A Preferred-Habitat Model of Term Premia and Currency Risk

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Motivation

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- Four broad empirical facts
  1. Strong patterns in currency returns: deviations from Uncovered Interest Parity (UIP) (Fama 1984...)
  2. Strong patterns in the term structure: deviations from the Expectation Hypothesis (EH) (Fama & Bliss 1987, Campbell & Shiller 1991...)
  3. The two risk premia are deeply connected (Lustig et al 2019, Lloyd & Marin 2019...)
  4. QE (which affects term premia) seems to have strong effect on exchange rates even with policy rates unchanged at the ZLB... Link between term premia and exchange rates?

- This is important
  - To understand how monetary policy transmits domestically (along the yield curve)...
  - ...but also internationally, via exchange rates and the foreign yield curve (spillovers)
  - To understand what determines exchange rates (volatility, disconnect...)

Motivation

- On the theory side:
  - Standard representative agent no-arbitrage models have a hard time...
  - Recent literature emphasizes the optimization of financial intermediaries and the constraints they face (Gabaix & Maggiori 2015, Itskhoki & Mukhin 2019, Koijen & Yogo 2020)
  - Revives an old literature on portfolio-balance (Kouri 1982, Jeanne & Rose 2002)
  - General sense that some segmentation/'deviation from UIP' is key to explain e
- This paper: introduce risk averse 'global rate arbitrageur' able to invest in fixed-income and currency market (global hedge fund, fixed income desk of broker-dealer, multinational corporation, central banks...)
- Formally: Two-country version of Vayanos & Vila's (2019) preferred-habitat model.
- Contemporaneous paper by Greenwood et al (2020), was just presented.

Findings

1. Can reproduce qualitative facts about bond and currency risk premia
2. When markets are segmented, rich transmission of monetary policy shocks (conventional and unconventional) via exchange rate and term premia
3. General message: floating exchange rates provide limited insulation.
   Failure of Friedman-Obtsfeld-Taylor's Trilemma

Framework is very rich. Can use it to answer more ambitious questions (not there yet):

(a) plunge into standard open economy macro model (Ray 2019)

(b) think about deviations from LOP (from UIP to CIP)

Set-Up

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
  [preference for bonds in a specific currency and maturity]

- Preferred-habitat spot and forward currency traders
  [preference for spot or specific maturity forward rates]

- Global Rate Arbitrageurs
  [can trade in both currencies, in domestic and foreign bonds]

Global Rate Arbitrageur

- 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)

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

- Wealth's law of motion:

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

Key insight: Risk averse arbitrageurs' holdings increase with expected return.

Preferred-habitat Bond and FX Investors

- 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:

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

Key Insight: Price elastic habitat traders. Price movements require portfolio rebalancing

Market Clearing (Stocks)

- 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 ($dB_{\gamma t}$)
- Nominal exchange rate is stationary in the model, but extension to stationary real exchange rate is straightforward.

1. Benchmark: Risk Neutral Global Rate Arbitrageur (aka Standard Model)

Consider the benchmark case of a risk neutral global rate arbitrageur: $a = 0$

- Expectation Hypothesis holds:

$$\mathbb{E}_t dP^{(\tau)}_{Ht} / P^{(\tau)}_{Ht} = r_{Ht} \quad ; \quad \mathbb{E}_t dP^{(\tau)}_{Ft} / P^{(\tau)}_{Ft} = r_{Ft}$$

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

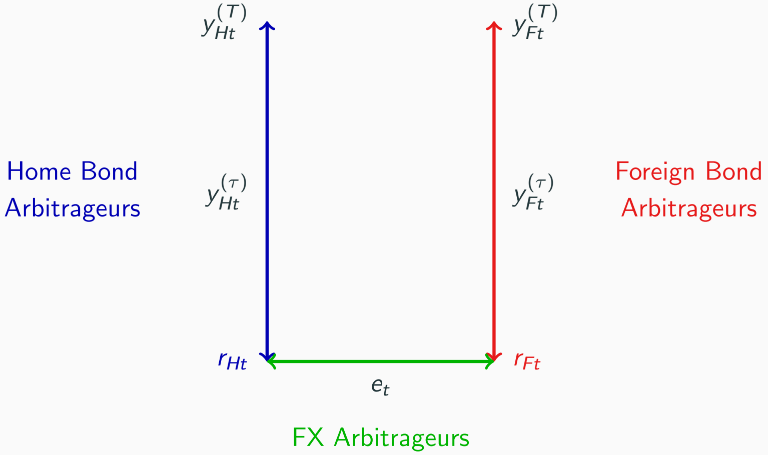
- Uncovered Interest Parity holds ($\mathbb{E}_t de_t / e_t = r_{Ht} - r_{Ft}$) and when $\mathbb{E} r_H = \mathbb{E} r_F$,

$$\log e_t = \frac{r_{Ft}}{\kappa_{rF}} - \frac{r_{Ht}}{\kappa_{rH}} - C_e$$

  - '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.



