International Macroeconomics with Frictional Capital Markets

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

Félix Neubergh Lecture
University of Gothenburg, 19 November 2025

Acknowledgement

Lecture draws on joint work with

- Pierre-Olivier Gourinchas (UC Berkeley and IMF)
- Walker Ray (Chicago Fed)

Textbook Models

Big Questions in International Macroeconomics

- How are exchange rates determined?
- How does monetary policy transmit domestically and internationally?
- What is optimal monetary policy in open economies?

Textbook models *(e.g., Gali 2015)* provide sharp answers.

Exchange Rate Determination

- Exchange rates determined by macroeconomic fundamentals, through Uncovered Interest Parity (UIP).
  - UIP: Expected returns from investing in different currencies (evaluated in same currency) are equal.

$$i_{Ht} = i_{Ft} + \frac{\mathbb{E}_t\left(\frac{de_t}{e_t}\right)}{dt},$$

    where

    - i_{Ht} is home short rate,
    - i_{Ft} is foreign short rate,
    - e_t is exchange rate defined as price of foreign currency in home currency.

    Exchange rate and short rates are nominal unless stated otherwise.

- Financial flows do not impact exchange rates.

Monetary Policy Transmission

- Term structure of interest rates is determined by current and expected future short rates, through Expectations Hypothesis (EH).
  - EH: Expected returns from investing in bonds of different maturity (evaluated over same horizon) are equal.

$$i_{jt} = \frac{\mathbb{E}_t\left(\frac{dP_{jt}^{(\tau)}}{P_{jt}^{(\tau)}}\right)}{dt},$$

  where $P_{jt}^{(\tau)}$ is price of country j bond with maturity τ.

- Conventional monetary policy:
  - Impacts domestic term structure.
  - Does not impact foreign term structure (if foreign short rate does not change).
  - Exchange rate absorbs short-rate differential through UIP.

- Unconventional monetary policy, such as Quantitative Easing and Tightening (QE/QT), does not impact domestic and foreign term structures and exchange rate.

Optimal Monetary Policy

- Under general assumptions, optimal monetary policy in sticky-price closed economies targets inflation only, fully stabilizing goods prices.
    - Optimal because costly price adjustment is then not needed.
- Under more restrictive assumptions, result extends to open economies. *(Gali-Monacelli REStud 2005)*
    - Assumptions: Producer currency pricing, log utility, and unit elasticity of substitution between home and foreign goods.
    - Targeting exchange rate is not optimal because exchange-rate movements provide the mechanism through which relative price of home and foreign goods can adjust.

Why UIP and EH Hold in Textbook Models?

- UIP.
  - Home and foreign households can invest in home and foreign assets → Perfect risk-sharing.
  - Borrowing in home currency and investing in foreign currency carries risk premium $\approx \gamma \frac{\mathbb{C}\text{ov}\left(\frac{de_t}{e_t}, \frac{dC_t}{C_t}\right)}{dt}$, where
    - γ is households' coefficient of relative risk aversion.
    - C_t is households' consumption.
  - Risk premium is small relative to exchange rate movements, and drops when linearizing the models.
    - Risk premium is of order $\sqrt{\frac{\mathbb{V}\text{ar}\left(\frac{de_t}{e_t}\right)}{dt}}$ (exchange rate movements) times $\sqrt{\frac{\mathbb{V}\text{ar}\left(\frac{dC_t}{C_t}\right)}{dt}}$ (consumption movements).
    - Both are first-order in the linearization → Risk premium is second-order.

- EH.
  - Only assets available are home and foreign short rate. No long-term bonds.
  - Even if long-term bonds were available, their risk premium would be small and dropped in the linearization because of above argument.

Answers from Textbook Models – A Summary

- Monetary policy should target domestic inflation.
- Monetary policy is conducted through short rate.
- Exchange rate should be flexible.
  - Absorbs short-rate differential. 'Mundellian' insulation.
  - Provides the mechanism through which relative price of home and foreign goods can adjust.
- Financial flows do not impact exchange rate and long rates.
  - Same for QE/QT and for foreign exchange interventions (FXI) by central banks.
- UIP and EH hold.
- Long rate is absent or irrelevant.

