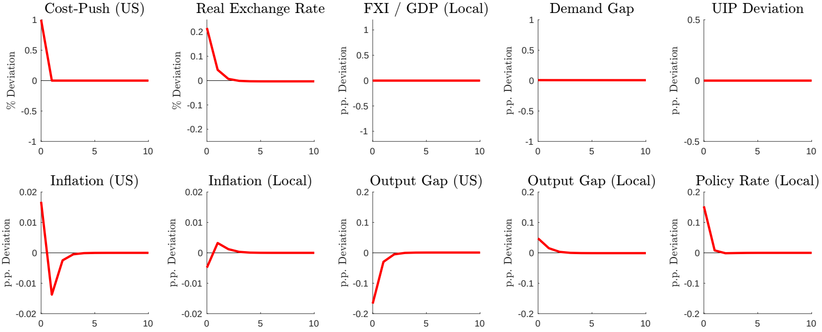
In response to a period-0 US cost-push shock,

- *US: deflation $\Rightarrow$ inflation, output gap < 0*
- *Local: inflation $\Rightarrow$ deflation, output gap > 0*
- *Local currency depreciates*

$$\frac{\partial \pi^*_{U0}}{\partial \mu^*_0} > 0, \quad \frac{\partial \pi^*_{U1}}{\partial \mu^*_0} < \frac{\partial \pi^*_{U2}}{\partial \mu^*_0} < \cdots < 0, \quad \frac{\partial \tilde{Y}_{U0}}{\partial \mu^*_0} < \frac{\partial \tilde{Y}_{U1}}{\partial \mu^*_0} < \cdots < 0,$$
$$\frac{\partial \pi_{L0}}{\partial \mu^*_0} < 0, \quad \frac{\partial \pi_{L1}}{\partial \mu^*_0} > \frac{\partial \pi_{L2}}{\partial \mu^*_0} > \cdots > 0, \quad \frac{\partial \tilde{Y}_{L0}}{\partial \mu^*_0} > \frac{\partial \tilde{Y}_{L1}}{\partial \mu^*_0} > \cdots > 0,$$
$$\frac{\partial \tilde{\mathcal{Q}}_0}{\partial \mu^*_0} > \frac{\partial \tilde{\mathcal{Q}}_1}{\partial \mu^*_0} > \cdots > 0.$$

Transmission of Cost-Push Shock (No FXI)

Parameters



- US cost-push shock $\rightarrow$ optimal MP $=$ commit to tightening
  - US temporary inflation $\rightarrow$ persistent deflation, output gap $\Downarrow$
  - Local and US goods are substitutes ($\sigma\phi > 1$) $\rightarrow$ negative correlation
  - Supply of US good $\Downarrow$ $\rightarrow$ demand $>$ supply for \$ $\rightarrow$ \$ appreciates ($\tilde{\mathcal{Q}}_t \Uparrow$)

Optimal MP and FXI: General Case

Details

Proposition 2 (Optimal Monetary Policy and FXI)

When both monetary policy and FXI are available, optimal monetary policy rules are given by:

$$0 = \theta\pi_{Lt} + (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1}) + \xi_\pi(\pi_{Lt} - \pi^*_{Ut}) + \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1}),$$
$$0 = \theta\pi^*_{Ut} + (\tilde{Y}_{Ut} - \tilde{Y}_{Ut-1}) - \xi_\pi(\pi_{Lt} - \pi^*_{Ut}) - \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1})$$

Optimal FXI is:

$$f_t = n^*_t + \xi_f E_t(\pi_{Lt+1} - \pi_{U,t+1})$$

- Zero-UIP deviation ($f = n^*$) is no longer an optimal FXI
- When the local inflation is higher than the US ($\pi_L > \pi^*_U$), optimal FXI is to buy the local currency ($f \Uparrow$).

International Transmission of Cost-Push Shock (FXI)

Proposition 3 (Transmission of shock: both MP and FXI)

Suppose that (i) local and US goods are substitutes ($\sigma\phi > 1$) and (ii) both MP and FXI follow the optimal rule.

Comparing the responses to a US cost-push shocks with and without FXI,

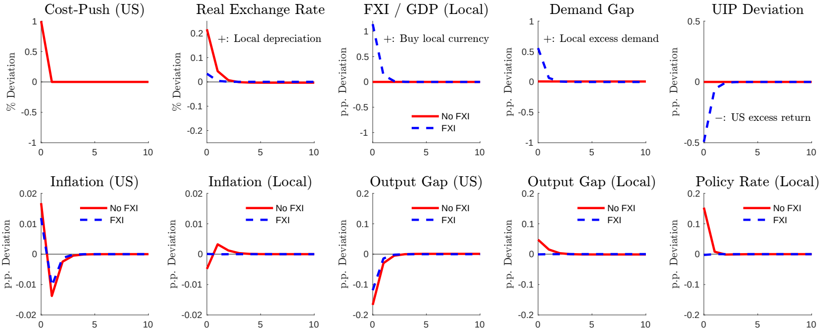
- *FXI smooths the paths of inflation, output gap, and real exchange rate.*
    - *Local inflation: less negative ($t = 0$) $\Rightarrow$ less positive ($t \geq 1$)*
    - *Local output gap: less positive (US: vice versa)*
    - *Local currency depreciates less*
- *However, UIP deviation becomes negative (local bond return $\Downarrow$).*

$$\frac{\partial \pi^*_{U0}}{\partial \mu^*_0} > \frac{\partial \pi^{*FXI}_{U0}}{\partial \mu^*_0}, \quad \frac{\partial \pi^*_{Ut}}{\partial \mu^*_0} < \frac{\partial \pi^{*FXI}_{Ut}}{\partial \mu^*_0}, \quad \frac{\partial \pi_{L0}}{\partial \mu^*_0} < \frac{\partial \pi^{FXI}_{L0}}{\partial \mu^*_0}, \quad \frac{\partial \pi_{Lt}}{\partial \mu^*_0} > \frac{\partial \pi^{FXI}_{Lt}}{\partial \mu^*_0},$$

$$\frac{\partial \tilde{Y}_{Ut}}{\partial \mu^*_0} < \frac{\partial \tilde{Y}^{FXI}_{Ut}}{\partial \mu^*_0}, \quad \frac{\partial \tilde{Y}_{Lt}}{\partial \mu^*_0} > \frac{\partial \tilde{Y}^{FXI}_{Lt}}{\partial \mu^*_0}, \quad \frac{\partial \tilde{Q}_t}{\partial \mu^*_0} > \frac{\partial \tilde{Q}^{FXI}_t}{\partial \mu^*_0}, \quad \frac{\partial \widetilde{UIP}_t}{\partial \mu^*_0} > \frac{\partial \widetilde{UIP}^{FXI}_t}{\partial \mu^*_0}$$

