A Preferred-Habitat Model of Term Premia and Currency Risk

Pierre-Olivier Gourinchas
UC Berkeley, Princeton IES
pog@berkeley.edu

Walker Ray
LSE and SF Federal Reserve
walkerdray@gmail.com

Dimitri Vayanos
LSE
d.vayanos@lse.ac.uk

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Motivation

- Predictability patterns in currencies and bonds.
  - Currency risk premia depend on interest-rate differential. Violations of Uncovered Interest Parity (UIP) (Fama 1984...)
  - Bond risk premia depend on term-structure slope. Violations of Expectation Hypothesis (EH) (Fama & Bliss 1987, Campbell & Shiller 1991...)
  - Currency and bond risk premia are deeply connected (Lloyd & Marin 2019, Lustig et al 2019, Chernov and Creal 2020...)

- Effect of central bank actions.
  - How does monetary policy transmit domestically, along the yield curve? How does it transmit internationally, to exchange rates and foreign yield curves?
  - How does QE affect the domestic yield curve? What are its effects on exchange rates and foreign yield curves?

This Paper

- Approach:
  - Introduce risk-averse 'global rate arbitrageur' able to invest in bonds and currencies (global hedge fund, fixed income desk of broker-dealer, multinational corporation...)
  - Two-country version of Vayanos & Vila's (2019) preferred-habitat model.
  - Contamporaneous paper by Greenwood et al (2020) in discrete time with two bonds

- Findings:
  - Can reproduce qualitative facts about bond and currency risk premia.
  - Rich transmission of monetary policy (conventional and unconventional) via exchange rate and term premia.
  - General message: floating exchange rates provide limited insulation.
    Failure of Friedman-Obtsfeld-Taylor Trilemma.

Set-Up: Two-country Vayanos & Vila (2019)

- Continuous time $t \in (0, \infty)$, 2 countries $j = H, F$
- Nominal exchange rate e_t: H price of F (increase $\equiv$ depreciation of H's currency)
- In each country j, continuum of zero coupon bonds in zero net supply with maturity $0 \leq \tau \leq T$, and $T \leq \infty$
- Bond price (in local currency) $P_{jt}^{(\tau)}$, with yield to maturity $y_{jt}^{(\tau)} = -\log P_{jt}^{(\tau)} / \tau$
- Exogenous nominal short rate (monetary policy) $r_{jt} = \lim_{\tau \to 0} y_{jt}^{(\tau)}$:

$$dr_{jt} = \kappa_{rj}(\bar{r}_j - r_{jr})dt + \sigma_{rj} dB_{rjt}$$

Arbitrageurs and Preferred-Habitat Investors

Three types of investors:

- Home and foreign preferred-habitat bond investors
  [demand bonds of a specific country and maturity]
- Currency traders
  [demand currency at spot or forward market]
- Global rate arbitrageurs
  [trade both currencies, and bonds of both countries and all maturities]

Arbitrageurs

- Wealth W_t
- W_{Ft} invested in country F (in Home currency)
- $X_{jt}^{(\tau)}$ invested in bond of country j and maturity τ (in Home currency)
- Instantaneous mean-variance optimization (limit of OLG model)

$$\max_{\{X_{Ht}^{(\tau)}, X_{Ft}^{(\tau)}\}_{\tau \in (0,T)}} \mathbb{E}_t(dW_t) - \frac{a}{2}\mathbb{V}\mathrm{ar}_t(dW_t)$$

- Budget constraint

$$\begin{aligned} dW_t = & W_t r_{Ht} dt + W_{Ft}\left(\frac{de_t}{e_t} + (r_{Ft} - r_{Ht})dt\right) \\ & + \int_0^T X_{Ht}^{(\tau)}\left(\frac{dP_{Ht}^{(\tau)}}{P_{Ht}^{(\tau)}} - r_{Ht}dt\right)d\tau + \int_0^T X_{Ft}^{(\tau)}\left(\frac{d(P_{Ft}^{(\tau)}e_t)}{P_{Ft}^{(\tau)}e_t} - \frac{de_t}{e_t} - r_{Ft}dt\right)d\tau \end{aligned}$$

Risk averse arbitrageurs' holdings increase with expected return.

