Exchange Rate Determination under Limits to CIP Arbitrage

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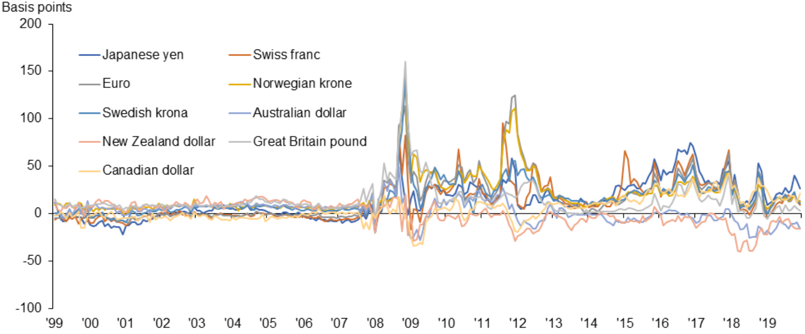
August 2024

Financial Segmentation and Limits to Arbitrage

- Increase in market segmentation since 2007. Limited arbitrage has implied deviations from CIP
- Synthetic USD borrowing often more expensive than direct USD borrowing: segmentation between "onshore" and "offshore" dollar markets
- Increases in CIP deviations often associated with "dollar shortages", i.e., an increase in the need for offshore dollars
- Federal Reserve has offered swap lines to alleviate dollar shortages

CIP Deviations

Deviations in covered interest parity among G10 currencies near zero before 2007, mostly positive since



NOTES: Covered interest parity deviation is the spread between the three-month synthetic dollar borrowing rate (via the swaps market) and the three-month U.S. dollar LIBOR. The synthetic dollar borrowing rate is the log of the three-month forward exchange rate minus the log of the spot exchange rate plus the three-month local currency interbank rate.

SOURCE: Bloomberg.

Exchange Rates and CIP Deviations

- The recent exchange rate literature has analyzed the impact of limited arbitrage on UIP deviations
  - E.g. Gabaix-Maggiori, Itskhoki-Muhkin
- To what extent do CIP deviations affect exchange rate behavior?
- We extend the recent models by introducing an FX swap market and imperfect CIP arbitrage
- FX swap market is larger than spot market, but is of limited interest when CIP holds
- Few papers link FX swaps (or forward) rates to spot exchange rates
  - Tsiang (1959) and Fang-Liao (2023) in partial equilibrium

Exchange Rates and CIP Deviations

- We propose a model where spot exchange rate and FX swap rate are determined jointly
- How does limited CIP arbitrage affect the response of exchange rates to shocks?
- First, there are "new" shocks that are specific to the swap market. Examples:
  - An increase in the demand for hedged dollar liquid assets
  - A reduction in CIP arbitrage
  - A reallocation from offshore to onshore dollars, leading to dollar shortages
  - Central bank swap lines
- These shocks do not matter when CIP holds

Exchange Rates and CIP Deviations

- Second, the impact of standard shocks to the spot market, e.g., UIP shocks or increase in global demand for USD assets, is amplified

- The implications for some other shocks are more complex

- We propose a simple graphical analysis representing the spot and FX swap markets to analyze these shocks

A Model of Segmented Dollar Markets

- We develop a two-country GE model with market segmentation in the spirit of Gabaix-Maggiori
  - We call the countries US (Home) and Europe (Foreign)
  - Three periods: $0, 1, 2$
- Asymmetric setup: full dollar dominance
  - US households only use dollars for their consumption and their assets
  - European households use both dollars and euros
- European households hold dollar liquid assets (money) issued in the US

A Model of Segmented Dollar Markets

- Strong segmentation assumption: households cannot issue foreign currency debt
- But European households can borrow dollars synthetically: borrow euros and get dollar in the swap market
- European households can also possibly borrow dollars from the ECB through Federal Reserve swap lines
- Households do not arbitrage between dollar and euro bonds or between onshore and offshore dollar bonds

A Model of Segmented Dollar Markets

- There are international UIP and CIP arbitrageurs
- UIP arbitrageurs are "standard"
- CIP arbitrageurs borrow in dollars in the US and provide dollars through the FX swap market: enable synthetic dollar borrowing by European households
- Before 2007, full CIP arbitrage. But limited arbitrage after the GFC