Textbook Models vs. Data – UIP, EH and Flows

- Empirical violations of UIP and EH.
  - Violations of UIP *(Bilson JB 1981, Fama JME 1984)*.
    - Currency carry trade (CCT) is profitable.
    - CCT: Borrow in low interest-rate currency, invest in high interest-rate currency.
  - Violations of EH *(Fama-Bliss AER 1987, Campbell-Shiller REStud 1991)*.
    - Bond carry trade (BCT) is profitable.
    - BCT: Borrow in low interest-rate maturity, invest in high interest-rate maturity.
  - Risk premia in bond and currency markets are connected *(Chen-Tsang RES 2013, Lustig-Stathopoulos-Verdelhan AER 2019, Chernov-Creal RFS 2020, Lloyd-Marin WP 2020)*.
- Price impact of QE.
  - QE affects exchange rate and bond yields, at home and abroad *(Gagnon-Raskin-Remache-Sack IJCB 2011, D'Amico-King JFE 2013, Bhattarai-Neely JEL 2022)*.
- Common thread: Large and time-varying risk premia.

Textbook Models vs. Data – Macroeconomic variables

- Exchange-rate disconnect. *(Meese-Rogoff JIE 1983)*
  - Exchange rate correlates weakly with other macroeconomic variables, such as consumption, GDP and inflation.
- Purchasing Power Parity (PPP) puzzle. *(Rogoff JEL 1996)*
  - Real exchange rate (RER) tracks nominal exchange rate closely.
- International risk-sharing puzzle. *(Backus-Smith JIE 1993)*
  - Countries with high RER have high consumption relative to countries with low RER, while international risk-sharing implies the opposite.

Segmented Market Models

Segmented Market Models

- New literature in International Macroeconomics emphasizes segmented capital markets and limited arbitrage.
- Draws on literature in Finance on the same topics.
- Answers to the big questions are different and more aligned with empirical evidence.

Answers from Segmented Market Models – So Far

- Financial flows impact exchange rate and long rates.
  - Same for QE/QT and FXI.
- UIP and EH do not hold.
  - CCT and BCT are profitable.
- Optimal monetary policy
  - Can target exchange rate in addition to domestic inflation.
  - Can involve quantity interventions in addition to moving the short rate.

Segmented Market Models of the Currency Market

Gabaix-Maggiori (QJE 2015).

- Assumptions:
  - *Segmentation:* Households in each of two countries can only invest in domestic bonds.
  - *Limited arbitrage:* International capital flows (ICF) are intermediated by arbitrageurs with quadratic holding costs.
    - Reduced form for risk aversion.
- Results:
  - (Exogenous) ICF move exchange rate but not interest rates.
  - $\rightarrow$ UIP can fail to hold.

Segmented Market Models of the Currency Market (cont'd)

Itskhoki-Mukhin (JPE 2021).

- Assumptions:
  - *Segmentation:*
    - Households in each of two countries can only invest in domestic bonds.
    - Noise traders are present in currency market.
  - *Limited arbitrage:* ICF are intermediated by risk-averse arbitrageurs.
    - Large coefficient of risk aversion → CCT risk premium does not drop in the linearization.
- Results:
  - Explain exchange-rate disconnect and PPP puzzle.
    - ICF move exchange rate and are disconnected from other macroeconomic variables.
  - Explain international risk-sharing puzzle.
    - High demand for domestic currency → (i) RER appreciates and (ii) domestic consumption rises because of expenditure switching.
  - Explain failure of UIP and profitability of CCT.
    - High demand for domestic currency → (i) exchange rate appreciates and is expected to depreciate and (ii) domestic interest rate drops because domestic consumption rises.

Segmented Market Models of the Bond Market

Vayanos-Vila (ECMA 2021).