Cost-Push Shock (Optimal MP & FXI)

Parameters



- FXI stabilizes the inflation & output gap but widens the demand gap
  - Buy LC → LC appreciates → demand for local goods ⇓ → output ⇓ → MP faces less inflation-output trade-off, local policy rate ⇓
  - Local bond return ⇓ but local HHs cannot invest in \$ bond → Local demand (purchasing power) ⇑ relative to US = Demand gap ⇑

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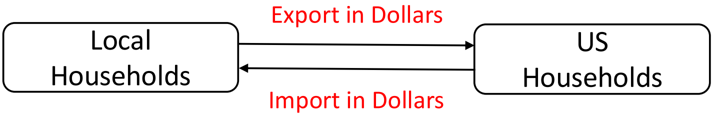
Dollar Pricing

▸ NKPC and loss function



- Exports and imports are both denominated in dollars (Gopinath/etal'20)
    - Law of one price (LOOP) does not hold for local goods
        - $\Delta_{Lt} \equiv \mathcal{E}_t P^*_{Lt}/P_{Lt}$: Price of local goods in \$ / local currency
        - $\Delta_{Lt} \neq 1$: inefficiency due to price dispersion (Engel'11)
    - Expenditure switching mainly works via local imports from US
- Key findings:
    - Optimal FXI targets the LOOP deviation (Δ_{Lt}).
    - Optimal FXI is larger under DCP than PCP.
    - Transmission of FXI is asymmetric across countries.
        - FXI stabilizes the local inflation more without large US inflation

Dollar Pricing

Optimal MP Optimal MP and FXI

Proposition 4 (Targeting the LOOP Deviation)

Under DCP and when both MP and FXI follow the optimal rules,[7]

1. *Optimal local currency purchase f_t is increasing in $\Delta_{Lt} \equiv \mathcal{E}_t P^*_{Lt}/P_{Lt}$.*
2. *FXI reduces the elasticity of Δ_{Lt} to the US cost-push shock.*
3. *The elasticity of optimal local currency purchase to the US cost-push shock is larger under DCP than PCP.*

$$\frac{\partial f_t}{\partial \Delta_{Lt}} > 0, \quad \frac{\partial \Delta^{FXI}_{Lt}}{\partial \mu^*_t} < \frac{\partial \Delta_{Lt}}{\partial \mu^*_t} (> 0), \quad \left(\frac{\partial f_t}{\partial \mu^*_t}\right)^{DCP} > \left(\frac{\partial f_t}{\partial \mu^*_t}\right)^{PCP} (> 0). \tag{1}$$

- US inflation ($\mu^*_t \Uparrow$) $\Rightarrow$, Local currency depreciates ($\mathcal{E}_t \Uparrow$) $\Rightarrow$ Local good is expensive in dollars ($\Delta_{Lt} \Uparrow$) $\Rightarrow$ buy local currency ($f_t \Uparrow$)
- Optimal FXI is larger under DCP than PCP

[7] Assumption: log and Cobb-Douglas preference (Cole/Obstfeld'91), linear labor disutility (Engel'11)

Dollar Pricing

Proposition 5 (Asymmetric Transmission)

Under PCP, optimal FXI decreases the local CPI inflation and increases the US CPI inflation by the same degree (symmetry):

$$\left(\frac{\partial \pi_t^{FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t}{\partial \mu_t^*}\right)^{PCP} = -\left(\frac{\partial \pi_t^{*FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t^*}{\partial \mu_t^*}\right)^{PCP} (< 0).$$

Under DCP, optimal FXI decreases the local CPI inflation more and increases the US CPI inflation less than the PCP case (asymmetry):

$$\left(\frac{\partial \pi_t^{FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t}{\partial \mu_t^*}\right)^{DCP} < \left(\frac{\partial \pi_t^{FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t}{\partial \mu_t^*}\right)^{PCP} (< 0),$$

$$\left(\frac{\partial \pi_t^{*FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t^*}{\partial \mu_t^*}\right)^{DCP} < \left(\frac{\partial \pi_t^{*FXI}}{\partial \mu_t^*} - \frac{\partial \pi_t^*}{\partial \mu_t^*}\right)^{PCP} (> 0).$$

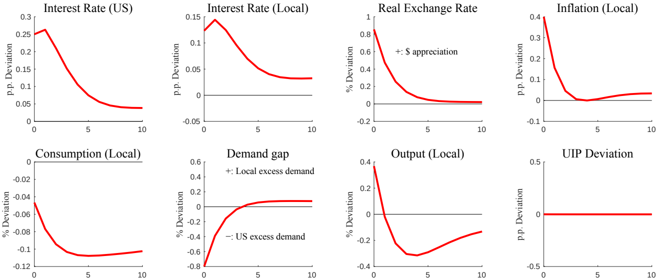
- FXI, local appreciation $\Rightarrow$ local import price from US $\Downarrow$
  but limited effects on US import price from local (as dollar-priced)

Full Quantitative Model

Calibration Household details Modified UIP

- Spillover of US monetary policy in a full quantitative model
  - Monetary policy: Taylor rule with AR(1) shock
  - Extensions: consumption habit, capital accumulation, wage rigidity
- **Result:** In response to a US monetary tightening shock,
  - **No FXI** $\Rightarrow$ LC **depreciates**, local inflation & interest rate $\Uparrow$, local consumption $\Downarrow$
  - **FXI** $\Rightarrow$ exchange rate, inflation, interest rate are **stable**, local consumption $\Uparrow$ relative to US consumption $\Downarrow$
- FXI insulates countries from the US monetary spillover
- TBD: Calibration to match with US-Japan or US-rest of the world data

