# Monetary and Exchange Rate Policies in a Global Economy

Naoki Yago

The University of Cambridge

January 19, 2025



### Introduction

- Foreign exchange intervention (FXI)
  - Central banks buy/sell foreign currency reserves
  - ex. China buys yuan, sells dollar reserves ⇒ 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



#### Tension 1:

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

#### Tension 2:

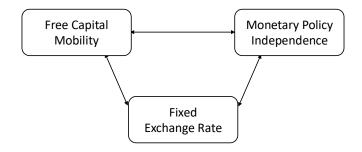
- Literature: separate objectives
  - Monetary policy  $\Rightarrow$  inflation, FXI  $\Rightarrow$  exchange rate
- Reality: related objectives
  - ex. Pandemic & war, high inflation
  - Low interest rates and intervention by selling the dollar

#### 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

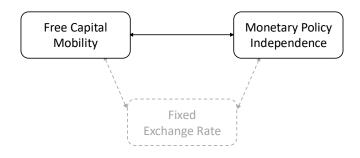
Intro



Classical Theory (Mundell-Fleming)

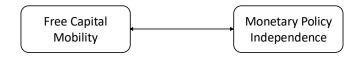
### International Macro in the Past Decades

Intro



- 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



#### Model Takeaway:

Intro

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

#### Literature

Intro



- 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
  - ⇒ 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
  - ⇒ 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
  - ⇒ Role of FXI in stabilizing exchange rates

### Roadmap

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

- (Corsetti/Dedola/Leduc'23) (Known) starting point: monetary policy
- Model setup: monetary policy & FXI
- Optimal policy under cooperation
- Extension: Dollar pricing
- Sobustness: Optimal policy under non-cooperation

### Roadmap

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

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

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

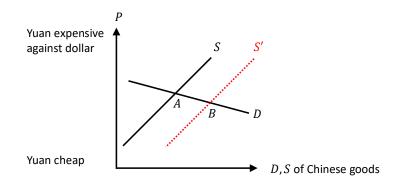
- Cannot trade state-contingent asset internationally
- Firms produce goods, price rigidity (Calvo'83)
  - Shocks: productivity and markup
  - Export in own currency
- Global planner sets local and US monetary policy rates





# International Risk Sharing (Concept)

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



# International Risk Sharing (Definition)

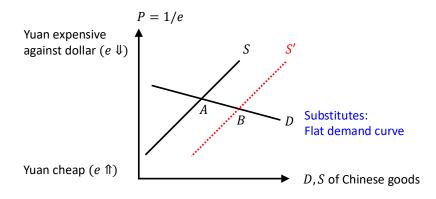
• Risk-sharing wedge = Difference in marginal utilities

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

- $\tilde{\mathcal{W}}_t > 0$  (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

- ullet China productivity  $\uparrow \uparrow \to {
  m excess}$  demand (  $ilde{W} = ilde{C} ilde{C}^* ilde{e} > 0$  )
- China consumption  $C \uparrow$  but small yuan depreciation  $e \uparrow$



### **Price Setting**

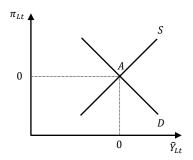


$$\pi_{Lt} = \beta E_t \pi_{Lt+1} + \kappa \big[ \tilde{Y}_{Lt} - \underbrace{2 a (1-a) (\phi-1) \tilde{\mathcal{T}}_t}_{\text{Terms-of-trade gap}} + \underbrace{(1-a) \tilde{\mathcal{W}}_t}_{\text{Risk-sharing wedge}} + \underbrace{\mu_t}_{\text{Markup shock}} \big]$$

- $\pi_{Lt}$ : 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  $ilde{\mathcal{T}}_t \Downarrow \to \mathsf{consumption} \Uparrow$ , inflation  $\Uparrow$
- $\tilde{\mathcal{W}}_t$ : Local excess demand  $\rightarrow$  inflation  $\uparrow$ 
  - ( $\phi$ : substitution of local/US goods, 1-a: trade openness)

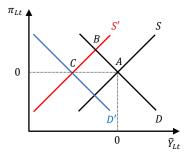
### Monetary Policy Trade-off: (1) Inflation Targeting

