Monetary and Exchange Rate Policies in a Global Economy

Naoki Yago

The University of Cambridge

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Introduction

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

Introduction

- Large open economies with huge foreign exchange reserves use FXI.
- Literature: separate objectives
  - Monetary policy $\Rightarrow$ inflation, FXI $\Rightarrow$ exchange rate
- During the pandemic & war,
  - Central banks set low interest rates despite high inflation.
  - They intervened by selling the dollar.

Example

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 (Itskhoki/Mukhin'23)
- **Result:** the two policies are interdependent for large countries.
  - FXI affects inflation by dampening/stimulating foreign demand
- Opens up a discussion on which policies to use.

Literature

Table | Relationship with Literature

- 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. Model setup 1: monetary policy (Corsetti/Dedola/Leduc'23)
2. Model setup 2: 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. Model setup 1: monetary policy (Corsetti/Dedola/Leduc'23)
    - Define international risk-sharing
    - Inflation-output trade-off due to the lack of risk-sharing
2. Model setup 2: monetary policy & FXI
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Monetary Policy under Cooperation (Corsetti/Dedola/Leduc'23)

- Two symmetric large countries: local & US
- **Households** consume local & US goods, supply labor

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

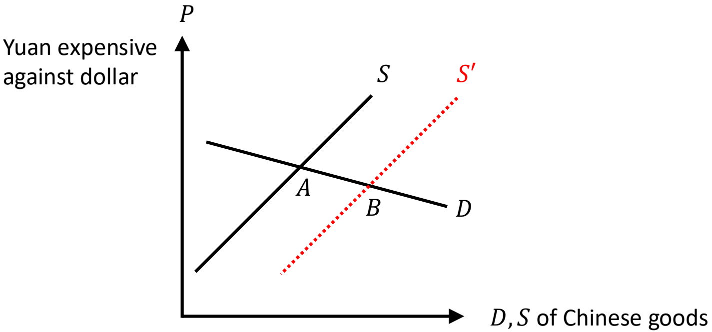
  - Cannot trade state-contingent asset internationally

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

Households detail | Firms detail

International Risk Sharing (Concept)

- 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)

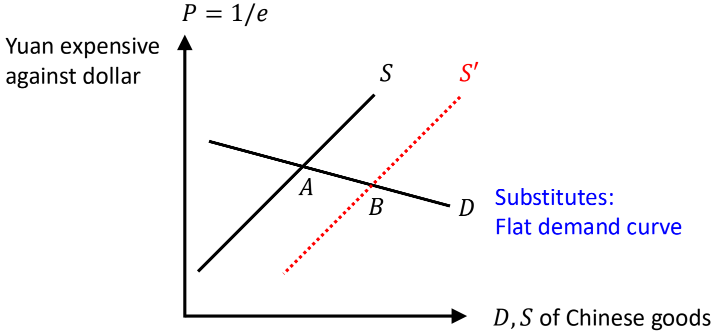
- Risk-sharing wedge = Difference in marginal utilities

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

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

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 exchange rate changes



Price Setting

▸ Firms' maximization ▸ Intuition

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

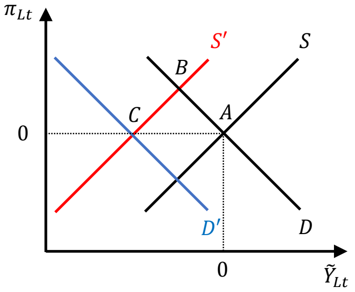
- π_{Lt}: inflation (local goods consumed by local households)
- $\tilde{Y}_{Lt}$: output gap
- $\tilde{\mathcal{T}}_t$: terms-of-trade gap (import − export price)
  - Import price $\tilde{\mathcal{T}}_t \Downarrow \rightarrow$ consumption $\Uparrow$, inflation $\Uparrow$
- $\tilde{\mathcal{W}}_t$: Local excess demand $\rightarrow$ inflation $\Uparrow$
- (ϕ: substitution of local/US goods, $1-a$: trade openness)

Inflation-Output Trade-off

- 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 $\tilde{Y}_{Lt} \Downarrow$

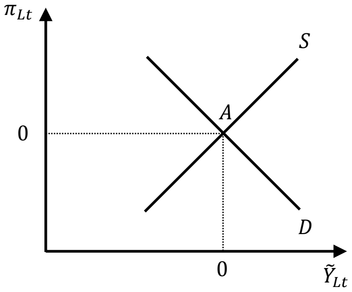


Inflation-Output Trade-off (Special Case)