Preferred-Habitat Bond Investors and Currency Traders

- Demand for bonds in currency j, of maturity τ (in Home currency):

$$Z_{jt}^{(\tau)} = -\alpha_j(\tau) \log P_{jt}^{(\tau)} - \theta_j(\tau)\beta_{jt}$$

  - $\theta_j(\tau) \geq 0$, $\beta_{jt} > 0 \iff$ decrease in net demand for bonds of maturity τ.

- Demand for foreign currency (spot) (in Home currency):

$$Z_{et} = -\alpha_e \log(e_t) - \theta_e \gamma_t,$$

  - Can accommodate forward demand. Under CIP, equivalent to spot + H and F bond trades.

- Exogenous bond and FX demand risk factors:

$$d\beta_{jt} = -\kappa_{\beta j}\beta_{jt}dt + \sigma_{\beta j} dB_{\beta jt} \quad ; \quad d\gamma_t = -\kappa_\gamma \gamma_t dt + \sigma_\gamma dB_{\gamma t}$$

Price-elastic habitat traders change their positions in response to price changes.

Market Clearing

- Home bonds

$$X_{Ht}^{(\tau)} + Z_{Ht}^{(\tau)} = 0$$

- Foreign bonds

$$X_{Ft}^{(\tau)} + Z_{Ft}^{(\tau)} = 0$$

- Currency Market

$$W_{Ft} + Z_{et} = 0$$

- 5 risk factors: short rates (dB_{rjt}), bond demands ($dB_{\beta jt}$) and currency demand ($dB_{\gamma t}$)

1. Benchmark: Risk Neutral Arbitrageurs

Suppose that arbitrageurs are risk-neutral: $a = 0$.

- EH holds:

$$\mathbb{E}_t dP_{Ht}^{(\tau)} / P_{Ht}^{(\tau)} = r_{Ht} \quad ; \quad \mathbb{E}_t dP_{Ft}^{(\tau)} / P_{Ft}^{(\tau)} = r_{Ft}$$

  - No effect of QE on yield curve, at Home or Foreign
  - Yield curve independent from foreign short-rate shocks.

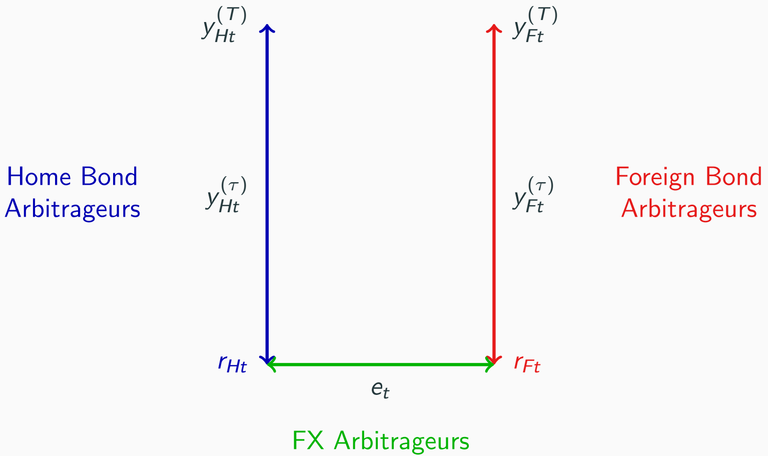
- UIP holds:

$$\log e_t = \frac{r_{Ft}}{\kappa_{rF}} - \frac{r_{Ht}}{\kappa_{rH}} - C_e \quad ; \quad \mathbb{E}_t de_t / e_t = r_{Ht} - r_{Ft}$$

  - ‘Mundellian’ insulation: shock to short rates ‘absorbed’ into the exchange rate.
  - Classical Trilemma: capital flows and floating exchange rates deliver monetary autonomy.

2. Segmented Arbitrage and No Demand Shocks ($\beta_{jt} = \gamma_t = 0$)

Assume foreign currency and bonds traded by three disjoint sets of arbitrageurs.



Assume r_{Ht} and r_{Ft} are independent.

