Monetary and Exchange Rate Policies in a Global Economy

Naoki Yago

The University of Cambridge

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UNIVERSITY OF CAMBRIDGE

Introduction

- Foreign exchange intervention (FXI)
  - Central banks buy/sell foreign currency reserves
  - ex. China buys yuan, sells dollar reserves $\Rightarrow$ yuan expensive
- Classical theory: inflation stabilization (Mundell-Fleming)
- In practice: exchange rate stabilization (Rey'15)
- I construct a theory with both monetary policy and FXI.
  - Which policy should central banks use?

Two Tensions between Theory & Practice

Example

Tension 1:

- Literature: small open economies
- Reality: large open economies use FXI actively

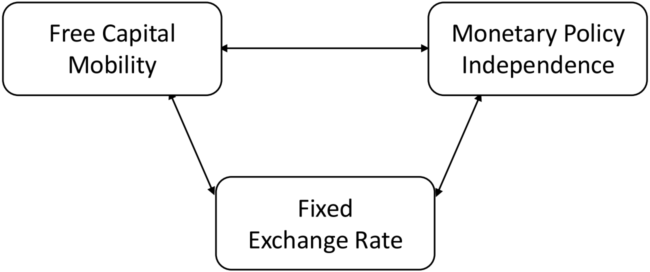
Tension 2:

- Literature: separate objectives
  - Monetary policy ⇒ inflation, FXI ⇒ exchange rate
- Reality: related objectives
  - ex. Pandemic & war, high inflation
  - Low interest rates and intervention by selling the dollar

What I do

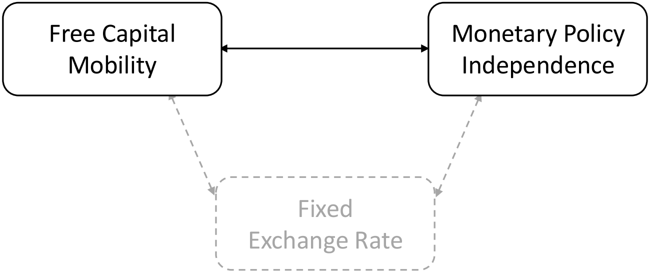
- A large two-country model with monetary policy and FXI based on:
  - Monetary policy in large open economies (Corsetti/Dedola/Leduc'23)
  - FXI in small open economies (Basu/etal'20, Itskhoki/Mukhin'23)
- **Result:** the two policies are interdependent for large countries.
  - FXI affects inflation by dampening/stimulating foreign demand

International Macro in the Past Decades



- Classical Theory (Mundell-Fleming)

International Macro in the Past Decades



- CB cannot keep monetary independence under free capital mobility even with a flexible exchange rate (Rey'15)
- International spillovers of shocks

International Macro in the Past Decades

Free Capital Mobility ⟷ Monetary Policy Independence

Model Takeaway:

- Without FXI, external shocks weaken the MP independence
    - MP cannot stabilize domestic inflation/output
- FXI improves the MP independence
    - Stabilize inflation/output with small interest rate changes
    - FXI complements the MP

Literature

▸ Table ▸ Literature on FXI under SOE

- 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

$\Rightarrow$ Two-country model with both monetary policy and FXI

- 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

- Non-fundamental volatility of exchange rates
  - 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 exchange rates

Roadmap

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

1. (Known) starting point: monetary policy (Corsetti/Dedola/Leduc'23)
2. Model setup: monetary policy & FXI
3. Optimal policy under cooperation
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

Roadmap

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

1. (Known) starting point: monetary policy (Corsetti/Dedola/Leduc'23)
   - Define international risk-sharing
   - Inflation-output trade-off due to the lack of risk-sharing
2. Model setup: monetary policy & FXI
3. Optimal policy under cooperation
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

Monetary Policy under Cooperation (Corsetti/Dedola/Leduc'23)

- Two symmetric large open economies: local & US
- **Households** consume local & US goods, supply labor ▸ Details

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

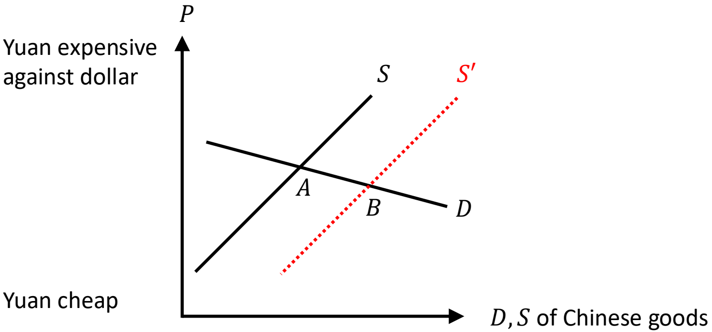
  - Cannot trade state-contingent asset internationally

- **Firms** produce goods, price rigidity (Calvo'83) ▸ Details
  - Shocks: productivity and markup
  - Export in own currency
- **Global planner** sets local and US monetary policy rates

International Risk Sharing (Concept)

▸ Incomplete asset market

- Planner targets **risk-sharing** under cooperation.
  - China supply $\Uparrow$ $\rightarrow$ China consumption $\Uparrow$
  - Cheap yuan $\rightarrow$ US import price $\Downarrow$, US consumption $\Uparrow$ (smoothing)



International Risk Sharing (Definition)

Incomplete asset market

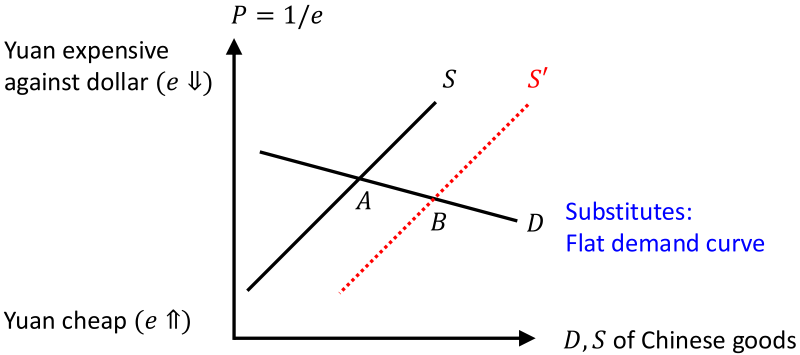
- Risk-sharing wedge = Difference in marginal utilities

$$\tilde{\mathcal{W}}_t \equiv \widetilde{U'(C_t^*)} - \widetilde{U'(C_t)} - \tilde{e}_t$$
$$= \tilde{C}_t - \tilde{C}_t^* - \tilde{e}_t \quad \text{(with log utility)}$$

- $\tilde{\mathcal{W}}_t > 0$ (China excess demand) when:
    - $\tilde{C}_t > \tilde{C}_t^*$ (China > US consumption)
    - $\tilde{e}_t \Downarrow$ (Yuan is expensive against the dollar)

Lack of Risk Sharing when Goods are Substitutes

- China productivity $\Uparrow$ $\rightarrow$ excess demand $(\tilde{W} = \tilde{C} - \tilde{C}^* - \tilde{e} > 0)$
- China consumption $C \Uparrow$ but small yuan depreciation $e \Uparrow$



Price Setting

▸ Firms' maximization ▸ Intuition

$$\pi_{Lt} = \beta E_t \pi_{Lt+1} + \kappa \Big[\tilde{Y}_{Lt} - \underbrace{2a(1-a)(\phi-1)\tilde{\mathcal{T}}_t}_{\text{Terms-of-trade gap}} + \underbrace{(1-a)\tilde{\mathcal{W}}_t}_{\text{Risk-sharing wedge}} + \underbrace{\mu_t}_{\text{Markup shock}} \Big]$$

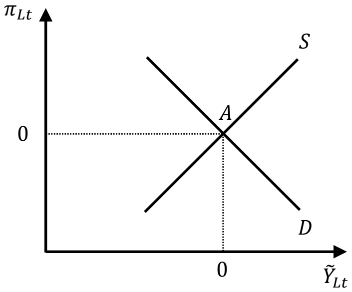
- π_{Lt}: inflation (local goods consumed by local households)
- $\tilde{Y}_{Lt}$: output gap
- $\tilde{\mathcal{T}}_t$: terms-of-trade gap (import − export price)
  - Import price $\tilde{\mathcal{T}}_t \Downarrow \;\rightarrow\;$ consumption $\Uparrow$, inflation $\Uparrow$
- $\tilde{\mathcal{W}}_t$: Local excess demand $\rightarrow$ inflation $\Uparrow$

(ϕ: substitution of local/US goods, $1-a$: trade openness)

