Exchange Rate Policies at the Zero Lower Bound

Manuel Amador, Javier Bianchi, Luigi Bocola, Fabrizio Perri

MPLS Fed and UMN MPLS Fed MPLS Fed and Stanford MPLS Fed

Interest Parity Condition

$$(1 + i_t) = (1 + i_t^\star)\,\frac{e_{t+1}}{e_t}$$

i_t	domestic nominal rate,	e_t	today's exchange rate
$i_t^\star$	foreign nominal rate,	e_{t+1}	tomorrow's exchange rate

Interest Parity Condition

$$(1 + i_t) = (1 + i_t^\star)\,\frac{e_{t+1}}{e_t}$$

i_t domestic nominal rate, e_t today's exchange rate
$i_t^\star$ foreign nominal rate, e_{t+1} tomorrow's exchange rate

- Central bank goal: depreciate exchange rate today (higher e_t)

$\Rightarrow \ \downarrow i$

Interest Parity Condition

$$(1 + i_t) = (1 + i_t^\star)\,\frac{e_{t+1}}{e_t}$$

i_t domestic nominal rate, e_t today's exchange rate
$i_t^\star$ foreign nominal rate, e_{t+1} tomorrow's exchange rate

- Central bank goal: depreciate exchange rate today (higher e_t)

$\Rightarrow \downarrow i$

But what if $i < 0$?

A Theory

Simple monetary model of exchange rate policy

- Limited international arbitrage
- Central bank intervention in FX markets

A Theory

Simple monetary model of exchange rate policy

- Limited international arbitrage
- Central bank intervention in FX markets

Main set of results:

1. At ZLB, accumulation of foreign reserves is necessary
    - Interventions more likely for safe-heaven currencies & increase with financial integration

A Theory

Simple monetary model of exchange rate policy

- Limited international arbitrage
- Central bank intervention in FX markets

Main set of results:

1. At ZLB, accumulation of foreign reserves is necessary
   - Interventions more likely for safe-heaven currencies & increase with financial integration
2. Costs of interventions = CIP deviations $\times$ foreign reserves

A Theory

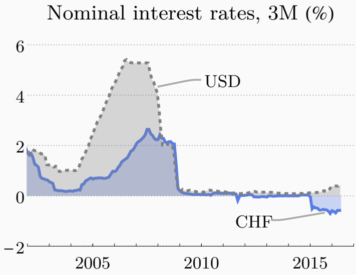
Simple monetary model of exchange rate policy

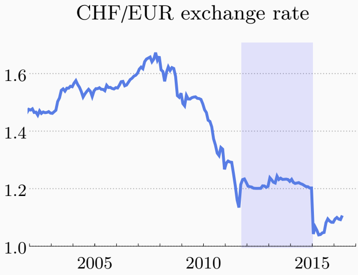
- Limited international arbitrage
- Central bank intervention in FX markets

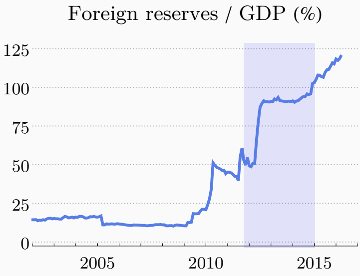
Main set of results:

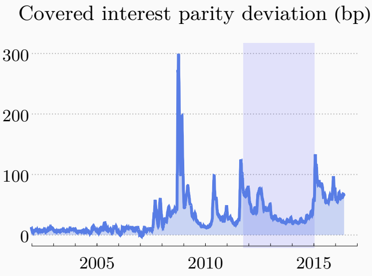
1. At ZLB, accumulation of foreign reserves is necessary
   - Interventions more likely for safe-heaven currencies & increase with financial integration
2. Costs of interventions = CIP deviations × foreign reserves
3. Rationalize recent evidence on CIP, interest rates, and reserves for advanced economies

Why do we care?