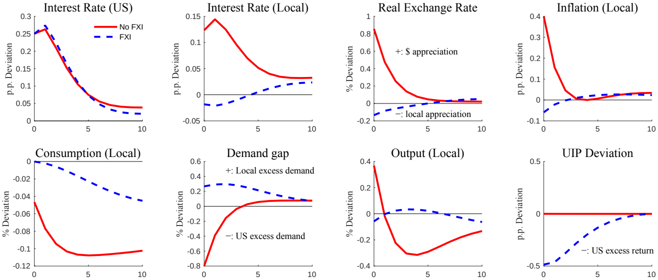
US Monetary Tightening Shock (No FXI)



Note: IRFs to an annualized one-percentage-point increase in the US interest rate.

- Without FXI, US monetary policy spillover
  - US interest rate $\Uparrow$ $\rightarrow$ LC depreciates $\rightarrow$ US demand for local goods $\Uparrow$ $\rightarrow$ Local inflation $\Uparrow$, interest rate $\Uparrow$, consumption $\Downarrow$

US Monetary Tightening Shock (FXI)



Note: IRFs to an annualized one-percentage-point increase in the US interest rate.

- FXI mitigates the US monetary spillover & improves MP independence
  - Buy LC $\Rightarrow$ local appreciates $\rightarrow$ local inflation, interest rate $\Downarrow$
  - Local consumption $\Uparrow$ but US consumption $\Downarrow$ (beggar-thy-neighbor)

Welfare Analysis

Table 1: Welfare Gain

(1) No FXI	(2) FXI targets UIP	(3) FXI targets UIP + inflation
0% (benchmark)	0.98%	2.21%

Note: The table shows the sum of unconditional welfare in the two countries in terms of consumption equivalence relative to no FXI case. I simulated the model for 1,100 periods and dropped the first 100 observations. I allow for productivity, cost-push,, nominal interest rate, and capital flow shocks.

- FXI that trades off UIP and inflation stabilization gives 2.2 times higher welfare than FXI that only targets UIP.

Conclusion

- A general two-country framework to study MP and FXI
- **MP and FXI are not two separate policy tools** but central banks should combine them to stabilize the exchange rate and inflation
- FXI improves the MP trade-off
  - FXI mitigates the currency depreciation and inflation without raising the domestic interest rate
- However, FXI distorts the exchange rate
  - FXI increases the local purchasing power over the US
- Bridges the gap between dollar pricing in international trade and capital flow management in international finance
- Important to understand how to combine FXI with other policies
  - Capital control, macroprudential policy
  - IMF's integrated policy framework

Appendix

Intuition

Back

- Different transmission channels of MP and FXI
- Raise interest rate $\rightarrow$ **inflation $\Downarrow$ and consumption $\Downarrow$**
- Buy LC, sell \$ bond $\rightarrow$ **inflation $\Downarrow$ but consumption $\Uparrow$**
    - FXI appreciates the local currency
        - US demand for local good $\Downarrow$ $\rightarrow$ domestic good inflation $\Downarrow$
        - Cheaper \$ $\rightarrow$ imported good inflation $\Downarrow$
    - Local bond return $\Downarrow$ relative to \$ bond return
        - Limits to arbitrage: local households cannot invest in US bonds[8]
        - Local currency stronger + consumption demand $\Uparrow$ relative to the US
- Central banks should combine MP and FXI appropriately

[8] In a standard model without financial friction, FXI has no effect on exchange rate (Backus/Kehoe'89).

Evidence for Limits to Arbitrage: UIP Deviation

Back

Country	Currency	α_0	(s.e.)	β_1	(s.e.)	$\chi^2(\alpha_0 = \beta_1 = 0)$	R^2
Australia	AUD	-0.001	(0.002)	-1.63***	(0.48)	16.3***	0.014
Austria	ATS	0.002	(0.002)	-1.75***	(0.58)	9.5***	0.023
Belgium	BEF	-0.0002	(0.002)	-1.58***	(0.39)	17.5***	0.025
Canada	CAD	-0.003	(0.001)	-1.43***	(0.38)	19.1***	0.013
Denmark	DKK	-0.001	(0.001)	-1.51***	(0.32)	25.4***	0.025
France	FRF	-0.001	(0.002)	-0.84	(0.63)	1.9	0.007
Germany	DEM	0.002	(0.001)	-1.58***	(0.57)	7.9**	0.015
Ireland	IEP	-0.002	(0.002)	-1.32***	(0.38)	12.3***	0.020
Italy	ITL	-0.002	(0.002)	-0.79**	(0.33)	7.0**	0.013
Japan	JPY	0.006***	(0.002)	-2.76***	(0.51)	28.9***	0.038
Netherlands	NLG	0.003	(0.002)	-2.34***	(0.59)	16.0***	0.041
Norway	NOK	-0.0003	(0.001)	-1.15***	(0.39)	10.4***	0.013
New Zealand	NZD	-0.001	(0.002)	-1.74***	(0.39)	28.3***	0.038
Portugal	PTE	-0.002	(0.002)	-0.45**	(0.20)	5.9*	0.019
Spain	ESP	0.002	(0.003)	-0.19	(0.46)	2.8	0.001
Sweden	SEK	0.0001	(0.001)	-0.42	(0.50)	0.9	0.002
Switzerland	CHF	0.005***	(0.002)	-2.06***	(0.55)	13.9***	0.026
UK	GBP	-0.003**	(0.001)	-2.24***	(0.60)	14.2***	0.028
Panel, pooled		0.0002	(0.001)	-0.79***	(0.15)	22.3***	
Panel, fixed eff.				-1.01***	(0.21)	19.1***	

Source: Valchev (2015).