Monetary Policy Trade-off: (1) Inflation Targeting

- Local productivity $A_t \Uparrow \rightarrow$ inflation $\Downarrow$

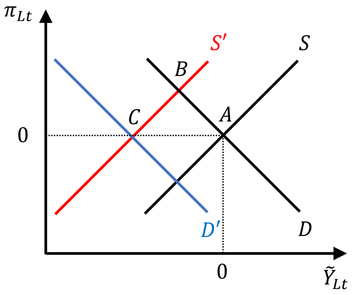
  $\rightarrow$ Interest rate $\Downarrow$ so that inflation $=$ output gap $= 0$



Monetary Policy Trade-off: (2) Risk-Sharing Channel

- Assume **inflation targeting** ($\pi_{Lt} = 0$) & goods are **substitutes**
- Local productivity $A_t \Uparrow$ $\rightarrow$ demand $\tilde{\mathcal{W}}_t \Uparrow$ $\rightarrow$ inflation $\pi_{Lt} \Uparrow$

  $\rightarrow$ Interest rate $\Uparrow$ to target inflation $\rightarrow$ output gap $\tilde{Y}_{Lt} \Downarrow$



Special case: Unit trade elasticity

Roadmap

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

1. (Known) starting point: monetary policy
2. Model setup: monetary policy & FXI
   - FXI is effective under frictions in international asset trade

     (Gabaix/Maggiori'15, Itskhoki/Mukhin'23)
   - FXI mitigates the inflation-output trade-off of monetary policy
3. Optimal policy under cooperation
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

FXI: Basic Idea

- Central banks use both MP and FXI
- **Data:** unhedged returns on savings are different across currencies
  - Uncovered Interest Parity (UIP) deviation (Fama'94) Details
- Assume households can only borrow/lend in their own currency.

  $\Rightarrow$ FXI affects the exchange rate (Gabaix/Maggiori'15, Itskhoki/Mukhin'21)
- **Example:** China buys the yuan $\rightarrow$ return on yuan $<$ \$
  - Households cannot borrow in yuan to invest in \$
  - (More formally) limits to financial intermediation Details

UIP Condition (Case 1: No FXI)

Households' net foreign assets

- No FXI and UIP shocks (known in Corsetti/Dedola/Leduc'23)

$$\underbrace{E_t\tilde{\mathcal{W}}_{t+1}-\tilde{\mathcal{W}}_t}_{\tilde{\mathcal{W}}_t>0:\ \text{local demand}} = \underbrace{\tilde{r}_t-\tilde{r}^*_t}_{\text{Local} - \$ \text{ interest rate}} - \underbrace{\left(E_t\tilde{e}_{t+1}-\tilde{e}_t\right)}_{\text{Local expected depreciation}} = 0$$

- Same return $\rightarrow$ consumption smoothing on average

- When goods are substitutes, $\tilde{\mathcal{W}}_t \neq 0$

  $\rightarrow$ MP trades off inflation-output

UIP Condition (Case 2: FXI)

Households' net foreign assets

- Formalization of Gabaix/Maggiori'15 gives: Details

$$\underbrace{E_t\tilde{\mathcal{W}}_{t+1} - \tilde{\mathcal{W}}_t}_{\tilde{\mathcal{W}}_t > 0:\ \text{local demand}} = \underbrace{\tilde{r}_t - \tilde{r}_t^*}_{\text{Local} - \$\ \text{interest rate}} - \underbrace{\left(E_t\tilde{e}_{t+1} - \tilde{e}_t\right)}_{\text{Local expected depreciation}} = 0 = \underbrace{\omega f_t^*}_{\text{FXI}}$$

(ω: intermediation friction, $\quad f_t^* > 0$: buy \$ / sell local)

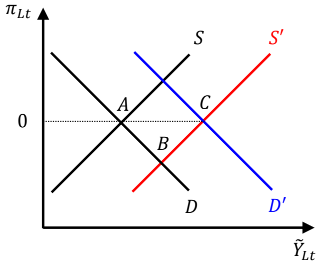
- **Buy \$:** $\rightarrow$ \$ expensive ($\tilde{e}_t \Uparrow$), return on local $>$ \$
  - Local demand $\tilde{\mathcal{W}}_t \Downarrow$
  - FXI affects the MP trade-off (My paper's focus)

FXI Affects the Inflation/Output Trade-off

- Buy \$ $\rightarrow$ \$ expensive

- **Income effect:**
    - Local demand $\tilde{\mathcal{W}}_t \Downarrow$, $\pi_{Lt} \Downarrow$ $\rightarrow$ interest rate $\Downarrow$, $\tilde{Y}_{Lt} \Uparrow$

- **Substitution effect:**
    - Demand shifts from US to local goods, $\tilde{Y}_{Lt} \Uparrow$



FXI Affects the Inflation/Output Trade-off

- Buy \$ $\rightarrow$ \$ expensive
- **Income effect:**
  - Local demand $\tilde{\mathcal{W}}_t \Downarrow$, $\pi_{Lt} \Downarrow$ $\rightarrow$ interest rate $\Downarrow$, $\tilde{Y}_{Lt} \Uparrow$
- **Substitution effect:**
  - Demand shifts from US to local goods, $\tilde{Y}_{Lt} \Uparrow$
- **Implications:**
  - The planner cares about both domestic and global distortions
  - FXI affects the inflation-output trade-off of monetary policy via changes in the exchange rate and global demand

Roadmap

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

1. (Known) starting point: monetary policy
2. Model setup: monetary policy & FXI
3. Optimal policy under cooperation
    - Analytical characterization of optimal MP and FXI rules
    - Calibrate the model and quantify the effect of FXI
    - Show that FXI mitigates the MP trade-off
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

Optimal Policy: Cooperation & Commitment

- Planner maximizes the sum of welfare in the two countries
- Minimize the weighted sum of: Objective function
  - Inflation rate for goods produced in each country (producer-price)
  - Output gap in each country
  - Risk-sharing wedge across countries (Corsetti/Dedola/Leduc'23)
- Analytical FXI rule + quantification
- Calibration: FXI & UIP data for 11 major currencies Details

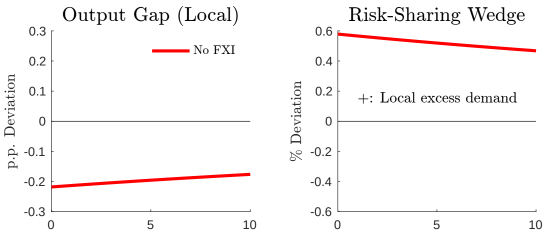
Optimal Policy: Cooperation & Commitment

- Planner maximizes the sum of welfare in the two countries
- Minimize the weighted sum of: Objective function
  - Inflation rate for goods produced in each country (producer-price)
  - Output gap in each country
  - Risk-sharing wedge across countries
- Case 1: No FXI, inflation-targeting MP (Corsetti/Dedola/Leduc'23)
- Case 2: Optimal FXI, inflation-targeting MP
- Case 3: Optimal MP & FXI

Case 1: Inflation-Targeting MP, No FXI (Recap)

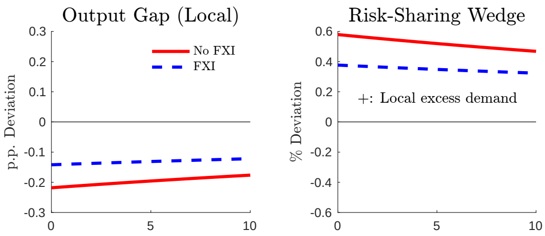
- Monetary policy follows strict inflation targeting ($\pi_{Lt} = 0$)
- Local productivity $A_t \Uparrow \;\rightarrow\;$ demand $\tilde{\mathcal{W}}_t \Uparrow$

  $\rightarrow\;$ Inflation $\pi_{Lt} \Uparrow \;\rightarrow\;$ interest rate $\Uparrow$, output gap $\tilde{Y}_{Lt} \Downarrow$



Case 2: Optimal FXI, Inflation-Targeting MP (Concept)

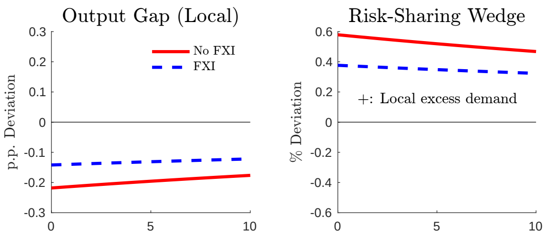
- Buy \$ $\rightarrow$ \$ expensive
- **Income effect:**
  - Local demand $\tilde{\mathcal{W}}_t \Downarrow$, $\pi_{Lt} \Downarrow$ $\rightarrow$ interest rate $\Downarrow$, $\tilde{Y}_{Lt} \Uparrow$
- **Substitution effect:**
  - Demand shifts from US to local goods, $\tilde{Y}_{Lt} \Uparrow$



Full Impulse Responses

Case 2: Optimal FXI, Inflation-Targeting MP (Concept)

- Without FXI, monetary policy trades off inflation and output due to the lack of risk-sharing.
- FXI mitigates this monetary policy trade-off.