2. Segmented Arbitrage and No Demand Shocks ($\beta_{jt} = \gamma_t = 0$)

Postulate: $\log P_{jt}^{(\tau)} = -A_{rj}(\tau) r_{jt} - C_j(\tau)$; $\log e_t = A_{rFe} r_{Ft} - A_{rHe} r_{Ht} - C_e$

Proposition (Segmented Arbitrage, Currency Carry Trade CCT and UIP Deviations)

When arbitrage is segmented, risk aversion $a > 0$ and FX price elasticity $\alpha_e > 0$

- Attenuation: $0 < A_{rej} < 1/\kappa_{rej}$
- CCT expected return $\mathbb{E}_t de_t/e_t + r_{Ft} - r_{Ht}$ decreases in r_{Ht} and increases in r_{Ft} (UIP deviation)

Intuition: Similar to Kouri (1982), Gabaix and Maggiori (2015)

- when $r_{Ft} \uparrow$, demand for CCT increases.
- Foreign currency appreciates ($e_t \uparrow$)
- As $e_t \uparrow$, price elastic FX traders reduce holdings ($\alpha_e > 0$): $Z_{et} \downarrow$
- FX arbitrageurs increase their holdings $W_{Ft} \uparrow$, which requires a higher CCT return.

2. Segmented Arbitrage and No Demand Shocks ($\beta_{jt} = \gamma_t = 0$)

Proposition (Segmented Arbitrage and Bond Carry Trade BCT)

When arbitrage is segmented, $a > 0$ and $\alpha(\tau) > 0$ in a positive-measure subset of $(0, T)$:

- Attenuation: $A_{rj}(\tau) < (1 - e^{-\kappa_{rj}\tau})/\kappa_{rj}$.
- Bond prices in country j only respond to country j short rates (no spillover).
- BCT_j expected return $\mathbb{E}_t dP_{jt}^{(\tau)}/P_{jt}^{(\tau)} - r_{jt}$ decreases in r_{jt}

Intuition: Similar to Vayanos & Vila (2019)

- When $r_{jt} \downarrow$ arbitrageurs want to invest more in the BCT
- Bond prices: $P_{jt}^{(\tau)} \uparrow$
- As $P_{jt}^{(\tau)} \uparrow$, price-elastic habitat bond investors ($\alpha_j(\tau) > 0$) reduce their holdings: $Z_{jt}^{(\tau)} \downarrow$
- Bond arbitrageurs increase their holdings, which requires a higher BCT return.

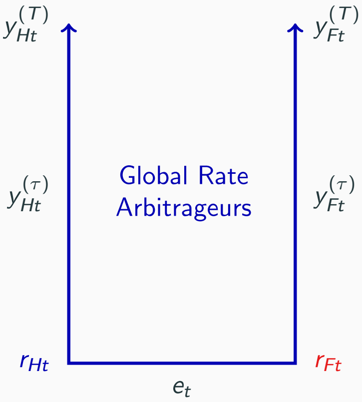
Effect of (Unexpected) Demand Shocks in Segmented Arbitrage Model

Assume $a > 0$, $\theta_j(\tau) > 0$ and $\theta_e > 0$.

- An unexpected increase in bond demand in country j (*e.g.* QE_j) reduces yields in country j. It has no effect on bond yields in the other country or on the exchange rate.
- An unexpected increase in demand for foreign currency (*e.g. sterilized intervention*) causes the foreign currency to appreciate. It has no effect on bond yields in either country.

3. Global Arbitrage and No Demand Shocks ($\beta_{jt} = \gamma_t = 0$)

Assume now global rate arbitrageur can invest in bonds (H and F) and FX.



Assume r_{Ht} and r_{Ft} are independent.

3. Global Rate Arbitrageur and No Demand Shocks ($\beta_{jt} = \gamma_t = 0$)

Postulate $\log P_{jt}^{(\tau)} = -A_{rjj}(\tau) r_{jt} - A_{rjj'}(\tau) r_{j't} - C_H(\tau)$; $\log e_t = A_{rFe} r_{Ft} - A_{rHe} r_{Ht} - C_e$

Proposition (Global Arbitrage and Carry Trades CCT, BCT)

when arbitrage is global, risk aversion $a > 0$ and price elasticities $\alpha_e, \alpha_j(\tau) > 0$:

- The results of the previous propositions obtain: both CCT and BCT_H return decrease with r_{Ht}, and attenuation is stronger than with segmented markets.
- ⚠ In addition, BCT_F increases with r_{Ht}.
- The effect of r_{jt} on bond yields is smaller in the other country: $A_{jj'}(\tau) < A_{jj}(\tau)$.

