Bond Convenience Yields and Exchange Rate Dynamics

Rosen Valchev (Boston College)

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Motivation

- s_t = log exchange rate, home currency units per 1 USD currency
- Uncovered Interest Rate Parity (UIP):

$$E_t(s_{t+1} - s_t) = i_t - i_t^*$$

- Central to exchange rate determination in standard models
- **UIP Puzzle:** significant time-variation in excess currency returns
  - $i_t - i_t^* \uparrow \Rightarrow$ excess returns on domestic currency increase
- Engel (2016): direction of the puzzle **reverses** at longer horizons
  - *Insufficient* FX depreciation at short-horizons
  - ... but *excess* depreciation at longer-horizons

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2. New mechanism based on bond convenience yields
   - Convenience yield $\equiv$ the non-pecuniary (liquidity) benefit of holding safe and liquid assets that can serve as substitute for money
   - Leads to modified UIP condition:

$$E_t(s_{t+1} - s_t) + i_t^* - i_t = \underbrace{\Psi_t^{\text{Home}} - \Psi_t^{\text{Foreign}}}_{\text{Convenience Yield Differential}}$$

   - The model can explain both classic puzzle and the reversal
     - non-linear dynamics due to interaction of monetary and fiscal policy
     - mechanism is particularly important at lower frequencies

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   - The model can explain both classic puzzle and the reversal
     - non-linear dynamics due to interaction of monetary and fiscal policy
     - mechanism is particularly important at lower frequencies
3. Document effect of bonds/liquid assets on FX returns in the data
   - Especially important for USD

Related Literature

- **Empirical UIP Literature:** Fama (1984), Hodrick (1987), Froot and Thaler (1990), Lewis (1995), Engel (1996, 2013, 2013b, 2016), Burnside et al (2006), Chinn (2006), Burnside (2011,2013), Chinn and Quayyum (2013), Hassan and Mano (2015), Lustig, Stathopolous and Verdelhan (2015)

- **Theoretical UIP Literature:** Burnside, Eichenbaum and Rebelo (2009), Burnside et al. (2010), Verdelhan (2010), Colacito and Croce (2011, 2013), Bansal and Shaliastovich (2012), Ilut(2012), Farhi and Gabaix(2015), Gabaix and Maggiori (2015), Itskhoki and Mukhin (2016)

- **Bond Convenience Yields**
  - **Empirics:** Krishnamurty (2002), Fontaine and Garcia (2012), Krishnamurty and Vissing-Jorgensen (2012)
  - **Theory:** Bansal and Coleman (1996), Lagos (2010,2011), Acharya and Viswanathan (2011), Bansal, Coleman and Lundblat (2011)

- **Liquid Assets and FX in the Data:** Brunnermeier, Nagel and Pedersen (2008), Adrian, Etula and Shin (2010), Junior (2013), Lustig, Stathopolous and Verdelhan (2015)

Presentation Outline

UIP in the data

- UIP implies excess returns should not be forecastable at **any** horizon:

$$E_t(\underbrace{s_{t+k+1} - s_{t+k} + i^*_{t+k} - i_{t+k}}_{=\lambda_{t+k}}) = 0, \quad k = 1, 2, \ldots$$

  where λ_{t+k} is a one-period excess foreign return that realizes at $t+k$

- I estimate the series of panel regressions

$$\lambda_{j,t+k} = \alpha_{j,k} + \beta_k(i_{j,t} - i^*_{j,t}) + \varepsilon_{j,t+k}, \quad k = 1, \ldots, 180 \quad \text{and} \quad j = AUD, \ldots$$

  - Data: 18 OECD currencies, 1976:M1 to 2013:M6

- Change the **horizon**, not the holding period of the left-hand side

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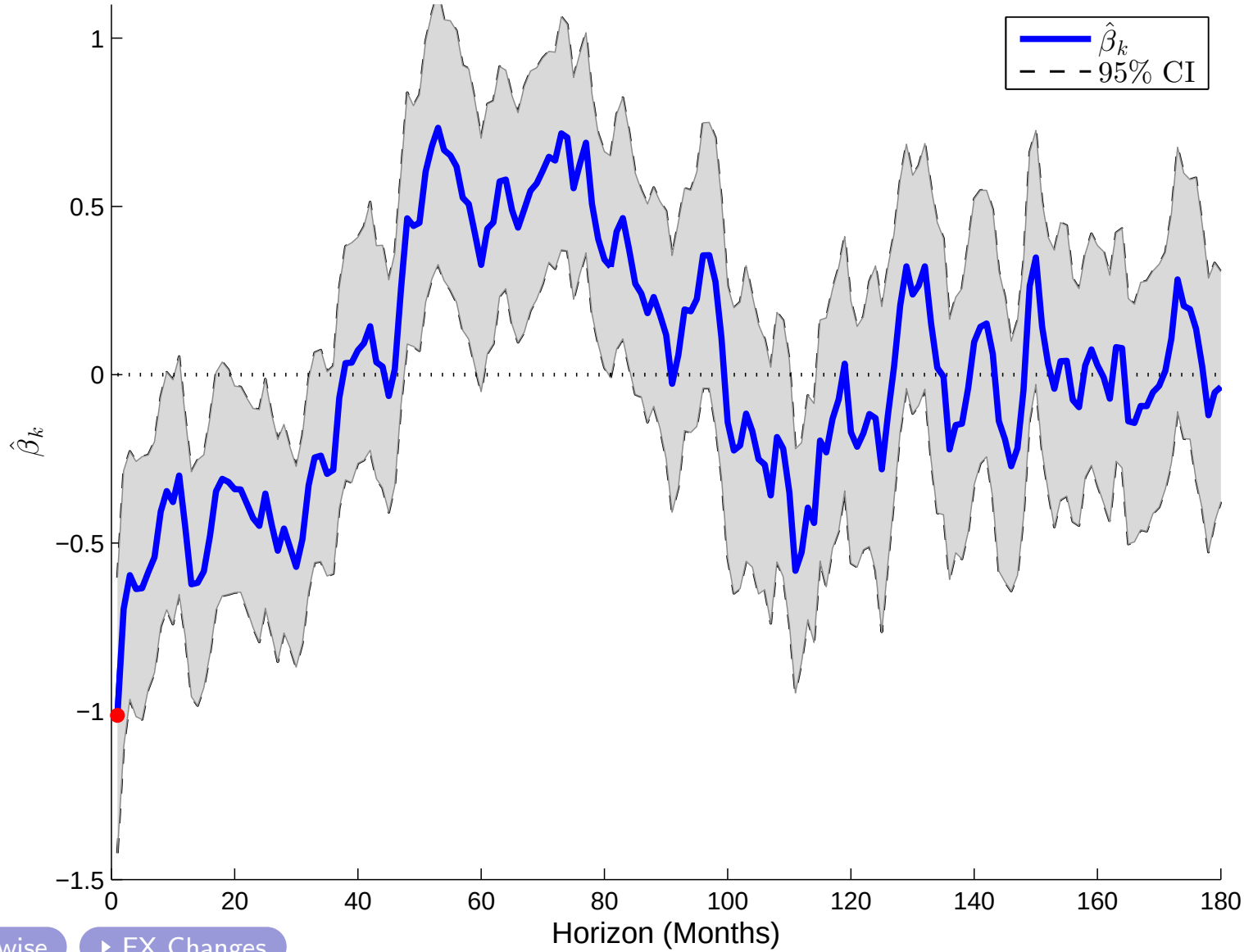
  - Data: 18 OECD currencies, 1976:M1 to 2013:M6
- Change the **horizon**, not the holding period of the left-hand side
- Under UIP we would have $\beta_k = 0$
  - But $\boldsymbol{\beta_k \neq 0}$ and **change sign** with the horizon

UIP violations at different horizons



▸ Pairwise ▸ FX Changes

The Underlying Exchange Rate Dynamics

- Is the changing direction due to the exchange rate or interest rates?
- Estimate IRF via Jorda-projections

$$E[s_{t+k} - s_t | i_t - i_t^*] = \gamma_k (i_t - i_t^*)$$

- Cumulative exchange rate change can be expressed as:

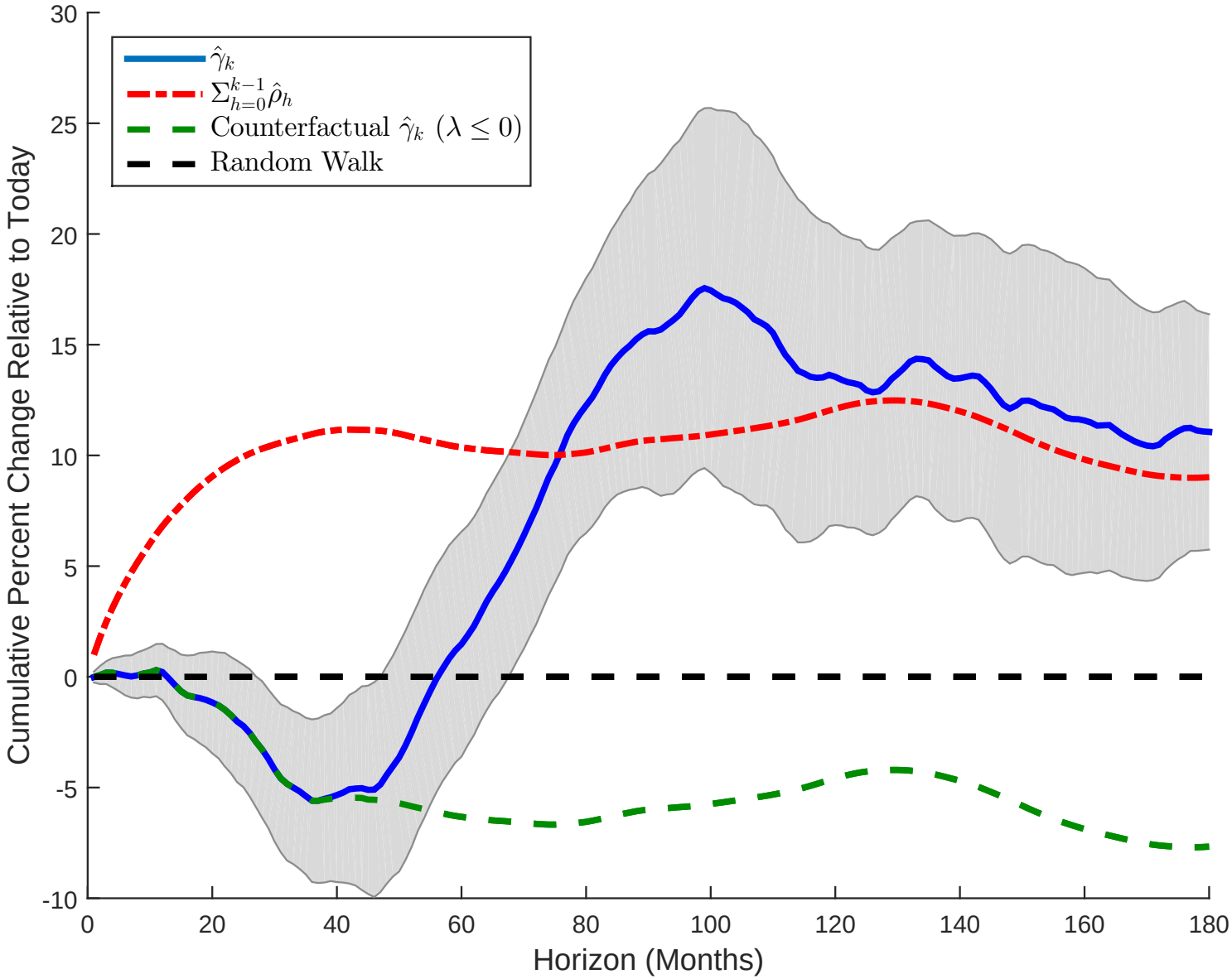
$$s_{t+k} - s_t = \sum_{h=0}^{k-1} (i_{t+h} - i_{t+h}^*) + \sum_{h=1}^{k} \lambda_{t+h}$$