Framework

- Two-period monetary model, $t \in \{1, 2\}$
    - Small open economy (central bank + households)
    - International Financial Market
    - Foreign Intermediaries
- Uncertainty realized at $t = 2$
    - $s \in S \equiv \{s_2, ..., s_N\}, \pi(s)$
- One (tradable) good, law of one price, foreign price normalized to 1

Asset markets: complete but segmented

International financial markets (IFM)

- Full set of Arrow-Debreu securities in foreign currency:
  - Security s: 1 unit of foreign currency in state s, 0 otherwise
  - Price $q(s)$ in terms of goods/foreign currency at $t = 0$

Domestic financial market

- Full set of Arrow-Debreu securities in domestic currency
  - Security s: 1 unit of domestic currency in state s, 0 otherwise
  - Price $p(s)$ in terms of domestic currency at $t = 0$

Foreign Intermediaries

- Trade securities with SOE (and with IFM)

Households

- Endowment: $(y_1, \{y_2(s)\})$, transfers: $(\{T_2(s)\})$

$$\max_{c_1,\{c_2(s),m,a(s),f(s)\}} u(c_1) + h\left(\frac{m}{e_1}\right) + \beta \sum_{s\in S} \pi(s)u(c_2(s))$$

subject to:

$$y_1 = c_1 + \sum_{s\in S}\left[q(s)f(s) + p(s)\frac{a(s)}{e_1}\right] + \frac{m}{e_1}$$

$$y_2(s) + T_2(s) + f(s) + \frac{a(s)+m}{e_2(s)} = c_2(s); \text{ for all } s \in S$$

$$f(s) \geq 0, \quad \forall s \in S$$

e_1, $e_2(s)$: exchange rates at $t = 0$ and $t = 1$

$f(s), a(s)$: holdings of foreign and domestic security s

Households

- Endowment: $(y_1, \{y_2(s)\})$, transfers: $(\{T_2(s)\})$

$$\max_{c_1,\{c_2(s),m,a(s),f(s)\}} u(c_1) + h\left(\frac{m}{e_1}\right) + \beta \sum_{s\in S} \pi(s) u(c_2(s))$$

subject to:

$$y_1 = c_1 + \sum_{s\in S}\left[q(s)f(s) + p(s)\frac{a(s)}{e_1}\right] + \frac{m}{e_1}$$

$$y_2(s) + T_2(s) + f(s) + \frac{a(s)+m}{e_2(s)} = c_2(s);\ \text{for all } s \in S$$

$$f(s) \geq 0, \quad \forall s \in S$$

e_1, $e_2(s)$: exchange rates at $t = 0$ and $t = 1$

$f(s), a(s)$: holdings of foreign and domestic security s

Foreign Intermediaries

$$\max_{\{a^\star(s), f^\star(s), m^\star\}} d_1^\star + \sum_{s \in S} \beta q(s) d^\star(s)$$

subject to:

$$\bar{w} = \frac{m^\star}{e_1} + \sum_{s \in S} \left[\frac{p(s) a^\star(s)}{e_1} + q(s) f^\star(s) \right] + d_1^\star$$

$$d_2^\star(s) = \frac{m^\star + a^\star(s)}{e_2(s)} + f^\star(s) \qquad \forall s \in S$$

$$d_1^\star \geq 0 \quad f^\star(s) \geq 0 \quad a^\star(s) \geq 0 \quad m^\star \geq 0, \quad \forall s \in S$$

Foreign Intermediaries

$$\max_{\{a^\star(s), f^\star(s), m^\star\}} d_1^\star + \sum_{s \in S} \beta q(s) d^\star(s)$$

subject to:

$$\bar{w} = \frac{m^\star}{e_1} + \sum_{s \in S} \left[\frac{p(s) a^\star(s)}{e_1} + q(s) f^\star(s) \right] + d_1^\star$$

$$d_2^\star(s) = \frac{m^\star + a^\star(s)}{e_2(s)} + f^\star(s) \qquad \forall s \in S$$

$$d_1^\star \geq 0 \quad f^\star(s) \geq 0 \quad a^\star(s) \geq 0 \quad m^\star \geq 0, \quad \forall s \in S$$

