Breaking Parity

Equilibrium exchange rates and currency premia

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VERY PRELIMINARY

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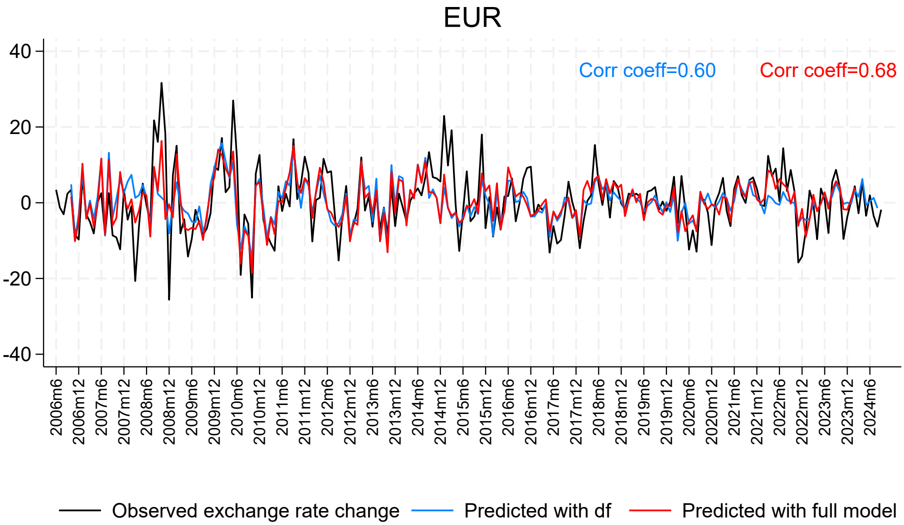
Introduction



Outline

Model of Intermediary Bank

- Balance sheet:

$$B_t^* + H_t^* + A_t^* = W_t^* + D_t^*$$

Assets						Liabilities
$B_t^* \geq 0$	:	$\underline{R}_t^*$	\$ reserves	net worth	W_t^* :	ROE
$H_t^* \geq 0$	:	$\tilde{R}_{t+1}^*$	\$ risky investment	borrowing in \$	D_t^* :	R_t^*
A_t^*	:	$R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$	£ investment (\$ value)			

Off balance sheet (zero-wealth positions)			
F_t^*	:	$\frac{R_t \mathcal{E}_t}{\mathcal{F}_t}\left(\frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1\right)$	currency forward
S_t^*	:	$R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}$	currency swap

Evolution of Net Worth

- **Lemma**:

$$W^*_{t+1} = R^*_t(W^*_t - Y^*_t) + \underline{R}^*_t B^*_t + \tilde{R}^*_{t+1} H^*_t + CIP_t \cdot X^*_t + UIP_{t+1} \cdot Z^*_t$$

  - where exposures are:

$$Y^*_t = B^*_t + H^*_t, \qquad X^*_t \equiv F^*_t + S^*_t, \qquad Z^*_t \equiv A^*_t + F^*_t$$

  - and premia are:

$$UIP_{t+1} \equiv R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - R^*_t \qquad \text{and} \qquad CIP_t \equiv R^*_t - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}$$

Intermediary Supply of Currency

- The objective of the bank:

$$\max_{B_t^* \geq 0, H_t^* \geq 0, A_t^*, F_t^*, S_t^*} \mathbb{E}_t \Theta_{t+1} W_{t+1}^*, \qquad \text{s.t. } \mathbb{E}_t \Theta_{t+1} = 1/R_t^*$$

- and the balance sheet constraint:

$$B_t^* \geq a_t [Y_t^* - B_t^*]^+ + b_t |Z_t^*| + \delta |X_t^*|, \qquad a_t \equiv \frac{\alpha}{2} \frac{|Y_t^* - B_t^*|}{W_t^*}, \qquad b_t \equiv \frac{\gamma \sigma_t}{2} \frac{|Z_t^*|}{W_t^*}$$

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- **Proposition**: If $\underline{R}_t^* < R_t^*$ and $\mathbb{E}_t[\Theta_{t+1}\tilde{R}_{t+1}] > 1$, then $\mu_t = R_t^* - \underline{R}_t^* > 0$ and

$$\overline{UIP}_t = \gamma \mu_t \sigma_t \frac{Z_t^*}{W_t^*} \qquad \text{and} \qquad CIP_t = \delta \mu_t \cdot \text{sign}(X_t^*)$$

  - where $\overline{UIP}_t \equiv \mathbb{E}_t \big\{ \frac{\Theta_{t+1}}{\mathbb{E}_t \Theta_{t+1}} UIP_{t+1} \big\}$ and $\sigma_t^2 = R_t^2 \cdot \text{var}_t\big(\mathcal{E}_t / \mathcal{E}_{t+1}\big)$
  - expected return on a forward F_t position is $\overline{UIP}_t + CIP_t$