Swap and Spot Markets

- **Swap market**: European households demand FX swaps to hedge their dollar liquid assets and other exchange rate exposure: $D^{\$}_{F,t}$

- CIP arbitrageurs supply dollar swaps. Market equilibrium:

$$D^{\$}_{F,t} = B^{\$}_{CIP,t}$$

- **Spot market**: net demand of European households + UIP arbitrageurs + noise:

$$Q^{\$,spot}_{F,1} + Q^{\$,spot}_{UIP,1} + Q^{\$,spot}_{noise,1} = 0$$

Some Notation

- Synthetic dollar interest rate:

$$1 + i_t^{\$,syn} = \frac{F_t}{S_t}\left(1 + i_t^{€}\right)$$

- CIP deviation:

$$cip_1 = i_t^{\$,syn} - i_t^{\$}$$

- Pre-shock CIP: $\overline{cip}$

- Interest differential: $i^d = i^{\$} - i^{€}$

Goods Market

- Agents have CES consumption index of domestic and foreign goods
- Dominant currency: goods produced and consumed in Europe are invoiced in € and other goods are invoiced in $
- In period 1, prices are sticky in currency of invoicing. In period 2, they are flexible
- Period-2 non-asset income of European agents depends on s_2
- s_2 depend on the stochastic relative supply of Home vs Foreign goods

Money Demand

- Money demand is cash in advance:

$$M^{\$}_{H,1} = \psi C_{H,1}$$
$$M^{\$}_{F,1} = \psi\omega \left(S_1 P^*_1\right)^{\theta} C_{F,1}$$
$$M^{€}_{F,1} = \psi(1-\omega) \left(P^*_1\right)^{\theta} C_{F,1}$$

- European have both euro and dollar money demand. Dollar money demand represents the demand for dollar liquid assets

- Increase in ψ implies an increase in the demand for dollar liquid assets

- For given interest rate and exchange rate, it is fully hedged $\Rightarrow$ impacts the swap market and no impact on the spot market

Households Portfolios

- European households maximize $\quad EC_{F,2} - 0.5\gamma var(C_{F,2})$

- Period-2 budget constraint:

$$\begin{aligned} P_2^* C_{F,2} &= Y_{F,2} + \Pi_{FCB,2} + \frac{1}{S_2} M_{F,1}^{\$} + M_{F,1}^{€} + (1 + i_1^{€}) W_{F,1} \\ &\quad - \left(\frac{1 + i_1^{\$,syn}}{S_2} - \frac{1 + i_1^{€}}{S_1} \right) D_{F,1}^{\$} - \left(\frac{1 + i_1^{\$,ECB}}{S_2} - \frac{1 + i_1^{€}}{S_1} \right) D_{swap,1}^{\$} \end{aligned}$$

- Optimal synthetic dollar portfolio:

$$D_{F,1}^{\$} = \rho + M_{F,1}^{\$} - D_{swap,1}^{\$} - \frac{i_1^{\$,syn} - i_1^{€} + s_1}{\gamma\sigma^2}$$

- Increase in dollar money balances leads to one-for-one drop in synthetic dollar positions to hedge exchange rate risk

Other Portfolios

- CIP and UIP arbitrageurs are modeled as in Gabaix-Maggiori with intermediating capacity Γ_{CIP} and Γ_{UIP}
- CIP arbitrageurs:
$$B^{\$}_{CIP,1} = \frac{i_1^{\$,syn} - i_1^{\$}}{\Gamma_{CIP}}$$
- UIP arbitrageurs:
$$B^{€}_{UIP,1} = \frac{i_1^{€} - i_1^{\$} - s_1}{\Gamma_{UIP}}$$
- Noise traders have exogenous demand $B^{€}_{noise,0} = 0$ and $B^{€}_{noise,1} = n_1$
- Spot market equilibrium:
$$CA^{\$}_{H,1} + dM^{\$}_{F,1} - dD^{\$}_{F,1} - D^{\$}_{swap,1} - S_1 dB^{€}_{UIP,1} - S_1 B^{€}_{noise,1} = 0$$