- Local productivity  $A_t \uparrow \rightarrow \text{inflation} \downarrow$ 
  - $\rightarrow$  Interest rate ↓ so that inflation = output gap = 0



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

- Assume inflation targeting  $(\pi_{Lt} = 0)$  & goods are substitutes
- ullet Local productivity  $A_t \Uparrow o ext{demand } ilde{\mathcal{W}}_t \Uparrow o ext{inflation } \pi_{Lt} \Uparrow$ 
  - ightarrow Interest rate  $\Uparrow$  to target inflation ightarrow output gap  $ilde{Y}_{Lt} \Downarrow$



### Roadmap

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

- (Known) starting point: monetary policy
- 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
- Optimal policy under cooperation
- Extension: Dollar pricing
- Sobustness: Optimal policy under non-cooperation

### FXI: Basic Idea

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

Known result in Corsetti/Dedola/Leduc'23 (No FXI case)

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

- ullet Same return o 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:

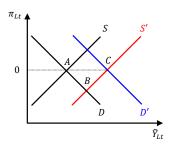
$$\underbrace{E_t \tilde{\mathcal{W}}_{t+1} - \tilde{\mathcal{W}}_t}_{\tilde{\mathcal{W}}_t > 0: \text{ local demand}} = \underbrace{\tilde{r}_t - \tilde{r}_t^* - \left(E_t \tilde{e}_{t+1} - \tilde{e}_t\right)}_{\text{Local} - \$ \text{ return}} = \underbrace{\omega f_t^*}_{\text{FXI}}$$

 $(ω: intermediation friction, 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  $\tilde{\mathcal{W}}_t \downarrow , \; \pi_{Lt} \downarrow \rightarrow \text{ interest rate } \downarrow, \; \tilde{Y}_{Lt} \uparrow \uparrow$
- Substitution effect:
  - Demand shifts from US to local goods,  $\tilde{Y}_{Lt} \uparrow \uparrow$



# FXI Affects the Inflation/Output Trade-off

- Buy  $\$ \rightarrow \$$  expensive
- Income effect:
  - Local demand  $\tilde{\mathcal{W}}_t \downarrow \!\! \downarrow$ ,  $\pi_{Lt} \downarrow \!\! \downarrow \rightarrow$  interest rate  $\downarrow \!\! \downarrow$ ,  $\tilde{Y}_{Lt} \uparrow \!\! \uparrow$
- 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

- (Known) starting point: monetary policy
- Model setup: monetary policy & FXI
- Optimal policy under cooperation
  - Analytical characterization of optimal MP and FXI rules
  - Calibrate the model and quantify the effect of FXI
  - Relationship with Mundell-Fleming "trilemma"
- Extension: Dollar pricing
- Sobustness: 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

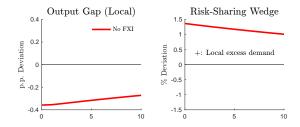


# Optimal Policy: Cooperation & Commitment

- Planner maximizes the sum of welfare in the two countries
- - 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

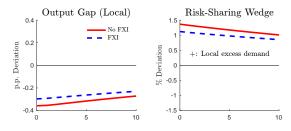
### Case 1: Inflation-Targeting MP, No FXI (Recap)

- Monetary policy follows strict inflation targeting  $(\pi_{Lt}=0)$
- Local productivity  $A_t \uparrow \uparrow \rightarrow \operatorname{demand} \tilde{\mathcal{W}}_t \uparrow \uparrow$ 
  - ightarrow Inflation  $\pi_{Lt} \Uparrow 
    ightarrow$  interest rate  $\Uparrow$ , output gap  $ilde{Y}_{Lt} \Downarrow$



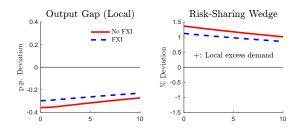
# Case 2: Optimal FXI, Inflation-Targeting MP (Concept)

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



# 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.



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

#### **Optimal FXI rule:**

$$\mathbf{f}_{t}^{*} = -\xi_{y} \{ (\tilde{Y}_{Lt} - E_{t} \tilde{Y}_{Lt+1}) - (\tilde{Y}_{Ut} - E_{t} \tilde{Y}_{Ut+1}) \}$$