Currency Market Equilibrium: aggregation

- A collection of heterogeneous intermediaries indexed with i that face exogenous balance sheet constraint parameters $(\gamma_{it}, \delta_{it})$ and endogenous $\{W_{it}^*, X_{it}^*, Z_{it}^*\}$

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- Denote $\mathbb{Z}_t$ and $\mathbb{X}_t$ aggregate demand to sell currency risk and buy currency swaps
- In equilibrium, dealer banks (intermediaries) clear the currency market:

$$\mathbb{Z}_t^* = \sum_i (A_{it}^* + F_{it}^*) \quad \text{and} \quad \mathbb{X}_t^* = \sum_i (F_{it}^* + S_{it}^*)$$

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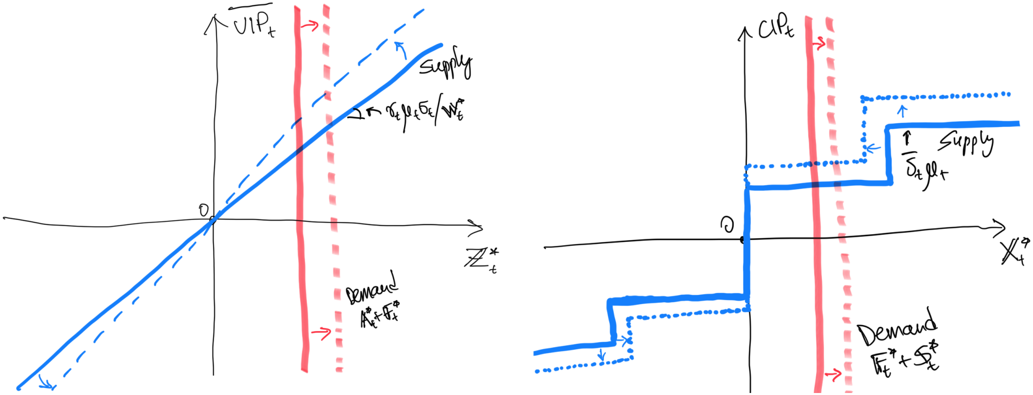
- **Proposition**: Eqm UIP & CIP premia as functions of agg. FX demand $(\mathbb{Z}^*_t, \mathbb{X}^*_t)$:

$$\overline{UIP}_t = \bar{\gamma}_t \mu_t \sigma_t \cdot \frac{\mathbb{Z}^*_t}{\mathbb{W}^*_t}, \qquad CIP_t = \bar{\delta}_t \mu_t \cdot \mathrm{sign}(\mathbb{X}^*_t),$$

where $\mathbb{W}^*_t \equiv \sum_i W^*_{it}$, $\bar{\gamma}_t \equiv \left(\sum_i \frac{W^*_{it}/\gamma_{it}}{\mathbb{W}^*_t}\right)^{-1}$, and $\bar{\delta}_t = \delta_{it}$ of marginal bank.

Currency Market Equilibrium: illustration



Summary of Theory

- In the panel of currencies k:

$$\overline{UIP}_{kt} \equiv R_{kt} \frac{\mathcal{E}_{kt}}{\widehat{\mathcal{E}}_{k,t+1}} - R_t^* = \mu_t \bar{\gamma}_{kt} \sigma_{kt} \cdot \frac{\mathbb{Z}_{kt}^*}{\mathbb{W}_{kt}^*}, \qquad CIP_{kt} \equiv R_t^* - R_{kt} \frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} = \mu_t \bar{\delta}_{kt} \cdot \operatorname{sign}(\mathbb{X}_{kt}^*),$$

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- In cross section, currencies with excess supply of local-currency savings (and v.v.):

$$\mathbb{E}\big\{\overline{UIP}_{kt}\big\} = \mathbb{E}\{R_{kt} - R_t^*\} < 0,$$

$$CIP_{kt} = R_t^* - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} < 0 \quad \Rightarrow \quad \frac{\mathcal{F}_{kt}}{\mathcal{E}_{kt}} < \frac{R_{kt}}{R_t^*} < 1$$

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- In time series, for $\mathrm{d}f_{kt}^*$ such that $\mathrm{d}\mathbb{Z}_{kt}^*/\mathrm{d}f_{kt}^* > 0$, $\mathrm{d}\mathbb{X}_{kt}^*/\mathrm{d}f_{kt}^* > 0$:

$$\mathrm{d}\,\overline{UIP}_{kt}/\mathrm{d}f_{kt}^* > 0, \quad \mathrm{d}\,CIP_{kt}/\mathrm{d}f_{kt}^* = 0 \;\text{ and }\; \mathrm{d}\left|\overline{UIP}_{kt}\right|/\mathrm{d}\mu_t > 0, \quad \mathrm{d}\left|CIP_{kt}\right|/\mathrm{d}\mu_t > 0$$