- Assumptions:
  - *Segmentation:*
    - Different investors within a single country can invest in different bond maturities. (Preferred habitats)
    - Short rate is set exogenously by central bank.
  - *Limited arbitrage:* Investor flows are intermediated by risk-averse arbitrageurs.
- Results:
  - (Exogenous) flows move bond yields but not short rate.
  - $\rightarrow$ EH can fail to hold and BCT is profitable.

Linking Currency and Bond Markets

- Previous papers focus on only one market.
  - *Gabaix-Maggiori (QJE 2015), Itskhoki-Mukhin (JPE 2021):* Currency market. One-period bonds only.
  - *Vayanos-Vila (ECMA 2021):* Bond market. One country only.
- Linking the two markets within a segmented markets model seems important.
  - Risk premia in bond and currency markets are connected *(Chen-Tsang RES 2013, Lustig-Stathopoulos-Verdelhan AER 2019, Chernov-Creal RFS 2020, Lloyd-Marin WP 2020).*
  - QE affects exchange rate *(Gagnon-Raskin-Remache-Sack IJCB 2011, D'Amico-King JFE 2013, Bhattarai-Neely JEL 2022).*
  - Effects of ICF on long rates may matter more than those on short rates.

Linking Currency and Bond Markets – Ongoing Research

- *Gourinchas-Ray-Vayanos (AER 2025, GRV I)*.
  - Two-country version of *Vayanos-Vila (ECMA 2021)*.
  - Contemporaneous related paper: *Greenwood-Hanson-Stein-Sunderam (QJE 2023)*.
- *Gourinchas-Ray-Vayanos (WiP 2025, GRV II)*.
  - Embed GRV I in New Keynesian model.

GRV I

Model

- Continuous time $t \in (0, \infty)$. Two countries, home (H) and foreign (F).
- Exchange rate e_t defined as price of foreign currency in home currency.
- Bonds in country $j = H, F$:
  - Continuum of zero coupon bonds in zero net supply with maturity $0 \le \tau \le T$.
  - Price $P_{jt}^{(\tau)}$ of bond with maturity τ in local currency. Yield to maturity $y_{jt}^{(\tau)} = -\log P_{jt}^{(\tau)} / \tau$.
- Exogenous short rate $i_{jt} = \lim_{\tau \to 0} y_{jt}^{(\tau)}$ in country j.
- Wealth and positions expressed in home currency.

Arbitrageurs

- Wealth W_t.
- W_{Ft} position in foreign assets.
- $X_{jt}^{(\tau)} d\tau$ position in bonds of country j with maturities in $[\tau, \tau + d\tau]$.
- Mean-variance objective:

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

- Budget constraint

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

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

Preferred-Habitat Bond Investors and Currency Traders

- Demand for bonds of country j and maturity τ (in H currency):

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

  - Bond demand elastic in the price $P_{jt}^{(\tau)}$.

- Demand for assets of country F (in H currency):

$$Z_{et} = -\alpha_e \left(\log(e_t) + \log(p_{Ft}) - \log(p_{Ht})\right) - \theta_e \gamma_t.$$

  - 'Demand for foreign currency.'
  - Currency demand elastic in the *real* exchange rate $e_t p_{Ft}/p_{Ht}$.

- Exogenous bond and currency demand risk factors: β_{jt} and γ_t.
- Assume constant inflation rates π_H and π_F. Non-stationary nominal exchange rate.

Market Clearing

- Home bonds

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

- Foreign bonds

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

- Foreign currency

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

Risk Factors and Dynamics

- Five risk factors: short rates (i_{jt}), bond demands (β_{jt}) and currency demand (γ_t)

- Linear mean-reverting dynamics

$$\mathrm{dq}_t = \mathbf{\Gamma}\left(\overline{\mathrm{q}} - \mathrm{q}_t\right)\mathrm{d}t + \mathbf{\Sigma}\,\mathrm{dB}_t\,,$$

where

$$\mathrm{q}_t = \begin{bmatrix} i_{Ht} & i_{Ft} & \beta_{Ht} & \beta_{Ft} & \gamma_t \end{bmatrix}^\top,$$

$$\mathrm{B}_t = \begin{bmatrix} B_{iHt} & B_{iFt} & B_{\beta Ht} & B_{\beta Ft} & B_{\gamma t} \end{bmatrix}^\top,$$

$(\mathbf{\Gamma}, \mathbf{\Sigma})$ are 5×5 matrices, the eigenvalues of $\mathbf{\Gamma}$ are positive, and the Brownian motions are independent.