- If households can invest freely in two currencies, the excess return is zero (uncovered interest rate parity holds). However, UIP does not hold in data.
- Fama (1985) regression: $e_{t+1} - e_t - (i_t - i_t^*) = \alpha_0 + \beta_1(i_t - i_t^*) + \epsilon_t$
- When $\beta_1 < 0$, high interest rate currency appreciates in future = positive return

Literature on MP and FXI in Open Economy

Back

	(1) Monetary Policy	(2) FX Intervention	(3) Both MP and FXI
(a) Small Open Economy	Gali & Monacelli (2005) Clarida, Gali & Gertler (2001) Kollmann (2002) Corsetti & Pesenti (2005) Faia & Monacelli (2008) Egorov and Mukhin (2023)	Fanelli & Straub (2021) Davis, Devereux & Yu (2023) Ottonello, Perez & Witheridge	Cavallino (2019), Amador et al. (2020) Basu et al. (2020) Itskhoki & Mukhin (2023)
(b) Large Open Economies (Two-country)	Clarida, Gali & Gertler (2002) Benigno & Benigno (2003, 2006) Devereux & Engel (2003), Engel (2011) Corsetti, Dedola & Leduc (CDL) (2010, 2020, 2023)	Gabaix & Maggiori (2015) Maggiori (2022)	**This Paper**

Literature on MP & FXI in a Small Open Economy

Back

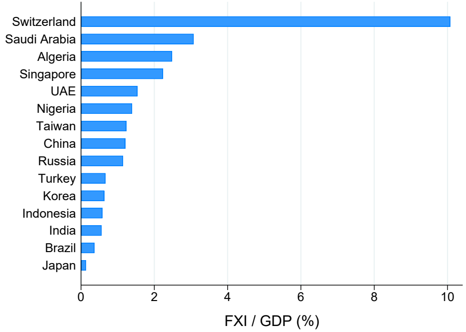
- Cavallino (2019)
  - Cost for central banks: FX purchase lowers the FX return
  - Profit for intermediaries: opposite carry trade position against central banks
  - Domestic intermediaries share $\beta = 1$: loss = profit, $\beta < 1$: loss > profit
- Basu et al. (2020) (IMF Integrated Policy Framework)
  - When banks face sudden stop, lower policy rate relaxes the domestic borrowing constraint but tightens the external borrowing constraint due to depreciation
  - FX sales limit the depreciation and improves the trade-off
- Itskhoki and Mukhin (2023)
  - MP and FXI eliminate nominal and financial frictions separately
  - Without FXI, MP trades off inflation and exchange rate stabilization
- My paper: MP and FXI in a large two-country model
  - FXI lowers the inflation but exacerbates the resource allocation
  - FXI trades off the internal & external objectives

FXI over GDP Share by Countries

Back to volume

- Large emerging and advanced economies conduct FXI on massive scales (1.2% of GDP on average).

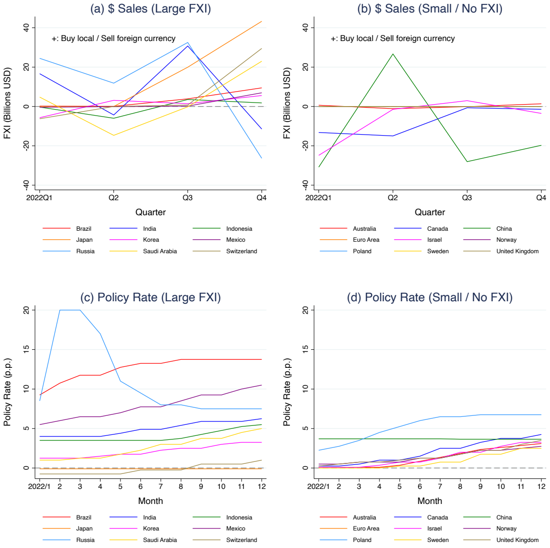
Figure 2: FXI Volumes by Country (Percentage Ratio over GDP)



Note: Quarterly FXI data in 122 countries (Adler et al., 2022). Excludes countries that mainly intervene against the euro.

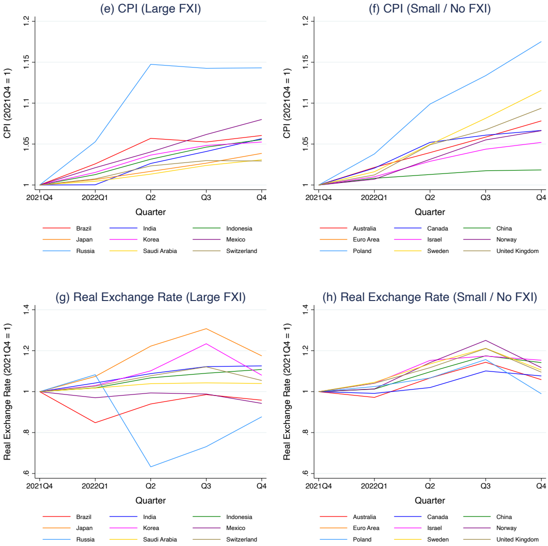
Raw Data (FXI Volume, Policy Rate)

Back



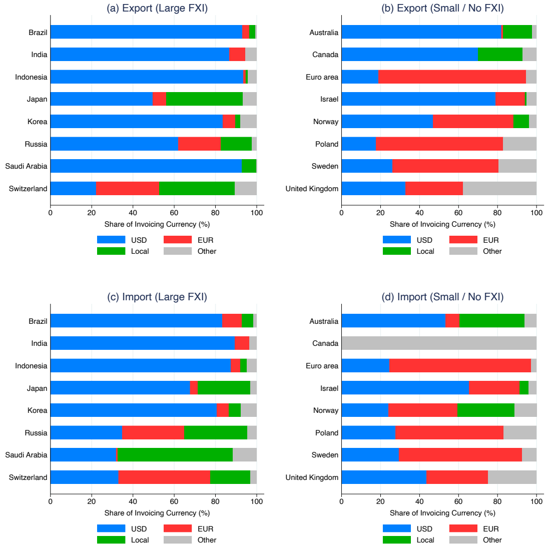
Raw Data (Inflation, Real Exchange Rate)

