Exchange Rate Determinants

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Exchange Rates as Shock Absorbers

- currency markets and bond markets are tightly connected
- exchange rates adjust to ensure that returns are aligned with risk for foreign and domestic investors
- exchange rate pricing $\sim$ price/dividend ratio for stocks

- exchange rates absorb shocks to future
  1. interest rates (short rates) (cash flows).
  3. deviations from CIP (convenience yields/balance sheet constraints).

- shocks to discount rate variation explain a large share of FX variance over short horizons
Exchange Rates as Shock Absorbers

- Currency markets and bond markets are tightly connected.
- Exchange rates adjust to ensure that returns are aligned with risk for foreign and domestic investors.
- Exchange rate pricing ~ price/dividend ratio for stocks.

- Exchange rates absorb shocks to future:
  1. Interest rates (short rates) (\textit{cash flows}).
  2. Deviations from U.I.P. (\textit{discount rates}): foreign currency risk premia (FXRP). \textit{discussed by Adrien}.
  3. Deviations from CIP (\textit{convenience yields/balance sheet constraints}). \textit{discussed by Wenxin}.

- Shocks to discount rate variation explain a large share of FX variance over short horizons.
Outline

1. Exchange Rates and Short Yields
2. Exchange Rates and Long Yields
3. Exchange Rates and Convenience Yields in Bonds
Foreign Demand for U.S. Treasurys

- $S_t$ denotes exchange rate in units of LC/FC; an increase means an appreciation of FC.

- Foreign investors can invest in U.S. Treasurys and foreign bonds:

  \[
  E_t \left( M_{t+1}^* \frac{S_{t+1}}{S_t} e^{y^*_t} \right) = 1, \\
  E_t \left( M_{t+1}^* e^{y^*_t} \right) = 1.
  \]

- Use log-normality, Euler equations can be restated as:

  \[
  0 = E_t \left[ m^*_{t+1} \right] + \frac{1}{2} \text{var}_t \left[ m^*_{t+1} \right] + y^*_t, \\
  0 = E_t \left[ m^*_{t+1} \right] + \frac{1}{2} \text{var}_t \left[ m^*_{t+1} \right] + y^*_t \\
  + E_t[\Delta s_{t+1}] + \frac{1}{2} \text{var}_t[\Delta s_{t+1}] - RP^*_t, \\
  \]

  with $RP^*_t = -\text{cov}_t (m^*_{t+1}, \Delta s_{t+1})$. 

the log FXRP \( rp_t^* = RP_t^* - \frac{1}{2} \text{var}_t[\Delta s_{t+1}] \) is given by:

\[
\mathbb{E}_t[\Delta s_{t+1}] + \left( y_t^s - y_t^* \right) = rp_t^* = \mathbb{E}_t r_{x_{t+1}}^{s,FX},
\]

where \( r_{x_{t+1}}^{s,FX} = \Delta s_{t+1} + \left( y_t^s - y_t^* \right) \).

we can iterate on this difference equation for \( s_t \).

\[
s_t = \mathbb{E}_t[s_{t+1}] + \left( y_t^s - y_t^* \right) - \mathbb{E}_t r_{x_{t+1}}^{s,FX}.
\]

fundamental exchange rate valuation equation (FEVE):

\[
s_t^s = \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^s - y_{t+j}^*) - \mathbb{E}_t \sum_{j=1}^{\infty} r_{x_{t+j}}^{s,FX} + \mathbb{E}_t [ \lim_{j \to \infty} s_{t+j}^s ].
\]
Exchange Rates and Short Yields

Result

The log of the nominal exchange rate in FC/USD is:

\[ S_t^\$ = \mathbb{E}_t \sum_{j=0}^{\infty} (y_t^\$ - y_t^*) - \mathbb{E}_t \sum_{j=1}^{\infty} r x_{t+j}^{\$,FX} + \mathbb{E}_t [ \lim_{j \to \infty} s_t^{\$} ]. \]

\( \text{deviations from short-run U.I.P.} \)

Campbell and Clarida [1987], Froot and Ramadorai [2005]

- does not rely on complete markets: \( M_{t+1}^* = M_{t+1} S_{t+1}^{\$} \)
- relies only on bond investor’s Euler equation, not on Euler equations in other asset markets.
Exchange Rates and Short Yields