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 larger BCT return.

Macro Implications of the Segmented Model

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

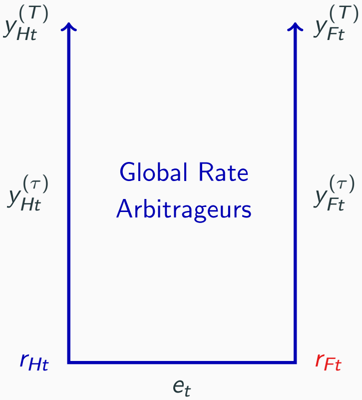
- An unexpected increase in bond demand in country j (*e.g.* QE_j) reduces yields in country j. It has no effect on bond yields in the other country or on the exchange rate.
- An unexpected increase in demand for foreign currency (*e.g. sterilized intervention*) causes the foreign currency to appreciate.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

Open Economy Macro Implications:

- Changes in Home monetary conditions (conventional or QE) have no effect on the foreign yield curve. Full insulation.
- Insulation is even stronger in the case of QE: exchange rate is unchanged.
- Trilemma? As we will see, this result arises because of markets segmentation (limited capital flows), not because of floating exchange rates.

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

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



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.

Macro Implications of Global Rate Arbitrageur 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.
- Unexpected *sterilized intervention* at Home causes the foreign currency to appreciate.

  ⚠ Also lowers bonds yields at Home and increases them in Foreign.

Open Economy Macro Implications:

- Changes in Home monetary conditions (conventional or QE) affect both yield curves and the exchange rate: potential spillovers from monetary policy. Imperfect insulation even with floating rates.
- QE or FX interventions in one country affects monetary conditions in both countries and depreciate the currency.
- Failure of the Classical Trilemma.

The Full Model

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:

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

- In general: dynamics matrix $\mathbf{\Gamma}$ 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 $\mathbf{\Gamma}$, block diagonal $\boldsymbol{\sigma}$.