Intuition: Bond and FX Premia Cross-Linkages

- When $r_{Ht} \downarrow$ global arbitrageurs want to invest more in CCT and BCT_H.
- e and $W_{Ft} \uparrow$: increased FX exposure (risk of $r_{Ft} \downarrow$).
- Hedge by investing more in BCT_F since price of foreign bonds increases when r_{Ft} drops: foreign yields decline and BCT_F decreases.

Effect of (Unexpected) Demand Shocks in Global Arbitrage Model

Assume $a > 0$ and $\alpha_e, \alpha_j(\tau) > 0$.

- Unexpected QE_j reduces yields in country j, as before.
  ⚠ Also reduces yields in the other country, and depreciates the currency.
  Intuition: Bond and FX Premia Cross-Linkages
  - To accommodate QE_j, arbitrageurs go short bonds in country j.
  - Hedge by investing more in the other country's currency since it appreciates when r_{jt} drops.
  - Hence currency position by investing more in the other country's bonds.
- Unexpected *sterilized intervention* at Home causes the foreign currency to appreciate.
  ⚠ Also lowers bonds yields at Home and increases them in Foreign.

Imperfect insulation even with floating rates.

Failure of the Classical Trilemma

The Full Model: Adding Demand Shocks $\beta_{jt} \neq 0$, $\gamma_t \neq 0$

- Can allow for rich demand structure embodied in VCV of risk factors. DGP:

$$\mathbf{q}_t = \begin{bmatrix} r_{Ht} & r_{Ft} & \beta_{Ht} & \beta_{Ft} & \gamma_t \end{bmatrix}^\top$$
$$\mathrm{d}\mathbf{q}_t = -\boldsymbol{\Gamma}\left(\mathbf{q}_t - \overline{\mathbf{q}}\right)\mathrm{d}t + \boldsymbol{\sigma}\,\mathrm{d}\mathbf{B}_t$$

- In general: dynamics matrix $\boldsymbol{\Gamma}$ and correlation matrix $\boldsymbol{\sigma}$ completely unrestricted.

- Today: we assume that short rates (r_{Ht}, r_{Ft}) may be correlated, and that demand factors may respond to short rates (but not vice versa).
  - $\implies$ block-lower-triangular $\boldsymbol{\Gamma}$, block diagonal $\boldsymbol{\sigma}$.

Numerical Calibration

Data: Zero coupon monthly data from Wright (2011); H: US, F: UK.