Simple Case: No Demand Shocks

Assume no demand shocks ($\beta_{jt} = \gamma_t = 0$) and diagonal $(\mathbf{\Gamma}, \mathbf{\Sigma})$.

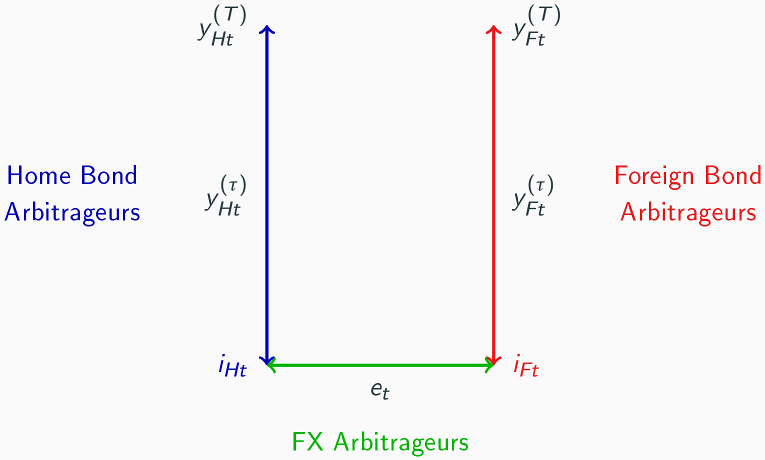
- Short rates i_{Ht} and i_{Ft} are independent.

- Write short-rate process as

$$di_{jt} = \kappa_{ij}(\bar{i}_j - i_{jt})dt + \sigma_{ij} dB_{ijt}.$$

Segmented Arbitrage and No Demand Shocks

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



UIP Deviations and CCT

Postulate: $\log e_t = A_{iFe} i_{Ft} - A_{iHe} i_{Ht} - C_e + (\pi_H - \pi_F)t.$

Proposition (Segmented Arbitrage, UIP Deviations and CCT)

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

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

Intuition: Similar to *Kouri (SJE 1976), Gabaix-Maggiori (QJE 2015)*.

- when $i_{Ft} \uparrow$, arbitrageurs want to invest more in the CCT.
- Foreign currency appreciates ($e_t \uparrow$).
- As $e_t \uparrow$, price-elastic currency traders reduce holdings ($\alpha_e > 0$): $Z_{et} \downarrow$.
- Currency arbitrageurs increase their holdings $W_{Ft} \uparrow$, which requires a higher CCT return.

EH Deviations and BCT

Postulate: $\log P_{jt}^{(\tau)} = -A_{ij}(\tau) i_{jt} - C_j(\tau)$.

Proposition (Segmented Arbitrage, EH Deviations and BCT)

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

- Attenuation: $A_{ij}(\tau) < (1 - e^{-\kappa_{ij}\tau})/\kappa_{ij}$.
- Bond prices in country j only respond to country j short rates (no spillovers).
- BCT$_j$ expected return $\frac{\mathbb{E}_t\left(dP_{jt}^{(\tau)}/P_{jt}^{(\tau)}\right)}{dt} - i_{jt}$ decreases in i_{jt}. (EH deviation)

Intuition: Similar to *Vayanos-Vila (ECMA 2021)*.

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

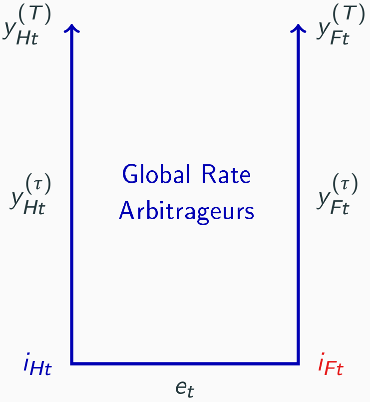
QE, FXI

Assume $a > 0$.