Outline

Theoretical Framework

- Intermediary supply of currency
- Currency market equilibrium

Empirical Results

- Data
- Cross-Section
- Dynamics of currency premia
- Exchange Rates

Interpretations

Data

- Currency premia:

$$
\begin{aligned}
CIP_{kt} &= -(r_{kt} - r_t^{US}) + 4 \cdot (\log \mathcal{F}_{kt} - \log \mathcal{E}_{kt}), \\
UIP_{k,t+3} &= \quad (r_{kt} - r_t^{US}) - 4 \cdot (\log \mathcal{E}_{k,t+3} - \log \mathcal{E}_{kt}), \\
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- Dealer banks' net FX futures position from the CFTC's TFF weekly report
  - — futures positions on CME: G7+ & 4 EMs (MXN, ZAR, BRL, RUB) vs USD
  - — split 4 ways: Dealer/Intermediary, Asset Manager, Leveraged Funds, & Other

$$
f^*_{kt} = 100 \cdot \frac{\text{Dealer Net Position}_{kt}}{\frac{1}{12}\sum_{j=0}^{11} \text{Open Interest}_{k,t-j}}, \qquad \mathrm{std}(\Delta f^*_{kt}) \approx 20
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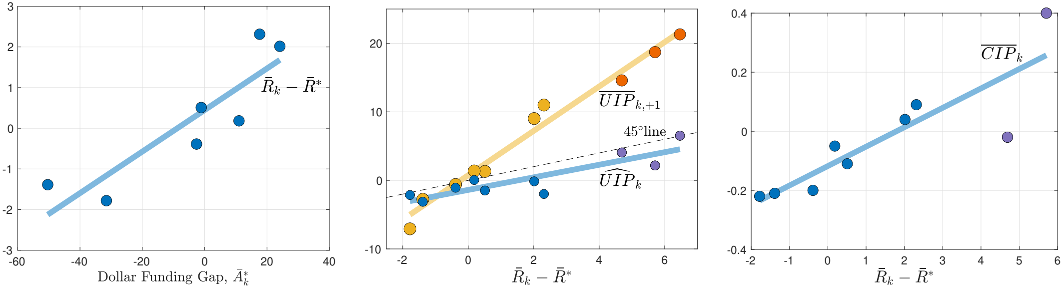
$$

- Various conventional measures of financial and dollar cycles:
  - — VIX, broad dollar index, treasury basis, intermediary wealth

Cross-section of Currency Returns



	Funding gap $\mathbb{A}^*_{kt}$	Interest rate gap $R_{kt} - R^*_t$	Carry return $UIP_{k,t+1}$	Survey UIP $\widehat{UIP}_{kt}$	CIP premium CIP_{kt}
<u>Funding</u>					
JPY	-31.53 (7.51)	-1.78 (1.71)	-7.07 (19.58)	-2.13 (9.42)	-0.22 (0.17)
CHF	-50.36 (23.51)	-1.39 (1.19)	-2.76 (18.10)	-3.12 (10.13)	-0.21 (0.21)
<u>Balanced</u>					
EUR	-2.61 (5.60)	-0.39 (1.32)	-0.60 (19.49)	-1.07 (9.74)	-0.20 (0.25)
GBP	-1.10 (5.64)	0.51 (1.26)	1.31 (18.18)	-1.48 (7.94)	-0.11 (0.17)
<u>Investment</u>					
CAD	11.02 (6.30)	0.18 (0.75)	1.38 (15.92)	0.06 (7.30)	-0.05 (0.14)
AUD	24.12 (6.13)	2.02 (1.66)	9.02 (25.47)	-0.14 (12.63)	0.04 (0.17)
NZD	17.64 (8.19)	2.31 (1.55)	10.99 (24.94)	-1.98 (13.33)	0.09 (0.20)
<u>Emerging</u>					
MXN	3.83 (3.29)	4.69 (1.36)	14.58 (23.59)	4.07 (8.54)	-0.02 (0.69)
ZAR	1.87 (9.13)	5.71 (2.07)	18.71 (34.82)	2.18 (16.50)	0.40 (0.40)

Cross-section of Currency Returns: Observations

1. Countries with excess supply of local-currency savings have low nominal interest rates in local currency (relative to R^*), and vice versa
2. Countries with high local-currency interest rates, feature UIP deviations roughly in proportion with interest rate differential (using market expectations) or larger (using average realized carry returns), and vice versa
   - $\approx$ one-to-one pass-through of nominal interest rate differential into UIP premium
3. The same is true for CIP deviations, which implies a positive correlation between $R_{kt} - R_t^*$ and $CIP_{kt} := R_t^* - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}}$ in the cross section
   - while $\mathcal{E}_{k,t+1} \approx \mathcal{E}_{kt}$, we have $\mathcal{F}_{kt}/\mathcal{E}_{kt} > R_{kt}/R_t^* > 0$, and vice versa
   - this is the forward premium puzzle in the long run (cross section)
4. Average CIP deviations are an order of magnitude smaller than average UIP deviations (20 vs 200 bps). The time series variation (std) in CIP deviations is two order of magnitudes smaller relative to UIP deviations (0.2% vs 10%).