- Let ρ_k be the k-th partial autocorrelation of $i_t - i_t^*$, then

$$\gamma_k = \underbrace{\sum_{h=0}^{k-1} \rho_h}_{\text{Sum of Expected Int Diffs}} + \underbrace{\sum_{h=1}^{k} \beta_h}_{\text{Sum of UIP Violations}}$$

- UIP – first term equals 0, RW – the two offset each other

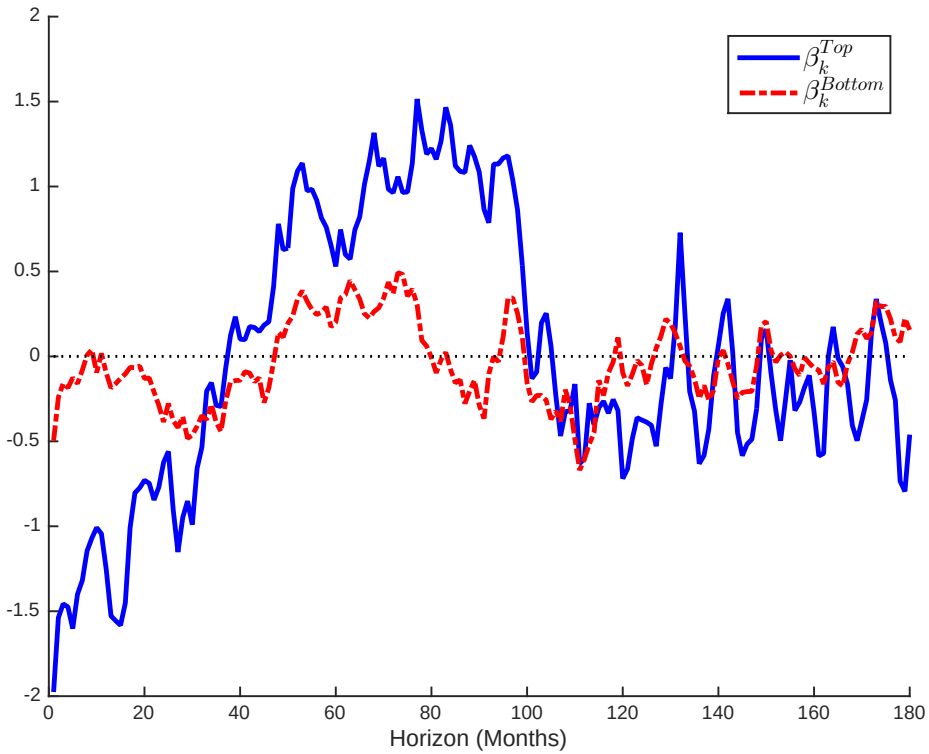
The Underlying Exchange Rate Dynamics



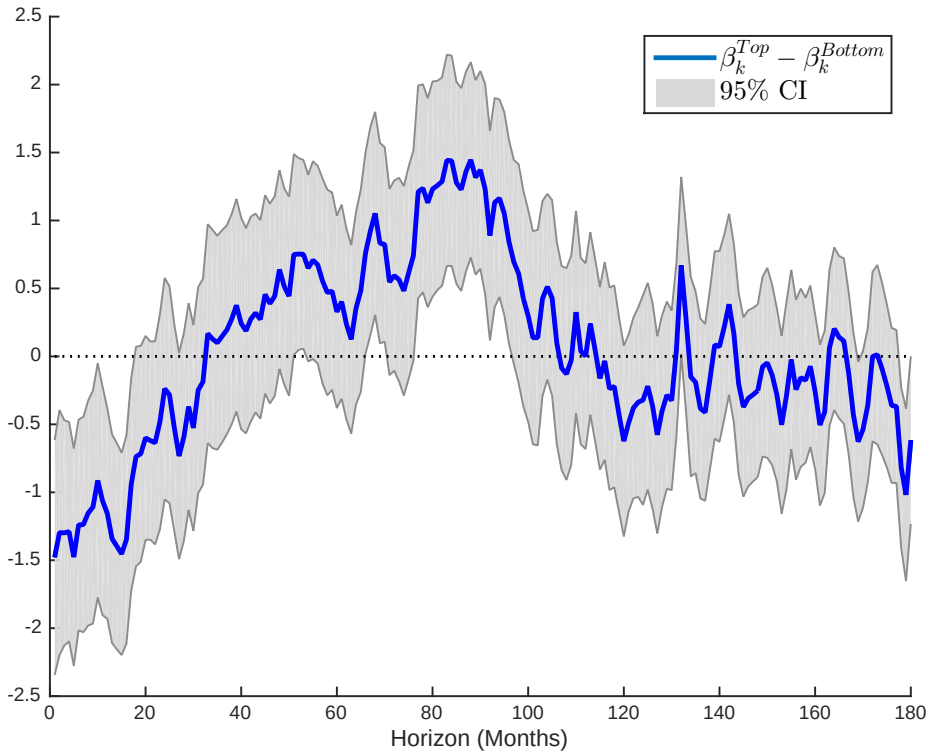
Monetary Policy Stance and UIP Violations

- UIP reversal present in all 18 currencies, but to a different extent
- Bansal and Dahlquist (2000) – classic UIP puzzle strongly related to monetary policy proxies
  - Is there a similar relationship with the reversal?
- Sort currency on monetary policy stance – four proxies:
  1. Average inflation
  2. Standard deviation of inflation
  3. Central Bank Independence Index (Grilli, Masciandro and Tabellini (1993))
  4. Capital Controls
- Take time averages and look at the cross-section. I compare
  1. Bottom (IEP, ITL, PTE, ESP) vs top (DEM, NLG, CHF) third with USD as base
  2. Bottom third as base vs USD as base (IEP, ITL, PTE, ESP)