- 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)



Roadmap

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

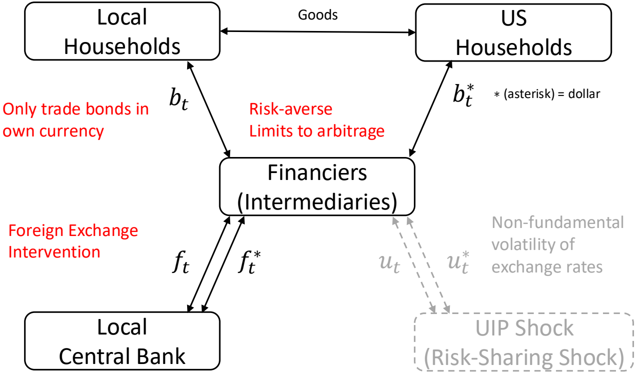
1. Model setup 1: monetary policy
2. Model setup 2: monetary policy & FXI
   - FXI is effective under frictions in international asset trade
     (Gabaix/Maggiori'15, Itskhoki/Mukhin'23)
   - FXI mitigates the inflation-output trade-off of monetary policy
3. Optimal policy under cooperation
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

FXI: Basic Idea (Gabaix/Maggiori'15, Itskhoki/Mukhin'23)

- 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
- **Example:** China buys the yuan $\rightarrow$ return on yuan < \$
  - Households cannot borrow in yuan to invest in \$

Friction in International Asset Market



- China buys the yuan $\rightarrow$ return on yuan $<$ \$
- Financiers are risk-averse $\Rightarrow$ risk-premium on \$ (UIP deviation)

Financiers' Problem (Itskhoki/Mukhin'21)

Details

- Risk-averse financiers trade local & US bonds.

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

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

UIP Condition

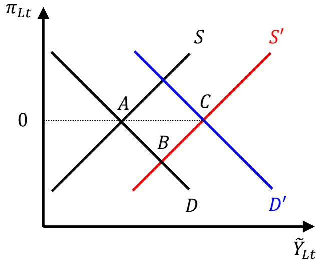
UIP general case

$$\underbrace{E_t\tilde{\mathcal{W}}_{t+1} - \tilde{\mathcal{W}}_t}_{\tilde{\mathcal{W}}_t > 0:\ \text{local demand}} = \underbrace{\tilde{r}_t - \tilde{r}_t^* - \left(E_t\tilde{e}_{t+1} - \tilde{e}_t\right)}_{\text{Local} - \$\ \text{return}} = \underbrace{-\bar{\omega}f_t}_{\substack{f_t > 0:\ \text{Buy local} \\ f_t < 0:\ \text{Buy } \$}}$$

- No FXI $\rightarrow$ $\tilde{\mathcal{W}}_t \neq 0$ if goods are substitutes
  - MP faces inflation-output trade-off (Corsetti/Dedola/Leduc'23)
- Buy \$: $\rightarrow$ \$ expensive ($\tilde{e}_t \Uparrow$), local demand $\tilde{\mathcal{W}}_t \Downarrow$
  - FXI mitigates MP trade-off (My paper's focus)

FXI Affects the Inflation/Output Trade-off

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



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

1. Model setup 1: monetary policy
2. Model setup 2: monetary policy & FXI
3. Optimal policy under cooperation
   - Case 1: Optimal FXI, inflation-targeting MP
   - Case 2: Optimal MP and FXI
   - Calibrate the model and quantify the effect of FXI
   - Relationship with Mundell-Fleming "trilemma"
4. Extension: Dollar pricing
5. Robustness: Optimal policy under non-cooperation

Optimal Policy: Cooperation & Commitment

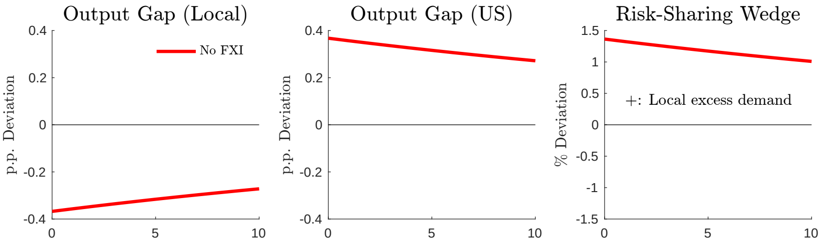
- Planner maximizes the sum of welfare in the two countries.
- Minimize the weighted sum of: Objective function
  - Inflation rate for goods produced in each country (producer-price)
  - Output gap in each country
  - Terms-of-trade gap and risk-sharing wedge across countries