Full Impulse Responses

Case 2: Optimal FXI, Inflation-Targeting MP (Formal)

Optimal FXI rule:

$$\underset{\Uparrow}{f_t^*} = -\xi_Y \{(\underset{\Downarrow}{\tilde{Y}_{Lt}} - E_t \tilde{Y}_{Lt+1}) - (\tilde{Y}_{Ut} - E_t \tilde{Y}_{Ut+1})\}$$

Local output $\tilde{Y}_{Lt} \Downarrow$

$\rightarrow$ Buy \$ $(f_t^* > 0)$

Transmission:

$$\left(\frac{\partial \tilde{Y}_{Lt}}{\partial A_t}\right)^{\text{No FXI}} < \left(\frac{\partial \tilde{Y}_{Lt}}{\partial A_t}\right)^{\text{FXI}} < 0$$

Output gap $\tilde{Y}_{Lt}$

$\rightarrow$ less negative

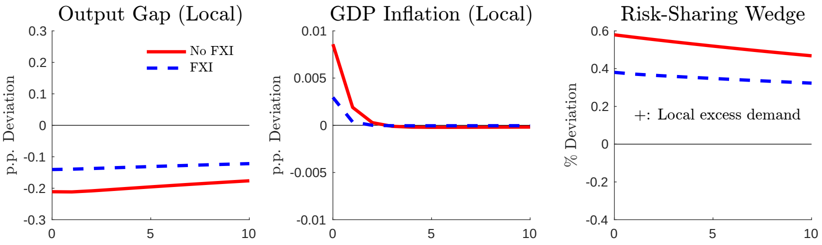
$$\left(\frac{\partial \tilde{\mathcal{W}}_t}{\partial A_t}\right)^{\text{No FXI}} > \left(\frac{\partial \tilde{\mathcal{W}}_t}{\partial A_t}\right)^{\text{FXI}} > 0$$

Risk-sharing gap $\tilde{\mathcal{W}}_t$

$\rightarrow$ less positive

Case 3: Optimal MP and FXI (Concept)

- **No FXI:** Local productivity $A_t \Uparrow \;\rightarrow\;$ demand $\tilde{\mathcal{W}}_t \Uparrow$, inflation $\pi_{Lt} \Uparrow$
- **FXI:** Buy \$ $\;\rightarrow\;$ \$ expensive $\;\rightarrow\;$ demand $\tilde{\mathcal{W}}_t \Downarrow$, inflation $\pi_{Lt} \Downarrow$
- FXI mitigates the inflation-output trade-off of monetary policy.



Full Impulse Responses

Case 3: Optimal MP and FXI (Formal)

Details

Optimal MP rule:

$$0 = \theta\pi_{Lt} + (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1}) - \xi_{\mathcal{T}}(\tilde{\mathcal{T}}_t - \tilde{\mathcal{T}}_{t-1}) + \xi_{\mathcal{W}}(\tilde{\mathcal{W}}_t - \tilde{\mathcal{W}}_{t-1})$$

Interest rate $\Uparrow$

(inflation $\pi_{Lt} \Downarrow$) when:

- Local output $\tilde{Y}_{Lt} \Uparrow$
- Import price $\tilde{\mathcal{T}}_t \Downarrow$ ($\rightarrow$ demand $\Uparrow$)
- Local demand $\tilde{\mathcal{W}}_t \Uparrow$

Optimal FXI rule:

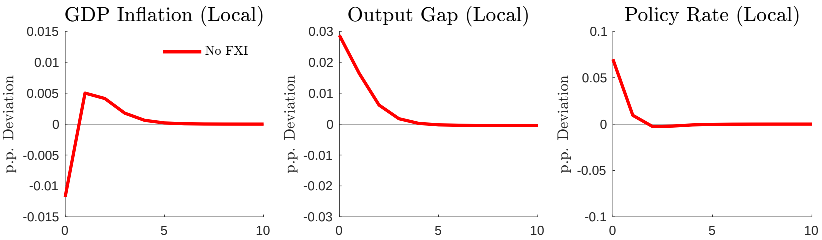
$$f_t^* = -\xi_Y\{(\tilde{Y}_{Lt} - E_t\tilde{Y}_{Lt+1}) - (\tilde{Y}_{Ut} - E_t\tilde{Y}_{Ut+1})\}$$

Local output $\tilde{Y}_{Lt} \Downarrow$

$\rightarrow$ Buy \$ ($f_t^* > 0$)

Cost-Push Shock (Case 1: No FXI, Optimal MP)

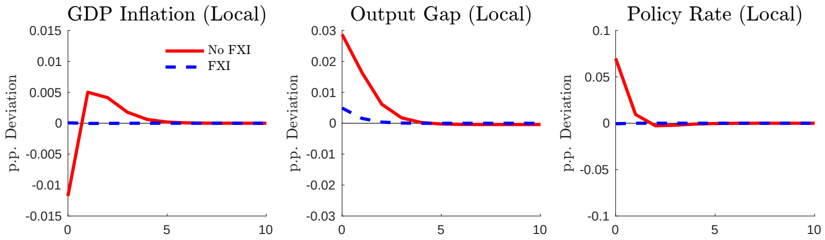
- US cost-push inflation $\rightarrow$ \$ expensive
  - Local demand $\tilde{\mathcal{W}}_t \Downarrow$, inflation $\pi_{Lt} \Downarrow$
  - US demand for local goods $\Uparrow$, output gap $\tilde{Y}_{Lt} \Uparrow$ $\rightarrow$ interest rate $\Uparrow$
- External shocks weaken monetary policy independence



Full Impulse Responses

Cost-Push Shock (Case 2: Optimal MP & FXI)

- **Buy local** $\rightarrow$ local expensive
  - Local demand $\tilde{\mathcal{W}}_t \Uparrow$, inflation $\Uparrow$
  - US demand for local goods $\Downarrow$, output gap $\Downarrow$ $\rightarrow$ interest rate $\Downarrow$

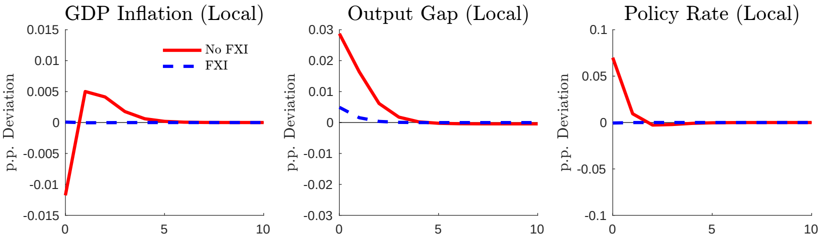


Full Impulse Responses

Cost-Push Shock (Case 2: Optimal MP & FXI)

- FXI improves monetary policy independence
  - Stabilizes inflation-output with small interest rate changes
  - Insurance against external shocks

- FXI trades off inflation-output and risk-sharing



Full Impulse Responses

Model Takeaway

Free Capital Mobility ⟷ Monetary Policy Independence

- Without FXI, external shocks weaken the MP independence
  - MP cannot stabilize domestic inflation/output
- FXI improves the MP independence
  - Stabilize inflation/output with small interest rate changes
  - FXI complements the MP

Model Takeaway

Free Capital Mobility $\longleftrightarrow$ Monetary Policy Independence

- Without FXI, external shocks weaken the MP independence
  - MP cannot stabilize domestic inflation/output
- FXI improves the MP independence
  - Stabilize inflation/output with small interest rate changes
  - FXI complements the MP
- **Literature:** separate objectives
  - MP $\Rightarrow$ inflation/output, FXI $\rightarrow$ capital flow (UIP) shocks

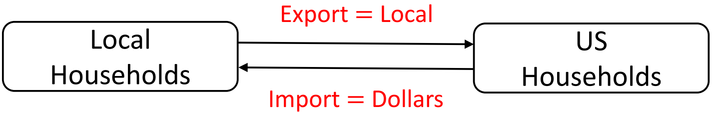
Roadmap

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

1. (Known) starting point: monetary policy
2. Model setup: monetary policy & FXI
3. Optimal policy under cooperation
4. Extension: Dollar pricing
    - Optimal FXI volume is large under dollar pricing
    - Transmission is asymmetric: FXI stabilizes local inflation more
    - Popularity of FXI in a dollarized world
5. Robustness: Optimal policy under non-cooperation

Producer Currency Pricing (Recap)

- Previous section:
  - Exports are invoiced in the exporters' (producers') currency
  - The law of one price holds