#### **Transmission:**

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

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

Local output  $\tilde{Y}_{Lt} \Downarrow$   $\rightarrow \text{Buy } \{ (f_t^* > 0) \}$ 

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

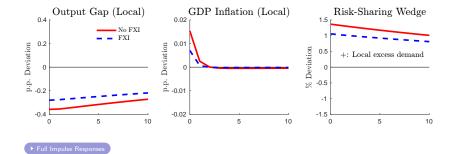
→ less negative

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

 $\rightarrow$  less positive

# Case 3: Optimal MP and FXI (Concept)

- No FXI: Local productivity  $A_t \uparrow \uparrow \rightarrow \text{demand } \tilde{\mathcal{W}}_t \uparrow \uparrow$ , inflation  $\pi_{Lt} \uparrow \uparrow$
- 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.



# Case 3: Optimal MP and FXI (Formal)

#### **Optimal MP rule:**

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

#### **Optimal FXI rule:**

$$\mathbf{f}_{t}^{*} = -\xi_{y}\{(\tilde{\mathbf{Y}}_{Lt} - E_{t}\tilde{\mathbf{Y}}_{Lt+1} - (\tilde{\mathbf{Y}}_{Ut} - E_{t}\tilde{\mathbf{Y}}_{Ut+1})\}$$

Interest rate  $\uparrow$  (inflation  $\pi_{Lt} \downarrow$ ) when:

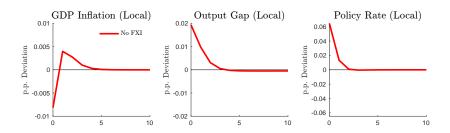
- Local output  $\tilde{Y}_{I,t}$   $\uparrow$
- Import price  $\tilde{\mathcal{T}}_t \Downarrow$  ( $\rightarrow$  demand  $\Uparrow$ )
- Local demand  $\tilde{\mathcal{W}}_t \uparrow$

Local output 
$$\tilde{Y}_{Lt} \Downarrow$$
 $\rightarrow \text{Buy } \{ (f_t^* > 0) \}$ 

# Optimal MP, Cost-Push Shock



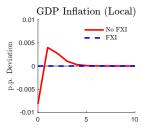
- US cost-push inflation  $\rightarrow$  \$ expensive
  - Local demand  $\tilde{\mathcal{W}}_t \downarrow$ , inflation  $\pi_{Lt} \downarrow$
  - US demand for local goods  $\Uparrow$ , output gap  $\tilde{Y}_{Lt} \Uparrow \to \text{interest rate } \Uparrow$
- External shocks weaken monetary policy independence

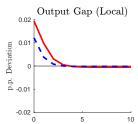


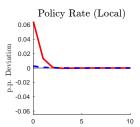
### Optimal MP & FXI, Cost-Push Shock



- ullet Buy local o local expensive
  - Local demand  $\tilde{W}_t \uparrow$ , inflation  $\uparrow$
  - ullet US demand for local goods  $\psi$ , output gap  $\psi$  o interest rate  $\psi$



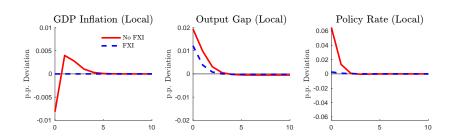




### Optimal MP & FXI, Cost-Push Shock



- 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



### Model Takeaway



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

#### Model Takeaway



- Without FXI, external shocks weaken the MP independence
  - MP cannot stabilize domestic inflation/output
- FXI improves the MP independence
  - Stabilize inflation with small interest rate changes
  - FXI complements the MP
- <u>Literature:</u> separate objectives
  - $\bullet \ \mathsf{MP} \Rightarrow \mathsf{inflation/output}, \quad \mathsf{FXI} \to \mathsf{capital} \ \mathsf{flow} \ (\mathsf{UIP}) \ \mathsf{shocks}$