- 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.

Global Arbitrage and No Demand Shocks

Assume that the same arbitrageurs can invest in bonds (H and F) and currency.



UIP/EH deviations and Carry Trades

Proposition (Global Arbitrage and Carry Trades (CCT/BCT))

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

$$\log P_{jt}^{(\tau)} = -A_{ijj}(\tau) i_{jt} - A_{ijj'}(\tau) i_{j't} - C_H(\tau); \log e_t = A_{iFe} i_{Ft} - A_{iHe} i_{Ht} - C_e + (\pi_H - \pi_F)t.$$

- Previous propositions hold: CCT and BCT_H return decrease with i_{Ht}, but attenuation is stronger than with segmented markets.
- ⚠ Cross-country linkages: BCT_F increases with i_{Ht}.

Intuition: Bond and currency premia cross-linkages

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

QE, FXI: Importance of Bond and FX Premia Cross-Linkages

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

- *QE*: Unexpected QE_j reduces yields in country j, as before ($\text{BCT}_j \downarrow$).

⚠ Reduces yields in the other country (when $\alpha_e > 0$), and depreciates the currency ($\text{BCT}_{j'} \downarrow$, $\text{CCT} \downarrow$).

  - To accommodate QE_j, arbitrageurs go short bonds in country j.
  - Hedge by investing in the other country's currency since it appreciates when i_{jt} drops.
  - Hedge currency position by investing in the other country's bonds.

- *Sterilized intervention*: Unexpected purchase of foreign currency causes the foreign currency to appreciate ($CCT \downarrow$).

⚠ Lowers bond yields at Home ($\text{BCT}_H \downarrow$) and increases them in Foreign ($\text{BCT}_F \uparrow$).

  - To accommodate intervention, arbitrageurs hold less foreign and more home currency.
  - More exposed to a decline in i_{Ht} and an increase in i_{Ft}
  - Hedge by investing more in home bonds and less in foreign bonds

The Full Model: Adding Demand Shocks

- Estimate model on US and Eurozone.
- Quarterly data on dollar/euro exchange rate, US and German bond yields, 06/1986-04/2021.
- Use maximum likelihood.
  - Generalized method of moments yields similar answers.

Policy Spillovers

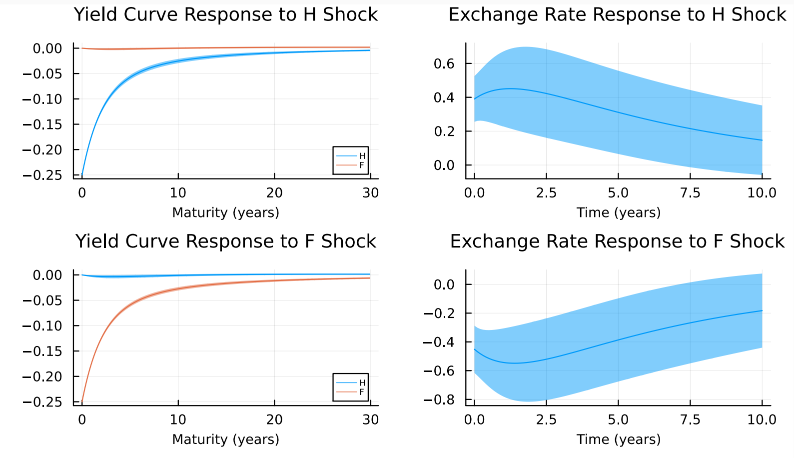
Conduct policy experiments:

- Monetary policy shock:
  - Unanticipated 25bp decrease in short rate (H or F).
  - Half-life = 1 year.
- QE shock:
  - Unanticipated positive demand shock (H or F) that represents about 10% of GDP.
  - Half-life = 7 years.
- Foreign exchange intervention:
  - Unanticipated purchases of foreign currency by central bank (home or foreign) that represents about 10% of GDP.
  - Half-life = 1 year.