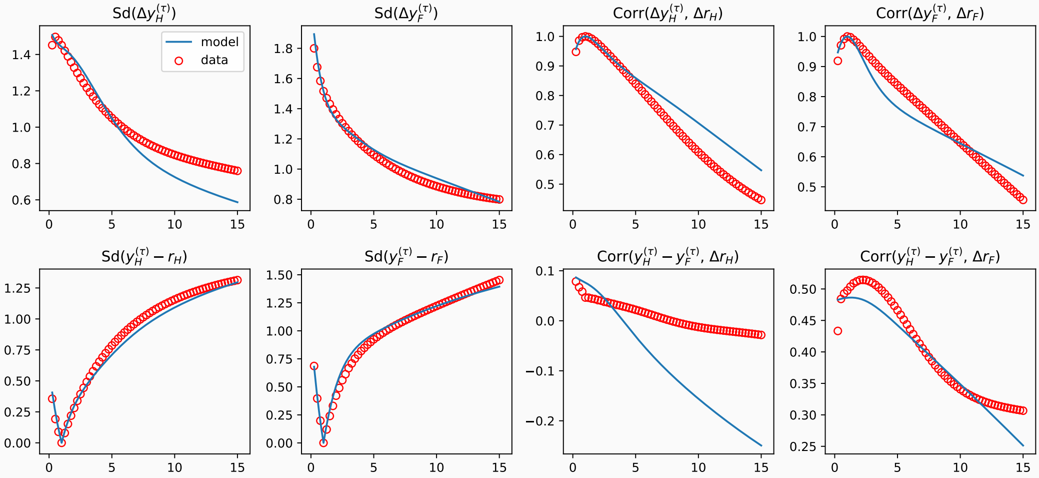
Targets

- Short rates: variance of short rates (detrended levels $y_j^{(1)}$ and annual differences $\Delta y_j^{(1)}$), short rate differentials $(y_H^{(1)} - y_F^{(1)})$ and covariance of differentials and short rate changes
- Exchange rates: variance of exchange rate changes (Δe), covariance of exchange rate changes and short rate differentials, and covariance of 1-year and 2-year changes in exchange rates $(\mathbb{C}\mathrm{ov}_t(e_{t+12} - e_t, e_{t+24} - e_t))$
- Long rates (across maturities $\tau =$ 3-month to 15-year): variance of changes in long rates $(\Delta y_j^{(\tau)})$, slopes $(y_j^{(\tau)} - y_j^{(1)})$, long rate differentials $(y_H^{(\tau)} - y_F^{(\tau)})$; and covariances with changes in short rates

Key estimates:

- $\hat{\alpha}_H(\tau) > \hat{\alpha}_F(\tau)$, $\hat{\theta}_H(\tau) > \hat{\theta}_F(\tau)$, reflecting the size and depth of the US Treasury market.
- Demand factors respond to short rates (similar to King 2019).

Model Fit



$\mathrm{Sd}(\Delta y_H^{(\tau)})$
model
data
$\mathrm{Sd}(\Delta y_F^{(\tau)})$
$\mathrm{Corr}(\Delta y_H^{(\tau)}, \Delta r_H)$
$\mathrm{Corr}(\Delta y_F^{(\tau)}, \Delta r_F)$
$\mathrm{Sd}(y_H^{(\tau)} - r_H)$
$\mathrm{Sd}(y_F^{(\tau)} - r_F)$
$\mathrm{Corr}(y_H^{(\tau)} - y_F^{(\tau)}, \Delta r_H)$
$\mathrm{Corr}(y_H^{(\tau)} - y_F^{(\tau)}, \Delta r_F)$

Policy Spillovers

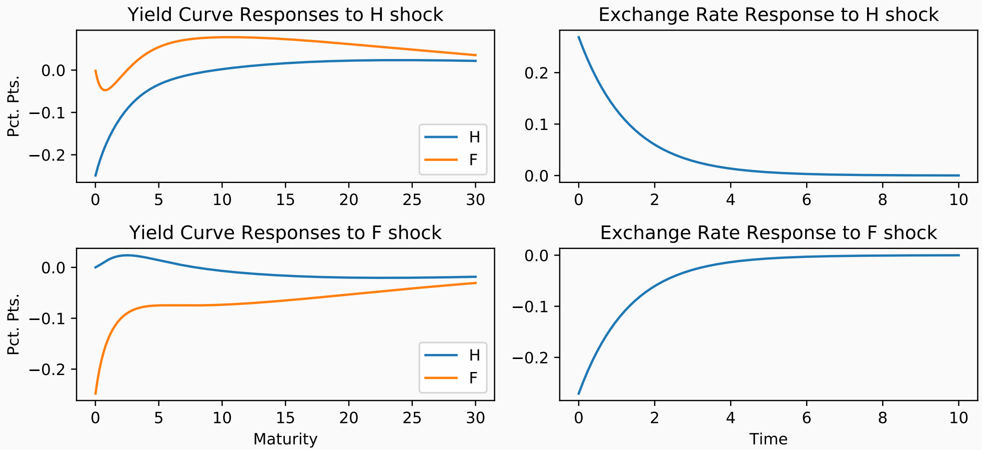
Conduct policy experiments:

- Monetary policy shock: unanticipated 25bp decrease in policy rate (H and F)
- QE shock: unanticipated positive demand shock (H and F), such that yields respond on average $\approx$ the same as to the given country's monetary shock

Examine spillovers:

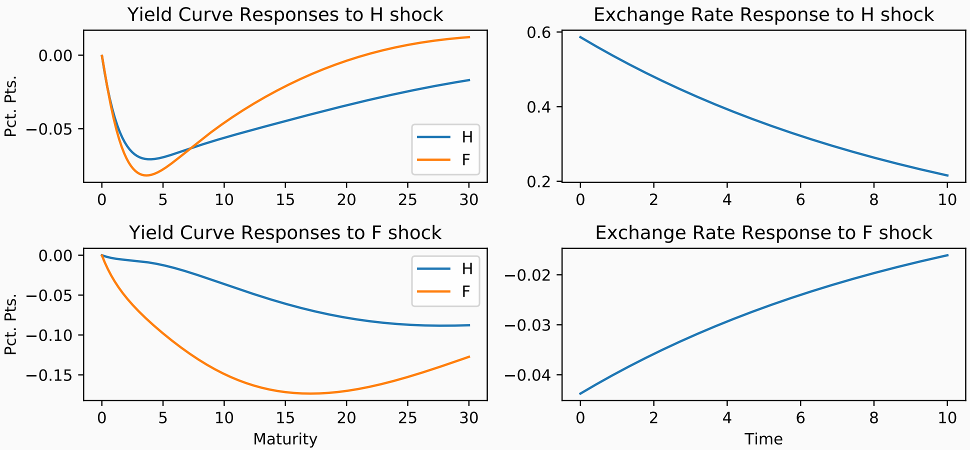
- Across the yield curves (short and long rates; and across countries)
- To the exchange rate

Monetary Shock Spillovers



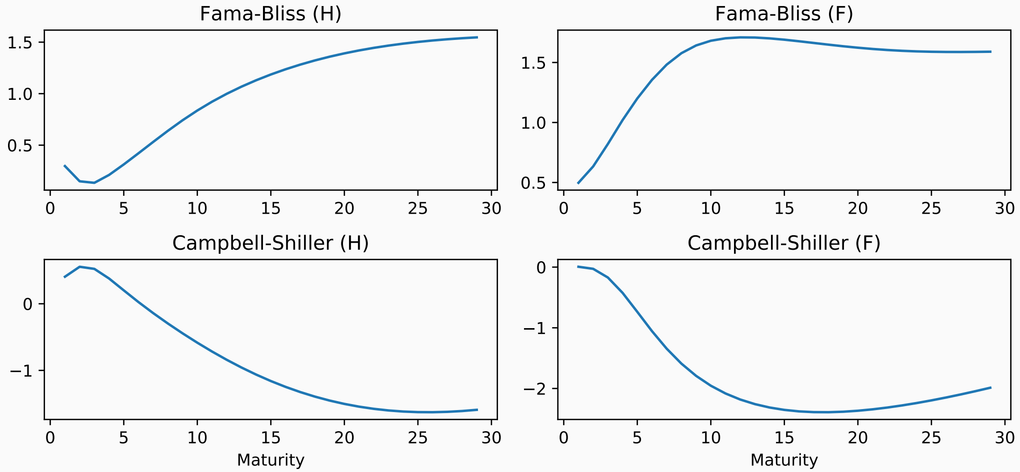
Implications: Small cross-country yield response, spillovers confined to exchange rates

QE Shock Spillovers



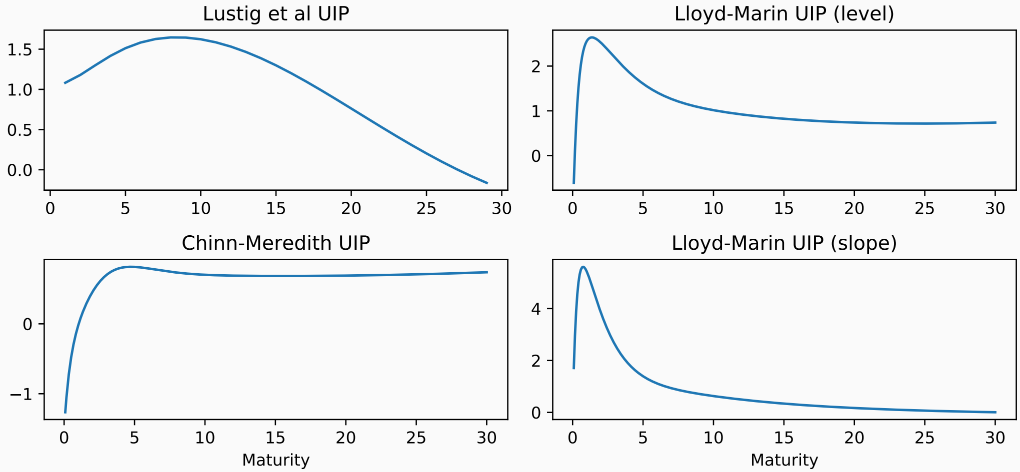
Implications: Large spillovers of US LSAPs, both to F yields and exchange rate

Regression Coefficients: Term Structure



Implications: Positive slope-premia relationship.