Groups of Countries

1. **Funding**: JPY and CHE
   - with $R_{kt} < R_t^*$ and negative UIP and CIP premia
2. **Balanced**: EUR and GBP
   - with $R_{kt} \approx R_t^*$ and small average UIP and CIP deviations
   - EUR often behaves like funding. GBP often behaves like investment/commodity
3. **Investment/commodity**: CAD, AUD and NZD
   - with $R_{kt} > R_t^*$ and positive UIP and CIP premia
   - CAD is recently more like GBP, and AUD recently as well
   - NZD often proxies EMs. Nonetheless, we include it as G7+ currency in our analysis.
4. **Emerging Markets**: MXN, ZAR, RUB, BRL
   - with $R_{kt} \gg R_t^*$ and large positive UIP premium

Dynamic Specification

- For various variables of interest v_{kt} and controls w_{kt}, we estimate:

$$\Delta v_{kt} = \alpha_k + \delta_t + \sum_{j=0,1,2} \beta_j \Delta f^*_{k,t-j} + \gamma w_{kt} + \rho v_{k,t-1} + \varepsilon_{kt}$$

- Our main RHS variable exibits a near-random-walk behavior with some mean reversion (see IRF below):

$$\Delta f^*_{kt} = \alpha_k + \delta_t - \underset{[4.50]}{0.130} \cdot f^*_{k,t-1} + \underset{[5.20]}{0.183} \cdot \Delta f^*_{k,t-1} - \underset{[3.83]}{0.119} \cdot \Delta f^*_{k,t-2} + \epsilon_{kt}, \quad R^2 = 0.402$$

- We estimate a dynamic impulse responses of v_{kt} projected on f_{kt} innovations
  - these innovations are not exogenous shocks per se, but rather identify a dynamic event in the time-series (deal banks expanding their currency positions)

Covered and Uncovered Interest Rate Premia

Dep. var Δv_{kt} :	$\Delta \widehat{UIP}_{kt}$		$\Delta UIP_{kt,t+3}$		ΔCIP_{kt}	
	(1)	(2)	(3)	(4)	(5)	(6)
Δf^*_{kt}	0.203^{***}	0.171^{***}	0.226^{***}	0.189^{***}	-0.0000	-0.0000
	[16.61]	[15.35]	[12.15]	[11.83]	[0.01]	[0.06]
$\Delta f^*_{k,t-1}$	-0.059^{***}	-0.053^{***}	0.000	-0.002	-0.0004	0.0002
	[5.03]	[5.31]	[0.02]	[0.13]	[1.57]	[1.07]
ΔCIP_{kt}	-6.753^{***}	0.491	-11.660^{***}	-2.432		
	[3.33]	[0.15]	[3.19]	[0.95]		
$\Delta \widehat{UIP}_{kt}$					-0.0018^{**}	0.0002
					[2.82]	[0.19]
$v_{k,t-1}$	-0.462^{***}	-0.499^{***}	-0.144^{***}	-0.193^{***}	-0.264^{***}	-0.272^{***}
	[10.57]	[9.26]	[5.48]	[7.11]	[8.01]	[4.64]
Observations	1,512	1,512	1,498	1,498	1,512	1,512
# currency FE	7	7	7	7	7	7
Time FE		✓		✓		✓
Within R^2	0.466	0.705	0.238	0.630	0.148	0.545

Covered and Uncovered Interest Rate Premia: Observations

- High comovement between Δf^*_{kt} with UIP, bot not CIP
- High R^2 for UIP. Most of R^2 for CIP comes from time FE
- Negative time-series comovement between UIP and CIP (unlike positive corr in the cross section), which disappears with inclusion of time fixed effects
- A lot of mean reversion in survey UIP, while CIP is both much less volatile but more presistent
- Survey UIP proxies well for realized UIP

Decomposition of Premia

Dep. var:	(1) $\Delta\widehat{UIP}_{kt}$	(2) ΔCIP_{kt}	(3) $4{\cdot}\Delta \log \mathcal{E}_{kt}$	(4) $4{\cdot}\Delta \log \mathcal{F}_{kt}$	(5) $4{\cdot}\Delta \log \widehat{\mathcal{E}}_{kt}$	(6) $\Delta \log(R_{kt}/R_t^*)$
Δf_{kt}^*	0.171^{***}	0.0000	0.227^{***}	0.225^{***}	0.055^{***}	-0.0005^{**}
	[15.47]	[0.34]	[23.18]	[22.87]	[7.77]	[2.64]
$\Delta f_{k,t-1}^*$	-0.052^{***}	0.0003	-0.048^{**}	-0.048^{**}	0.004	-0.0004
	[5.38]	[1.39]	[3.04]	[3.10]	[0.23]	[1.26]
Observations	$1,512$	$1,512$	$1,512$	$1,512$	$1,512$	$1,512$
# currency FE	7	7	7	7	7	7
Time FE	✓	✓	✓	✓	✓	✓
Within R^2	0.705	0.545	0.690	0.690	0.767	0.672