Examine spillovers:

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

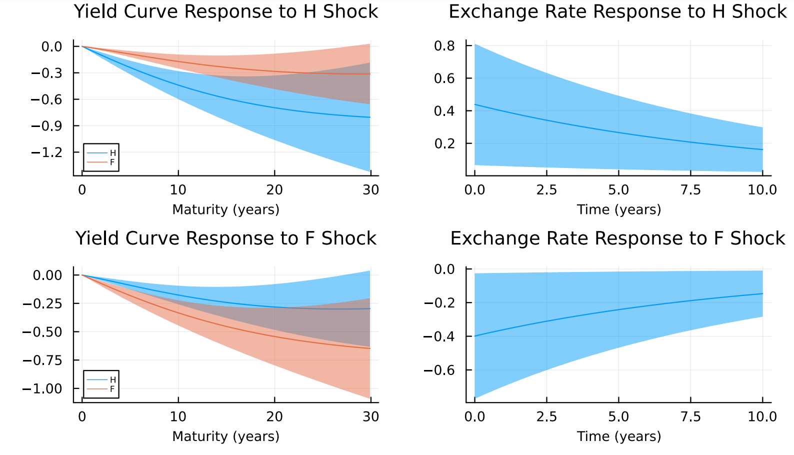
Monetary Shock Spillovers



Small spillover of conventional MP to international yields.

Intuition: Exchange rate is disconnected from long-term bond yields.

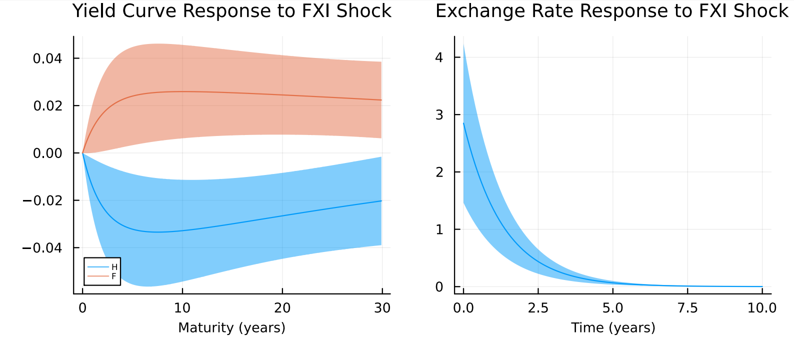
QE Shock Spillovers, $a = 40$



Large spillover of QE to international yields. Smaller spillovers to exchange rate.

Intuition: QE affects bond positions directly, and bond yields are connected across countries.

FXI Shock Spillovers, $a = 40$



Small spillovers of FXI to yields.

Intuition: Exchange rate is disconnected from long-term bond yields.

GRV II

From GRV I to GRV II

- Shortcomings of GRV I:
  - Exogenous downward-sloping demand for bonds and currency.
  - Exogenous short rates and constant inflation.
  - Focus only on financial markets and not on links with macroeconomy
- GRV II: Embed GRV I into New Keynesian model as its finance block.
  - Micro-founded demand for bonds and currency.
  - Endogenous short rates and inflation.
  - Implications of flows for real economy.

Model

- Households in each country.
  - Intertemporal utility over consumption of home and foreign final good and over labor.
  - Hold fixed-weight portfolio of home and foreign bonds, and short and long maturities.
    - Weighted maturity of bonds in portfolio = Effective maturity.
- Final goods firms. Competitive.
- Intermediate goods firms. Imperfectly competitive and sticky prices.
- Governments. Issue bonds and collect taxes.
- Arbitrageurs in each country.
  - Invest in all bonds and can freely modify their portfolio.
  - Return profits to households.
  - Mean-variance objective.

Preliminary Results: Effects of ICF

- Scenario 1: Effective maturity is short and flows are into foreign short-term bonds (*Itskhoki-Mukhin JPE 2021*).
  - Foreign currency appreciates and CCT expected return drops.
  - Foreign GDP drops because of expenditure switching.
  - Foreign PPI drops because labor demand drops. i_{Ft} drops because of Taylor rule.
  - Foreign consumption rises because of expenditure switching.