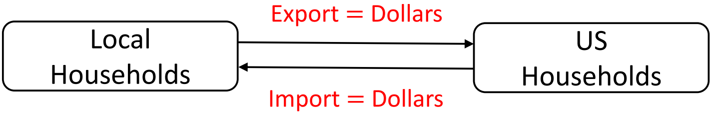
$$\underbrace{P_{Lt}}_{\substack{\text{Sticky in the}\\ \text{local currency}}} = \mathcal{E}_t P^*_{Lt}$$

- P_{Lt}, P^*_{Lt}: The price of local goods faced by the local/US households
- $\mathcal{E}_t$: nominal exchange rate, $\mathcal{E}_t \Uparrow =$ dollars expensive

Dollar Pricing

- Bridge the gap between:
  - Dollar dominance in international trade (Gopinath/etal'20)
  - Capital flow management in international finance (Itskhoki/Mukhin'23)

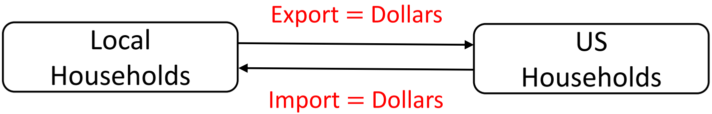
- Assume both exports and imports are invoiced in dollars
- The law of one price does not hold



$$\underbrace{P_{Lt}}_{\text{Sticky in the local currency}} \neq \mathcal{E}_t \underbrace{P^*_{Lt}}_{\text{Sticky in dollars}}$$

Dollar Pricing

- Local supply $A_t \Uparrow \;\rightarrow\;$ \$ expensive $\mathcal{E}_t \Uparrow$, \$ price of local goods $\Uparrow$
  - Same marginal cost but different prices across countries

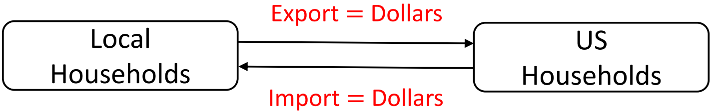


$$\underbrace{P_{Lt}}_{\text{Sticky in the local currency}} \quad < \quad \underbrace{\mathcal{E}_t \Uparrow}_{\text{\$ expensive}} \times \underbrace{P^*_{Lt}}_{\text{Sticky in dollars}}$$

Dollar Pricing

- $\Delta_{Lt} \equiv \mathcal{E}_t P^*_{Lt} / P_{Lt} \neq 1$: Price of local goods in \$ / local currency
- Central banks target Δ_{Lt} under cooperation ▸ NKPC and loss function

(Engel'11, Corsetti/Dedola/Leduc'20,23)

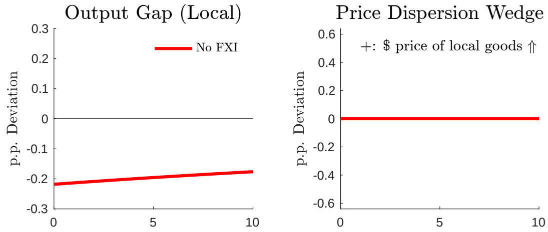


$$\underbrace{P_{Lt}}_{\text{Sticky in the local currency}} < \underbrace{\mathcal{E}_t \Uparrow}_{\text{\$ expensive}} \times \underbrace{P^*_{Lt}}_{\text{Sticky in dollars}}, \qquad \underbrace{\Delta_{Lt} = \frac{\mathcal{E}_t P^*_{Lt}}{P_{Lt}} > 1}_{\text{Price dispersion wedge}}$$

Case 1: Producer Currency Pricing (Recap)

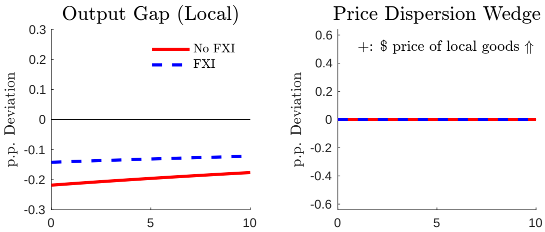
- Assume **inflation-targeting MP**
- **No FXI:** Local productivity $A_t \Uparrow \;\rightarrow\;$ demand $\tilde{\mathcal{W}}_t \Uparrow$

  $\rightarrow\;$ Inflation $\pi_{Lt} \Uparrow \;\rightarrow\;$ interest rate $\Uparrow$, output gap $\tilde{Y}_{Lt} \Downarrow$



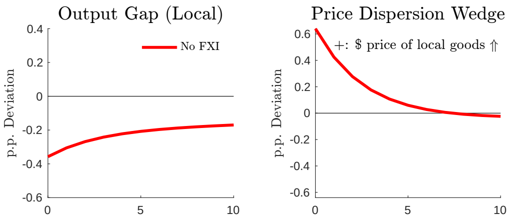
Case 1: Producer Currency Pricing (Recap)

- **FXI:** Buy \$ $\rightarrow$ \$ expensive $\rightarrow$ demand local goods, $\tilde{Y}_{Lt} \Uparrow$



Case 2: Dollar Pricing (Concept)

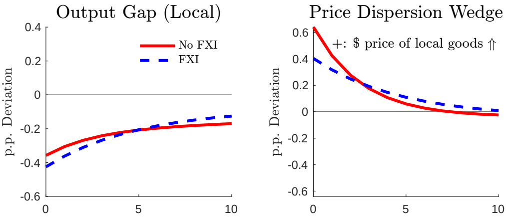
- **No FXI:** Local productivity $A_t \Uparrow$ $\rightarrow$ \$ expensive
  $\rightarrow$ \$ price of local goods $\Delta_{Lt} \Uparrow$



▸ Full IRFs (productivity) ▸ Full IRFs (cost-push)

Case 2: Dollar Pricing (Concept)

- **FXI:** Sell $ $\rightarrow$ $ cheap
  - $ price of local goods $\Delta_{Lt} \Downarrow$ $\rightarrow$ stabilize price dispersion
  - Demand US goods, $\tilde{Y}_{Lt} \Downarrow$ $\rightarrow$ destabilize the output gap (trade-off)



Full IRFs (productivity) Full IRFs (cost-push)

Case 2: Dollar Pricing (Formal)

Optimal FXI rule:

$$\underset{\Downarrow}{f_t^*} = -\xi_Y^{DCP}\{(\underset{\Uparrow}{\tilde{Y}_{Lt}} - E_t\tilde{Y}_{Lt+1}) - (\tilde{Y}_{Ut} - E_t\tilde{Y}_{Ut+1})\}$$

$$+\xi_\Delta^{DCP}(\{(\underset{\Uparrow}{\tilde{\Delta}_{Lt}} - E_t\tilde{\Delta}_{Lt+1})$$

Local output $\tilde{Y}_{Lt} \Uparrow$,

$ price of local goods $\tilde{\Delta}_{Lt} \Uparrow$

$\rightarrow$ Sell $ $(f_t^* < 0)$

Roadmap

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

1. (Known) starting point: monetary policy
2. Model setup: monetary policy & FXI
3. Optimal policy under cooperation
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation
    - FXI stabilizes inflation/output but worsens the risk-sharing
    - Abstract from full strategic interaction in repeated games

Robustness: Non-Cooperative Equilibrium

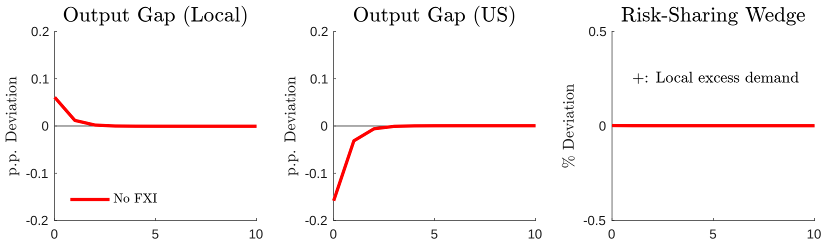
- CB in each country maximizes domestic objective
  - Abstract from full strategic interaction in repeated games

- Assumptions:
  - CBs target domestic inflation/output gap (Bodenstein/etal'23)
  - **Case 1:** Local CB uses both MP & FXI, US CB uses only MP
  - **Case 2:** Local CB uses only MP, US CB uses both MP & FXI

▸ Maximization & optimal rules

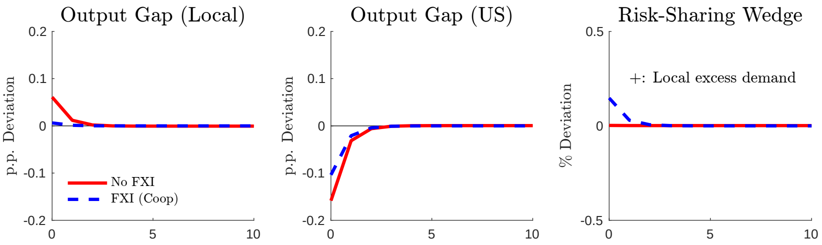
No FXI, Inflation-Targeting MP (Recap)