Central Bank

- CB exchange rate policy is taken as given: $(e_1, \{e_2(s)\})$
- CB achieves its objective by choosing
  - nominal rate i
  - balance sheet $(\{A(s)\}, F)$ and
  - and transfers $(\{T_2(s)\})$ subject to budget constraint .
- Given exchange rate objective, the optimal policy $(\{A(s), F(s), T_2(s)\})$ maximizes welfare

Intertemporal Resource constraint

$$y_1 - c_1 + \sum q(s)(y_2(s) - c_2(s)) = \Pi$$

where Π are the benefits for intermediaries

Intertemporal Resource constraint

$$y_1 - c_1 + \sum q(s)(y_2(s) - c_2(s)) = \Pi$$

where Π are the benefits for intermediaries

In an "equal-gap" equilibrium

$$\Pi = \Delta(i) \times \bar{w}$$

where

$$\Delta(i) \equiv \mathbb{E}\left[\Lambda(s)\left(\frac{e_1}{e_2(s)}(1+i) - (1+i^\star)\right)\right] \geq 0$$

is the return differential between risk-free home and foreign bonds

Intertemporal Resource constraint

$$y_1 - c_1 + \sum q(s)(y_2(s) - c_2(s)) = \Pi$$

where Π are the benefits for intermediaries

In an "equal-gap" equilibrium

$$\Pi = \Delta(i) \times \bar{w}$$

where

$$\Delta(i) \equiv \mathbb{E}\left[\Lambda(s)\left(\frac{e_1}{e_2(s)}(1+i) - (1+i^\star)\right)\right] \geq 0$$

is the return differential between risk-free home and foreign bonds

$\Delta(0)$ is the return differential of money and foreign bonds

Optimal CB policy given $(e_1, \{e_2(s)\})$

Two cases:

Optimal CB policy given $(e_1, \{e_2(s)\})$

Two cases:

$\Delta(0) \leq 0$ (*Away from ZLB*):

- CB sets nominal rate consistent with parity, $\Delta(i) = 0$
- Reserve accumulation is irrelevant

Optimal CB policy given $(e_1, \{e_2(s)\})$

Two cases:

$\Delta(0) \leq 0$ (*Away from ZLB*):

- CB sets nominal rate consistent with parity, $\Delta(i) = 0$
- Reserve accumulation is irrelevant

$\Delta(0) > 0$ (*At the ZLB*):

- Domestic assets attractive to intermediaries, even at $i = 0$
- CB **must** issue more liabilities to satisfy foreign appetite and buy foreign reserves

$$\underbrace{\sum q(s)f(s) + \overline{q}F}_{\text{capital outflow}} + \underbrace{(c_1 - y_1)}_{\text{trade deficit}} = \underbrace{\overline{w}}_{\text{capital inflow}}$$

Optimal CB policy given $(e_1, \{e_2(s)\})$

Two cases:

$\Delta(0) \leq 0$ (*Away from ZLB*):

- CB sets nominal rate consistent with parity, $\Delta(i) = 0$
- Reserve accumulation is irrelevant

$\Delta(0) > 0$ (*At the ZLB*):

- Domestic assets attractive to intermediaries, even at $i = 0$
- CB **must** issue more liabilities to satisfy foreign appetite and buy foreign reserves

$$\underbrace{\sum q(s)f(s) + \overline{q}F}_{\text{capital outflow}} + \underbrace{(c_1 - y_1)}_{\text{trade deficit}} = \underbrace{\overline{w}}_{\text{capital inflow}}$$

When are reserves more likely to be needed?