High vs Low Monetary Independence

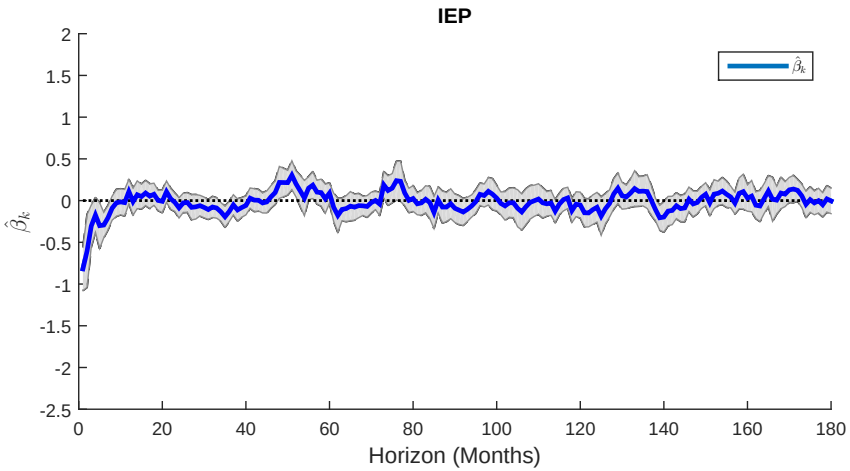


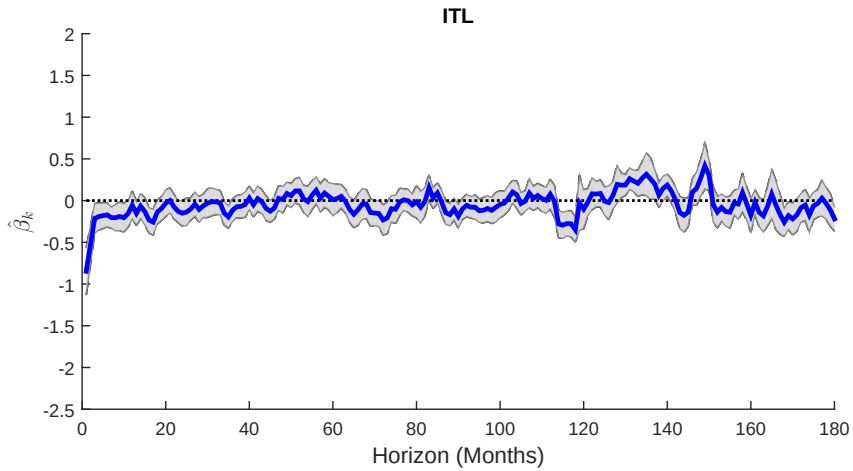
(a) Top vs Bottom Third

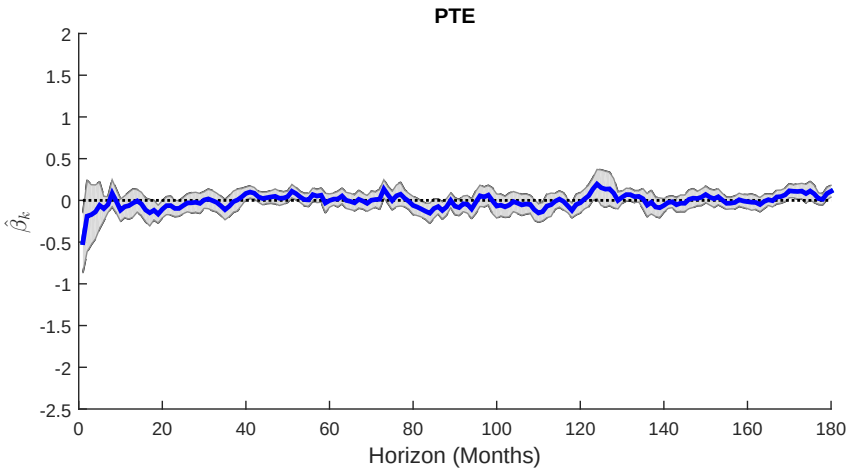


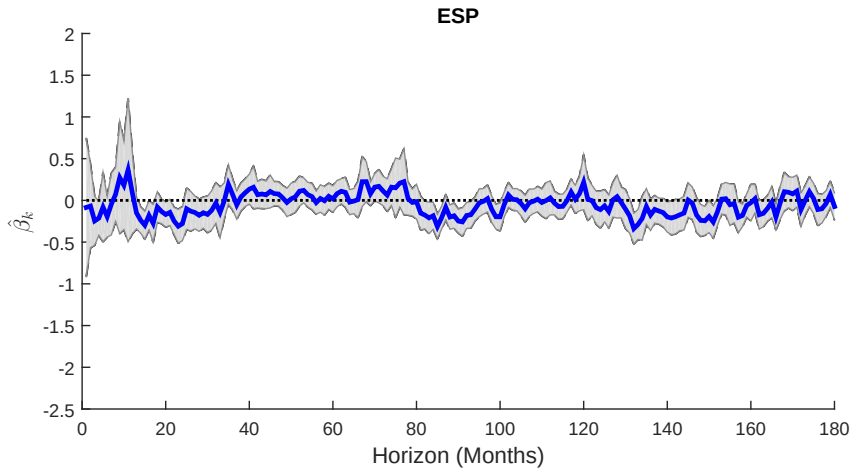
(b) $\beta_k^{Top} - \beta_k^{Bottom}$

Dovish Monetary Policy Currency as Base









Presentation Outline

Bond Convenience Yields and UIP violations

- The literature has focused on two explanations for UIP failure
  - 1) risk premia and 2) deviations from rational expectations
- This paper: bonds offer non-pecuniary benefit (i.e. convenience yield)
  - Excess FX returns compensate for convenience yield differential

$$E_t(s_{t+1} - s_t) + i_t^* - i_t = \Psi_t^{\text{Home}} - \Psi_t^{\text{Foreign}}$$

  - Potentially important wedge
    - Large (mean for US: 75 to 166 bp) and volatile (std. dev. 45 to 115bp)
- Is it at all related to exchange rates?
  - No predictability in cross-currency returns on less special assets
    - Long-term bonds (Lustig et.al. (2016)), Equities (Hau and Rey (2006))
  - BAA - Treasury spread: a common model-free conv yield measure
    - Captures both safety and liquidity premia (KVJ(2012))

Corporate Spreads and FX Returns

$$\lambda_{j,t+1} = \alpha_j + \beta(i_t - i^*_{j,t}) + \gamma(\text{BAA - Treasury}) + \text{Additional Controls} + \varepsilon_{j,t+1}$$

Table: Excess Currency Returns and Credit Spreads, 1986 - 2007

	(1)	(2)	(3)	(4)
BAA - Treasury	6.40**	5.51*	4.89*	4.77*
	(3.06)	(2.88)	(2.98)	(2.86)
$i_t - i^*_t$			-0.98***	-0.94***
			(0.33)	(0.37)
US Controls	Yes	Yes	Yes	Yes
Foreign Controls	No	Yes	No	Yes
Fixed Effects	Yes	Yes	Yes	Yes

Additional controls (as per KVJ (2012)):

- Yield Curve Slope
- Stock volatility (last 12-months daily volatility)
- Both home and foreign pairs of these variables

Analytical Model Setup

- Large **home** country, **small** (measure zero) foreign country
- The home household maximizes

$$\sum_{k=0}^{\infty} E_t \beta^k u(c_{t+k}, b_{h,t+k}, b_{f,t+k})$$

- General preferences over liquidity
  - $u(c_t, b_{ht}, b_{ft})$ is concave in all arguments
  - Key: home and foreign bonds are not perfect substitutes

$$u_{b_h b_h} < u_{b_h b_f} < 0$$

  - Cashless economy limit; introduce money in quant. model
- Constant endowment, HH faces the budget constraint:

$$c_t + b_{ht} + b_{ft} = y - \tau_t + b_{h,t-1} \frac{(1 + i_{t-1})}{\Pi_t} + b_{f,t-1} \frac{(1 + i^*_{t-1})}{\Pi_t} \frac{S_t}{S_{t-1}}$$

Euler Equations

- Household's Euler equations:

$$1 = \beta E_t \left(\frac{u_c(c_{t+1}, b_{h,t+1}, b_{f,t+1})}{u_c(c_t, b_{ht}, b_{ft})} \frac{1 + i_t}{\Pi_{t+1}} \right) + \underbrace{\frac{u_{b_h}(c_t, b_{ht}, b_{ft})}{u_c(c_t, b_{ht}, b_{ft})}}_{\text{Convenience Benefit of Home Bonds} \equiv \Psi_t^H}$$

$$1 = \beta E_t \left(\frac{u_c(c_{t+1}, b_{h,t+1}, b_{f,t+1})}{u_c(c_t, b_{ht}, b_{ft})} \frac{1 + i_t^*}{\Pi_{t+1}} \frac{S_{t+1}}{S_t} \right) + \underbrace{\frac{u_{b_f}(c_t, b_{ht}, b_{ft})}{u_c(c_t, b_{ht}, b_{ft})}}_{\text{Convenience Benefit of Foreign Bonds} \equiv \Psi_t^F}$$

Government

- Follows the (log-linearized) Taylor rule where v_t is iid

$$\hat{i}_t = \phi_\pi \hat{\pi}_t + v_t$$

- Constant expenditures g, financed by lump-sum tax τ_t and bonds b_t^G
- Budget constraint:

$$b_t^G + \tau_t = \frac{(1 + i_{t-1})}{\Pi_t} b_{t-1}^G + g$$

- Taxation rule following Leeper (1991)

$$\tau_t = \rho_\tau \tau_{t-1} + (1 - \rho_\tau) k_\tau b_{t-1}^G$$

Model Solution

- Log-linearize around symmetric steady-state

$$\underbrace{\hat{i}_t - E_t(\hat{\pi}_{t+1})}_{\text{Real Interest Rate}} + \underbrace{\frac{\Psi^H}{\beta(1+i)}\hat{\Psi}_t^H}_{\text{Home Conv Yield}} = -E_t(\hat{M}_{t+1})$$

- Foreign Bonds Euler

$$E_t(s_{t+1} - s_t) + \hat{i}_t^* - E_t(\hat{\pi}_{t+1}) + \frac{\Psi^F}{\beta(1+i)}\hat{\Psi}_t^F = -E_t(\hat{M}_{t+1})$$

- Combining the two

$$E_t(\underbrace{\hat{s}_{t+1} - s_t + \hat{i}_t^* - \hat{i}_t}_{\hat{\lambda}_{t+1}=\text{ Excess currency return}}) = \underbrace{\frac{\Psi^H}{\beta(1+i)}(\hat{\Psi}_t^H - \hat{\Psi}_t^F)}_{\text{Conv Yield Differential}}$$

Equilibrium Dynamics

- Constant endowment and small foreign country imply

$$c_t = y_t = y; \qquad b_{ht} = b_{ht}^G; \qquad b_{ft} = 0$$

- Equilibrium conveniences yield reduce to

$$\frac{\psi^H}{\beta(1+i)}\hat{\psi}_t^H = -\gamma_\psi \hat{b}_{ht}^G \quad , \quad \hat{\psi}_t^F = 0$$

- Excess returns

$$E_t(\hat{\lambda}_{t+k+1}) = -\chi_b E_t(\hat{b}_{h,t+k}^G)$$

- Classic UIP Puzzle is a fundamental feature of the model
  - Through home Euler equation
- The direction of UIP violations at longer horizons depends on government debt dynamics