- Assume MP targets zero inflation in each country
- US cost-push inflation
  - **Direct:** US interest rate $\Uparrow$, $\tilde{Y}_{Ut} \Downarrow$
  - **Indirect:** \$ expensive $\rightarrow$ $\tilde{Y}_{Lt} \Uparrow$, $\tilde{Y}_{Ut} \Downarrow$



Cooperative FXI (Recap)

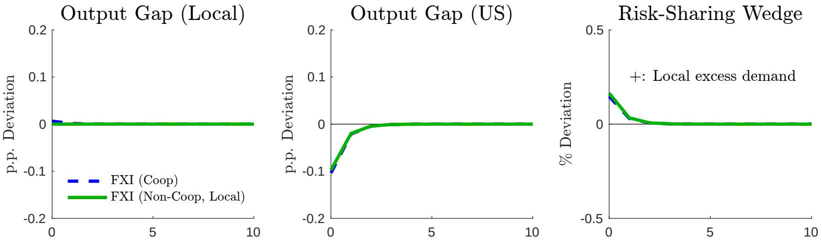
- **Buy local** $\rightarrow$ local expensive
  - Demand for local goods $\Uparrow$, $\rightarrow$ $\tilde{Y}_{Lt} \Downarrow$, $\tilde{Y}_{Ut} \Uparrow$
  - FXI stabilizes the local output gap



Maximization & optimal rules

Case 1: Non-Cooperative FXI by the Local Central Bank

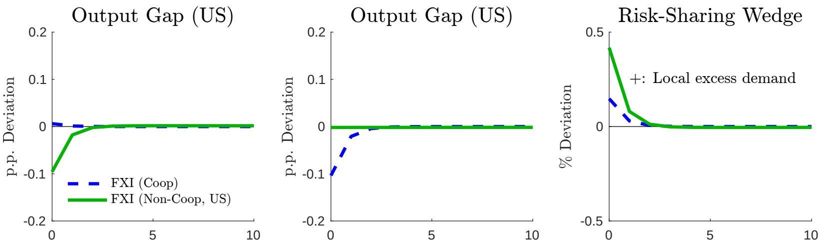
- Local CB stabilizes the local output gap over time: $E_t \tilde{Y}_{Lt+1} = \tilde{Y}_{Lt}$
  - Small difference between cooperation and non-cooperation



Maximization & optimal rules Full IRFs (inflation-targeting) Full IRFs (optimal)

Case 2: Non-Cooperative FXI by the US Central Bank

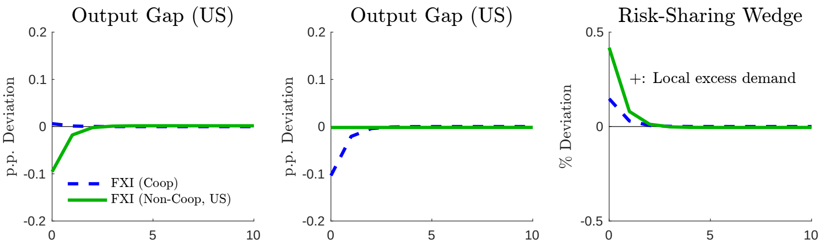
- US CB (Fed) stabilizes the US output gap over time: $E_t \tilde{Y}_{Ut+1} = \tilde{Y}_{Ut}$
  - US buys more local currency $\rightarrow$ $\tilde{Y}_{Lt} \Downarrow$, $\tilde{Y}_{Ut} \Uparrow$
  - However, FXI destabilizes the local output gap and risk-sharing



Maximization & optimal rules
Full IRFs (inflation-targeting)
Full IRFs (optimal)

Case 2: Non-Cooperative FXI by the US Central Bank

- Non-cooperative FXI **stabilizes** domestic inflation-output but **destabilizes** foreign output and risk-sharing
  - US cost-push $\rightarrow$ US FXI destabilizes local output
  - Local cost-push $\rightarrow$ Local FXI destabilizes US output



▸ Maximization & optimal rules ▸ Full IRFs (inflation-targeting) ▸ Full IRFs (optimal)

Conclusion

- A two-country framework with monetary policy and FXI
  - Characterize optimal MP and FXI rules
- Without FXI, MP faces an inflation-output trade-off
- FXI mitigates this trade-off & improves MP independence
  - FXI insulates countries from global business cycles
- Challenges:
  - Identification of FXI, empirical analysis (Rodnyansky/Timmer/Yago'24)
  - How to combine FXI with capital control and macroprudential policy (Basu/etal'20)

Appendix

Monetary Policy and FXI: Recent Examples

Back

- Low interest rate policy during the pandemic and war:
  - China and India set a record low of 4% interest rate.
  - Brazil lowered the rate to 2%.
  - Japan set a negative interest rate.

- FXI by large open economies:
  - China and Japan have 3.5 trillion and 1.4 trillion dollars of foreign exchange reserves
    - 40% of the world's reserves, 20-30% of Chinese/Japanese GDP
  - US monitoring list for gaining unfair competitive advantage in trade
  - World foreign exchange reserves fell by 1 trillion dollars in 2021-22.
  - China and Brazil sold 38 billion and 25 billion dollars in 2020.
  - India and Japan sold 32 billion and 63 billion dollars in 2022.

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 (2024)	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)
  - Sudden stop $\Rightarrow$ a monetary easing relaxes banks' domestic borrowing constraint but depreciation tightens their external borrowing constraint
  - 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:
  - FXI trades off the internal (inflation) & external objectives (exchange rate, purchasing power)
  - Cooperative MP & FXI in two large countries

Households (Details)

Back

- CRRA, CES bundle of local and US goods

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

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

- $\sigma = \phi = 1$: log and Cobb-Douglas utility (Cole/Obstfeld '91)

- Budget constraint:

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

Solution to Households' Problem

Back

- 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:

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

Firms' Maximization Problem

Back

- Producer currency pricing (PCP): law of one price $P_t(l) = \mathcal{E}_t P_t^*(l)$
- Firms cannot reset price with probability ξ (Calvo'83)

$$\max_{\{P_t(l),\, \mathcal{E}_t P_t^*(l)\}} E_t \left\{ \sum_{k=0}^{\infty} Q_{t,t+k}\xi^k \left(\begin{array}{c} (1+\tau_t)\left[P_t(l)Y_{t+k}(l) + \mathcal{E}_t P_t^*(l) Y_{t+k}^*(l)\right] \\ -MC_{t+k}(l)\left[Y_{t+k}(l) + Y_{t+k}^*(l)\right] \end{array} \right) \right\}$$

- New Keynesian Phillips Curve:

$$\pi_{Lt} = \beta E_t \pi_{Lt+1} + \kappa \Big[\tilde{Y}_{Lt} - \underbrace{2a(1-a)(\phi-1)\tilde{\mathcal{T}}_t}_{\text{Terms-of-trade gap}} + \underbrace{(1-a)\tilde{\mathcal{W}}_t}_{\text{Risk-sharing wedge}} + \underbrace{\mu_t}_{\text{Markup shock}} \Big]$$

- Slope of NKPC: $\kappa = (1-\xi)(1-\xi\beta)/\xi$
- Shocks: productivity A_t and markup $\mu_t = \theta/(\theta-1)(1-\tau_t)$

Intuition on NKPC

Back

Effects of terms-of-trade gap: (Clarida/Gali/Gertler'02)

- Consider US output $\tilde{Y}_{Ut} \Uparrow$, local appreciation, import price $\Downarrow$ ($\tilde{\mathcal{T}}_t \Downarrow$)

- $\phi > 1$: Local and US goods are substitutes
  - Import price $\Downarrow$, local consumption $C_t \Uparrow$ via risk sharing
  - Marginal cost $w_t = \frac{V'(L_t)}{U'(C_t)} \Uparrow$, inflation $\pi_{Lt} \Uparrow$

- $\phi < 1$: Local and US goods are complements
  - Export price $\Uparrow \rightarrow$ marginal benefit of export $\Uparrow$, inflation $\pi_{Lt} \Downarrow$

Effect of demand gap: (Corsetti/Dedola/Leduc'10)

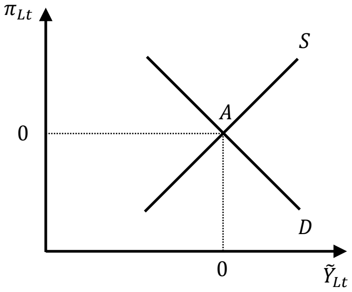
- $\mathcal{W}_t \Uparrow = U'(C_t) \Downarrow \rightarrow$ marginal cost $w_t = \frac{V'(L_t)}{U'(C_t)} \Uparrow$, inflation $\pi_{Lt} \Uparrow$