- Scenario 2: Effective maturity is long and flows are into foreign long-term bonds.
  - Foreign bond prices rise and BCT expected return drops.
  - Foreign consumption rises because long rate drops.
  - Foreign PPI rises because labor supply drops. i_{Ft} rises because of Taylor rule.
  - Foreign GDP drops because of rise in i_{Ft}.
  - Foreign currency appreciates because of rise in i_{Ft} even though CCT expected return rises.
  - Stronger effects than in Scenario 1.

Implications

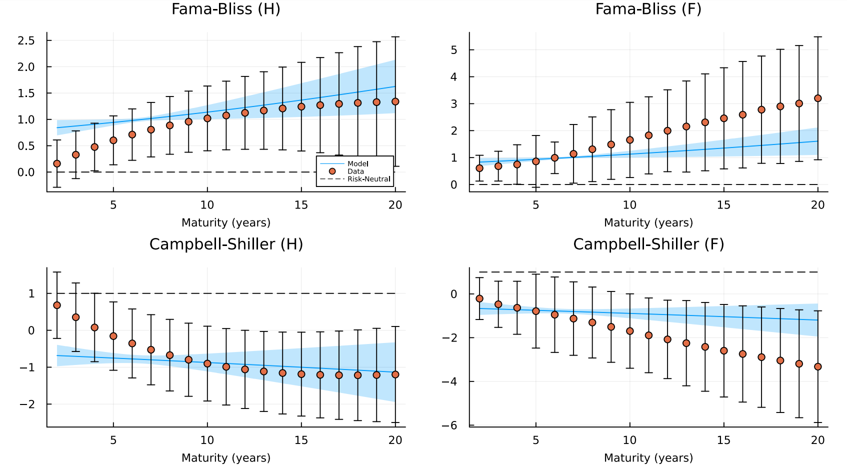
- ICF into long-term assets have stronger macroeconomic effects, especially when effective maturity is long.
- Important to bring long rate into macroeconomic models.

Conclusion

- Exciting new literature in International Macroeconomics emphasizing segmented capital markets and limited arbitrage.
  - Draws on literature in Finance on the same topics.
- Results on
  - Exchange rate determination,
  - Monetary policy transmission,
  - Optimal monetary policy,

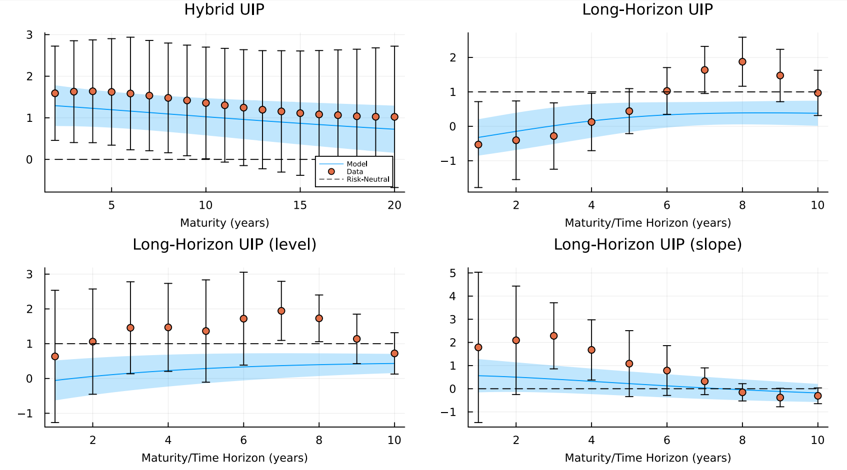
  can differ significantly from standard models and align better with empirical evidence.

Regression Coefficients: EH



Positive slope-premia relationship.

Regression Coefficients: UIP



CCT's profitability declines if done with long-term bonds or over long horizon. Slope differential predicts CCT return.