    (Corsetti/Dedola/Leduc'23)
- Analytical FXI rule + quantification
  - Calibration: FXI & UIP data for 11 major currencies Details

No FXI, Inflation-Targeting MP (Corsetti/etal'23)

- Local productivity $A_t \Uparrow \;\rightarrow\;$ demand $\tilde{\mathcal{W}}_t \Uparrow$

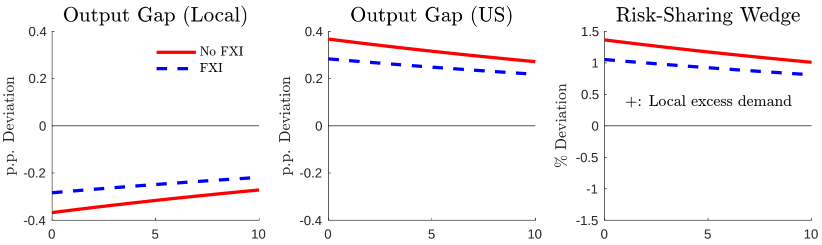
  $\rightarrow$ Inflation $\pi_{Lt} \Uparrow \;\rightarrow\;$ interest rate $\Uparrow$, output gap $\tilde{Y}_{Lt} \Downarrow$



Optimal FXI under Inflation-Targeting MP

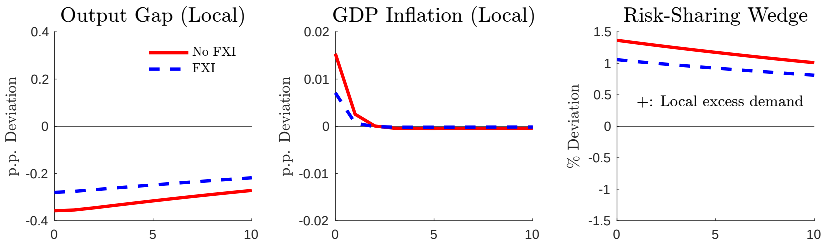
Optimal rule Full IRFs

- **Buy $** $\rightarrow$ \$ expensive $\rightarrow$ local demand $\tilde{\mathcal{W}}_t \Downarrow$, inflation $\pi_{Lt} \Downarrow$ $\rightarrow$ Interest rate $\Downarrow$, output gap $\tilde{Y}_{Lt} \Uparrow$
- Demand shifts from US to local goods, $\tilde{Y}_{Lt} \Uparrow$



Optimal MP and FXI

- **Buy \$** $\rightarrow$ \$ expensive $\rightarrow$ local demand $\tilde{\mathcal{W}}_t \Downarrow$, inflation $\pi_{Lt} \Downarrow$ $\rightarrow$ Interest rate $\Downarrow$, output gap $\tilde{Y}_{Lt} \Uparrow$
- Demand shifts from US to local goods, $\tilde{Y}_{Lt} \Uparrow$

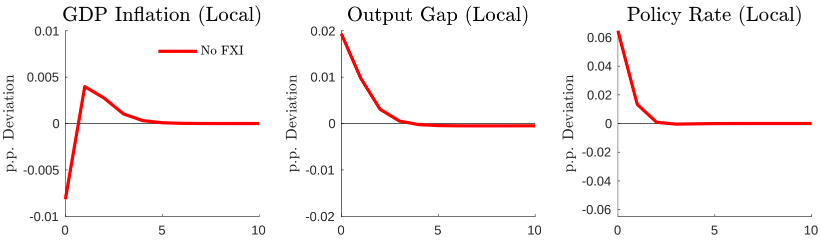


Optimal Rule Full IRFs

Optimal MP, Cost-Push Shock (Corsetti/etal'23)