- Strong contemporaneous response of spot and forward exchange rate, almost no response of interest rate; some response in survey expectations of spot quarter ahead
- UIP comoves with spot, while forward adjusts to eliminate the effect on CIP

UIP and CIP premia: individual currencies

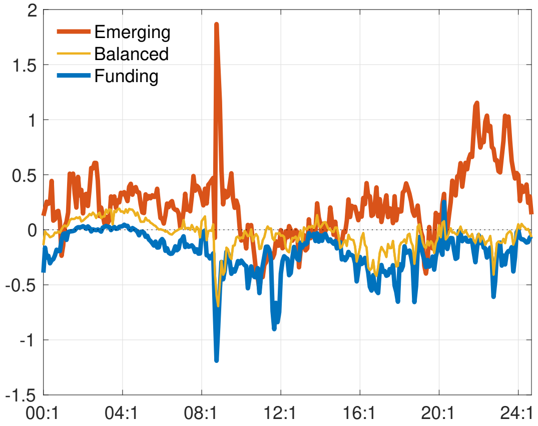
- UIP premia:
  - Most variation in UIP is with Δf^*_{kt}, consistent across currencies (incl. MXN). R^2 between 55 and 65%.
  - Differential effect of VIX: like for CIP, but stronger (esp. for Balanced and EMs)
  - Common effect of broad dollar (in reverse of CIP), no further comovement with CIP

- CIP Premia:
  - Common effect of broad dollar reducing CIP (except for EMs: MXN, cf. NZD)
  - Differential effect of VIX: more negative for funding and more positive for EMs
  - No association with dealer positions. R^2 around 20%.
  - Most variation from time fixed effects (common trends): Funding & Balanced comove negatively with EMs

UIP and CIP premia: individual currencies

	(1) JPY	(2) CHF	(3) EUR	(4) GBP	(5) CAD	(6) AUD	(7) NZD	(8) MXN
Panel A: Dependent variable $\Delta\widehat{UIP}_{kt}$								
Δf^*_{kt}	0.191^{***}	0.113^{***}	0.252^{***}	0.153^{***}	0.107^{***}	0.162^{***}	0.166^{***}	0.075^{***}
	[8.07]	[5.05]	[5.33]	[6.49]	[6.71]	[5.46]	[8.19]	[3.55]
$\Delta\log\overline{\mathcal{E}_t^{USD}}$	1.506^{***}	1.827^{***}	2.119^{***}	1.446^{**}	1.804^{***}	1.410^{**}	1.687^{***}	1.917^{***}
	[4.04]	[4.84]	[9.71]	[3.99]	[5.84]	[3.51]	[3.74]	[4.02]
$\Delta\log\text{VIX}_t$	-0.103^{***}	-0.068^{**}	-0.017	0.048^{**}	0.079^{***}	0.154^{***}	0.117^{***}	0.089^{***}
	[3.21]	[2.06]	[1.19]	[2.17]	[6.41]	[5.32]	[6.19]	[2.77]
Panel B: Dependent variable ΔCIP_{kt}								
Δf^*_{kt}	-0.0004	0.0004	-0.0006	0.0003	0.0008	0.0000	0.0001	-0.0011
	[0.93]	[0.86]	[0.67]	[0.74]	[1.59]	[0.14]	[0.25]	[0.59]
$\Delta\log\overline{\mathcal{E}_t^{USD}}$	-0.0228^{**}	-0.0158	-0.0250^{**}	-0.0192^{**}	-0.0199^{***}	-0.0240^{***}	0.0002	0.0735^{*}
	[2.16]	[1.31]	[2.26]	[2.00]	[3.71]	[4.02]	[0.02]	[1.82]
$\Delta\log\text{VIX}_t$	-0.0015^{***}	-0.0014^{*}	-0.0012^{**}	-0.0004	0.0001	0.0006	0.0009^{*}	0.0005
	[2.79]	[1.95]	[2.23]	[1.00]	[0.32]	[0.81]	[1.86]	[0.27]
Observations	216	216	216	216	216	216	216	216
R^2 for $\Delta\widehat{UIP}_{kt}$	0.560	0.539	0.623	0.570	0.671	0.629	0.568	0.529
R^2 for ΔCIP_{kt}	0.293	0.270	0.265	0.165	0.287	0.197	0.237	0.198