  $\Rightarrow$ determined by interaction of monetary and fiscal policy

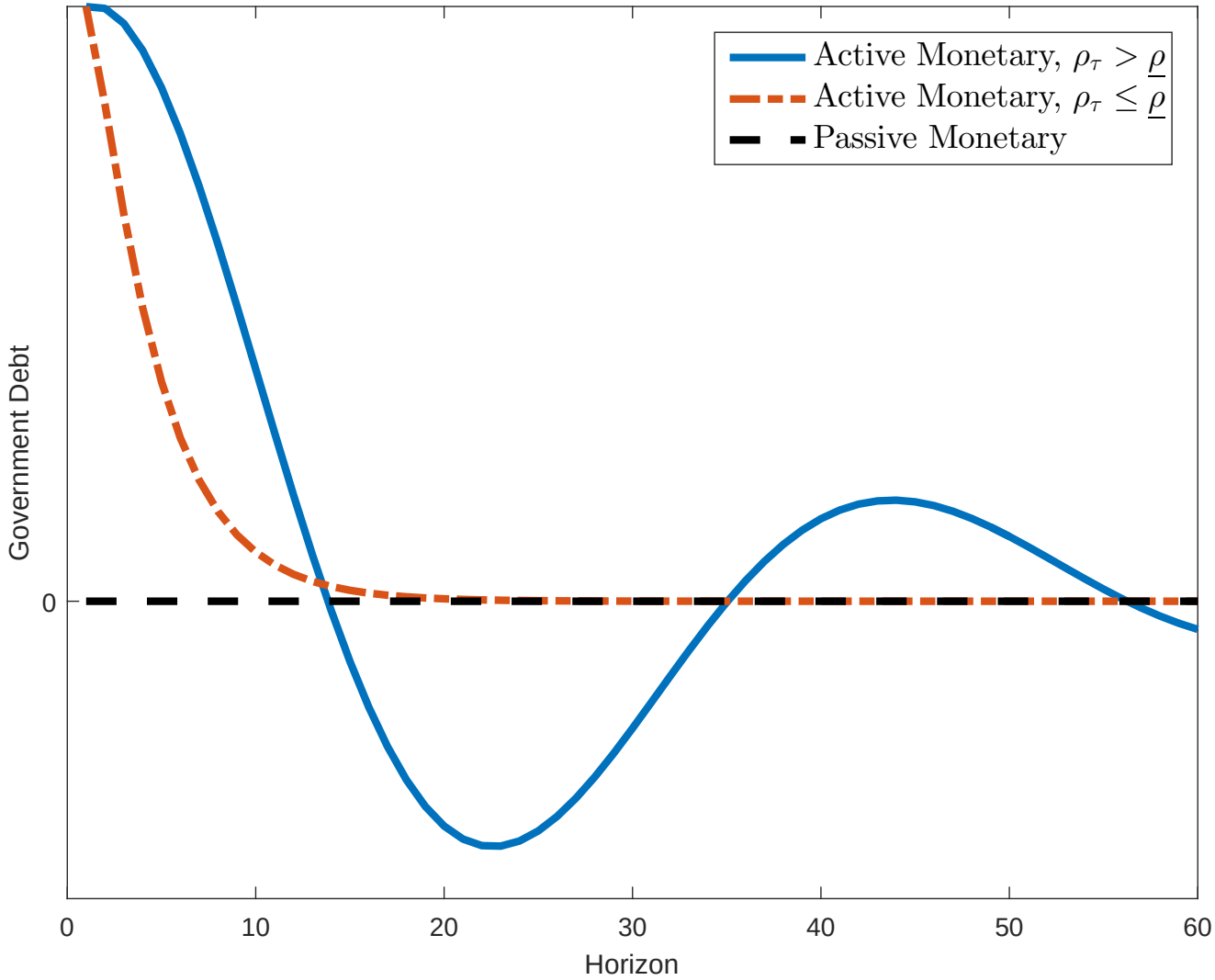
Equilibrium Dynamics

- There are two types of equilibria
  1. Active Monetary / Passive Fiscal Policy (i.e. $\phi_\pi > 1$)
  2. Passive Monetary / Active Fiscal Policy (i.e. $\phi_\pi < 1$)
- Important similarities and differences
  - The UIP puzzle ($\beta_k < 0$ for small k) holds in both cases
  - But only active MP can generate $\beta_k > 0$ at longer horizons
- The dynamics of the system governed by either real or complex roots
  1. Real Roots: negative UIP coefficients at all horizons
  2. Complex Roots: Cyclical debt dynamics $\Rightarrow$ cyclical excess returns

$$\hat{\tau}_t = \overline{\Psi} \sum_{k=0}^{\infty} \rho_\tau^k \hat{b}_{t-k-1}$$

  - UIP coefficients are negative at first, turn positive at longer horizons

Bonds IRF Example



UIP Violations

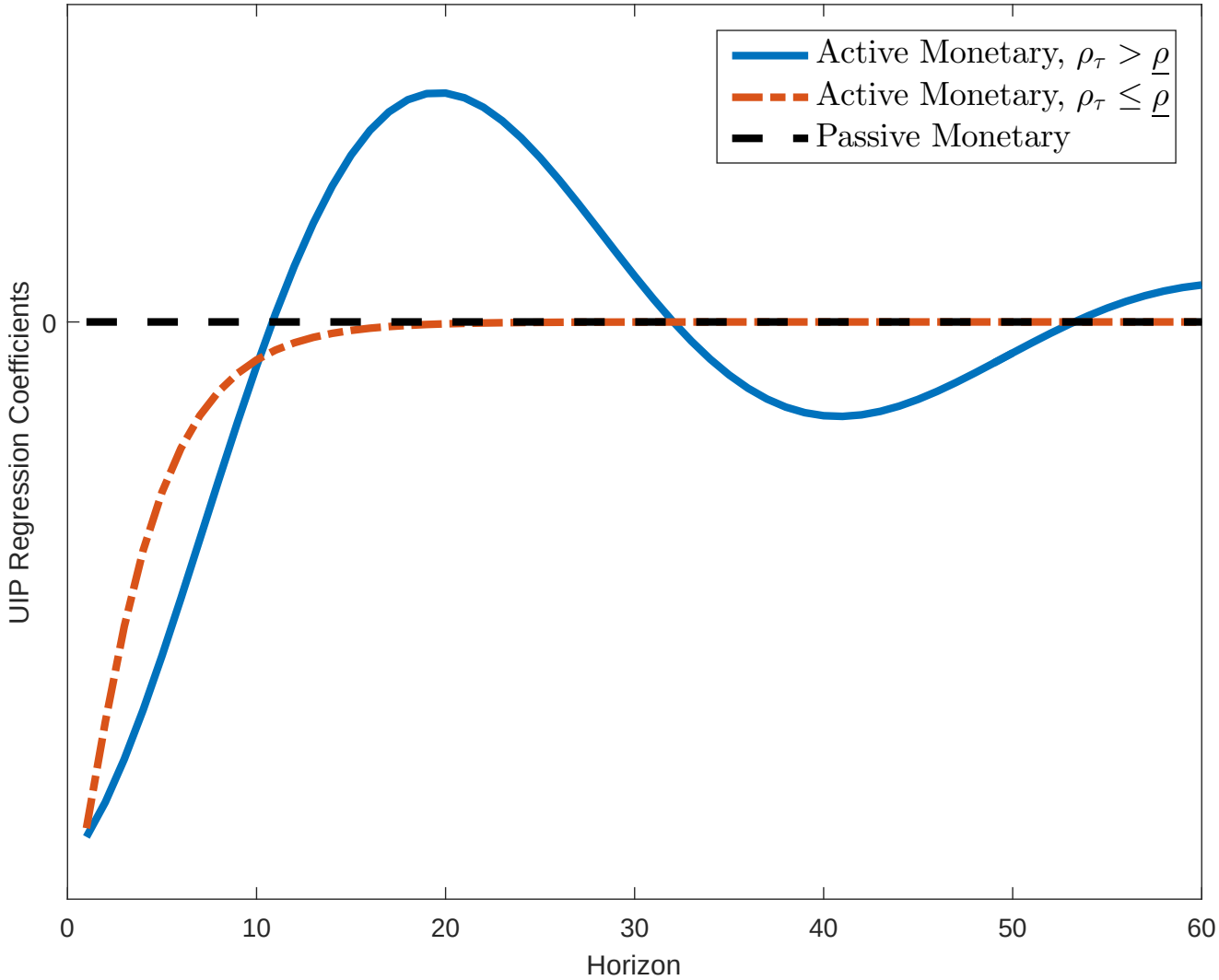
- Recall that excess returns are given by

$$E_t(\hat{\lambda}_{t+1}) = -\chi_b \hat{b}_{h,t}$$

- Contractionary monetary shock lowers $\hat{\pi}_t$ and increases $\hat{b}_{ht}$
  - Lower convenience yield $\Rightarrow$ higher (domestic) excess currency returns
  - Also higher interest rate $\Rightarrow$ std UIP Puzzle ($\beta < 0$)
- When monetary policy is active and ρ_τ high
  - Cyclical $\hat{b}_{ht}$ dynamics lead to cyclical dynamics in excess returns
  - UIP violations change direction
- PM/AF: No violations specific to simple cashless economy
  - Introducing money (i.e. extra state variable) leads to $\beta_k < 0$
  - The key result are the real roots, hence no UIP violation reversal

UIP Regression Coefficients

Figure: $\lambda_{t+k} = \alpha_k + \beta_k(i_t - i_t^*) + \varepsilon_{t+k}$



Main Takeaways

- The model can match UIP violations at **both** short and long horizons
- UIP violation dynamics depend on the convenience yield differential

$$E_t(\hat{\lambda}_{t+k}) = \frac{\Psi^H}{\beta(1+i)}(\hat{\psi}_t^H - \hat{\psi}_t^F) = -\gamma_\Psi \hat{b}_{ht}$$

- In turn, that depends on the monetary-fiscal interaction and resulting debt dynamics
- UIP violation reversals only present under active MP
  - Depend on monetary policy that strongly anchors inflation expectations, and a taxation policy that is relatively sluggish
- Passive monetary policy:
  1. Smaller UIP violations
  2. No reversals at longer horizons

Presentation Outline

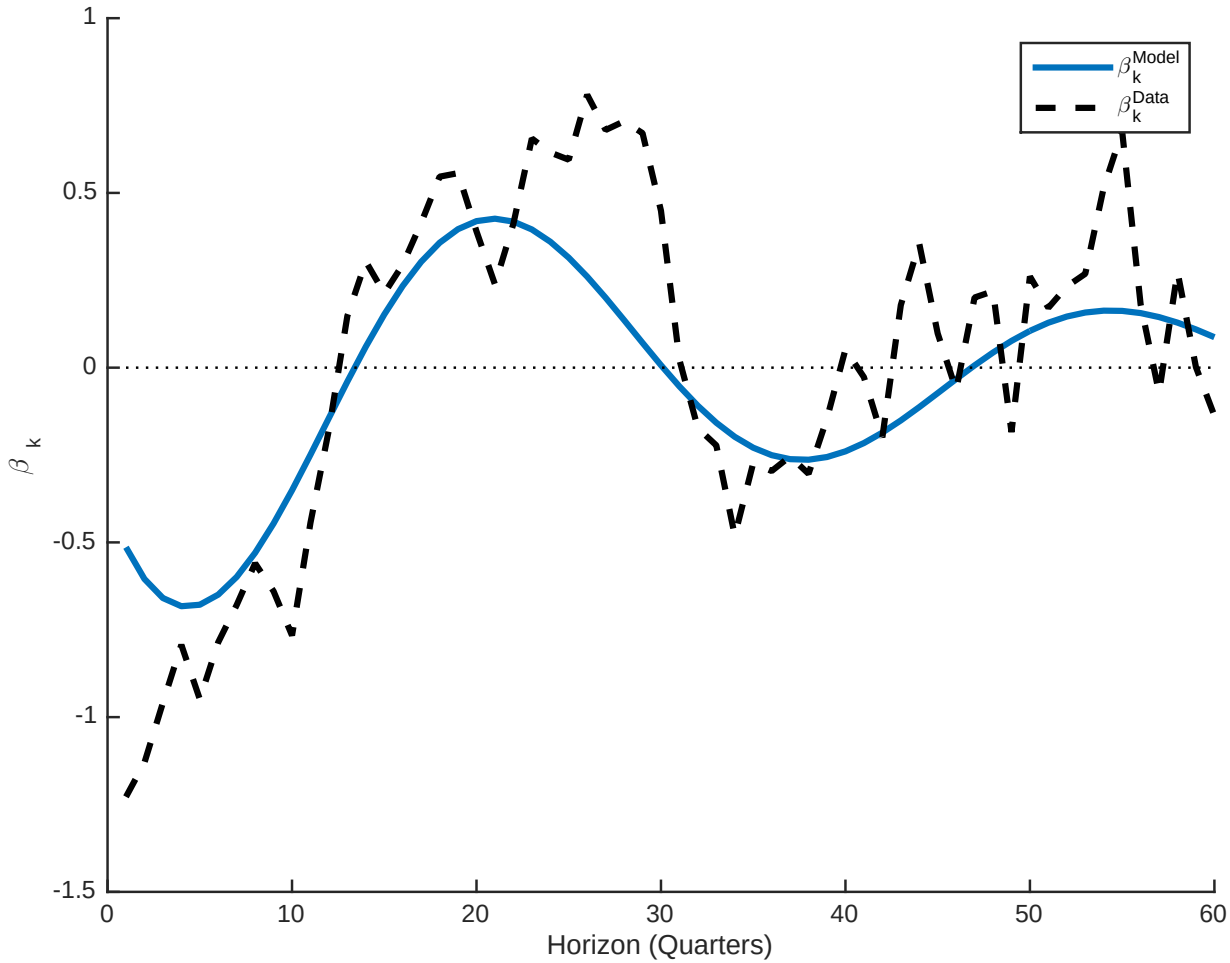
Quantitative Model Overview

- Standard benchmark two-country model (Clarida, Gali and Gertler (2002))
  - Two symmetric countries, two final goods with home bias
  - Monopolistic competition + Calvo + Taylor rule
  - Shocks – monetary and technology
- Augment with
  1. Preference for liquidity (money and bonds) ▸ Transaction Costs
  2. Fiscal Policy and Government Debt
- Calibrate to standard parameters in the literature ▸ Calibration
- Key mechanism is identical as in the analytical model
  - The modified UIP condition is now

$$E_t(\hat{\lambda}_{t+1}) = \underbrace{\hat{\Psi}_t^H - \hat{\Psi}_t^F}_{\text{Convenience Yield Differential}} = \gamma_b(\hat{b}_{f,t} - \hat{b}_{h,t})$$