#### Roadmap

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

- (Known) starting point: monetary policy
- Model setup: monetary policy & FXI
- Optimal policy under cooperation
- Extension: Dollar pricing
  - Optimal FXI volume is large under dollar pricing
  - Transmission is asymmetric: FXI stabilizes local inflation more
- Sobustness: 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)
- I find that FXI is powerful under dollar pricing.
- Assume both exports and imports are invoiced in dollars



#### **Dollar Pricing**



- Identical local goods have different prices in different currencies despite the same marginal cost of production
  - Strong \$ ⇒ Chinese goods are more expensive in \$ than yuan
  - $\Delta_{Lt} \equiv \mathcal{E}_t P_{Lt}^* / P_{Lt} 
    eq 1$  : Price of local goods in \$ / local currency
  - Central banks target the price dispersion wedge Δ<sub>Lt</sub>
     (Engel'11, Corsetti/Dedola/Leduc'20)
- Exchange rate has limited effect on US import prices

#### **Dollar Pricing**



Consider US cost-push inflation.

- Optimal FXI is increasing in the price-dispersion wedge  $(\Delta_{Lt})$ 
  - ullet \$ expensive o local good is expensive in \$  $(\Delta_{Lt} \Uparrow)$  o sell \$
- Optimal FXI volume is larger under dollar pricing
- Transmission of FXI is asymmetric
  - Decreases local consumer inflation more
  - Increases US consumer inflation less
- FXI is powerful under dollar pricing

#### Roadmap

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

- (Known) starting point: monetary policy
- Model setup: monetary policy & FXI
- Optimal policy under cooperation
- Extension: Dollar pricing
- Sobustness: Optimal policy under non-cooperation
  - Case 1: Optimal FXI, inflation-targeting MP
  - Case 2: Optimal MP and FXI

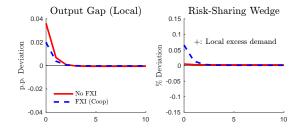
## Robustness: Non-Cooperative Equilibrium

- CB in each country maximizes domestic objective
  - Abstract from full strategic interaction in repeated games
- Assumptions:
  - 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 (Recap)

- No FXI: US cost-push inflation  $\Uparrow \to \$$  expensive  $\to \tilde{Y}_{Lt} \Uparrow$
- **FXI** (Cooperation): Sell  $\$ \rightarrow \$$  cheap  $\rightarrow \tilde{Y}_{Lt} \Downarrow$

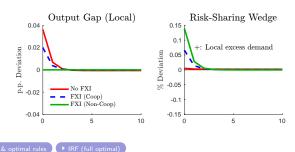


Maximization & ontimal rules

Full Impulse Response

# Optimal FXI under Inflation-Targeting MP

- ullet FXI (Non-Cooperation) stabilizes local output:  $E_t ilde{Y}_{Lt+1} = ilde{Y}_{Lt}$
- Sell \$ more than cooperation
- **Stabilizes** the output gap, **destabilizes** the risk-sharing



#### Conclusion

- A two-country framework with monetary policy and FXI
- •
- •
- 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



- 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



Country	Currency	$\alpha_0$	(s.e.)	$\beta_1$	(s.e.)	$\chi^2(\alpha_0=\beta_1=0)$	$\mathbb{R}^2$
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

## Literature on MP and FXI in Open Economy



	(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



- 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 ⇒ 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

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

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

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

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

#### Solution to Households' Problem

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

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

Demand for differentiated goods produced within each country:

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

▶ Back

#### Firms' Maximization Problem



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

$$\max_{\{P_{t}(I), \mathcal{E}_{t}P_{t}^{*}(I)\}} E_{t} \left\{ \sum_{k=0}^{\infty} Q_{t,t+k} \xi^{k} \left( \begin{array}{c} (1+\tau_{t}) \left[ P_{t}(I) Y_{t+k}(I) + \mathcal{E}_{t}P_{t}^{*}(I) Y_{t+k}^{*}(I) \right] \\ -MC_{t+k}(I) \left[ Y_{t+k}(I) + Y_{t+k}^{*}(I) \right] \end{array} \right) \right\}$$

New Keynesian Phillips Curve:

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

- 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



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

- ullet Consider US output  $ilde{Y}_{Ut} \uparrow \! \uparrow$ , local appreciation, import price  $\Downarrow ( ilde{\mathcal{T}}_t \Downarrow)$
- $\bullet$   $\phi > 1$ : 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  $\pi_{Lt} \uparrow$
- ullet  $\phi < 1$ : Local and US goods are complements
  - Export price  $\Uparrow \to \mathsf{marginal}$  benefit of export  $\Uparrow$ , inflation  $\pi_{\mathsf{Lt}} \Downarrow$

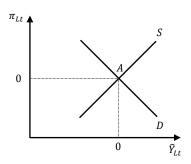
#### Effect of demand gap: (Corsetti/Dedola/Leduc'10)

•  $\mathcal{W}_t \Uparrow = U'(\mathcal{C}_t) \Downarrow \to \mathsf{marginal} \ \mathsf{cost} \ w_t = rac{V'(L_t)}{U'(\mathcal{C}_t)} \Uparrow$ , inflation  $\pi_{Lt} \Uparrow$ 

## Monetary Policy Trade-off: Special Case



- Assume inflation targeting  $(\pi_{Lt} = 0) \& \text{trade elasticity} = 1$
- ullet Local productivity  $A_t \uparrow has no effect on <math> ilde{\mathcal{W}}_t$ 
  - $\rightarrow$  Inflation = output gap = 0 (No trade-offs)



#### International Asset Market: Details



- ullet  $ar{R}_t \equiv R_t R_t^* rac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$ : 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:

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

## Loss Function (PCP, Details)

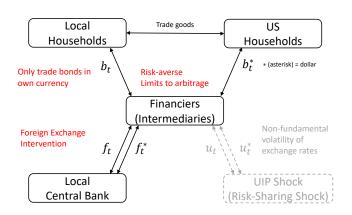
$$\mathcal{L} = -E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[ \begin{array}{c} \left( \tilde{Y}_{Lt}^2 + \tilde{Y}_{Ut}^2 \right) + \frac{\theta}{\kappa} \left( \pi_{Lt}^2 + \pi_{Ut}^{*2} \right) \\ - \frac{2a(1-a)(\phi-1)}{4a(1-a)(\phi-1)+1} \left( \tilde{Y}_{Lt} - \tilde{Y}_{Ut} \right)^2 \\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

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

- ullet Local supply  $ilde{Y}_{Lt} \uparrow \!\!\! \uparrow \to \mathsf{local}$  currency cheap, import price  $ilde{\mathcal{T}}_t \uparrow \!\!\! \uparrow$
- $\tilde{\mathcal{W}}_t \neq 0$  under incomplete asset market
  - Local productivity ↑
    - → local HHs lend to US HHs (under complete market)

#### Friction in International Asset Market





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

#### Financiers' Problem



• 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<sub>t</sub>: local bond purchases (\$ sales)

# UIP condition (General Case)



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

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  $\omega$  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.

#### Calibration



- 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



#### **Countries:**

- Australia, Brazil, Canada, China, Euro area, India, Japan, Korea, Russia, Switzerland, and the United Kingdom
  - <u>Robustness:</u> 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	Media	n 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



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)
$\zeta_I = 13.3$	Labor disutility (local)	${\sf Steady\text{-}state\ labor} = 1/3$
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	$\Delta(\textit{UIP})/\Delta(\textit{FXI}/\textit{GDP}) = 0.47$
$\rho_{\rm a}=0.97$	Persistence of productivity shock	Itskhoki and Mukhin (2021)
$ ho_{\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



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
- $\gamma_i$ : country fixed effect

#### First-step Regression



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 <sup>2</sup>	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

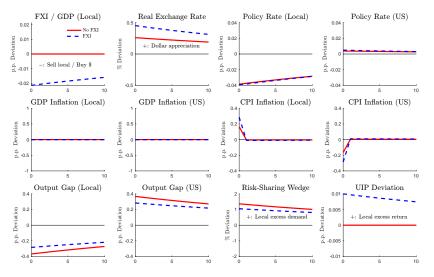


Dependent Variable	$\mathit{UIP}_t - \mathit{UIP}_{t-1}$					
	(1)	(2)	(3)	(4)		
Net \$ Sales / GDP (%)	-0.589**	-0.509**	-1.599***	-1.106***		
	(0.264)	(0.212)	(0.182)	(0.178)		
$R^2$	0.004	0.013	0.009	0.020		
N	706	392	367	212		
Country Fixed Effect	✓	✓	✓	✓		
Identified		✓		✓		
Exclude Small Economy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