Common components of CIP

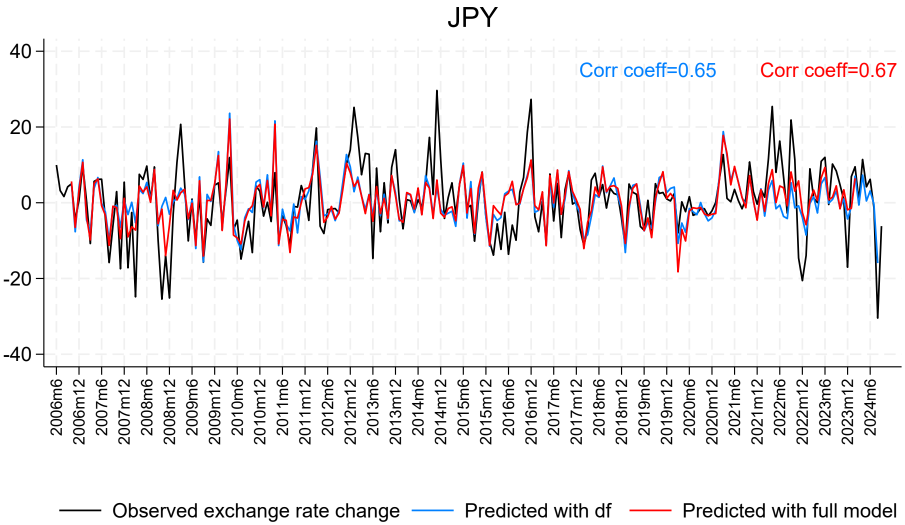


- Funding bin constructed using JPY, CHE, EUR. Emerging bin: NZD, MXN, ZAR.
- Balanced: GBP, CAD, AUD. Much of the time like funding, occasionally like EMs.

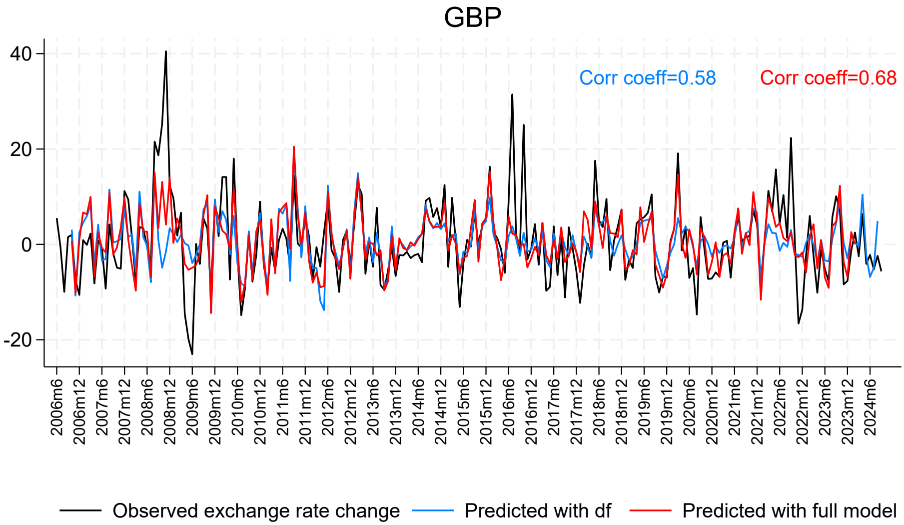
Spot Exchange Rates

Dep.var: $\Delta \log \mathcal{E}_{kt}$	(1) JPY	(2) CHF	(3) EUR	(4) GBP	(5) CAD	(6) AUD	(7) NZD	(8) MXN
Δf^*_{kt}	0.071^{***}	0.061^{***}	0.103^{***}	0.060^{***}	0.050^{***}	0.062^{***}	0.069^{***}	0.045^{***}
	[9.04]	[12.65]	[9.71]	[7.63]	[11.63]	[11.79]	[15.87]	[4.00]
$\Delta f^*_{k,t-1}$	0.006	−0.005	0.007	−0.005	−0.003	0.004	−0.002	0.006
	[0.97]	[1.17]	[0.98]	[1.16]	[0.54]	[0.55]	[0.46]	[0.86]
$\Delta f^*_{k,t-2}$	0.015^{**}	0.018^{***}	0.027^{***}	0.004	0.003	0.008	0.015^{***}	0.010
	[2.21]	[5.11]	[4.35]	[0.90]	[0.73]	[1.04]	[2.71]	[1.65]
$\Delta(i_{kt} - i^*_t)$	1.739^{**}	0.004	2.906^{***}	2.875^{***}	2.942^{***}	3.793^{***}	2.908^{***}	1.362
	[2.31]	[0.00]	[3.14]	[3.95]	[3.72]	[3.60]	[4.46]	[1.59]
ΔT-basis$_t$	0.851	-1.802^{*}	−1.533	−1.052	-2.591^{***}	3.104^{***}	2.089^{**}	3.336^{**}
	[1.00]	[1.90]	[1.55]	[1.31]	[2.78]	[3.24]	[2.03]	[2.43]
$\Delta \log$ VIX$_t$	-0.014^{*}	−0.004	−0.006	0.001	0.010^{*}	0.034^{***}	0.019^{**}	0.034^{**}
	[1.68]	[0.44]	[0.72]	[0.18]	[1.86]	[4.07]	[2.17]	[2.40]
$\Delta \log \mathbb{W}^*_t$	0.011	−0.030	-0.074^{***}	-0.098^{***}	-0.086^{***}	-0.084^{***}	-0.104^{***}	-0.115^{***}
	[0.44]	[1.64]	[5.31]	[3.26]	[4.17]	[3.16]	[2.82]	[2.81]
$\log \mathcal{E}_{k,t-1}$	0.007	−0.017	0.017	−0.002	−0.002	0.004	−0.004	−0.005
	[0.84]	[1.58]	[1.50]	[0.17]	[0.18]	[0.39]	[0.36]	[0.66]
Observations	209	209	209	209	209	209	209	209
R^2	0.450	0.436	0.473	0.485	0.592	0.606	0.607	0.444
R^2 due to Δf^*_{kt}	0.812	0.890	0.686	0.636	0.515	0.416	0.628	0.352
$\text{std}(\Delta \log \mathcal{E}_{kt})$	1.32	1.30	1.16	1.09	0.93	1.19	1.61	0.90
HL (months)	8	7	∞	8	8	12	6	6