Optimal Rule IRFs

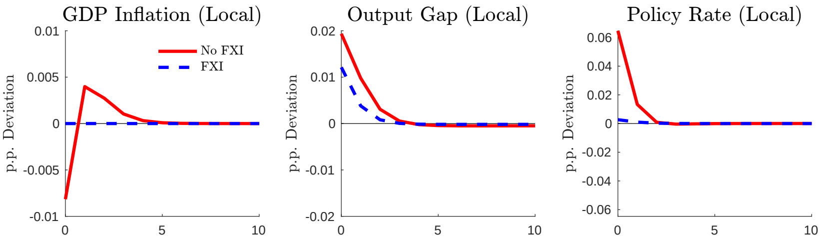
- US cost-push inflation $\rightarrow$ \$ expensive
  - Local demand $\Downarrow$, inflation $\Downarrow$
  - US demand for local goods $\Uparrow$, output gap $\Uparrow$ $\rightarrow$ interest rate $\Uparrow$



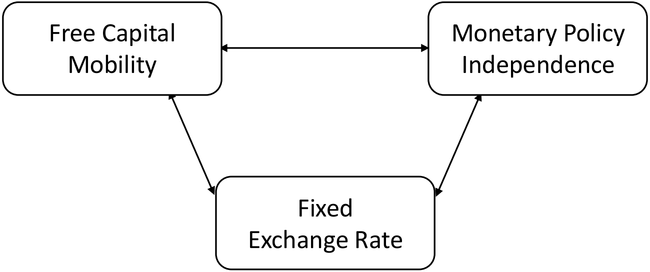
Optimal MP & FXI, Cost-Push Shock

▸ Optimal Rule ▸ IRFs

- Buy local $\rightarrow$ local expensive
  - Local demand $\Uparrow$, inflation $\Uparrow$
  - US demand for local goods $\Downarrow$, output gap $\Downarrow$ $\rightarrow$ interest rate $\Downarrow$



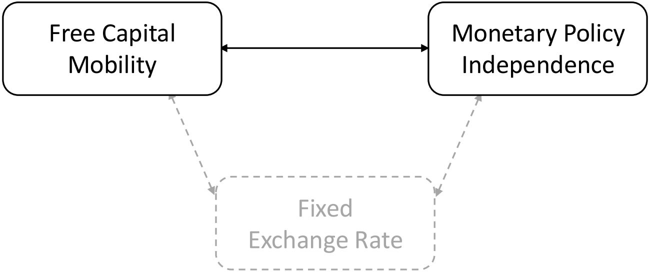
Mundell-Fleming "Trilemma"



- Free capital mobility + CB gives up fixed exchange rate

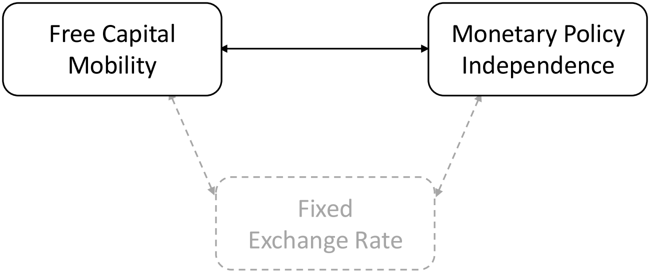
  $\rightarrow$ MP targets domestic inflation (independence)

Rey (2015) "Dilemma, Not Trilemma"



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

Relationship of My Paper with Dilemma/Trilemma



My paper:

- Without FXI, external shocks weaken the MP independence
- FXI improves the MP independence

Literature: separation

- MP $\Rightarrow$ inflation/output, FXI $\rightarrow$ capital flow (UIP) shocks

Roadmap

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

1. Model setup 1: monetary policy
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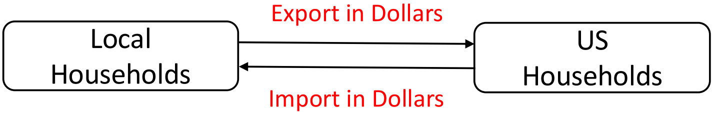
3. Optimal policy under cooperation
4. Extension: Dollar pricing
   - Optimal FXI volume is large under dollar pricing
   - Transmission is asymmetric: FXI stabilizes local inflation more
5. Robustness: Optimal policy under non-cooperation

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



Dollar Pricing

NKPC and loss function

1. Identical local goods have different prices in different currencies despite the same marginal cost of production

    - Strong \$ $\Rightarrow$ Chinese goods are more expensive in \$ than yuan
    - $\Delta_{Lt} \equiv \mathcal{E}_t P^*_{Lt} / P_{Lt}$: Price of local goods in \$ / local currency
    - $\Delta_{Lt} \neq 1$: price dispersion wedge
    - Central banks target Δ_{Lt} (Corsetti/Dedola/Leduc'20)

2. Exchange rate has limited effect on US import prices

Dollar Pricing

Optimal MP Optimal MP and FXI

Consider an inflationary US cost-push shock.