Result

The log of the nominal exchange rate in FC/USD is:

\[ s_t^* = \mathbb{E}_t \sum_{j=0}^{\infty} (y_t^j - y_t^{*j}) - \mathbb{E}_t \sum_{j=1}^{\infty} r_{X_t+j}^*,FX + \mathbb{E}_t [\lim_{j \to \infty} s_t^{*j}] \]

\[ \text{deviations from short-run U.I.P} \]

Campbell and Clarida [1987], Froot and Ramadorai [2005]

- dollar exchange rate today reflects future
  1. cash flows: short rate differences \( (y_t^j - y_t^{*j}) \)
  2. discount rates: FXRP \( \mathbb{E}_t r_{X_t+j}^*,FX = y_t^j - y_t^{*j} + \mathbb{E}_{t+j} \Delta s_{t+j+1} \)

- dollar appreciates when \( y_t^j \uparrow \) and dollar FXRP \( \mathbb{E}_t r_{X_t+1+j}^*,FX \downarrow \)
Empirical Evidence: Unconditional Carry Trade

Result

The log of the nominal exchange rate in USD/FC is:

\[
\frac{s}{t} = \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^* - y_{t+j}^\dollar) - \mathbb{E}_t \sum_{j=1}^{\infty} r_{x_{t+j}^*,FX}^\dollar + \mathbb{E}_t \left[ \lim_{j \to \infty} s_{t+j}^* \right].
\]

- persistent interest rate diffs. across developed and EM countries (Lustig, Roussanov, and Verdelhan [2011], Hassan and Mano [2019])

- persistently high \( y_{t}^* \) → persistently high FXRP

\[
\mathbb{E}_t[r_{X_{t+j}^*,FX}^\dollar] = y_{t}^* - y_{t}^\dollar + \mathbb{E}_t \Delta s_{t+1}^\dollar \text{ earned by US investors going long in FX}
\]

- discount rates counteract cash flows \( \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^* - y_{t+j}^\dollar) \) (Unconditional Carry Trade)

- this keeps foreign currencies with persistently high (low) interest rates from appreciating (depreciating).
Outline

1. Exchange Rates and Short Yields
2. Exchange Rates and Long Yields
3. Exchange Rates and Convenience Yields in Bonds
Exchange Rates and Long Yields

- Currency markets and bond markets are tightly connected.
- Exchange rates adjust to ensure that returns are aligned with risk for foreign and domestic investors.

- Exchange rates reflect future:
  1. Long rates (cash flows)
  2. Deviations from short-run U.I.P. in FX markets
  3. Deviations from Expectations Hypothesis in bond markets

- When exchange rates are stationary, then (2) and (3) cancel out.
- Long-run UIP is restored.
Returns and Yields

- note that \( hpr_{t+1}^N = p_{t+1}^{N-1} - p_t^N \) is a difference equation that can be solved forwards:

\[
p_t^N = - \sum_{i=0}^{N-1} hpr_{t+i+1}^{N-i}
\]

\[
y_t^N = (1/N) \sum_{i=0}^{N-1} hpr_{t+i+1}^{N-i}
\]

- define \( rx_t^*,N = hpr_t^N - y_t^* \).
- note \( Ny_t^*,N = \sum_{j=1}^N rx_{t+j}^*,N-j+1 + \sum_{j=0}^N y_t^* \).
- plug into the FEVE:

\[
s_t^* = \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^* - y_{t+j}^*) - \mathbb{E}_t \sum_{j=1}^{\infty} rx_{t+j}^*,FX + \mathbb{E}_t[ \lim_{j \to \infty} s_{t+j} ].
\]
Result

The log of the exchange rate is

\[
\log s_t^\$ = \lim_{N \to \infty} N(y_t^\$,N - y_t^\$,N) + \lim_{N \to \infty} \mathbb{E}_t^* \sum_{j=1}^{N} (r_x^*,N-j+1 - r_x^\$,N-j+1)
\]

 deviations from EH

\[
- \lim_{N \to \infty} \mathbb{E}_t \sum_{j=1}^{N} r_x^\$,FX_{t+j}
\]

 deviations from short-run UIP

\[
+ \mathbb{E}_t \left[ \lim_{j \to \infty} s_{t+j}^\$ \right]
\]
Exchange Rates and Long Yields