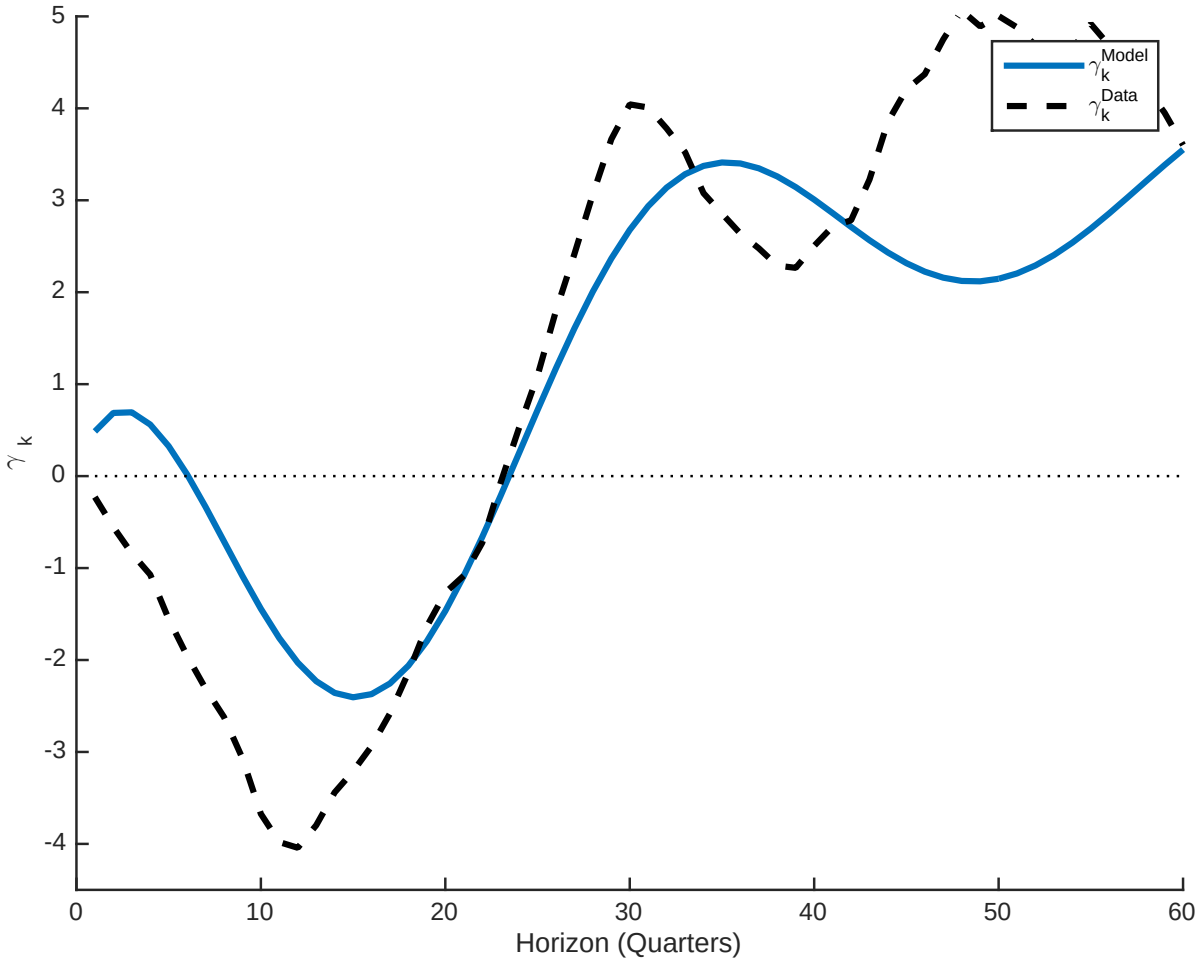
Implied UIP Regression Coefficients

Figure: $\lambda_{t+k} = \alpha_k + \beta_k(i_t - i_t^*) + \varepsilon_{t+k}$



Exchange Rate Behavior

Figure: $s_{t+k} - s_t = \alpha_k + \gamma_k(i_t - i_t^*) + \varepsilon_{t+k}$



Understanding the Mechanism

- Illustrate conditional on monetary shock
- Similar intuition as in the analytical model
  - The shock moves interest rate differentials and convenience yield differentials in **different directions**
  - Tax rates are smooth and bond supply **overshoots** before converging to steady state
- International spillover of shocks acts as an amplification mechanism
  - Persistent FX appreciation leads to higher inflation and output abroad
  - $\hat{b}^G_{ft}$ falls $\Rightarrow$ MB of foreign bonds increases, reinforces original effect
- Importantly it is all about the *differential* convenience yield
  - $\hat{i}_t \uparrow \Rightarrow \hat{m}_t \downarrow$ and this tends to increase liquidity value of the other liquidity assets – both home and foreign bonds
  - However, $\hat{\Psi}^H_t - \hat{\Psi}^F_t$ unambiguously falls

Model Discussion

- The model also matches unconditional moments very well
  - Importantly, unconditional volatility of exchange rates and interest rate differentials
  - Generally little effect on unconditional moments of macro-aggregates
- System dynamics vs shocks
  - Same results for monetary, technology, fiscal, tax, and liquidity shocks

▸ Monetary ▸ Technology ▸ Fiscal ▸ Tax

- Long-term bond returns equalized, even if we assume they have same liquidity benefit
  - Essentially conv. yield on long-term bonds will be equal to the sum of future expected, short-term convenience yields – but those roughly cancel out over long horizons

$$E_t(\Delta s_{t+1} + \hat{R}^{*,(N)}_{t+1} - \hat{R}^{(N)}_{t+1}) = E_t \sum_{k=0}^{N-1} (\hat{\Psi}_{t+k} - \hat{\Psi}^*_{t+k}) \approx 0$$

Presentation Outline

1. Motivation
2. Related Literature
3. The Data
4. A Convenience Yields Model of Exchange Rates
5. **Testing the Mechanism**
   - Government Debt and the UIP violations
6. Conclusion

Government Debt and Currency Returns

- Recall the model implies:

$$E_t(\hat{s}_{t+1} - \hat{s}_t + \hat{i}_t^* - \hat{i}_t) = \hat{\Psi}_{b_h,t} - \hat{\Psi}_{b_f,t} = \gamma_b(\hat{b}_{f,t} - \hat{b}_{h,t})$$

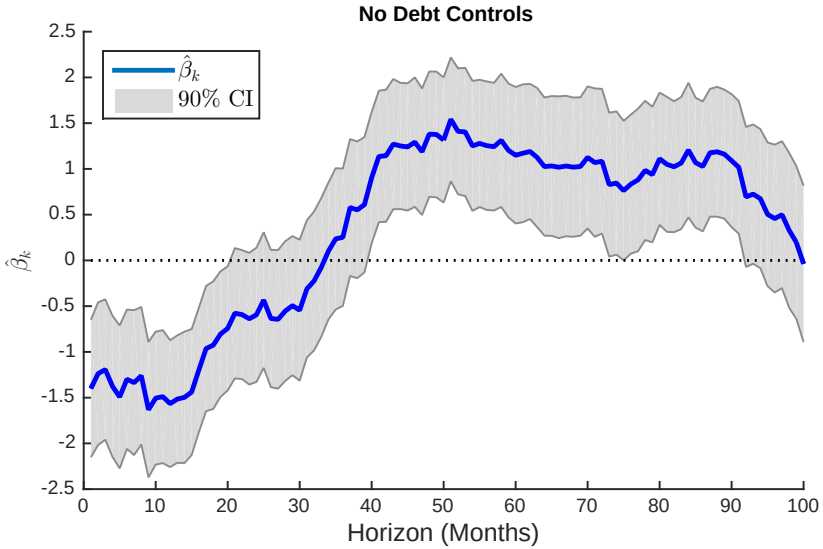
- Estimate a standard UIP regression adding US Debt-to-GDP
- Additional Controls
  1. Commercial Paper (substitution effects between private and public debt) ▸ CP Figure
  2. Signed VIX index (risk-premium considerations)
- Debt variables eliminate the significance of the interest rate differential