Numerical Calibration

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

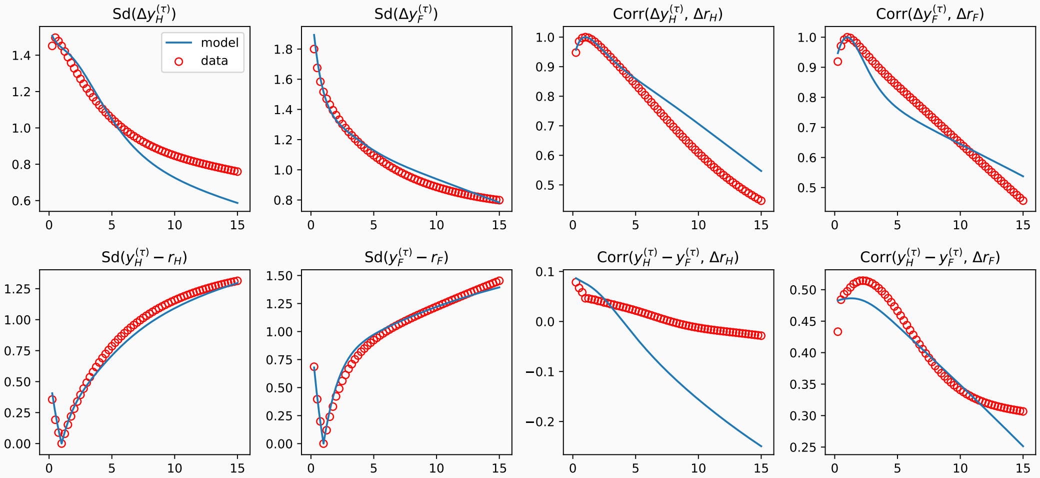
Targets

- 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



regression coeffs

Policy Spillovers

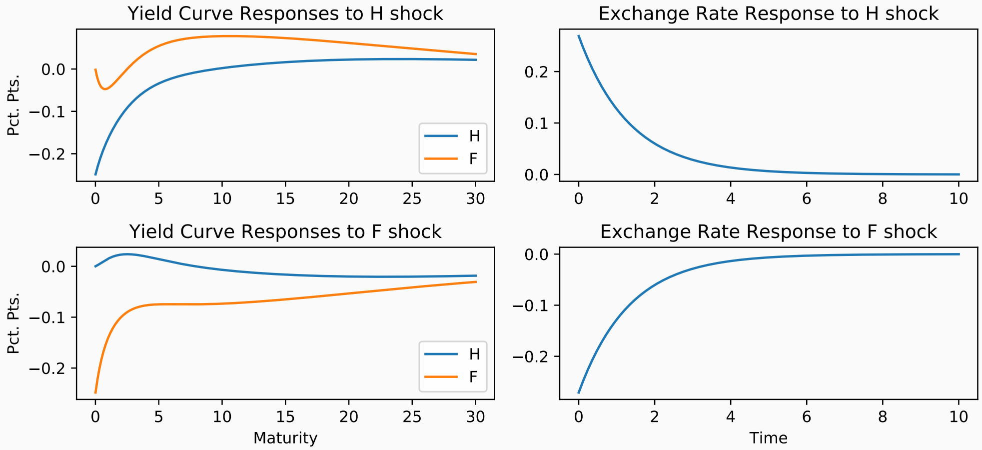
Conduct policy experiments:

- 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:

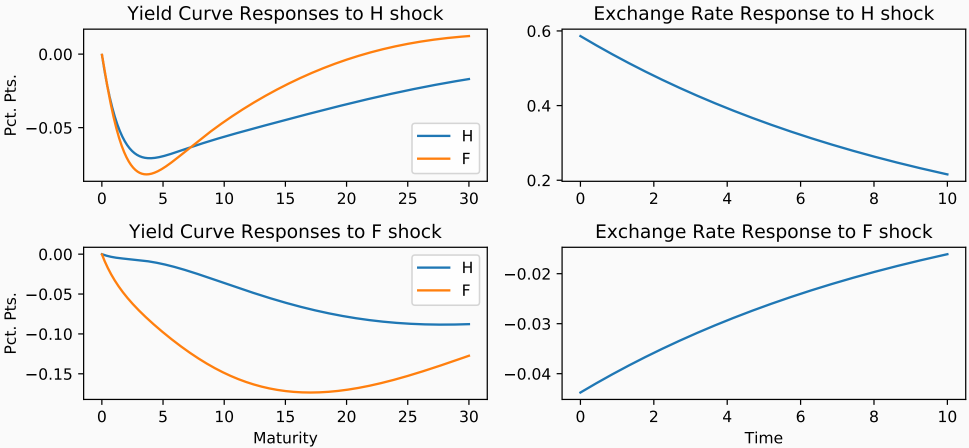
- Across the yield curves (short and long rates; and across countries)
- To the exchange rate

Monetary Shock Spillovers



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

QE Shock Spillovers



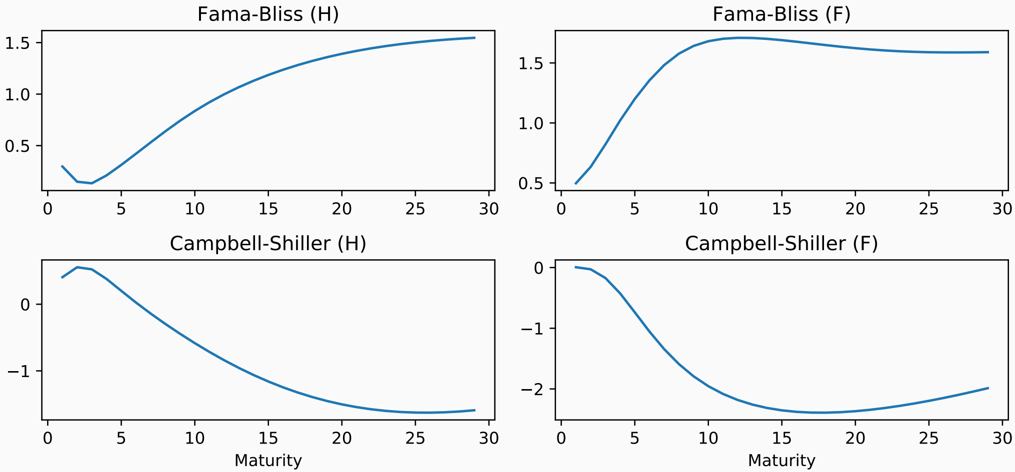
Implications: large spillovers of US LSAPs, both to F yields and exchange rate

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
  - Deviations from Uncovered Interest Parity (CCT, GCT and LCCT)
  - Deviations from Expectation Hypothesis (BCT)
- Allows rich demand specification with complex potential interactions between hedging demands
- 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 Du, Hebert & Huber (2019); (c) consider non-conventional monetary policy and official interventions