Back



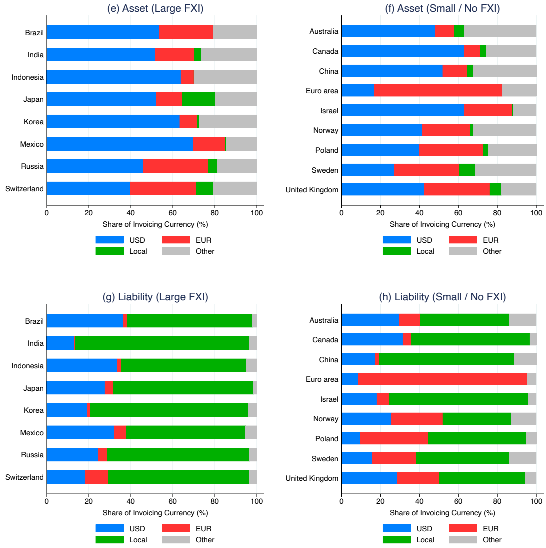
Raw Data (Export, import)

Back



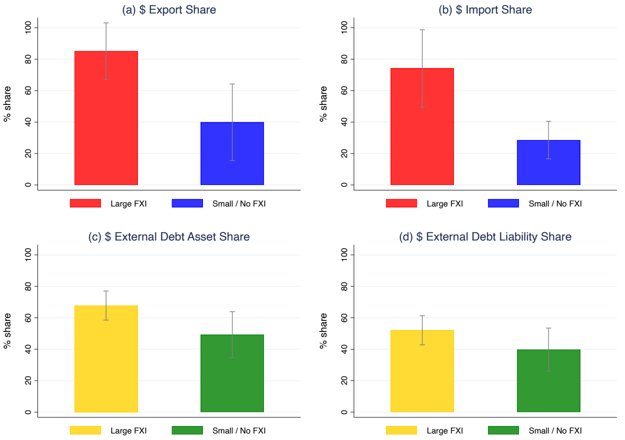
Raw Data (Asset, Liability)

Back



Invoicing Currency (Debt Asset & Liability)

Back



- Export and import: more dollarized in large FXI countries
- Debt Asset and liability: small difference

Households (Details)

- General CRRA, CES bundle of local and US goods

$$U(C_t, L_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \iota_l \frac{L_t^{1+\eta}}{1+\eta}, \quad C_t = \left[a^{\frac{1}{\phi}} C_{Lt}^{\frac{\phi-1}{\phi}} + (1-a)^{\frac{1}{\phi}} C_{Ut}^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{1-\phi}}$$

$$C_{Lt} = \left[\int_0^1 C_t(l)^{\frac{\zeta-1}{\zeta}} dj\right]^{\frac{\zeta}{1-\zeta}}, \quad C_{Ut} = \left[\int_0^1 C_t(u)^{\frac{\zeta-1}{\zeta}} du\right]^{\frac{\zeta}{1-\zeta}}$$

- $\sigma = 1/\theta$: risk-aversion (inverse of intertemporal elasticity)
- Budget constraint:

$$P_{Lt} C_{Lt} + P_{Ut} C_{Ut} + \frac{B_t}{R_t} = B_{t-1} + W_t L_t + \Pi_t + T_t$$

Households (simple) Households (general) Full quantitative model

Solution to Households' Problem

- Euler equation for the local bond: $\beta R_t E_t \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} = 1$
- Labor supply equation: $C_t^{\sigma} L_t^{\eta} = \frac{W_t}{P_t}$
- Demand for local and US goods:

$$C_{Lt} = a \left(\frac{P_{Lt}}{P_t} \right)^{-\phi} C_t, \quad C_{Ut} = (1-a) \left(\frac{P_{Ut}}{P_t} \right)^{-\phi} C_t$$

- Demand for differentiated goods produced within each country:

$$C_t(l) = \left(\frac{P_t(l)}{P_{Lt}} \right)^{-\zeta} C_{Lt}, \quad C_t(u) = \left(\frac{P_t(u)}{P_{Lt}} \right)^{-\zeta} C_{Ut}$$

Households (simple) Households (general)

Firms' Maximization Problem

- Producer currency pricing (PCP): law of one price $P_t(l) = \mathcal{E}_t P_t^U(l)$
- Firms set prices subject to price adjustment cost (Rotemberg '82)

$$\max \sum_{t=0}^{\infty} \beta^t \frac{U'(C_{t+k})}{U'(C_t)} \left[P_t(l) \left(\frac{P_t(l)}{P_{Lt}} \right)^{-\zeta} Y_{Lt} - \frac{W_t}{A_t} \frac{1}{1-\tau_t} \left(\frac{P_t(l)}{P_{Lt}} \right)^{-\zeta} Y_{Lt} - \frac{AC_p}{2} \left(\frac{P_t(l)}{P_{t-1}(l)} - 1 \right)^2 P_{Lt} Y_{Lt} \right]$$

- New Keynesian Phillips Curve:

$$\pi_{Lt} = \beta E_t \pi_{Lt+1} + \kappa \{ \underbrace{(\sigma + \eta)\tilde{Y}_{Lt}}_{\text{Output gap}} + \underbrace{2a(\sigma\phi - 1)(\tilde{P}_{Lt} - \tilde{P}_{Ut})}_{\text{Relative price}} + \underbrace{(1-a)\tilde{\mathcal{D}}_t}_{\text{Demand gap}} + \underbrace{\mu_t}_{\text{Cost-push}} \}$$

- Productivity: $\log(A_t) = \rho_a \log(A_{t-1}) + \epsilon_{at}, \ \epsilon_{at} \sim N(0, \sigma_a^2)$
- Markup shock: $\mu_t = \frac{\zeta}{(\zeta-1)(1-\tau_t)}$

Households (simple) Households (general)