- the dollar exchange rate is given by:

\[ s_t^* \] = \lim_{N \to \infty} N( y_t^{*,N} - y_t^{*,N} ) + \lim_{N \to \infty} E_t^* \sum_{j=1}^{N} \left( r_{N-j+1}^{*,N} - r_{N-j+1}^{*,N} \right) 

\text{deviations from EH}

\[ - \lim_{N \to \infty} E_t \sum_{j=1}^{N} r_{N-j+1}^{*,FX} + E_t \left[ \lim_{j \to \infty} s_{t+j}^{*,} \right] 
\text{deviations from short-run UIP}

- dollar appreciates when

1. long USD yields \textbf{today} \uparrow
2. future LC US BRP \( r_{N-j+1}^{*,N} \) \downarrow
da future dollar FXRP \( r_{N-j+1}^{*,FX} \) \downarrow
Stationary Exchange Rates and Long Yields

▷ iff

1. exchange rates are stationary, or
2. shocks to long-run exchange rates are not priced.

▷ exchange rate reflects differences in long yields today

$$\frac{1}{N} (s_t - s_0) = \lim_{N \to \infty} (y_t^N - y_t^*)$$

long-run UIP

$$+ \lim_{N \to \infty} \frac{1}{N} \sum_{j=1}^{N} (r_{x,t+j}^{*,N-j+1} - r_{x,t+j}^*) - \lim_{N \to \infty} \frac{1}{N} \sum_{j=1}^{N} r_{x,t+j}^*)$$

FXRP offset by LC BRP

▷ long-run U.I.P. because no additional long-run risk in long USD bond for foreign investor. (Lustig, Stathopoulos, and Verdelhan [2019])
Stationary Exchange Rates and Long Yields

Result

The log exchange rate reflects differences in long yields today

\[ \frac{1}{N} (s_t^\$ - s_0) = \lim_{N \to \infty} (y_t^N \$ - y_t^*,N) \]

long-run UIP

- FXRP offset by LC BRP
- long-run U.I.P.: no additional long-run risk in long USD bond for foreign investor. (Lustig et al. [2019])
  - or any model without permanent, country-specific priced innovations (see also Backus, Boyarchenko, and Chernov [2018]);
  - \approx Gourinchas, Ray, and Vayanos [2019] and Greenwood, Hanson, Stein, and Sunderam [2020] models
Empirical Evidence: TS of Carry Trade FXRP

- High FXRP offset by negative LC BRP (Lustig et al. [2019])

- In X-section: no currency carry premium at long maturities

\[
\mathbb{E}_t[r_{x_{t+1}}^{\$,N}] \approx \mathbb{E}_t[r_{x_{t+1}}^{JPY,N} + r_{x_{t+1}}^{USD,FX}] \approx \mathbb{E}_t[r_{x_{t+1}}^{AUD,N} + r_{x_{t+1}}^{USD,FX}]
\]

- In Time-Series: current interest rates/term spread do not predict long GBP bond excess returns converted into USD

\[
r_{x_{t+j}}^{GBP,N} + r_{x_{t+j}}^{USD,FX}
\]

- Consistent with evidence in favor of long-run U.I.P. (Meredith and Chinn [2005], Boudoukh, Richardson, and Whitelaw [2013])
Empirical Evidence: TS of Carry Trade FXRP

- Exchange rates should be spanned by long rates.

$$s_t - s_0 = \lim_{N \to \infty} N(Y^N_t - Y^*_t)$$

\[\text{long-run UIP}\]

$$+ \lim_{N \to \infty} \mathbb{E}^*_t \sum_{j=1}^{N} (r^N_{t+j} - r^*_t) - \lim_{N \to \infty} \mathbb{E}_t \sum_{j=1}^{N} r^*_{t+j}$$

- In data, exchange rates sensitive to long rates \((\text{Greenwood et al. [2020]})\), but maybe not enough? (see work by \text{Chernov and Creal [2018]})
Why Traditional DAPMs Fail to Match Evidence