Regression Coefficients: UIP



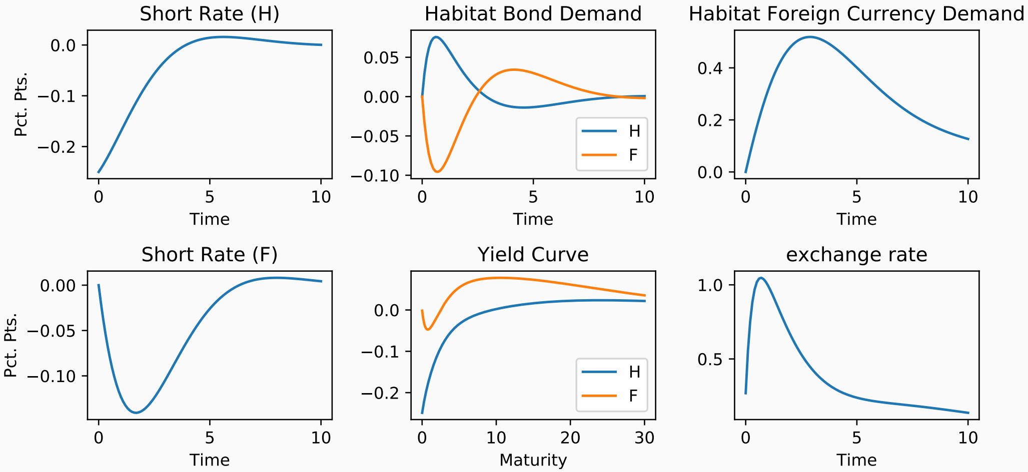
Implications: CCT is profitable, but profitability goes to zero if CCT is done with long-term bonds or over long horizon. Slope differential predicts CCT return.

Conclusion

- Present an integrated framework to understand term premia and currency risk
- Extend Vayanos & Vila (2019) to a two-country environment
- Resulting model ties together
  - Violations of UIP.
  - Violations of EH.
- Allow rich demand specification.
- Break the 'Friedman-Obstfeld-Taylor' Trilemma: monetary policy transmits to other countries via exchange rates and term premia.
- Extensions: (a) endogenize policy rates as in Ray (2019); (b) consider deviations from LOP as in Hebert Du & Wang (2019); (c) embed into New Keynesian open-economy model.

APPENDIX

Reduced Form Monetary Shock (H)



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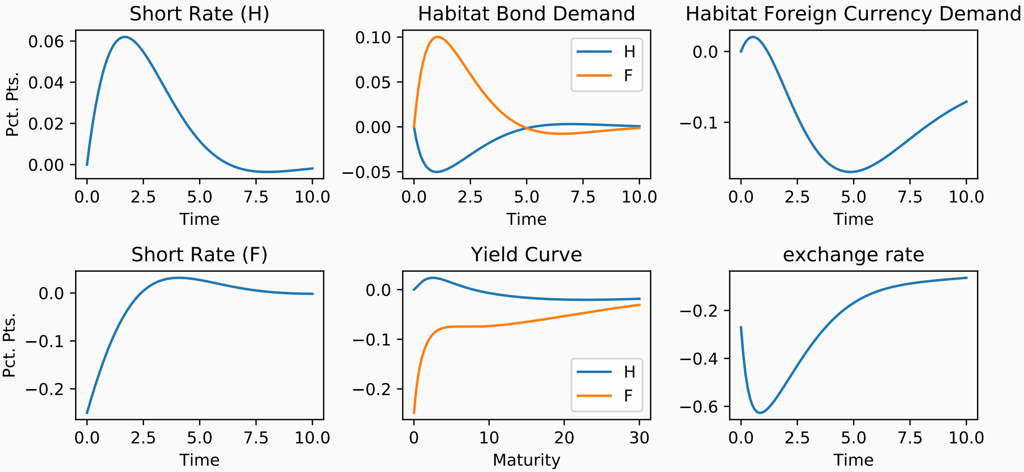
Reduced Form Monetary Shock (F)



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