Lagrangian for Cooperative Policy

CO Solution CO Solution (FXI)

$$
\begin{aligned}
\mathcal{L}_t^W =& -\frac{1}{2}\left[\tilde{Y}_{Lt}^2 + \tilde{Y}_{Ut}^2 + \frac{\zeta}{\kappa}((\pi_t^{CPI})^2 + (\pi_t^{CPI*})^2)\right] + \frac{a(1-a)(\sigma\phi-1)\sigma}{4a(1-a)(\sigma\phi-1)+1}(\tilde{Y}_{Lt} - \tilde{Y}_{Ut})^2 \\
& - \frac{a(1-a)\phi}{4a(1-a)(\sigma\phi-1)+1}(\hat{\Delta}_t + \tilde{\mathcal{D}}_t)^2 \\
& + \gamma_{Lt}^J \left[\begin{array}{l} -\pi_{Lt} + \beta E_t \pi_{Lt+1} \\ +\kappa\left\{(\sigma+\eta)\tilde{Y}_{Lt} - (1-a)[2a(\sigma\phi-1)(\tilde{T}_t + \hat{\Delta}_t) - (\hat{\Delta}_t + \tilde{\mathcal{D}}_t)]\right\} \end{array} \right] \\
& + \gamma_{Lt}^U \left[\begin{array}{l} -\pi_{Lt}^* + \beta E_t \pi_{Lt+1}^U \\ +\kappa\left\{(\sigma+\eta)\tilde{Y}_{Lt} - (1-a)[2a(\sigma\phi-1)(\tilde{T}_t + \hat{\Delta}_t) - (\hat{\Delta}_t + \tilde{\mathcal{D}}_t) - \Delta_t]\right\} \end{array} \right] \\
& + \gamma_{Ut}^U \left[\begin{array}{l} -\pi_{Ut}^* + \beta E_t \pi_{U,t+1}^U \\ +\kappa\left\{(\sigma+\eta)\tilde{Y}_{Ut} - (1-a)[2a(\sigma\phi-1)(\tilde{T}_t + \hat{\Delta}_t) - (\hat{\Delta}_t + \tilde{\mathcal{D}}_t)]\right\} \end{array} \right] \\
& + \gamma_{Ut}^J \left[\begin{array}{l} -\pi_{Ut} + \beta E_t \pi_{U,t+1}^J \\ +\kappa\left\{(\sigma+\eta)\tilde{Y}_{Ut} - (1-a)[2a(\sigma\phi-1)(\tilde{T}_t + \hat{\Delta}_t) - (\hat{\Delta}_t + \tilde{\mathcal{D}}_t) + \Delta_t]\right\} \end{array} \right] \\
& + \gamma_t \left[-\pi_{Lt} + \pi_{Ut} - \hat{T}_t + \hat{T}_{t-1} - \hat{\Delta}_t + \hat{\Delta}_{t-1}\right] \\
& + \lambda_t \left[-E_t\tilde{\mathcal{D}}_{t+1} + \tilde{\mathcal{D}}_t + n_t^* - f_t\right]
\end{aligned}
$$

- Under PCP, $\hat{\Delta}_t = 0$ and no constraint for TOT misalignment

Back to Loss Function

Asset Market

Back Asset market clearing

- **Households** can only trade in their own currency
- **Financiers** can trade both local and US bonds but they are risk-averse = **Limits to arbitrage**[9]

$$\max_{d_t^*} E_t \left\{ -\frac{1}{\omega} \exp\left(-\omega \Pi_t\right) \right\}, \quad \Pi_t = \bar{R}_t^* \frac{D_t^*}{P_t^*}$$

  - $\omega > 0$: risk aversion
  - $\bar{R}_t^* = R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$: carry trade return ($\neq 0$ when $\omega > 0$)
  - D_t^*: carry trade position
- **Central bank** uses FXI (F_t, F_t^*)
- **Noise (Liquidity) traders** generate capital flow shocks (N_t, N_t^*)

[9] I assume that the financiers' profit is transferred to the local households in a lump-sum way.

International Asset Market

Back UIP general case

$$\underbrace{E_t\tilde{\mathcal{D}}_{t+1}-\tilde{\mathcal{D}}_t}_{\Delta\text{ Demand gap}} = \underbrace{\tilde{r}_t-\tilde{r}^*_t-(E_t\tilde{e}_{t+1}-\tilde{e}_t)}_{\substack{\text{UIP deviation}\\ \text{(LC } - \text{ dollar return)}}} = \underbrace{\chi(n^*_t-f_t)}_{\substack{\text{Noise trader buys \$ } (n^*_t)\\ - \text{ CB buys LC } (f_t)}}$$

- \$ demand ($n^*_t \Uparrow$) $\rightarrow$ LC return $\tilde{r}_t \Uparrow$, depreciation $\mathcal{Q}_t \Uparrow$ $\rightarrow$ $UIP > 0$, local savings $\Uparrow$, future excess demand $E_t\tilde{\mathcal{D}}_{t+1} \Uparrow$
- If CB's LC demand offsets NTs' \$ demand ($f_t = n^*_t$), $UIP = 0$ and the risk sharing holds: $\tilde{\mathcal{D}}_t = 0$.[10][11][12]

[10] Without log and Cobb-Douglas preference, $E_t\tilde{\mathcal{D}}_{t+1} - \tilde{\mathcal{D}}_t = 0$: risk sharing holds only in expectation but not for every state of the economy.

[11] $\chi = \omega\sigma_e^2/\beta$ is increasing in financiers' risk-aversion (ω) and exchange rate volatility (σ_e^2).

[12] I assume that the size of the financial sector is large enough relative to the households.

Asset Market Clearing

- B_t, N_t, D_t, F_t: aggregate demand for local bond
- Zero net position:

$$B_t/R_t + \mathcal{E}_t B_t^*/R^* = 0, \quad N_t/R_t + \mathcal{E}_t N_t^*/R^* = 0$$
$$D_t/R_t + \mathcal{E}_t D_t^*/R^* = 0, \quad F_t/R_t + \mathcal{E}_t F_t^*/R^* = 0$$

- Market clearing for local and US bonds:

$$B_t + N_t + D_t + F_t = 0, \quad B_t^* + N_t^* + D_t^* + F_t^* = 0$$

Back to maximization

UIP condition (General Case)

UIP simple case Quantitative model

- The maximization problem for intermediaries implies:

$$\underbrace{E_t\tilde{\mathcal{D}}_{t+1} - \tilde{\mathcal{D}}_t}_{\Delta \text{ Demand gap}} = \underbrace{\tilde{r}_t - \tilde{r}_t^* - E_t\Delta\tilde{e}_{t+1}}_{\substack{\text{UIP deviation} \\ (\text{LC} - \$ \text{ return})}} = \underbrace{\chi_1(n_t^* - f_t)}_{\substack{\text{Noise trader buys } \$ \ (n_t^*) \\ - \text{ CB buys LC } (f_t)}} - \underbrace{\chi_2 b_t}_{\text{HHs' savings}}$$

where $\chi_1 \equiv m_n(\omega\sigma_e^2/m_d)$, $\chi_2 \equiv \bar{Y}(\omega\sigma_e^2/m_d)$ for finite $(\omega\sigma_e^2/m_d)$.