- Optimal FXI is increasing in the price-dispersion wedge (Δ_{Lt}).
  - \$ appreciates $\rightarrow$ local good is expensive in \$ ($\Delta_{Lt} \Uparrow$)
    $\rightarrow$ optimal FXI is to buy local currency
- Optimal FXI volume is larger under dollar pricing.
- Transmission is asymmetric.
  - Optimal FXI decreases the local consumer-price inflation more and increases the US consumer price inflation less.

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    - Case 2: Optimal MP and FXI

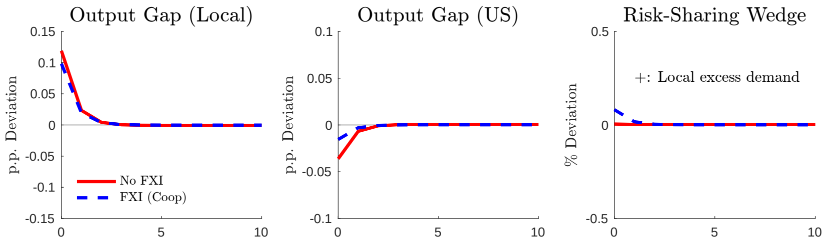
Robustness: Non-Cooperative Equilibrium

- CB in each country maximizes domestic objective
  - Abstract from full strategic interaction in repeated games
- Assumptions:
  - Assume CBs target domestic inflation/output gap (Bodenstein/etal'23)
  - Local CB uses both MP & FXI
  - US (Fed) uses only MP

Maximization & optimal rules

Optimal FXI under Inflation-Targeting MP

- **No FXI:** Local markup $\Downarrow \rightarrow \tilde{Y}_{Lt} \Uparrow, \ \tilde{Y}_{Ut} \Downarrow$
- **FXI (Cooperation):** Sell \$ $\rightarrow$ \$ cheap $\rightarrow \tilde{Y}_{Lt} \Downarrow, \ \tilde{Y}_{Ut} \Uparrow$

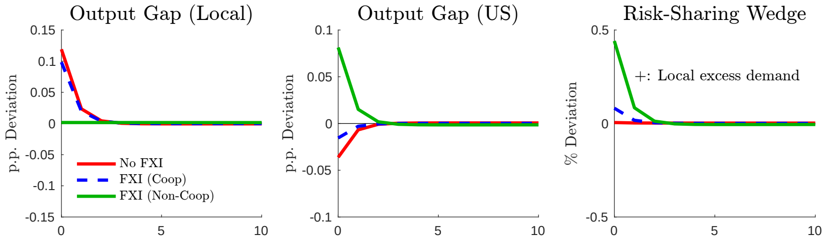


Maximization & optimal rules

Full Impulse Response

Optimal FXI under Inflation-Targeting MP

- **FXI (Non-Cooperation):** Sell $ more than cooperation
- **Stabilizes** local output, **destabilizes** US output & risk-sharing

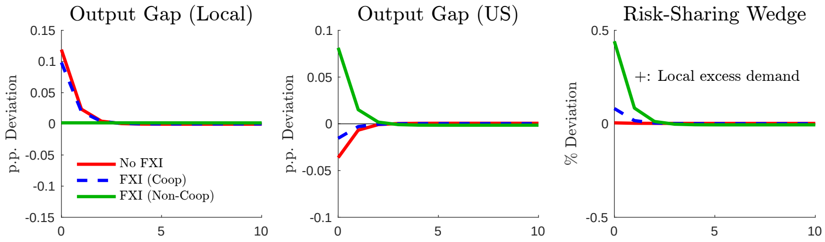


Maximization & optimal rules

IRF (full optimal)

Optimal FXI under Inflation-Targeting MP

- **FXI (Non-Cooperation):** Sell $ more than cooperation
- Under full optimal policy, FXI **stabilizes** local inflation/output but **destabilizes** US inflation/output



Maximization & optimal rules

IRF (full optimal)

Conclusion

- A two-country framework with monetary policy and FXI
- Trade-off between internal (inflation-output) and external objectives (risk-sharing)
- Opens up a discussion on how to combine different policies
- Challenges:
    - Identification of FXI, empirical analysis (Rodnyansky/Timmer/Yago'24)
    - How to combine FXI with capital control and macroprudential policy (IMF's integrated policy framework) (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.

