Exchange Rate Policies at the Zero Lower Bound

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MPLS Fed and UMN      MPLS Fed      MPLS Fed and Stanford      MPLS Fed
Interest Parity Condition

\[(1 + i_t) = (1 + i_t^*) \frac{e_{t+1}}{e_t}\]

- \(i_t\) domestic nominal rate,
- \(e_t\) today’s exchange rate
- \(i_t^*\) foreign nominal rate,
- \(e_{t+1}\) tomorrow’s exchange rate
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- \(e_t\): today’s exchange rate
- \(i^*_t\): foreign nominal rate,
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- Central bank goal: depreciate exchange rate today (higher \(e_t\))

\(\Rightarrow \downarrow i\)
Interest Parity Condition

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- $i_t$ domestic nominal rate, $e_t$ today’s exchange rate
- $i_t^*$ 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
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Main set of results:

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

2. Costs of interventions = CIP deviations \times foreign reserves
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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 \text{foreign reserves}

3. Rationalize recent evidence on CIP, interest rates, and reserves for advanced economies
Why do we care?

Nominal interest rates, 3M (%)

CHF/USD exchange rate

Foreign reserves / GDP (%)

Covered interest parity deviation (bp)
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: \((\{T_2(s)\})\)

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

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

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

\(f(s), a(s)\): holdings of foreign and domestic security \(s\)
max \{a^*(s), f^*(s), m^*\} \quad d_1^* + \sum_{s \in S} \beta q(s) d^*(s)

subject to:

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

d_2^*(s) = \frac{m^* + a^*(s)}{e_2(s)} + f^*(s) \quad \forall s \in S

d_1^* \geq 0 \quad f^*(s) \geq 0 \quad a^*(s) \geq 0 \quad m^* \geq 0, \quad \forall s \in S
Foreign Intermediaries

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\max \{a^*(s), f^*(s), m^*\} \quad d_1^* + \sum_{s \in S} \beta q(s) d^*(s)
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\[
d_1^* \geq 0 \quad f^*(s) \geq 0 \quad a^*(s) \geq 0 \quad m^* \geq 0, \quad \forall s \in S
\]
• 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 \( \Pi \) are the benefits for intermediaries
Intertemporal Resource constraint

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where \( \Pi \) are the benefits for intermediaries

In an “equal-gap” equilibrium

\[ \Pi = \Delta(i) \times \bar{\nu} \]

where

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

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

\[ \Delta(0) \leq 0 \text{ (Away from ZLB):} \]
\[ \cdot \text{CB sets nominal rate consistent with parity, } \Delta(i) = 0 \]
\[ \cdot \text{Reserve accumulation is irrelevant} \]

\[ \Delta(0) > 0 \text{ (At the ZLB):} \]
\[ \cdot \text{Domestic assets attractive to intermediaries, even at } i = 0 \]
\[ \cdot \text{CB must issue more liabilities to satisfy foreign appetite and buy foreign reserves} \]

\[ \sum q(s)f(s) + qF \leq \text{capital outflow} + (c_1 - y_1) \leq \text{trade deficit} = w \leq \text{capital inflow} \]
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- Domestic assets attractive to intermediaries, even at \(i = 0\)
- CB **must** issue more liabilities to satisfy foreign appetite and buy foreign reserves

\[
\sum q(s)f(s) + qF + (c_1 - y_1) = \overline{w}
\]

- \(q(s)f(s)\) capital outflow
- \(qF\) trade deficit
- \(\overline{w}\) capital inflow
Optimal CB policy given \((e_1, \{e_2(s)\})\)

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\[ \sum q(s)f(s) + \bar{q}F + (c_1 - y_1) = \bar{w} \]

- capital outflow
- trade deficit
- capital inflow
When are reserves more likely to be needed?

Recall

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

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

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

1. High expected appreciation
2. Low \( i^* \)
3. Higher is the covariance (safe heaven property)
CIP deviations for economies with rates close to zero

Nominal interest rate (%)

Annualized CIP gap (basis points)

See also Du, Tepper and Verdelhan (2017)
How to measure losses: UIP or CIP?

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

\[
\Delta(i) = \left\{ \frac{1 + i}{1 + i^*} \mathbb{E} \left[ \frac{e_0}{e_1(s)} \right] - 1 \right\} + \text{COV} \left[ \frac{q(s)}{\pi(s)}, \frac{e_0}{e_1(s)} \right]
\]

- **UIP deviation**

- **Risk premium**

- Empirical literature using UIP misses risk premium!
How to measure losses: UIP or CIP?

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\[\text{UIP deviation} \quad \text{risk premium}\]

- 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 $\Delta(i) = \text{CIP deviation}$:

$$\Delta(i) = \left\{ \frac{1 + i}{1 + i^*} \frac{e_0}{\hat{e}} - 1 \right\}$$

\[\text{CIP deviation}\]
Quantifying the costs in Switzerland

CIP deviations and Reserves

Annualized CIP gap (basis points)

Reserves/GDP (%)

CIP deviation

reserves/GDP

− Remark: can approximate \( \bar{w} = F - (c_1 - y_1) \sim F \)
- 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
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• Potentially role for purchases of domestic assets too
Conclusions

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  - Limited international arbitrage
  - Central bank intervention in FX markets
- At ZLB, accumulation of foreign reserves is necessary
- Costs of interventions = CIP × foreign reserves
- Rationalize recent evidence on CIP, interest rates, and reserves for advanced economies
- Agenda:
  - Optimal Reserve Management