Pre-Shock Equilibrium

- Assume $\Gamma_{UIP} = \gamma\sigma^2 = \Gamma$ and $\Gamma_{CIP} = \phi\Gamma$
- Let $n_1 = 0$ and $\bar{D}^{\$}_{swap} = 0$
- The CIP deviation is

$$\overline{cip} = \frac{\phi}{1+\phi}\left[\Gamma\left(\bar{M}^{\$}_F + \rho\right) - \bar{i}^d\right]$$

- Synthetic dollar borrowing:

$$\bar{D}^{\$}_F = \frac{1}{1+\phi}\left(\rho + \bar{M}^{\$}_F - \frac{\bar{i}^d}{\Gamma}\right)$$

- In equilibrium, the hedge ratio is $1/(1+\phi)$ when $\bar{i}^d = 0$

Linearized Model

- Linearized spot market schedule:

$$\nu_1 s_1 + cip_1 = shock_1^{spot}$$

- $\nu_1 > 0$: s_1 and cip_1 negatively related in spot market schedule

- When CIP deviation is higher, more costly to hedge $\Rightarrow$ increase in spot demand for dollars $\Rightarrow$ $s_1 \searrow$

Linearized Model

- Linearized swap market schedule:

$$\nu_2 s_1 + \frac{1+\phi}{\phi} cip_1 = shock_1^{swap}$$

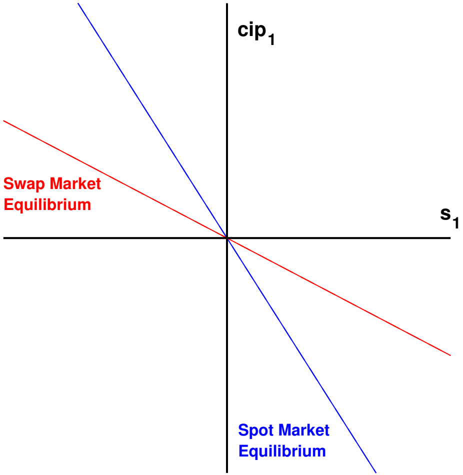
- Sign of ν_2 ambiguous, but positive with reasonable parameters

- An increase in cip_1 reduces demand for synthetic dollar. Compensated by a dollar appreciation to make dollar borrowing more attractive

- Flatter slope of swap market schedule

- When $\phi = 0$, swap market schedule is flat

Figure: Spot and Swap Market Equilibrium Schedules



Shocks

- Shocks to the FX swap market: no impact when CIP holds
- Shocks affecting only the spot market have standard effect, but the impact on the exchange rate is amplified
- Shocks affecting both markets are more complex

Swap Market Shock

- Swap market shocks:

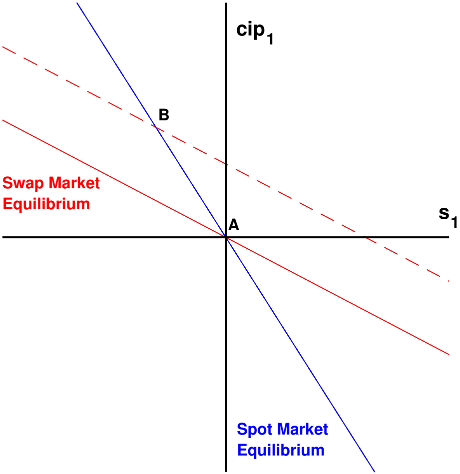
$$shock_1^{swap} = \Gamma\omega\bar{C}_{F,1}\hat{\psi} + \frac{\overline{cip}}{\phi}\frac{\hat{\Gamma}_{CIP}}{\Gamma_{CIP}} - \Gamma\hat{D}^{\$}_{swap,1}$$

$$+\Gamma\hat{\rho} - \hat{i}_1^d + \left(\overline{cip} + \bar{i}^d\right)\frac{\hat{\Gamma}_F}{\Gamma_F}$$

- Shocks in red only affect swap market. Example: "dash for cash", increase in ψ
- Increase in dollar liquidity is hedged $\Rightarrow$ demand for dollar swaps $\nearrow$. This raises the synthetic dollar interest rate $\Rightarrow$ hedging is more costly
- Europeans use the spot market to exchange euros for dollars. Causes a dollar appreciation