- see habit model (Verdelhan [2010]) and LRR model (Bansal and Shaliastovich [2012])
  - large permanent innovations to pricing kernel to generate large equity premium relative to long BRP (Alvarez and Jermann [2005], Hansen and Scheinkman [2009])
- permanent innovations to (real) exchange rate that are priced by marginal investors in FX and bond markets

\[
\lim_{N \to \infty} E_t \sum_{j=1}^{N} r_{x_{t+j}}^{*,N-j+1} \neq \lim_{N \to \infty} E_t \sum_{j=1}^{N} [r_{x_{t+j}}^{S,N-j+1} + r_{x_{t+j}}^{*,FX}]
\]

- permanent country-specific innovations to the pricing kernel lead to deviations from long-run PPP and long-run U.I.P
- no downward sloping TS of carry trade FX RP (no offset of BRP and FXRP)
Policy Experiment: Bond Supply Shock

- increase in US supply of long bonds: US arbitrageurs demand larger BRP;

1. increase in LC BRP in U.S. \(\rightarrow\) in USD long yields \(\rightarrow\) USD appreciates right away to offset the effect of the higher USD yield. \(s_t - s_0 \rightarrow \lim_{N \to \infty} N(y_{t,N}^\$, - y_{t,N}^*).\) 
   e.g. if \(y_{t,20}^\$\) \(\rightarrow\) by 5 bps, then we expect 5 bps \(\downarrow\) p.a. of the USD over the next 20 years; USD \(\rightarrow\) by 100 bps now.

2. increase in BRP in U.S \(\rightarrow\) offset by FXRP \(r_{x_t}^{\$\cdot FX} \downarrow\)

\[
\lim_{N \to \infty} \mathbb{E}_t^* \sum_{j=1}^{N} r_{x_t}^{*,N-j+1} = \lim_{N \to \infty} \mathbb{E}_t \sum_{j=1}^{N} [r_{x_t}^{\$,N-j+1} \uparrow + r_{x_t}^{\$\cdot FX} \downarrow]
\]

- in long run foreign investor does not need higher return for holding long USD bonds than foreign bonds; no long-run exchange rate risk.
Policy Experiment: QE

shrink net supply of long bonds: US arbitrageurs earn smaller BRP

1. decrease in LC BRP in U.S. $\rightarrow$ in USD long yields $\rightarrow$ USD depreciates right away to offset the effect of the lower USD yield. $s_t - s_0 \downarrow = \lim_{N \to \infty} N(y_{t,N} - y_{t,N}^*)$. e.g. if $y_{t,20} \downarrow$ by 5 bps, then we expect 5 bps $\uparrow$ p.a. of the USD over the next 20 years; USD $\downarrow$ by 100 bps now.

2. decrease in LC BRP in U.S $\rightarrow$ offset by FXRP $r_{t+j}^{\$,FX}$

$$\lim_{N \to \infty} \mathbb{E}_t^* \sum_{j=1}^N r_{t+j}^{*,N-j+1} = \lim_{N \to \infty} \mathbb{E}_t \sum_{j=1}^N [r_{t+j}^{\$,N-j+1} \downarrow + r_{t+j}^{\$,FX} \uparrow]$$

in long run foreign investor does not accept lower LC return for holding long USD bonds than foreign bonds; no long-run exchange rate risk.
Outline

1. Exchange Rates and Short Yields
2. Exchange Rates and Long Yields
3. **Exchange Rates and Convenience Yields in Bonds**
Foreign Demand for U.S. Treasurys

Foreign investors can invest in U.S. Treasurys and foreign bonds:

\[
\mathbb{E}_t \left( M_{t+1}^* \frac{S_{t+1}}{S_t} e^{y_t^*} \right) = e^{-\lambda_t^*,*},
\]

\[
\mathbb{E}_t \left( M_{t+1}^* e^{y_t^*} \right) = e^{-\lambda_t^*,*}.
\]

use log-normality, Euler equations can be restated as:

\[
-\lambda_t^*,* = \mathbb{E}_t \left[ m_{t+1}^* \right] + \frac{1}{2} \text{var}_t \left[ m_{t+1}^* \right] + y_t^*,
\]

\[
-\lambda_t^*,* = \mathbb{E}_t \left[ m_{t+1}^* \right] + \frac{1}{2} \text{var}_t \left[ m_{t+1}^* \right] + y_t^*
\]

\[
+ \mathbb{E}_t [\Delta s_{t+1}] + \frac{1}{2} \text{var}_t [\Delta s_{t+1}] - RP_t^*,
\]

with \( RP_t^* = -\text{cov}_t \left( m_{t+1}^*, \Delta s_{t+1} \right) \).
Exchange Rates and Convenience Yields