APPENDIX

Regression Coefficients: Term Structure



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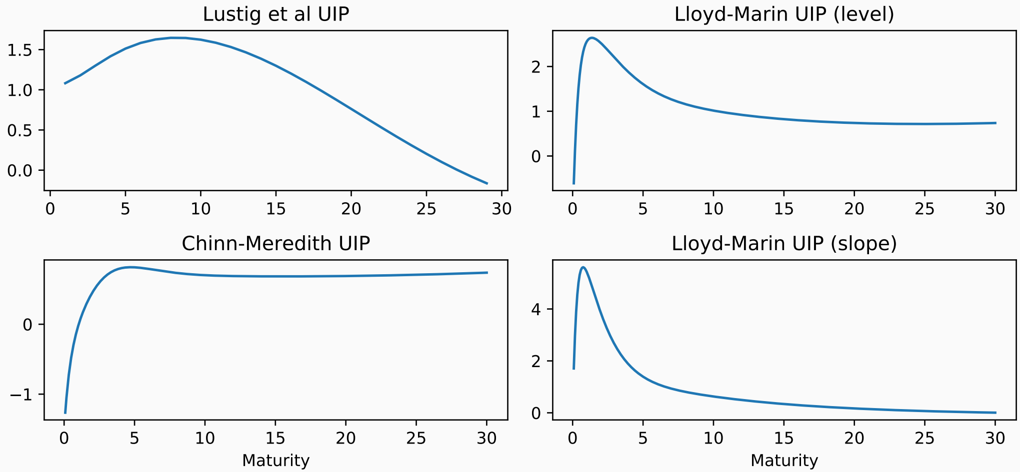
Regression Coefficients: UIP



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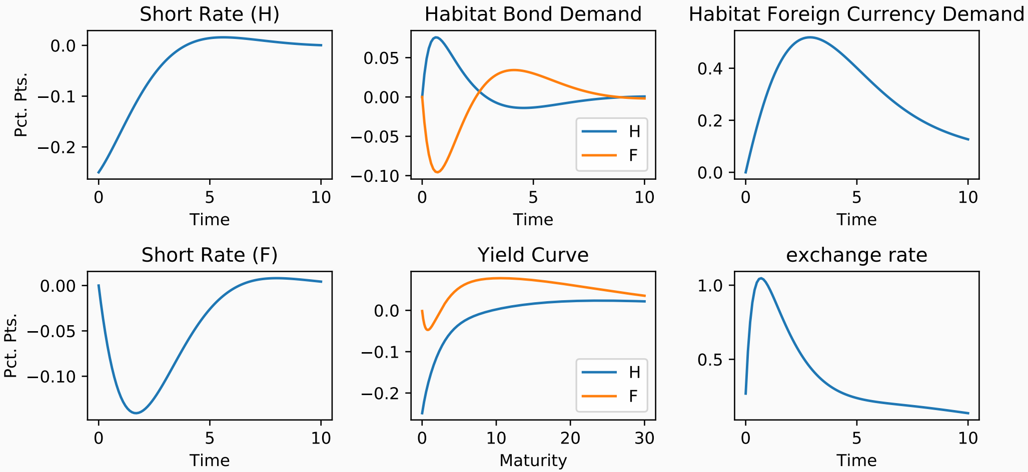
Reduced Form Monetary Shock (H)



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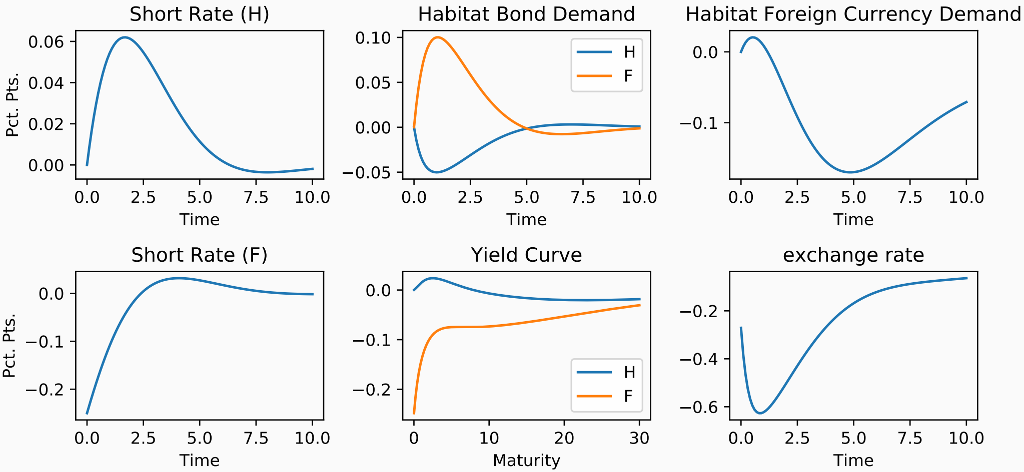
Reduced Form Monetary Shock (F)



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