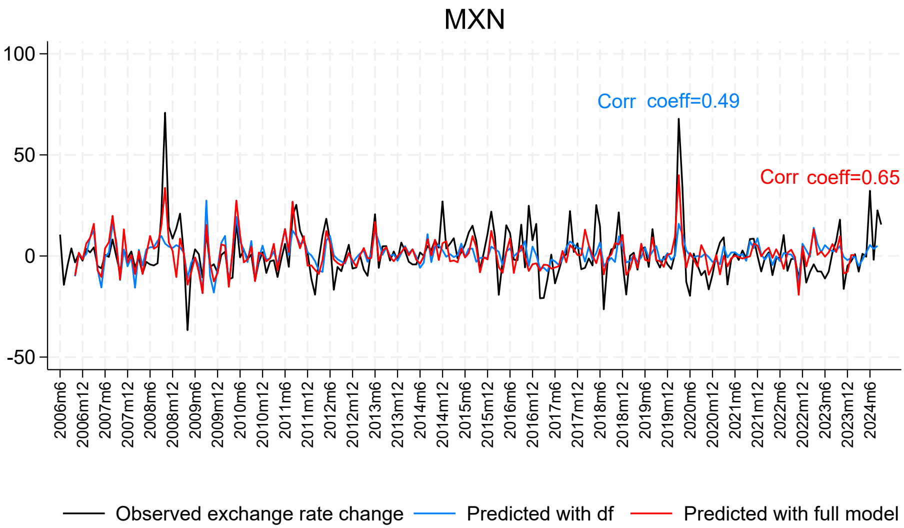
Exchange Rate Fit: in changes



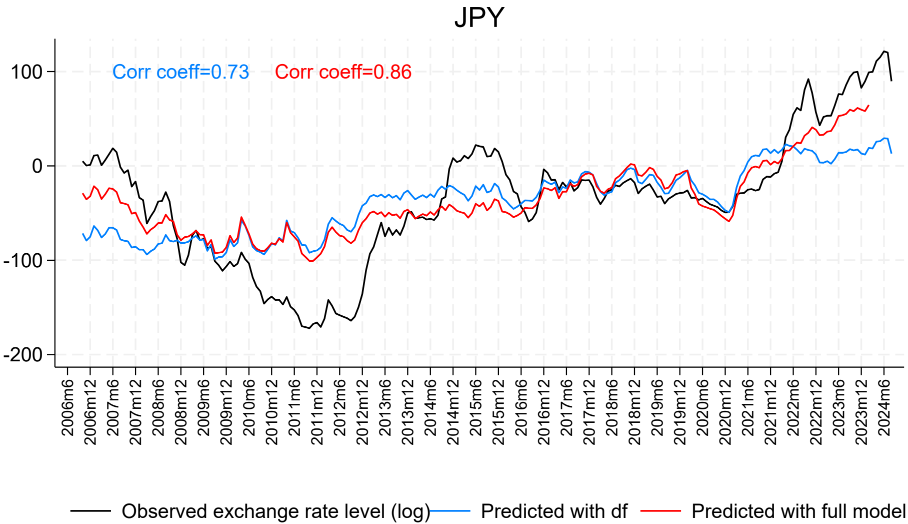
Exchange Rate Fit: in changes



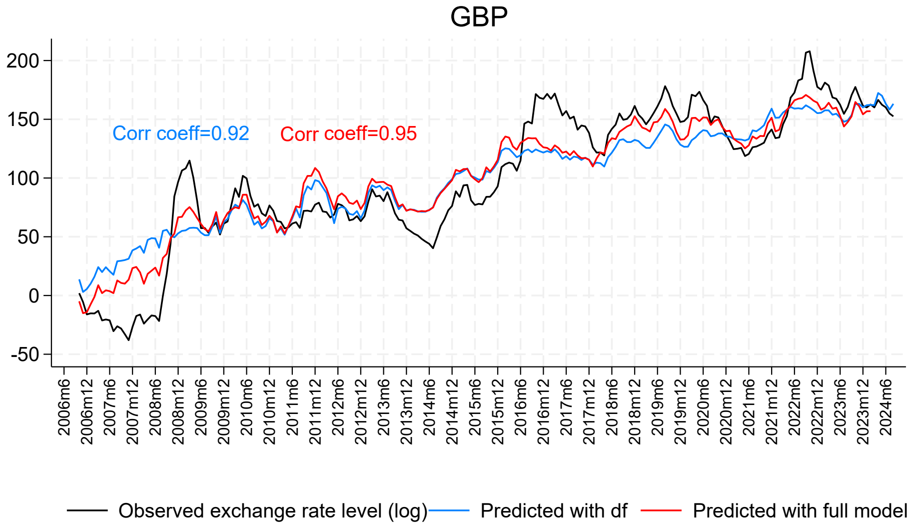
Exchange Rate Fit: in changes



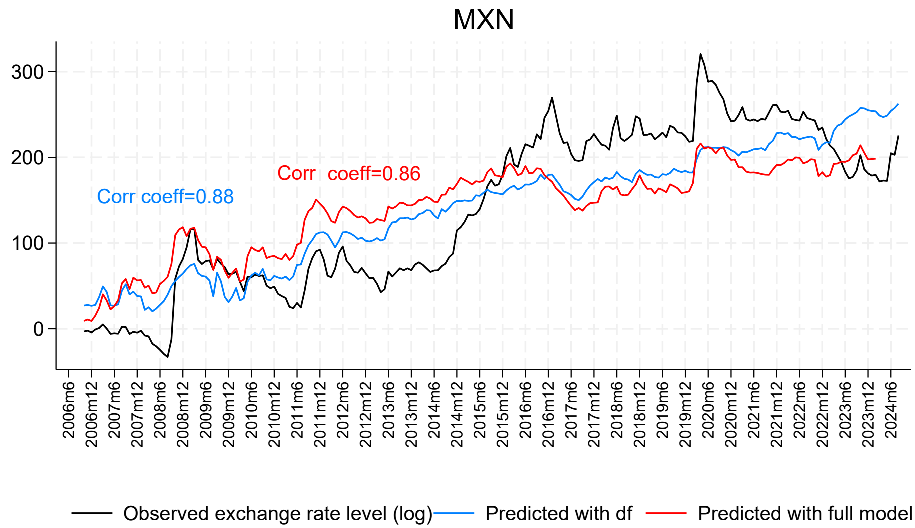
Exchange Rate Fit: in levels



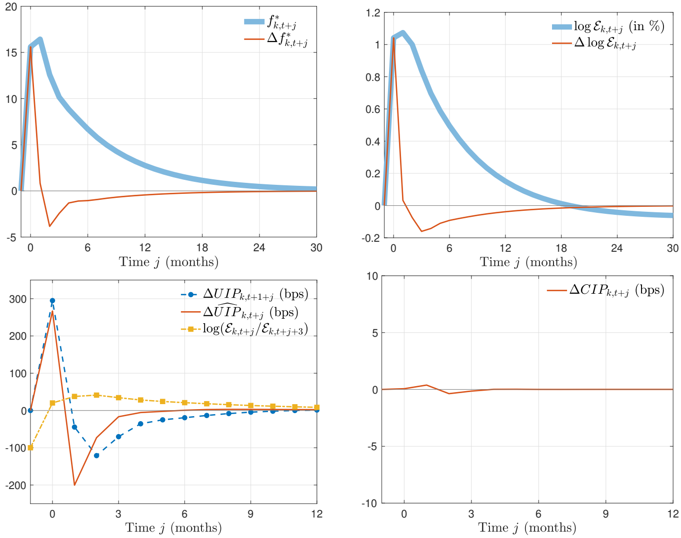
Exchange Rate Fit: in levels



Exchange Rate Fit: in levels



Impulse Responses



Outline

Theoretical Framework

- Intermediary supply of currency
- Currency market equilibrium

Empirical Results

- Data
- Cross-Section
- Dynamics of currency premia
- Exchange Rates

Interpretations

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  - — interest rates, UIP, CIP and forward prices

- In the time series, CIP across currencies driven by common financial shocks

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- Cross section driven by net local-currency supply of savings:
  - — interest rates, UIP, CIP and forward prices
- In the time series, CIP across currencies driven by common financial shocks
- In contrast, UIP and exchange rates respond to currency-specific demand shocks
  - — proxied by currency futures positions of intermediary dealer banks
- Does not identify primitive drivers of currency demand
  - — macro news shocks, pure financial shocks, or their combination
  - — yet, FX demand shocks frictionally intermediated at a substantial (UIP) premium
  - — dynamics of UIP premium requires dynamic adjustment of the exchange rate