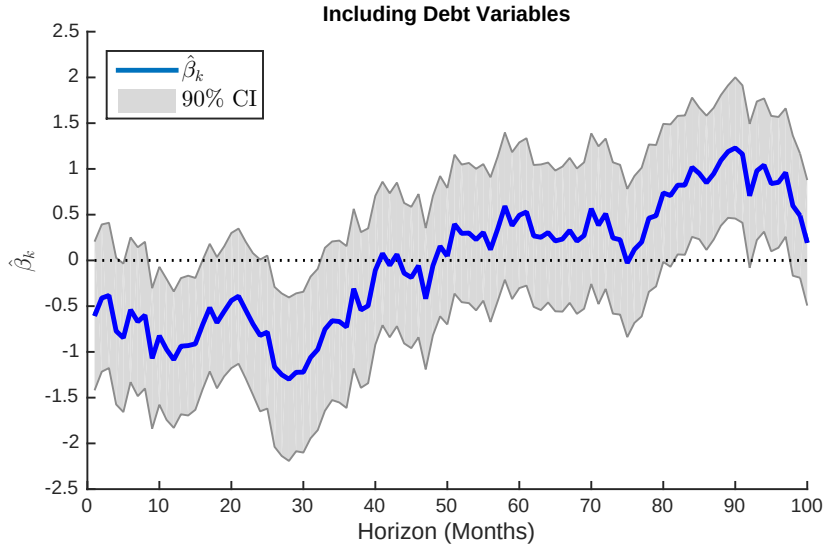
Government Debt and Currency Returns

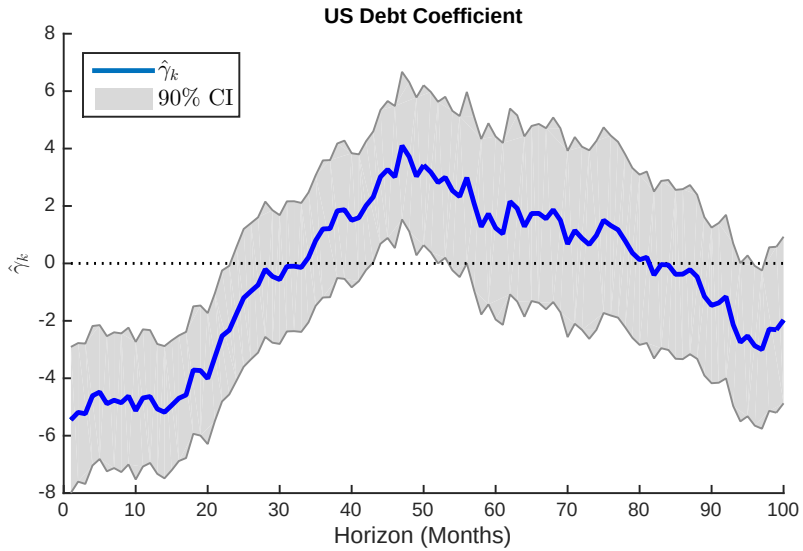
Table: Excess Currency Returns and Debt

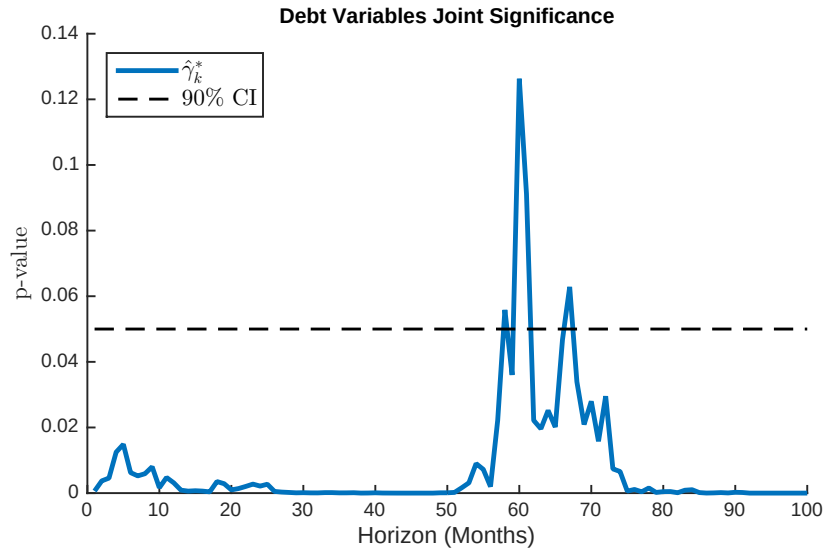
	1991 - 2007			
	(1′)	(2′)	(3′)	(4′)
$i_t - i_t^*$	-1.83***	-1.97***	-0.65	-0.08
	(0.49)	(0.49)	(0.51)	(0.52)
ln(Debt)		-2.65***	-7.85***	-7.71***
		(0.70)	(1.57)	(1.91)
ln(Debt*)		0.18	0.33*	0.39**
		(0.17)	(0.17)	(0.15)
ln(CP)			-3.24***	-3.32**
			(0.83)	(1.32)
Add. Controls	No	No	No	Yes
# Currencies	10	10	10	10
Fixed Effects	Yes	Yes	Yes	Yes

Government Debt and Currency Returns









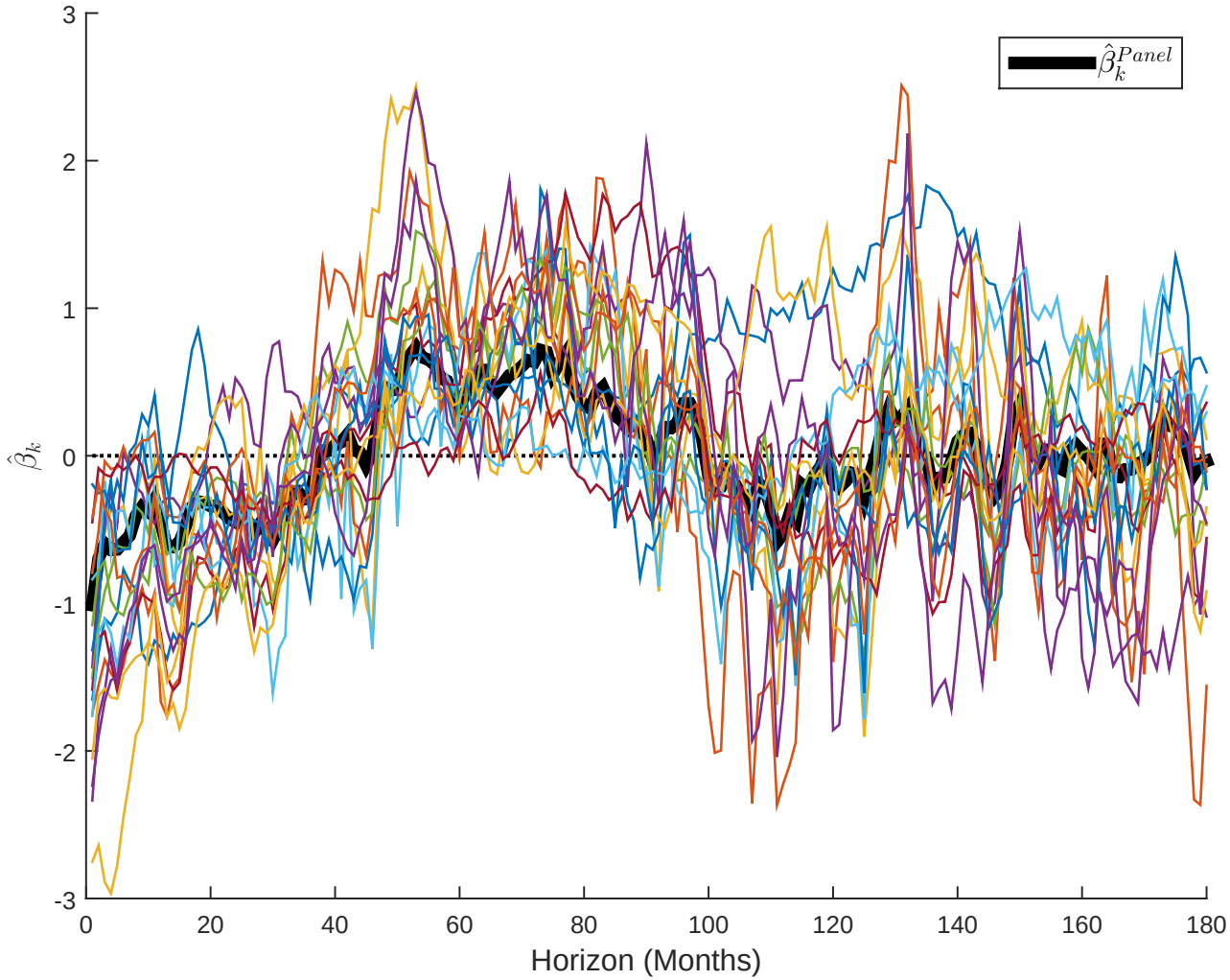
Conclusion

- The nature of the UIP puzzle changes with the horizon
  - Insufficient depreciation at short-horizons, excess depreciation at long
  - A challenge to existing models addressing the UIP puzzle
- Clear cross-sectional relationship with monetary policy stance
- New model based on endogenous convenience yield fluctuations
  - Can rationalize std puzzle + change in direction
  - Explicit role for monetary policy and demand/supply of liquid assets
- The key features of the mechanism borne out by the data
- A rich framework for further study

Going Forward

- Micro-found the convenience yield mechanism
  - Link to deeper economic forces, study optimal policy
  - Consider and quantify different potential channels
  - Differential liquidity demands in addition to supply
  - Optimal Policy
- Jointly estimate risk and convenience yield factors
- Political economy foundations of the policy structure
- Private supply of safe assets, substitution effects
- Further empirical implications of the model
  - Direct measurements of conv. yields and UIP violations
  - Exploit cross-sectional variation in policies across countries
  - Conv. yield factors and carry trade returns
- Implications about international transmission mechanism
- Differentiate between convenience yields and risk-bearing capacity