Monetary Policy Trade-off: Special Case

Back

- Assume **inflation targeting** ($\pi_{Lt} = 0$) & **trade elasticity $= 1$**
- Local productivity $A_t \Uparrow$ has no effect on $\tilde{\mathcal{W}}_t$

  $\rightarrow$ Inflation $=$ output gap $= 0$ (No trade-offs)



Evidence for Limits to Arbitrage: UIP Deviation

Back

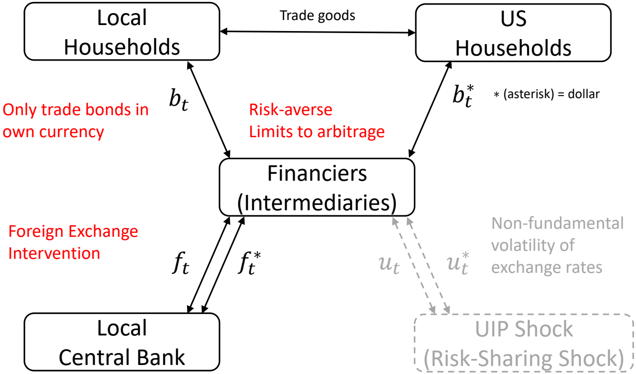
Country	Currency	α_0	(s.e.)	β_1	(s.e.)	$\chi^2(\alpha_0 = \beta_1 = 0)$	R^2
Australia	AUD	-0.001	(0.002)	-1.63***	(0.48)	16.3***	0.014
Austria	ATS	0.002	(0.002)	-1.75***	(0.58)	9.5***	0.023
Belgium	BEF	-0.0002	(0.002)	-1.58***	(0.39)	17.5***	0.025
Canada	CAD	-0.003	(0.001)	-1.43***	(0.38)	19.1***	0.013
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 could 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

Friction in International Asset Market

Back



- China buys the yuan $\rightarrow$ return on yuan $<$ \$
- Financiers are risk-averse $\rightarrow$ risk premium on \$

Financiers' Problem

Back

- Risk-averse financiers trade local & US bonds (Itskhoki/Mukhin'21)

$$\max_{d_t} E_t \left\{ -\frac{1}{\omega} \exp\left(-\omega^F \bar{R}_t d_t\right) \right\}$$

  - $\omega^F > 0$: risk aversion
  - $\bar{R}_t$: local $-$ \$ bond return ($\neq 0$ when risk-averse)
  - d_t: local bond purchases (\$ sales)

UIP condition (General Case)

▸ UIP simple case

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

where $\omega_1 \equiv m_n(\omega\sigma_e^2/m_d)$, $\omega_2 \equiv \bar{Y}(\omega\sigma_e^2/m_d)$ for finite $(\omega\sigma_e^2/m_d)$.

- The risk aversion ω is scaled so that $\omega\sigma_e^2$ is finite and nonzero and risk premium is first-order. (Hansen/Sargent'11)
- I assume $\omega_2 = 0$ for analytical traceability.
  - The financial sector's population (m_d financiers and m_n traders) is larger than households.

International Asset Market: Details

Back

- $\bar{R}_t \equiv R_t - R_t^* \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$: local − \$ bond return

- Zero net position (aggregate):

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

- Market clearing:

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

Loss Function (PCP, Details)

Risk sharing definition | Optimal policy

$$\mathcal{L} = -E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[\begin{array}{l} \left(\tilde{Y}_{Lt}^2 + \tilde{Y}_{Ut}^2\right) + \frac{\theta}{\kappa}\left(\pi_{Lt}^2 + \pi_{Ut}^{*2}\right) \\ -\frac{2a(1-a)(\phi-1)}{4a(1-a)(\phi-1)+1}\left(\tilde{Y}_{Lt} - \tilde{Y}_{Ut}\right)^2 \\ +\frac{2a(1-a)\phi}{4a(1-a)(\phi-1)+1}\tilde{\mathcal{W}}_t^2 \end{array} \right],$$

where $\tilde{Y}_{Lt} - \tilde{Y}_{Ut} = [\{4a(1-a)(\phi-1)+1\}\tilde{\mathcal{T}}_t + (2a-1)\tilde{\mathcal{W}}_t]$.

- Local supply $\tilde{Y}_{Lt} \Uparrow$ $\rightarrow$ local currency cheap, import price $\tilde{\mathcal{T}}_t \Uparrow$
- $\tilde{\mathcal{W}}_t \neq 0$ under incomplete asset market
    - Under complete market, local productivity $\Uparrow$

      $\rightarrow$ local HHs lend to US HHs to smooth consumption

Calibration

▸ Back ▸ Countries / Sumstats ▸ Parameters ▸ Identification ▸ Regression

- Estimate the effect of FXI on UIP deviation
  - 2000-23, quarterly, 11 major currencies against the dollar
  - UIP deviation: exchange rate forecast & interbank rate (Bloomberg)
  - FXI: central bank websites, FRED, IMF data (Adler/etal'23)
- Identify FXI via deviation from estimated policy rules

  (Fratzscher/etal'19, Rodnyansky/Timmer/Yago'24)
- Result: sell \$ (1% of GDP) $\rightarrow$ UIP $\Downarrow$ by 0.51pp (local return $\Downarrow$)

Countries / Summary Statistics

Back

Countries:

- Australia, Brazil, Canada, China, Euro area, India, Japan, Korea, Russia, Switzerland, and the United Kingdom
  - **Robustness:** exclude small-open economies (Australia, Canada, Korea, and Switzerland) and managed exchange rate regime (China)

Summary Statistics of FXI:

	Mean	Median	SD	p25	p75	p90	Max	Obs
Sell Dollars (Billions)	10.19	2.09	24.65	0.74	7.73	22.10	179.88	262
Buy Dollars (Billions)	14.66	5.53	25.71	1.59	13.21	33.79	164.17	448

	Mean	Median	SD	p25	p75	p90	Max	Obs
Sell Dollars (% GDP)	0.48	0.18	0.92	0.06	0.52	1.09	9.11	262
Buy Dollars (% GDP)	0.91	0.35	1.79	0.13	1.02	2.08	19.86	448

Parameter Values

Back

Table 1: Parameter Values

Value	Description	Notes
$\beta = 0.995$	Discount factor (local)	Annual interest rate $= 2\%$
$\sigma = 2$	Relative risk aversion	Itskhoki and Mukhin (2021)
$\eta = 0.35$	Inverse Frisch elasticity	Bodenstein et al. (2023)
$\zeta_l = 13.3$	Labor disutility (local)	Steady-state labor $= 1/3$
$a = 0.88$	Home bias of consumption	Bodenstein et al. (2023)
$\phi = 2.0$	CES Local & US goods	Bodenstein et al. (2023)
$\theta = 10$	CES differentiated goods	Price markup $= 11\%$
$\xi_p = 0.60$	Calvo price stickiness	Duration of four quarters
$\bar{\pi} = 1$	Steady-state inflation	
$\chi = 1.42$	UIP coefficient on FXI	$\Delta(UIP)/\Delta(FXI/GDP) = 0.47$
$\rho_a = 0.97$	Persistence of productivity shock	Itskhoki and Mukhin (2021)
$\rho_\mu = 0.2$	Persistence of markup shock	Bodenstein et al. (2023)
$\sigma_a = 0.015$	SD of productivity shock	Bodenstein et al. (2023)
$\sigma_\mu = 0.019$	SD of markup shock	Bodenstein et al. (2023)

Identification of FXI

Back

- Identify direct effect of FXI by deviations from an FXI policy rule

$$FXI_{i,t} = \alpha + \beta X_{i,t-1} + \gamma_i + \epsilon_{i,t}$$

- $FXI_{c,t}$: FXI in country i, quarter t (> 0: sell \$, % over GDP)
- $X_{i,t-1}$: controls (lagged)
  - Past FXI over GDP ratio, trend/volatility of the spot exchange rate, UIP deviation, VIX, local/US policy rates, consumer price inflation, unemployment rate, current account over GDP ratio
- γ_i: country fixed effect

First-step Regression

Back

Dependent Variable	FXI / GDP (%)	
	(1)	(2)
Lagged FXI / GDP (%)	0.129***	0.283***
	(0.040)	(0.056)
Lagged Exchange Depreciation (%)	0.005	0.006
	(0.014)	(0.011)
Lagged Exchange Volatility (%)	0.089	0.006
	(0.062)	(0.044)
Lagged UIP Deviation (p.p.)	0.010	0.012**
	(0.007)	(0.006)
Lagged log(VIX)	-0.135	-0.065
	(0.203)	(0.162)
Lagged Policy Rate (Local)	-0.078*	-0.030
	(0.046)	(0.032)
Lagged Policy Rate (US)	0.041	-0.077*
	(0.048)	(0.040)
Lagged CPI Inflation (%)	0.041	0.026
	(0.039)	(0.026)
Lagged Unemployment Rate (%)	0.004	-0.003
	(0.055)	(0.035)
Lagged Current Account / GDP (%)	-0.115***	-0.069*
	(0.031)	(0.038)
R^2	0.176	0.259
N	627	309
Country Fixed Effect	✓	✓
Exclude Small Economy		✓
Exclude Managed Exchange Rate		✓

- 74 - 82% of variation in intervention cannot be explained.