- Itskhoki and Mukhin (2021, 2023) scale the risk aversion ω so that $\omega\sigma_e^2$ is finite and nonzero and risk premium is first-order.[13]

- When deriving analytical result, I assume $\chi_1 = 1$ and $\chi_2 = 0$ for tractability. Assume financial sector (m_d financiers and m_n noise traders) is larger than HHs.

[13] See Hansen and Sargent (2011).

Optimal Monetary Policy and FXI: Details

IRF

Optimal monetary policies for local and US central banks are:

$$0 = \zeta\pi_{Lt} + (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1}) + \xi_\pi(\pi_{Lt} - \pi^*_{Ut}) + \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1})$$
$$0 = \zeta\pi_{Ut} + (\tilde{Y}_{Ut} - \tilde{Y}_{Ut-1}) - \xi_\pi(\pi_{Lt} - \pi^*_{Ut}) - \xi_D(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1})$$

where

$$\xi_\pi = (1-a)\frac{2a(\sigma\phi-1)+1}{\sigma+\eta\{4a(1-a)(\sigma\phi-1)+1\}}\frac{2a(\sigma\phi-1)+1-\sigma}{2a(\phi-1)+1}\zeta$$
$$\xi_D = \frac{2a(1-a)\phi}{\sigma+\eta\{4a(1-a)(\sigma\phi-1)+1\}}\frac{2a(\sigma\phi-1)+1-\sigma}{2a(\phi-1)+1}.$$

Optimal FXI is:

$$f_t = n^*_t + \xi_f E_t(\pi_{Lt+1} - \pi^U_{U,t+1})$$

where

$$\xi_f = \frac{1-a}{\chi}\frac{2a(\sigma\phi-1)+1}{2a(1-a)\phi} \text{ and } \chi = \frac{\omega\sigma_e^2}{\beta} \quad \left(\xi_f > 0 \text{ if } \sigma\phi > 1 - \frac{1}{2a}\right).$$

NKPC and Loss Function under Dollar Pricing

Back

- NKPCs for local goods in LC (π_{Lt}) and \$ (π^*_{Lt}), US goods in \$ (π^*_{Ut})
  - Local good inflation depends on the LOOP deviation (Δ_{Lt})

$$\pi_{Lt} = \beta\pi_{Lt+1} + \kappa\{(\sigma+\eta)\tilde{Y}_{Lt} - (1-a)[2a(\sigma\phi-1)(\tilde{\mathcal{T}}_t + \tilde{\Delta}_{Lt}) + (\tilde{D}_t + \tilde{\Delta}_{Lt})] + \mu_t\}$$
$$\pi^*_{Lt} = \beta\pi^*_{Lt+1} + \kappa\{(\sigma+\eta)\tilde{Y}_{Lt} - (1-a)[2a(\sigma\phi-1)(\tilde{\mathcal{T}}_t + \tilde{\Delta}_{Lt}) + (\tilde{D}_t + \tilde{\Delta}_{Lt})] - \tilde{\Delta}_{Lt} + \mu^*_t\}$$
$$\pi^*_{Ut} = \beta\pi^*_{Ut+1} + \kappa\{(\sigma+\eta)\tilde{Y}_{Ut} + (1-a)[2a(\sigma\phi-1)\tilde{\mathcal{T}}_t - \tilde{D}_t] + \mu^*_t\}$$

- Loss function depends on the LOOP deviation (Δ_{Lt}):

$$\mathcal{L} = -E_0\sum_{t=0}^{\infty}\beta^t\frac{1}{2}\left[\begin{array}{l}(\sigma+\eta)\left(\tilde{Y}^2_{Lt}+\tilde{Y}^2_{Ut}\right)+\frac{\zeta}{\kappa}\left(a\pi^2_{Lt}+(1-a)\pi^{*2}_{Lt}+\pi^{*2}_{Ut}\right)\\ -\frac{2a(1-a)(\sigma\phi-1)\sigma}{4a(1-a)(\sigma\phi-1)+1}\left(\tilde{Y}_{Lt}-\tilde{Y}_{Ut}\right)^2\\ +\frac{2a(1-a)\phi}{4a(1-a)(\sigma\phi-1)+1}\left(\tilde{\mathcal{D}}_t+\Delta_{Lt}\right)^2\end{array}\right]. \quad (2)$$

Dollar Pricing: Optimal Monetary Policy

Back

Optimal monetary policy under DCP when FXI is not available:

$$0 = \theta a \pi_{Lt} + (\tilde{C}_t - \tilde{C}_{t-1}) + \frac{2a(1-a)\phi}{2a(\phi-1)+1}\frac{\sigma-1}{\sigma}(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1} + \tilde{\Delta}_t - \tilde{\Delta}_{t-1})$$

$$0 = \theta[(1-a)\pi^*_{Lt} + \pi^*_{Ut}] - (\tilde{C}^*_t - \tilde{C}^*_{t-1}) - \frac{2a(1-a)\phi}{2a(\phi-1)+1}\frac{\sigma-1}{\sigma}(\tilde{\mathcal{D}}_t - \tilde{\mathcal{D}}_{t-1} + \tilde{\Delta}_t - \tilde{\Delta}_{t-1})$$

- Local: trades off local inflation and demand growth.
- US: trades off international dollar price inflation and demand growth.
- When $\sigma \neq 1$, MP also trades off the LOOP deviation.