Shock to Swap Market

Figure: Rise in ψ or Γ_{CIP}



Central Bank Swap Lines

- Central bank swap lines between Fed and foreign central banks
- ECB and Fed exchange euros for dollars. ECB then provides dollar liquidity to European agents. At maturity the transaction is reversed
- The swap line increases the supply in the swap market and shifts down the swap market line
- Similar effect with shock to other sources of dollar funding, e.g., Europeans issuing dollar bonds

Spot Market Shock

- Spot market shocks

$$shock_1^{spot} = -\Gamma \hat{n}_1 + \overline{uip}\frac{\hat{\Gamma}_{UIP}}{\Gamma_{UIP}} + \Gamma\hat{\rho} - 2\hat{i}_1^d + \left(\overline{cip} + \overline{uip}\right)\frac{\hat{\Gamma}_F}{\Gamma_F}$$

- Noise shock and UIP arbitrage shocks only affects spot market
- UIP shocks, driven by an increase in noise n_1 or reduction in UIP arbitrage Γ_{UIP}, imply an appreciation. Appreciation is larger with CIP deviations

UIP Shock

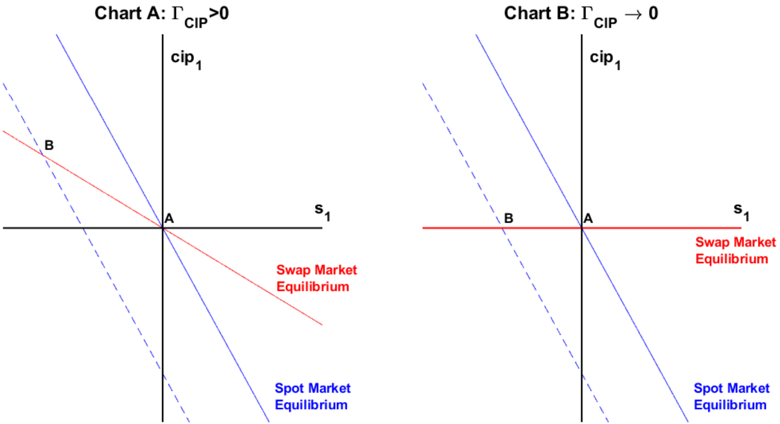
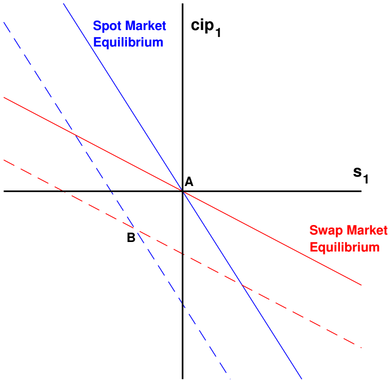


Chart A: Γ_{CIP}>0
cip1
B
A
s1
Swap Market Equilibrium
Spot Market Equilibrium
Chart B: $\Gamma_{CIP} \rightarrow 0$
cip1
B
A
s1
Swap Market Equilibrium
Spot Market Equilibrium

Monetary Policy Shocks

- Monetary policy shocks (i^d) affect both swap and spot market schedules
- Example: monetary contraction in the US, $i^d \nearrow$
- Both curves shift down. Swap market shifts down because synthetic dollar is more expensive (for a given cip_1)
- Dollar appreciates but less than without CIP deviations. CIP deviation decreases

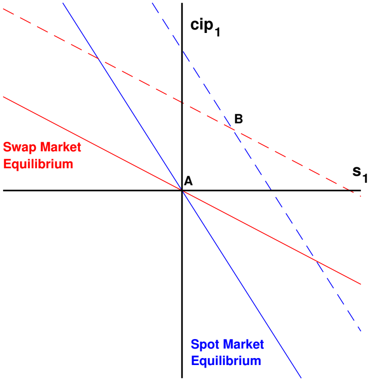
Monetary Policy Shock



Currency Hedge Shocks

- Hedging shocks (changes in ρ or $\gamma\sigma^2$) also affect both swap and spot market schedules
- Increase in hedged dollars through swap market reduces demand for spot dollars
- Increase in hedging increases CIP deviation
- But leads to dollar depreciation

Hedging Shock



Conclusion

- We extend the recent literature by introducing explicitly the FX swap market and limits to CIP arbitrage
- We identify "new" shocks that affect the exchange rate
- We examine how the impact of standard shocks is affected by limited CIP arbitrage
- The framework allows to analyze the impact of central bank swap lines on exchange rates