Estimating the Effect of FXI on UIP Deviation

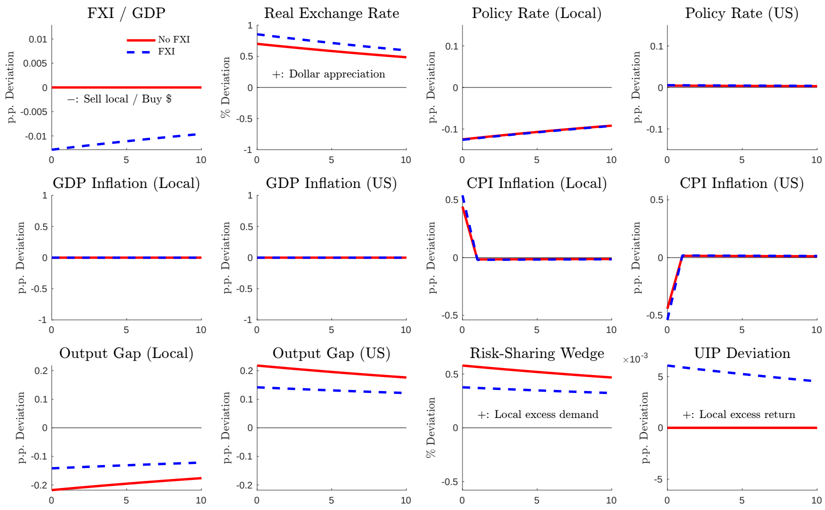
Back

Dependent Variable	$UIP_t - UIP_{t-1}$			
	(1)	(2)	(3)	(4)
Net \$ Sales / GDP (%)	-0.589**	-0.509**	-1.599***	-1.106***
	(0.264)	(0.212)	(0.182)	(0.178)
R^2	0.004	0.013	0.009	0.020
N	706	392	367	212
Country Fixed Effect	✓	✓	✓	✓
Identified		✓		✓
Exclude Small Economy			✓	✓
Exclude Fixed Exchange Rate			✓	✓

- Sell \$ (1% of GDP) $\rightarrow$ UIP $\Downarrow$ by 0.5-0.6 pp (local return $\Downarrow$)
- More effective without small economies (Swiss franc: liquid)

Optimal FXI + Inflation-Targeting MP (Productivity)

Back



- The local policy rate can increase (buy $) or decrease (to target inflation).

Optimal MP and FXI Rules (Details)

Back

Optimal MP Rule: $(\xi_{\mathcal{T}} = \xi_{\mathcal{W}} = 0 \text{ if } \sigma = \phi = 1)$

$$0 = \theta \pi_{Lt} + (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1}) - \xi_{\mathcal{T}}(\tilde{\mathcal{T}}_t - \tilde{\mathcal{T}}_{t-1}) + \xi_{\mathcal{W}}(\tilde{\mathcal{W}}_t - \tilde{\mathcal{W}}_{t-1}) \quad \text{where}$$

$$\xi_{\mathcal{T}} = \frac{2a(\sigma\phi - 1) + 1}{\sigma + \eta(4a(1-a)(\sigma\phi - 1) + 1} \frac{2a(\sigma\phi - 1) + 1 - \sigma}{2a(\phi - 1) + 1}(1-a)\theta,$$

$$\xi_{\mathcal{W}} = \frac{2a(1-a)\phi}{\sigma + \eta(4a(1-a)(\sigma\phi - 1) + 1} \frac{2a(\sigma\phi - 1) + 1 - \sigma}{2a(\phi - 1) + 1}$$

Optimal FXI Rule: $(\xi_Y > 0 \text{ if } \sigma\phi > 1 - \frac{1}{2a} \ (< \frac{1}{2}))$

$$f_t^* = -\xi_Y \{ (\tilde{Y}_{Lt} - E_t \tilde{Y}_{Lt+1} - (\tilde{Y}_{Ut} - E_t \tilde{Y}_{Ut+1}) \} \quad \text{where}$$

$$\xi_Y = \frac{2a(\sigma\phi - 1) + 1}{2a\phi\chi} \times (\text{const})$$

Impulse Response to a Local Productivity Increase

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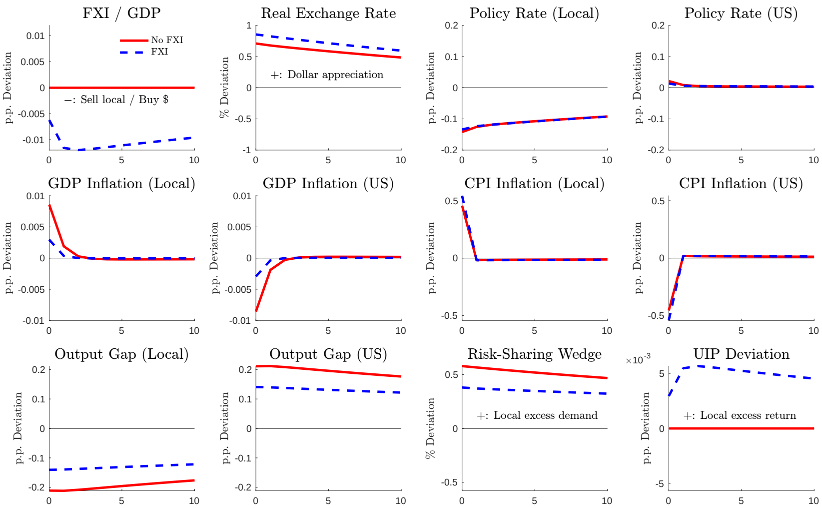
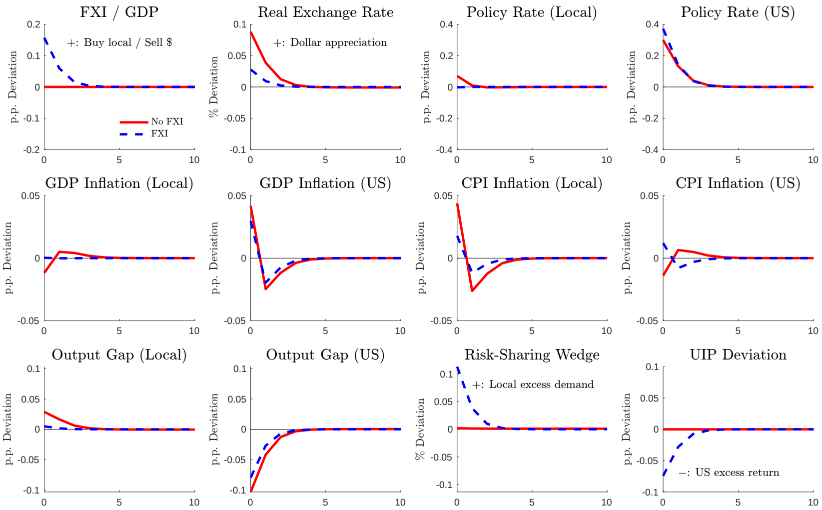


Impulse Response to a US Markup Increase

Back



NKPC and Loss Function under Dollar Pricing

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- 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}):

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

DCP, Local Productivity Increase

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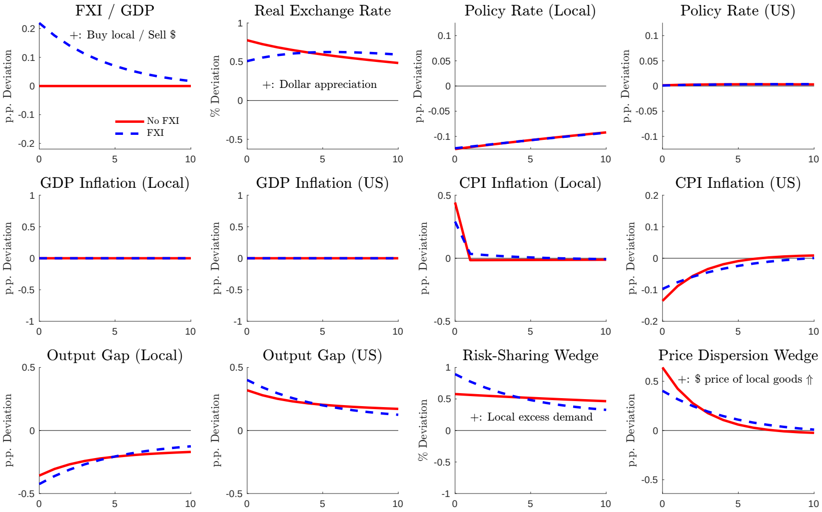