Dollar Pricing: Optimal Monetary Policy and FXI

Back

Optimal monetary policy and FXI under DCP:

$$
\begin{aligned}
0 &= \tilde{Y}_{Lt} + \theta[a\pi_{Lt} + (1-a)\pi^*_{Lt}], \\
0 &= \tilde{Y}_{Ut} + \theta\pi^*_{Ut} + \gamma_{\Delta_{Lt}} - \gamma_{\Delta_{Lt-1}}, \\
\gamma_{\Delta_{Lt}} &= -\frac{4a(1-a)}{2a-1}(\tilde{\Delta}_{Lt} + \tilde{\mathcal{D}}_t) + \theta\frac{1}{2a-1} \\
&\quad \times [a\pi_{Lt} - ((1-a)\pi^*_{Lt} + \pi^*_{Ut})] - (2a-1)[a\pi_{Lt} + (1-a)\pi^*_{Lt} + \pi^*_{Ut}] \\
f_t &= n^*_t + \frac{\theta}{2a\chi_1}E_t[a\pi_{Lt+1} + (1-a)\pi^*_{Lt+1} + \pi^*_{Ut+1}] \\
&\quad + \frac{2a-1}{2a(1-a)\chi_1}(E_t\gamma_{\Delta t+t} - \gamma_{\Delta t}).
\end{aligned}
$$

- Local: MP trades off local inflation and output growth.
- US: MP trades off US inflation, output growth, LOOP deviation, and demand gap.
- FXI responds to the LOOP deviation.

Calibration (Optimal Policy)

Table 2: Benchmark Parameters

	Description	Value	Notes
β	Discount factor (local)	0.995	Annual interest rate $= 2\%$
σ	Relative risk aversion	5	Cole and Obstfeld (1991)
η	Inverse Frisch elasticity	1.5	Itskhoki and Mukhin (2021)
ζ_l	Labor disutility (local)	1	$\bar{L} = 1$
a	Home bias of consumption	0.88	Bodenstein et al. (2023)
ϕ	CES Local & US goods	1.5	Cole and Obstfeld (1991)
θ	CES differentiated goods	10	Ottonello and Winberry (2020)
ρ_a	Persistence of productivity shock	0.95	Bodenstein et al. (2023)
χ_1	Elasticity of UIP to FXI	0.43	$\Delta \log \text{UIP}_t / \Delta \log \text{FXI}_t$
χ_2	Elasticity of UIP to NFA	0.001	UIP/NFA ratio

Note: The table shows the parameter settings for the CO case (Cole/Obstfeld'91) where $\sigma = \phi = 1$ and non-CO case where $\sigma, \phi \neq 1$.

▸ Productivity shock ▸ Cost-Push shock (No FXI) ▸ Cost-Push shock (FXI)

Externally Set Parameters

	Description	Value	Notes
σ	Relative risk aversion	2	Corsetti et al. (2010)
h	Habit formation	0.90	Verdelhan (2010)
η	Inverse Frisch elasticity	1.0	Corsetti et al. (2010)
AC_k	Investment adjustment cost	2.5	Christiano et al. (2005)
ϕ	CES Local & US goods	1.5	Itskhoki and Mukhin (2021)
θ	CES differentiated goods	10	Ottonello and Winberry (2020)
θ_w	CES differentiated labor	10	
ψ	Price adjustment cost	90	Ottonello and Winberry (2020)
ψ_w	Wage adjustment cost	100	
ϕ_π	Taylor coefficient on inflation	1.5	Taylor (1993)
ϕ_y	Taylor coefficient on output	0.125	Taylor (1993)
ρ_a	Persistence of productivity shock	0.90	Jermann and Quadrini (2012)
ρ_μ	Persistence of markup shock	0.90	Jermann and Quadrini (2012)
ρ_r	Persistence of interest rate shock	0.20	Jermann and Quadrini (2012)
$\bar{\rho}_r$	Interest rate smoothing	0.75	Jermann and Quadrini (2012)

Calibrated Parameters

	Description	Value	Source / Matched Moment
β	Discount factor (local)	0.9996	Interest rate $= 0.04\%$
β^*	Discount factor (US)	0.9986	Interest rate $= 0.14\%$
ζ_l	Labor disutility (local)	46.3	Working hours $= 0.29$
ζ_l^*	Labor disutility (US)	60.0	Working hours $= 0.29$
α	Capital share (local)	0.43	Penn World Table 10.0
α^*	Capital share (US)	0.39	Penn World Table 10.0
δ	Capital depreciation rate (local)	0.01	Investment-to-capital ratio
δ^*	Capital depreciation rate (US)	0.01	Investment-to-capital ratio
a	Home bias of consumption (local)	0.87	$0.5 \times$ (export $+$ import)/ GDP
a^*	Home bias of consumption (US)	0.87	$0.5 \times$ (export $+$ import)/ GDP
s	US relative size	2.93	$Y_U^*/(eY_L)$
χ_1	Elasticity of UIP to FXI	0.43	$\Delta \log \text{UIP}_t / \Delta \log \text{FXI}_t$
χ_2	Elasticity of UIP to NFA	0.001	UIP/NFA ratio
ρ_n	Persistence of capital flow shock	0.39	$\rho(\Delta \log \text{UIP}_t) = 0.39$
σ_a	SD of technology shock (local)	0.78	$\sigma(\Delta \log Y_{Lt}) = 1.62$
σ_a^*	SD of technology shock (US)	0.22	$\sigma(\Delta \log Y_{Ut}) = 1.32$
σ_μ	SD of cost-push shock (local)	1.59	$\sigma(\Delta \log \pi_t) = 0.42$
σ_μ^*	SD of cost-push shock (US)	0.37	$\sigma(\Delta \log \pi_t^*) = 0.38$
σ_r	SD of interest rate shock (local)	0.40	$\sigma(\Delta \log R_t) = 0.05$
σ_r^*	SD of interest rate shock (US)	0.46	$\sigma(\Delta \log R_t^*) = 0.24$
σ_n	SD of capital flow shock	0.46	$\sigma(\Delta \log \text{UIP}_t) = 5.02$