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 (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)

- CRRA, CES bundle of local and US goods

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

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

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

- Budget constraint:

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

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:

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

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Firms' Maximization Problem

Back

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

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

- 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 $\pi_{Lt} \Uparrow$

Loss Function (PCP, Details)

Back

Global planner minimizes the quadratic loss function:

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

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

International Asset Market: Details

Back

- $\bar{R}_t \equiv R_t - R_t^* \dfrac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$: 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:

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

UIP condition (General Case)

UIP simple case

- The maximization problem for intermediaries implies:

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

where $\chi_1 \equiv m_n(\omega\sigma_e^2/m_d)$, $\chi_2 \equiv \bar{Y}(\omega\sigma_e^2/m_d)$ 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.[1]
- When deriving analytical result, I assume $\chi_2 = 0$ for tractability. Assume the financial sector (m_d financiers and m_n traders) is larger than households.

[1] See Hansen and Sargent (2011).

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

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Countries:

- Australia, Brazil, Canada, China, Euro area, India, Japan, Korea, Russia, Switzerland, United Kingdom
  - **Robustness:** exclude small-open economies (Australia, Canada, Korea, 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

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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

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- 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, spot exchange rate (trend, volatility), UIP deviation, VIX, policy rate (local, US), consumer price inflation, unemployment rate, current account over GDP ratio
- γ_i: country fixed effect

First-step Regression

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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.

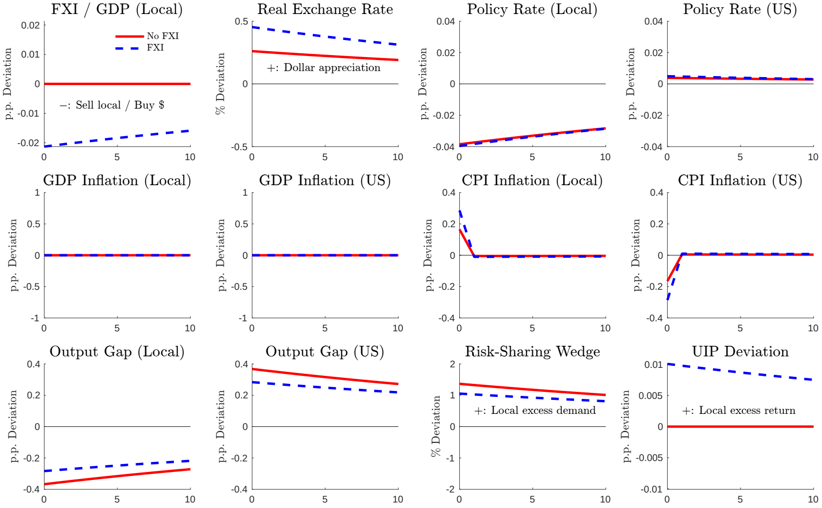
Estimating the Effect of FXI on UIP Deviation

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)



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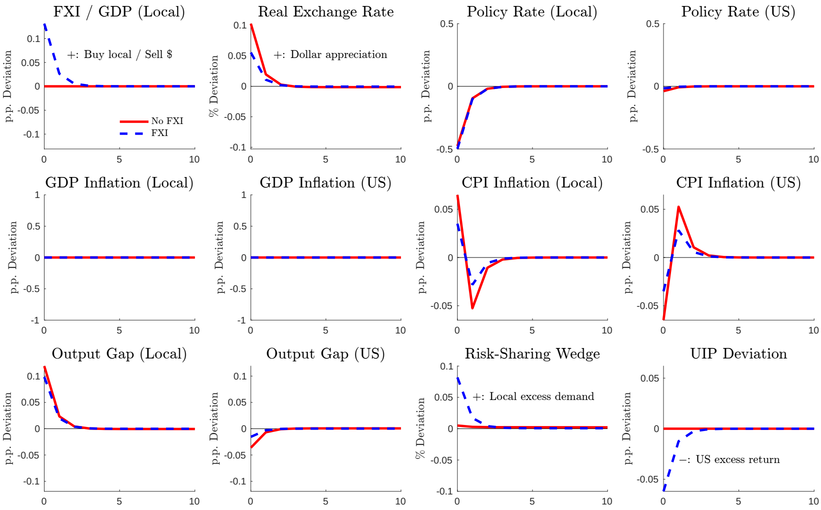
Optimal FXI + Inflation-Targeting MP (Cost-Push)