- the log FXRP $r_p^* = R P^* - \frac{1}{2} \text{var}_t[\Delta s_{t+1}]$ is given by:
  \[ E_t[\Delta s_{t+1}] + (y_t^$ - y_t^*) = r_p^* - (\lambda_t^$,* - \lambda_t^*,*). \]

- we can iterate on this difference equation for $s_t$.
  \[ s_t = E_t[s_{t+1}] + (\lambda_t^$,* - \lambda_t^*,*) + (y_t^$ - y_t^*) - E_t r_{t+1}^* , FX \]

- fundamental exchange rate valuation equation:
  \[ s_t^* = E_t \sum_{j=0}^{\infty} (\lambda_{t+j}^$,* - \lambda_{t+j}^*,*) + E_t \sum_{j=0}^{\infty} (y_{t+j}^$ - y_{t+j}^*) - E_t \sum_{j=1}^{\infty} r_{t+j}^* , FX \]
  \[ + E_t \lim_{j \to \infty} s_{t+j}^$. \]
Exchange Rates and Convenience Yields

Result

The nominal exchange rate in FC/USD is:

\[
S_t^* = \mathbb{E}_t \sum_{j=0}^{\infty} (\lambda_{t+j}^\$,\*-t^* - \lambda_{t+j}^{*,*}) + \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^\$ - y_{t+j}^*) - \mathbb{E}_t \sum_{j=1}^{\infty} r x_{t+j}^{*,FX} + \ldots
\]

Jiang, Krishnamurthy, and Lustig [2018]

 mêasured by CIP deviation in Treasury

\[
(1 - \beta)(\lambda_{t+j}^\$,\*-t^* - \lambda_{t+j}^{*,*}) = -x_t \text{ also in } Du, Im, \text{ and Schreger [2018]}
\]

dollar appreciates when future US Treasury CY \(\lambda_{t+j}^\$,\*\) ↑
Define Treasury basis as

\[ x_t^{Treasury} \equiv y_t^\$ - (y_t^* - (f_t^1 - s_t)) \]

Cash Treasury position offers more convenience yield than a foreign government bond (less liquid) hedged into USD

The basis is our proxy for the convenience yield, \( \lambda_t^* \):

\[ x_t^{Treasury} = - (\lambda_t^\$,* - \lambda_t^*,*) \left( 1 - \beta^*,h \right) \]

or,

\[ (\lambda_t^\$,* - \lambda_t^*,*) = - \frac{x_t^{Treasury}}{1 - \beta^*,h} \]
Exchange Rates and Convenience Yields

Result

The nominal exchange rate in FC/USD is:

\[ s_t^\$ = \mathbb{E}_t \sum_{j=0}^{\infty} (\lambda_{t+j}^\$,\$ - \lambda_{t+j}^*,*) + \mathbb{E}_t \sum_{j=0}^{\infty} (y_{t+j}^\$ - y_{t+j}^*) - \mathbb{E}_t \sum_{j=1}^{\infty} r x_{t+j}^{*, FX} + \ldots \]

*Jiang et al. [2018]*

- dollar appreciates when future US Treasury CY \( \lambda_{t+j}^\$,\$ \uparrow \)
- CY channel also creates a role for flows/quantities.
  1. QE: when Fed buys long-dated Treasurys, \( \lambda_{t+j}^\$,\$ \uparrow \rightarrow s_t \uparrow \)
     (wrong way?)
  2. QE: when Fed buys MBS and issues reserves, \( \lambda_{t+j}^\$,\$ \downarrow \rightarrow s_t \downarrow \)
  3. QE: when Fed buys long-dated Treasurys and issues reserves??
Conclusion

- exchange rates absorb shocks to future

1. interest rates (short rates) (**cash flows**).
2. deviations from U.I.P. (**discount rates**): foreign currency risk premia (FXRP).
3. deviations from CIP (**convenience yields**).