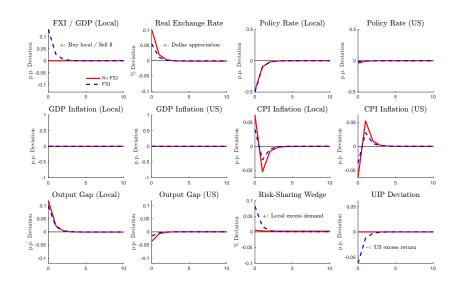




The local policy rate can increase (buy \$) or decrease (to target inflation).

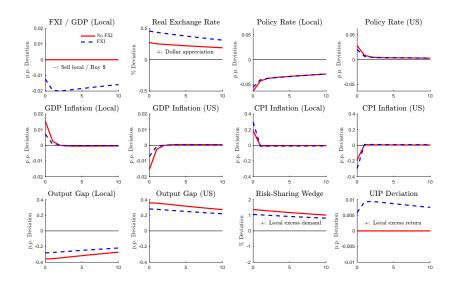
## Optimal FXI + Inflation-Targeting MP (Cost-Push) $\bullet$ Back





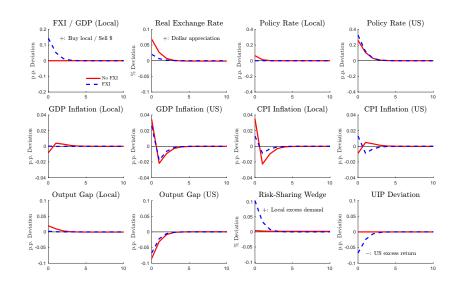
#### Impulse Response to a Local Productivity Increase





#### Impulse Response to a US Markup Increase





## NKPC and Loss Function under Dollar Pricing



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

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

• Loss function depends on the LOOP deviation  $(\Delta_{Lt})$ :

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

## Dollar Pricing: Optimal Monetary Policy



Optimal monetary policy under DCP when FXI is not available:

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

- 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



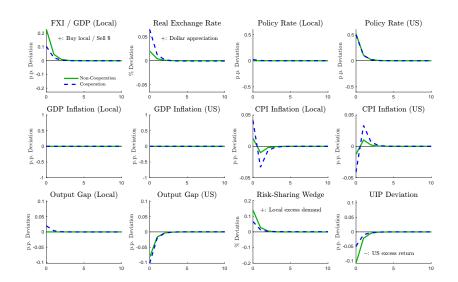
Optimal monetary policy and FXI under DCP:

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

- 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.

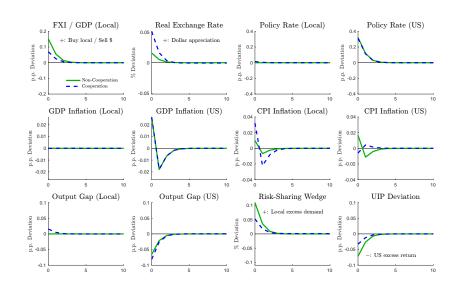
## Non-Cooperative FXI, Inflation-Targeting MP





#### Non-Cooperative MP and FXI





## Maximization Problem (Non-Cooperation)

• The local CB solves:

$$\begin{aligned} \max \mathcal{L} &= -E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[ \tilde{Y}_{Lt}^2 + \frac{\theta}{\kappa} \pi_{Lt}^2 \right] \quad \text{s.t.} \\ \pi_{Lt} &= \beta E_t \pi_{Lt+1} + \kappa \left[ \tilde{Y}_{Lt} - 2a(1-a)(\phi-1)\tilde{\mathcal{T}}_t + (1-a)\tilde{\mathcal{W}}_t, \right. \\ &E_t \tilde{\mathcal{W}}_{t+1} - \tilde{\mathcal{W}}_t = -\bar{\omega} f_t \end{aligned}$$

Optimal MP & FXI rules:

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