Pairwise regression



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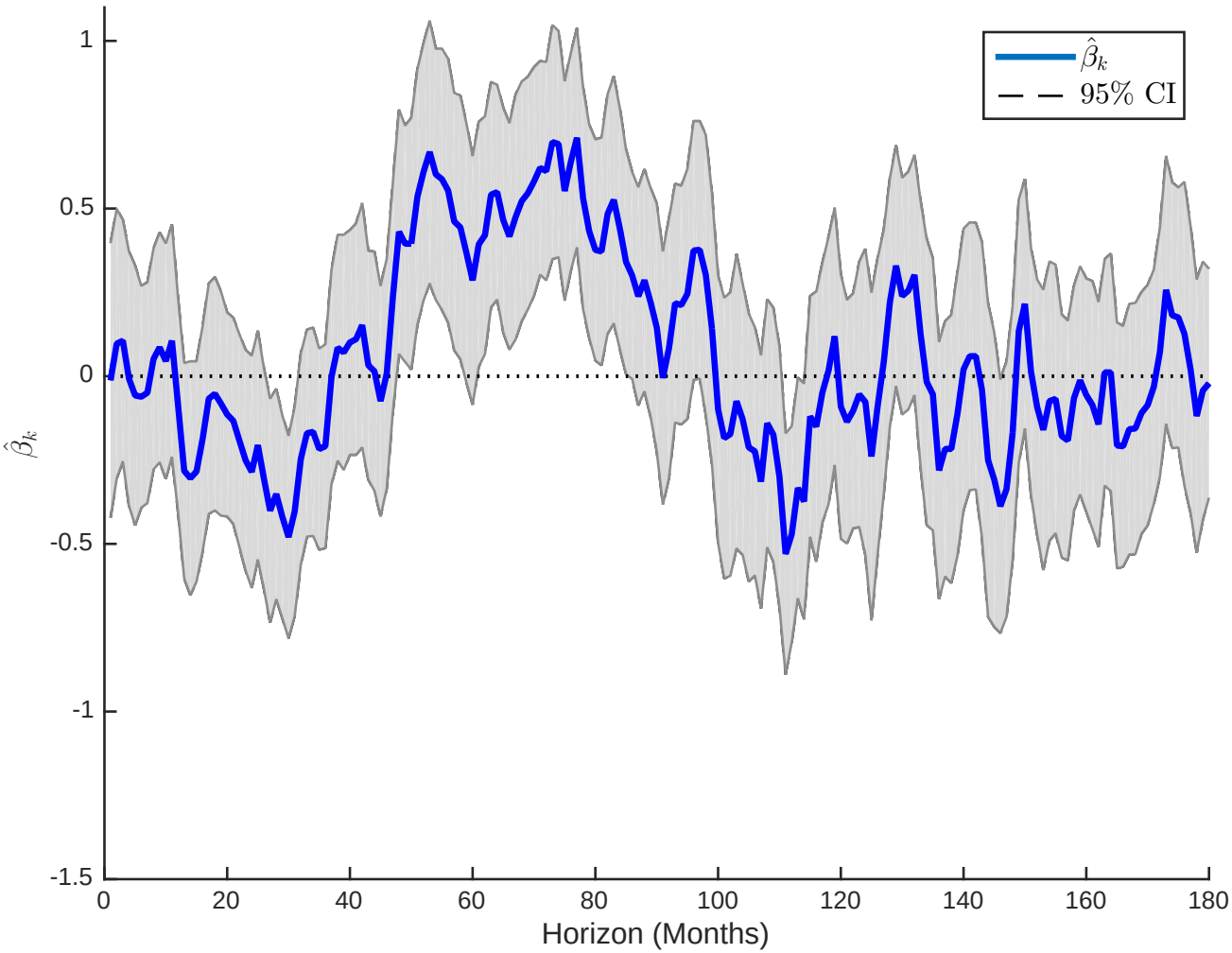
FX Changes: $\Delta s_{j,t+k+1} = \alpha_{j,k} + \beta_k(i_{j,t} - i^*_{j,t}) + \varepsilon_{j,t+k}$



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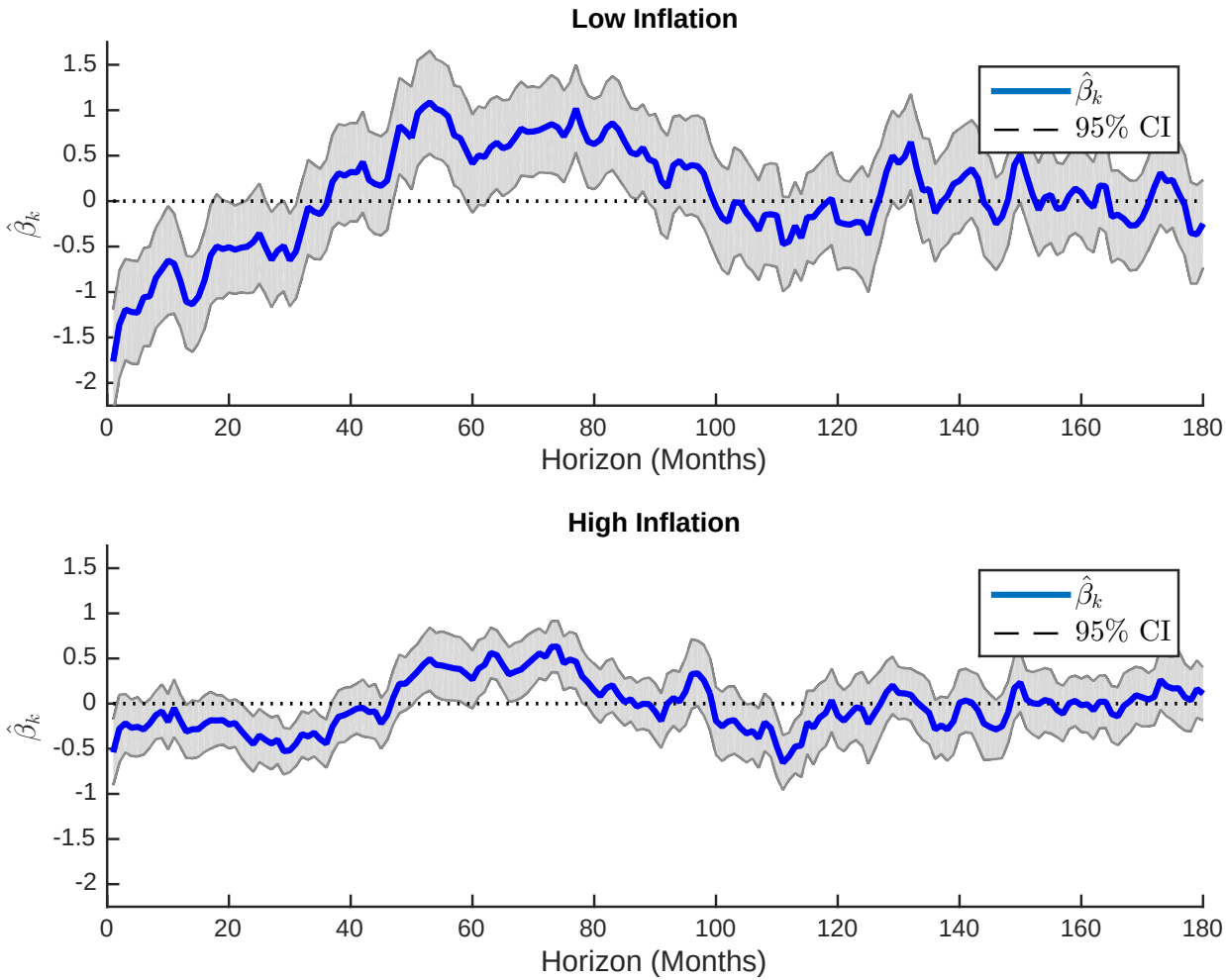
Monetary Independence and UIP Violations

Figure: $\lambda_{t+j} = \alpha_{k,j} + \beta_j(i_{k,t} - i^*_{k,t}) + \varepsilon_{i,t+j}$



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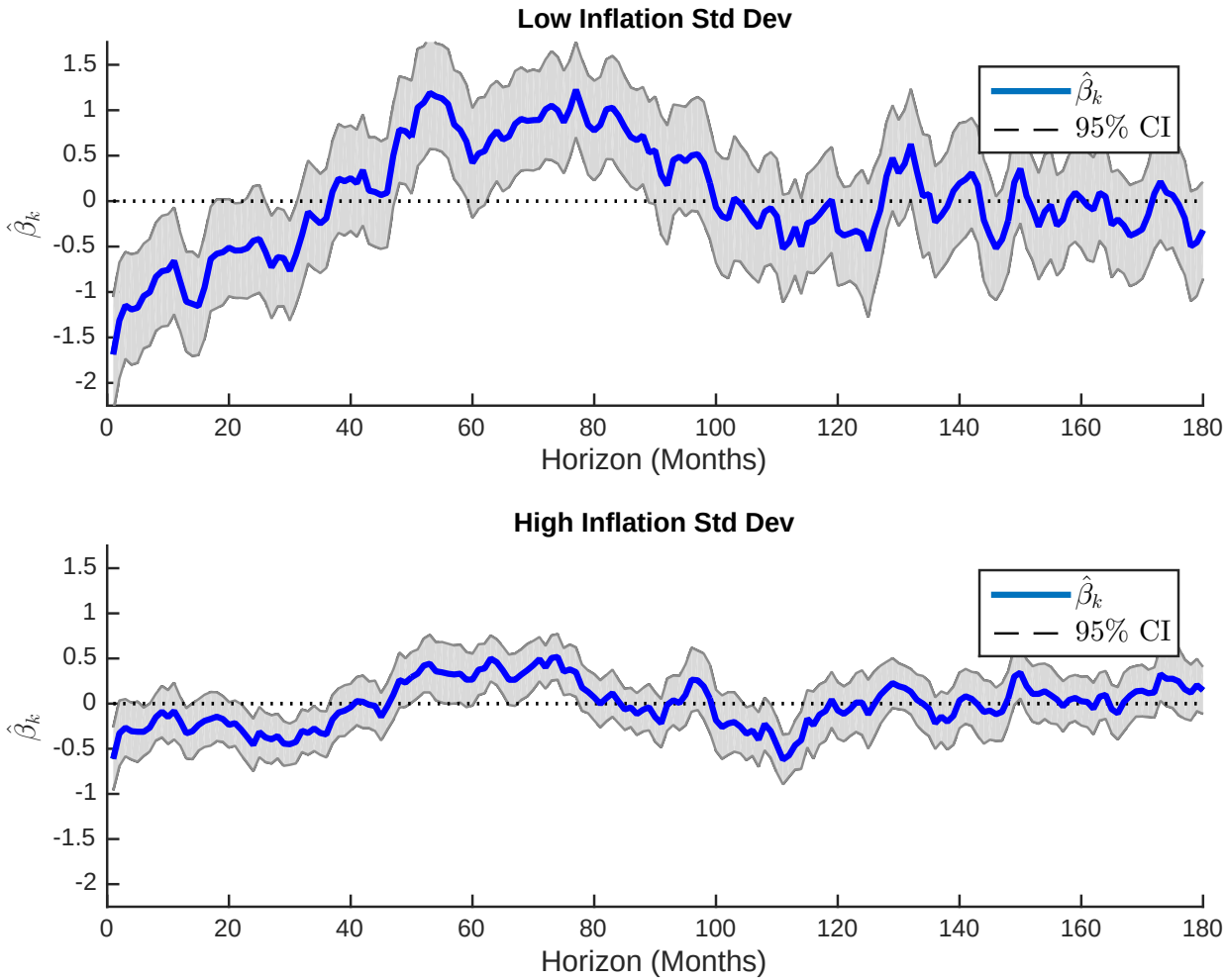
Monetary Independence and UIP Violations

Figure: $\lambda_{t+j} = \alpha_{k,j} + \beta_j(i_{k,t} - i^*_{k,t}) + \varepsilon_{i,t+j}$



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Monetary Independence and UIP Violations