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Optimal FXI under Inflation-Targeting MP

Proposition 1 (Optimal FXI under inflation-targeting monetary policy)

Suppose strict inflation-targeting monetary policy $(\pi_{Lt} = \pi^*_{Ut} = 0)$*.*

The optimal FXI rule is:

$$f_t = u^*_t + \xi_y\{-(E_t\tilde{Y}_{Lt+1} - \tilde{Y}_{Lt}) + (E_t\tilde{Y}_{Ut+1} - \tilde{Y}_{Ut})\} + \xi_d\{-(E_t\tilde{\mathcal{D}}_{t+1} - \tilde{\mathcal{D}}_t)\}$$

Local productivity $\Uparrow$ or cost-pull $\rightarrow$ Buy \$ if trade elasticity ϕ is high

- $\xi_y > 0$ if $\phi > 1 - \dfrac{1}{2a}$
- $\xi_d > 0$ if $\phi > 1$

Back (productivity) Back (cost-push)

Optimal MP and FXI Rules

Back (productivity) Back (cost-push)

Proposition 2 (Optimal MP and FXI Rules)

Optimal monetary policy rules:

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

Optimal FXI rule:

$$f_t = u^*_t + \xi_y\{-(E_t\tilde{Y}_{Lt+1} - \tilde{Y}_{Lt}) + (E_t\tilde{Y}_{Ut+1} - \tilde{Y}_{Ut})\} + \xi_d\{-(E_t\tilde{\mathcal{D}}_{t+1} - \tilde{\mathcal{D}}_t)\}$$

$$f_t = u^*_t + \xi_\pi E_t(\pi_{Lt+1} - \pi^*_{U,t+1}) \quad \textit{(in terms of inflation)}$$

- Local import price $\tilde{\mathcal{T}}_t \Downarrow$ or excess demand $\tilde{\mathcal{W}}_t \Uparrow \rightarrow$ inflation $\pi_{Lt} \Uparrow$

Impulse Response to a Local Productivity Increase

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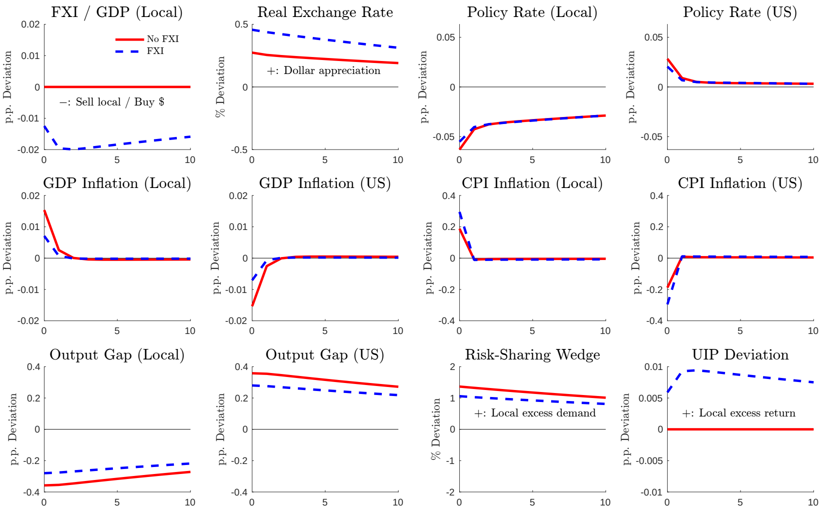