DCP, US Cost-Push Inflation

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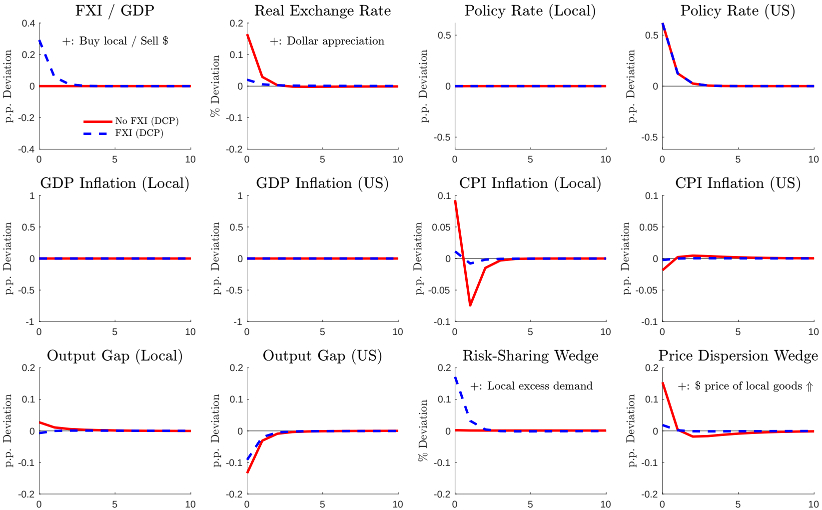

Maximization Problem (Non-Cooperation)

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- The local CB solves:

$$\max \mathcal{L} = -E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[\tilde{Y}_{Lt}^2 + \frac{\theta}{\kappa} \pi_{Lt}^2 \right] \quad \text{s.t.}$$

$$\pi_{Lt} = \beta E_t \pi_{Lt+1} + \kappa \Big[\tilde{Y}_{Lt} - 2a(1-a)(\phi - 1)\tilde{\mathcal{T}}_t + (1-a)\tilde{\mathcal{W}}_t,$$

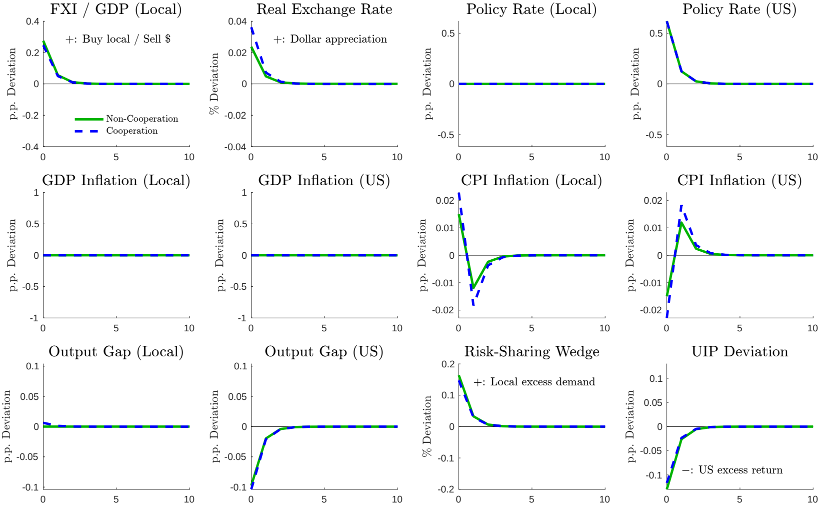
$$E_t \tilde{\mathcal{W}}_{t+1} - \tilde{\mathcal{W}}_t = -\bar{\omega} f_t$$

- Optimal MP & FXI rules:

$$0 = \theta \pi_{Lt} + \frac{\sigma + \eta}{\sigma + \eta - \frac{(1-a)(\sigma-1)}{2a(\phi-1)+1}} (\tilde{Y}_{Lt} - \tilde{Y}_{Lt-1})$$

$$E_t \tilde{Y}_{Lt+1} = \tilde{Y}_{Lt} \quad (E_t \tilde{\pi}_{Lt+1} = 0)$$

Non-Cooperative FXI by Local CB (Inflation-Targeting)



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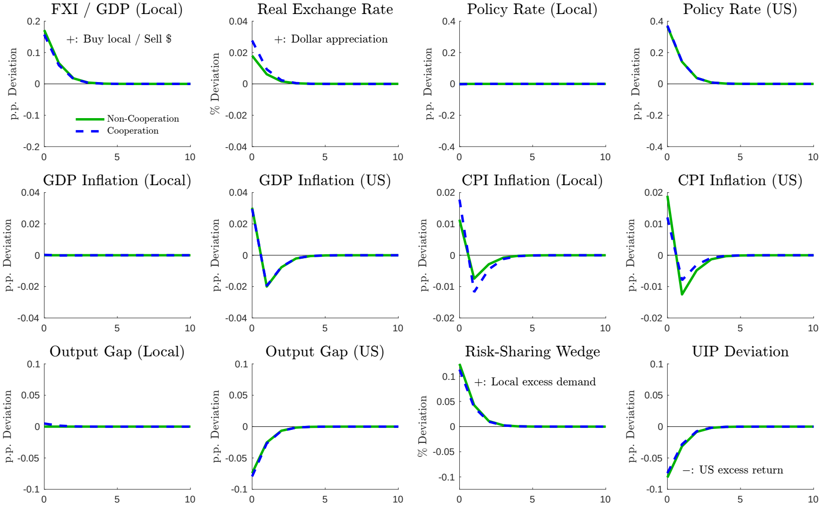
Non-Cooperative FXI by Local CB (Full Optimal)



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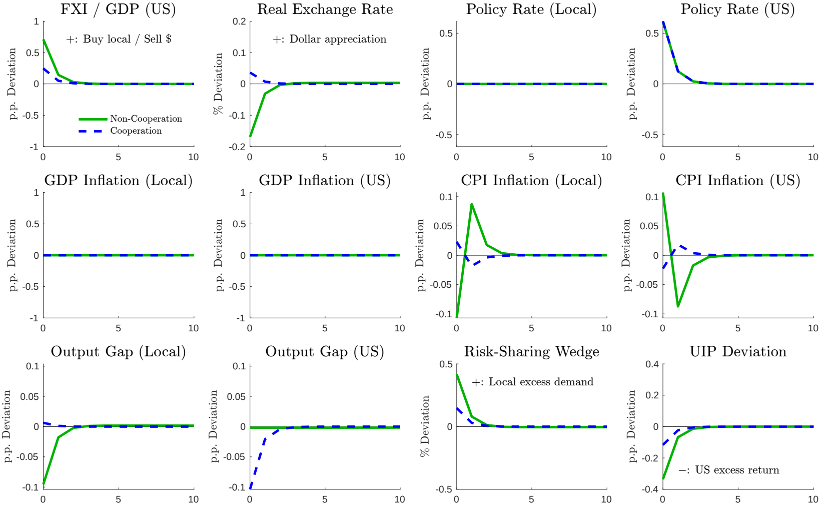
Non-Cooperative FXI by US CB (Inflation-Targeting)



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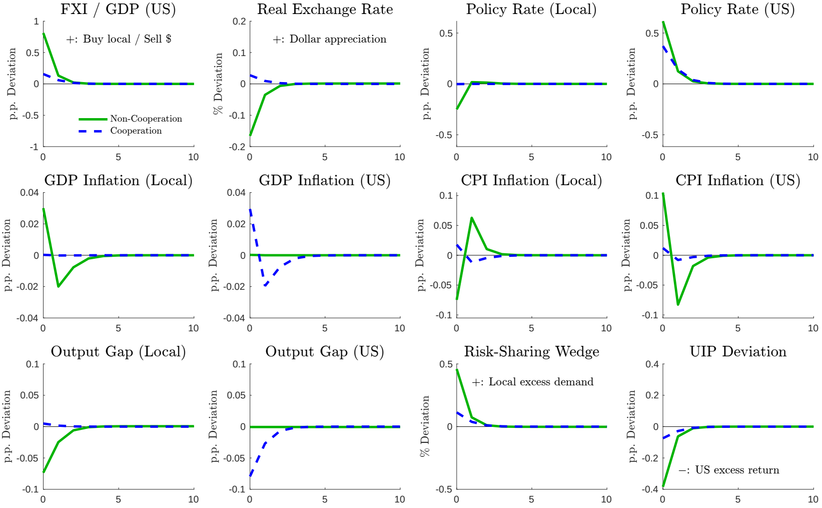
Non-Cooperative FXI by US CB (Full Optimal)



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