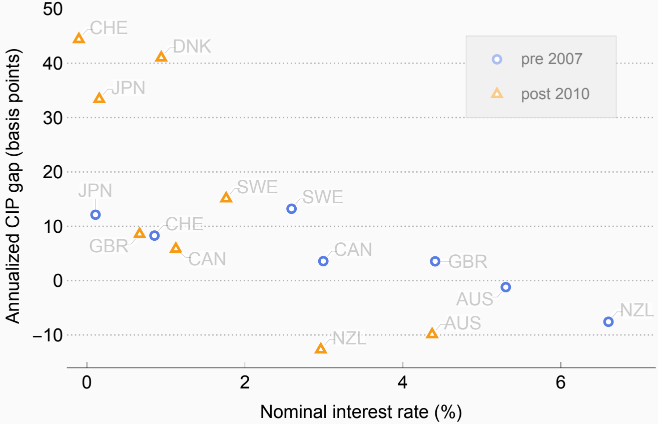
Recall

$$\Delta(0) = \mathbb{E}\left[\Lambda(s)\left(\frac{e_1}{e_2(s)} - (1+i^\star)\right)\right]$$
$$= \frac{\mathbb{E}\left[e_1/e_2(s)\right]}{1+i^\star} - 1 + \mathbb{COV}\left(\Lambda(s), \frac{e_1}{e_2(s)}\right)$$

$\Delta(0)$ is more likely to be negative whenever

1. High expected appreciation
2. Low $i^\star$
3. Higher is the covariance (safe heaven property)

CIP deviations for economies with rates close to zero



See also Du, Tepper and Verdelhan (2017)

How to measure losses: UIP or CIP?

- Two possible approaches to measure $\Delta(i)$:

$$\Delta(i) = \underbrace{\left\{ \frac{1+i}{1+i^{\star}} \mathbb{E}\left[\frac{e_0}{e_1(s)} \right] - 1 \right\}}_{\text{UIP deviation}} + \underbrace{\mathbb{COV}\left[\frac{q(s)}{\pi(s)}, \frac{e_0}{e_1(s)} \right]}_{\text{risk premium}}$$

- Empirical literature using UIP misses risk premium!

How to measure losses: UIP or CIP?

- Two possible approaches to measure $\Delta(i)$:

$$\Delta(i) = \underbrace{\left\{ \frac{1+i}{1+i^\star} \mathbb{E}\left[\frac{e_0}{e_1(s)} \right] - 1 \right\}}_{\text{UIP deviation}} + \underbrace{\mathbb{COV}\left[\frac{q(s)}{\pi(s)}, \frac{e_0}{e_1(s)} \right]}_{\text{risk premium}}$$

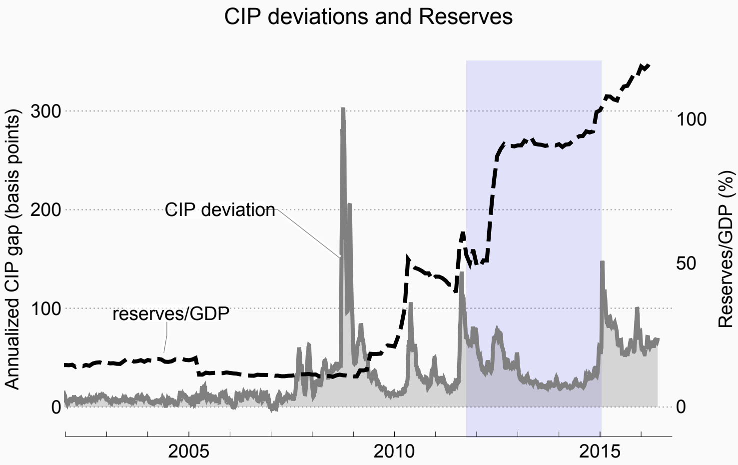
- Empirical literature using UIP misses risk premium!
- Using pricing of the forward exchange rate $\hat{e}$:

$$\sum_{s \in S} q(s) \left[\frac{1}{e_1(s)} - \frac{1}{\hat{e}} \right] = 0$$

we obtain $\Delta(i) =$CIP deviation:

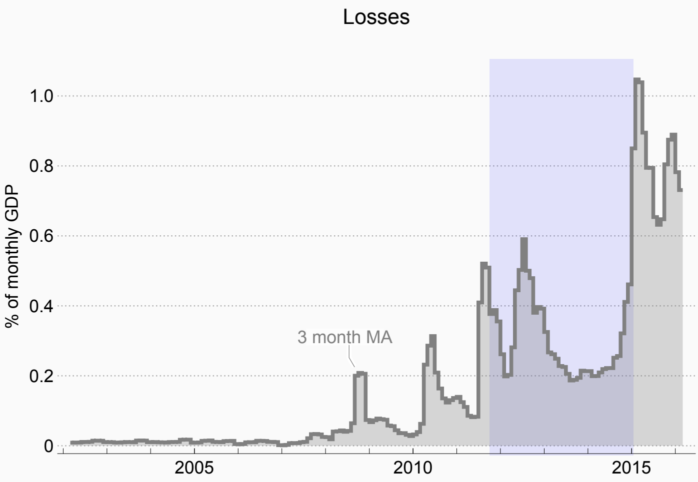
$$\Delta(i) = \underbrace{\left\{ \frac{1+i}{1+i^\star} \frac{e_0}{\hat{e}} - 1 \right\}}_{\text{CIP deviation}}$$

Quantifying the costs in Switzerland



- Remark: can approximate $\bar{w} = F - (c_1 - y_1) \sim F$

Losses in Switzerland



- Losses can be sizable (1% of monthly GDP)

Agenda: Which assets should CB buy?

- Policy for (e, i) + CB portfolio problem
- Two goals: minimize losses and inter and intratemporal distortions
- Relatively closed economies:
    - Buy foreign assets that pay when the currency appreciates.
    - Idea: Make money less attractive to hold by reducing $u'(c)$ when money pays a higher return

      $\Rightarrow$ Reduce intertemporal distortions
- Relatively open economies:
    - Make sure that foreign investors hold risk free bonds
      $\Rightarrow$ Reduce losses

Agenda: Which assets should CB buy?

- Policy for $(e, i) +$ CB portfolio problem
- Two goals: minimize losses and inter and intratemporal distortions
- Relatively closed economies:
  - Buy foreign assets that pay when the currency appreciates.
  - Idea: Make money less attractive to hold by reducing $u'(c)$ when money pays a higher return

    $\Rightarrow$ Reduce intertemporal distortions
- Relatively open economies:
  - Make sure that foreign investors hold risk free bonds
    $\Rightarrow$ Reduce losses

Agenda: Which assets should CB buy?

- Policy for (e, i) + CB portfolio problem
- Two goals: minimize losses and inter and intratemporal distortions
- Relatively closed economies:
  - Buy foreign assets that pay when the currency appreciates.
  - Idea: Make money less attractive to hold by reducing $u'(c)$ when money pays a higher return

    $\Rightarrow$ Reduce intertemporal distortions
- Relatively open economies:
  - Make sure that foreign investors hold risk free bonds
    $\Rightarrow$ Reduce losses

Agenda: Which assets should CB buy?

- Policy for (e, i) + CB portfolio problem
- Two goals: minimize losses and inter and intratemporal distortions
- Relatively closed economies:
  - Buy foreign assets that pay when the currency appreciates.
  - Idea: Make money less attractive to hold by reducing $u'(c)$ when money pays a higher return

    $\Rightarrow$ Reduce intertemporal distortions
- Relatively open economies:
  - Make sure that foreign investors hold risk free bonds
    $\Rightarrow$ Reduce losses
- Potentially role for purchases of domestic assets too

Conclusions

- Simple monetary model of exchange rate policy
    - Limited international arbitrage
    - Central bank intervention in FX markets
- At ZLB, accumulation of foreign reserves is necessary
- Costs of interventions = CIP $\times$ foreign reserves
- Rationalize recent evidence on CIP, interest rates, and reserves for advanced economies
- Agenda:
    - Optimal Reserve Management