Impulse Response to a Local Markup Decrease

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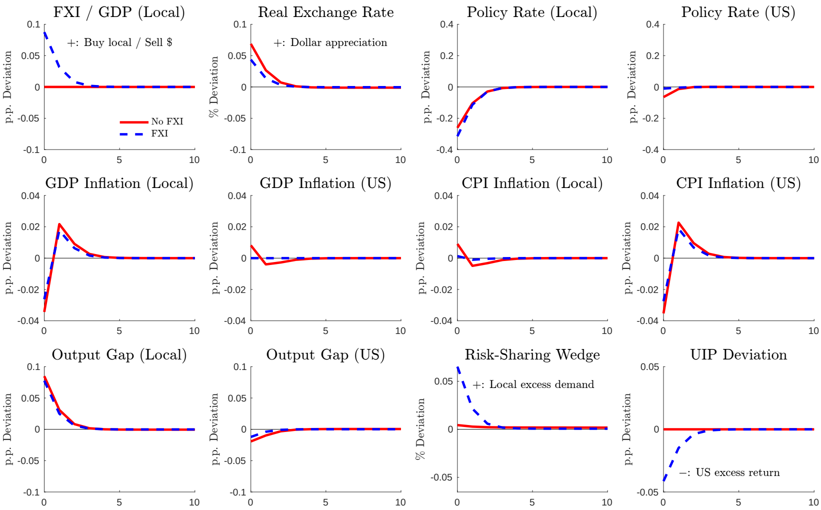

NKPC and Loss Function under Dollar Pricing

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}):

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

Dollar Pricing: Optimal Monetary Policy

Back

Optimal monetary policy under DCP when FXI is not available:

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

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

- 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:

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

- 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.

Non-Cooperative FXI, Inflation-Targeting MP

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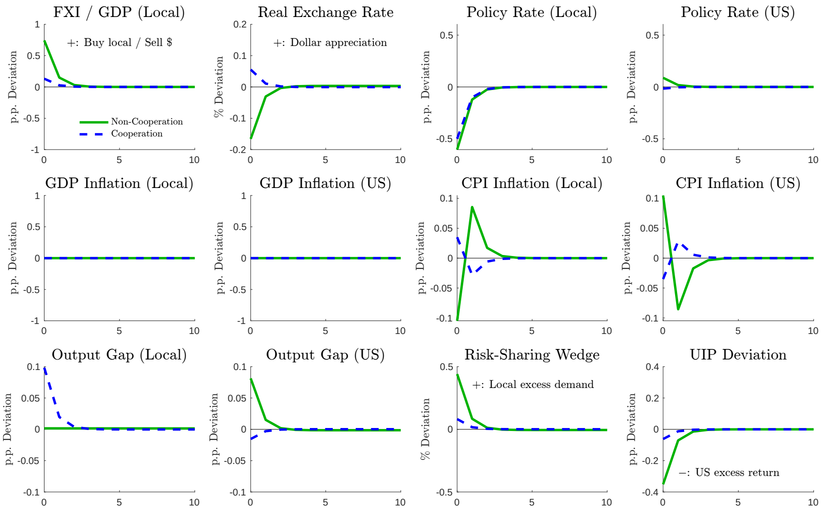

Non-Cooperative MP and FXI

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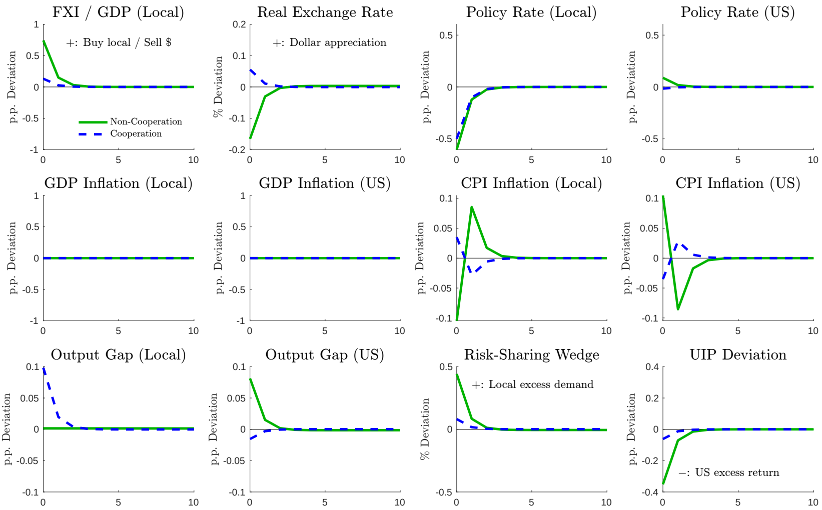

Maximization Problem (Non-Cooperation)

- The local CB solves:

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

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

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

- Optimal MP & FXI rules:

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

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

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