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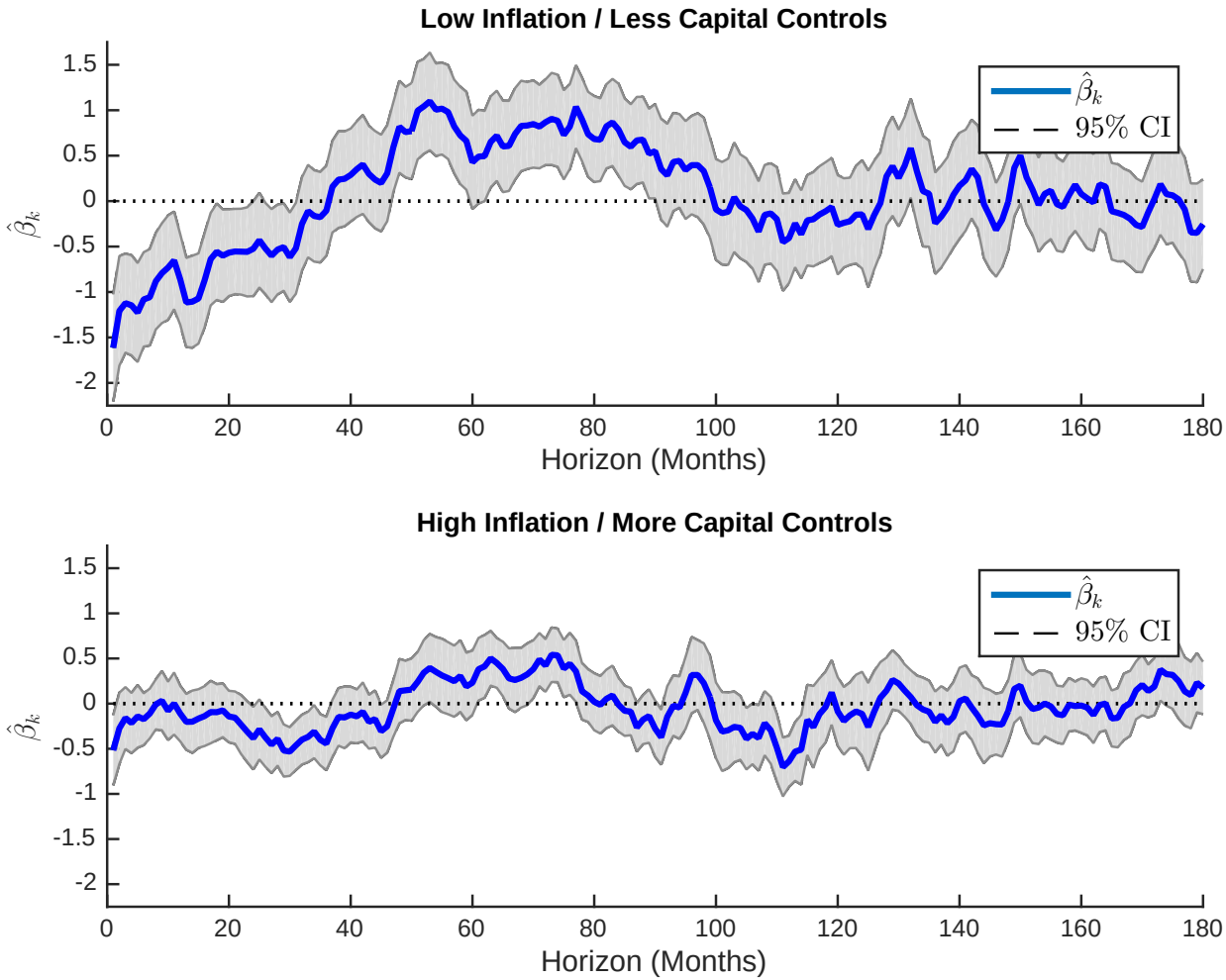

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Monetary Independence and UIP Violations

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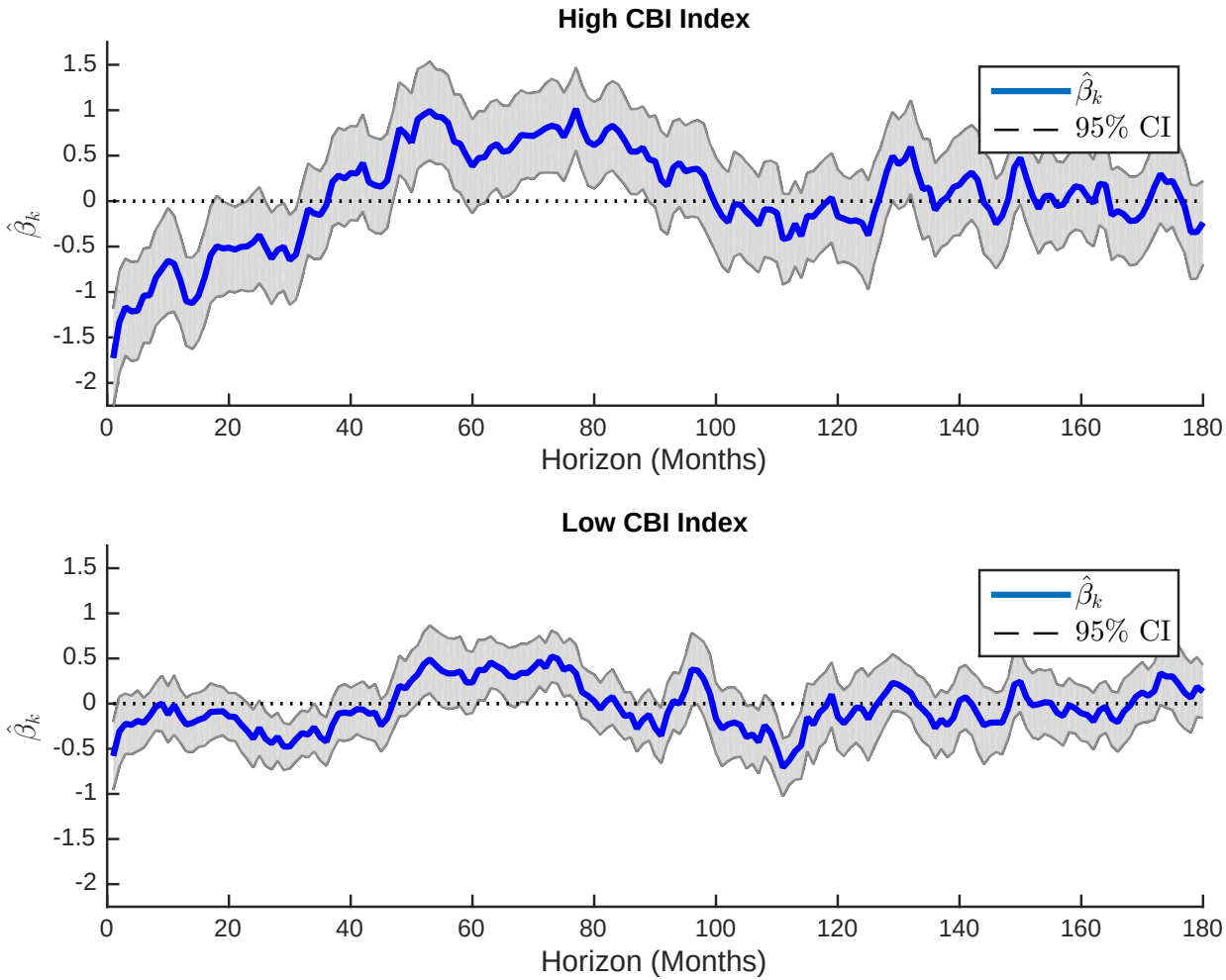

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The Demand for Convenience Assets

- Transaction costs function

$$\Psi(C_t, m_t, b_{ht}, b_{ft}) = \bar{\psi} c_t^{\alpha} h(m_t, b_{ht}, b_{ft})^{1-\alpha_1}, \quad \alpha > 1$$

- Two components - the level of transactions c_t and a bundle of transaction services $h(\cdot)$
- The bundle of transaction services is defined as a flexible nested CES specification:

$$h(m_t, b_{ht}, b_{ft}) = (m_t^{\frac{\eta_m - 1}{\eta_m}} + \tilde{h}(b_{ht}, b_{ft})^{\frac{\eta_m - 1}{\eta_m}})^{\frac{\eta_m}{\eta_m - 1}}$$

$$\tilde{h}(b_{ht}, b_{ft}) = k_b(a_b b_{ht}^{\frac{\eta_b - 1}{\eta_b}} + (1 - a_b) b_{ft}^{\frac{\eta_b - 1}{\eta_b}})^{\frac{\eta_b}{\eta_b - 1}}$$

- Treats money and bonds as separate *classes* of conv. assets
  - Possibly different elasticity of substitution between and within types of assets

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Calibration

Table: Calibrated Parameter Values

Param	Description	Value	Param	Description	Value
σ	Risk Aversion	2	$\frac{G}{Y}$	Gov Exp to GDP	0.22
ϕ	Inv Labor Elast	1.5	$\frac{b_h^D}{Y}$	Gov Debt to GDP	0.4
η	Elast Subst Cons	1.5			
a_h	Home Bias Cons	0.76	ϕ_π	TR Infl Coef	1.5
β	Time Discount	0.9901	ρ_i	TR Smoothing	0.9
			ρ_v	Autocorr Mon Shock	0
α		19	σ_v	Std Dev Mon Shock	0.0033
η_m		0.097			
k_b		0.46	ρ_τ	Tax Smoothing	0.92
$\bar{\psi}$		5.60E-19	k_τ	Tax Debt Coef	0.42
a_b		0.9998			
η_b		0.25	ρ_a	Autocorr TFP Shock	0.97
μ		2.17	σ_a	Std Dev TFP Shock	0.0075

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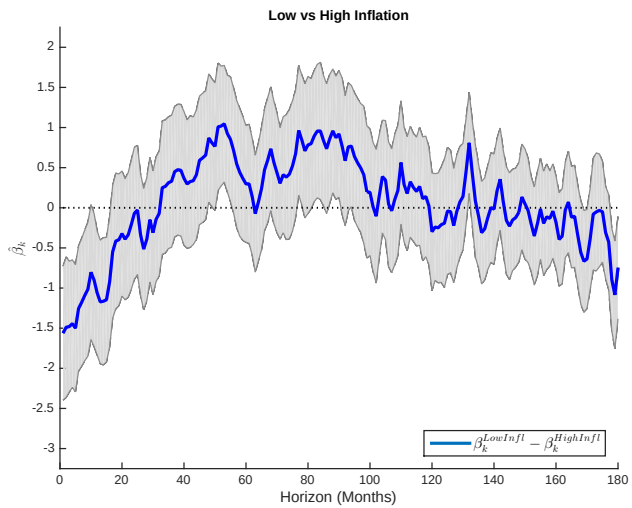
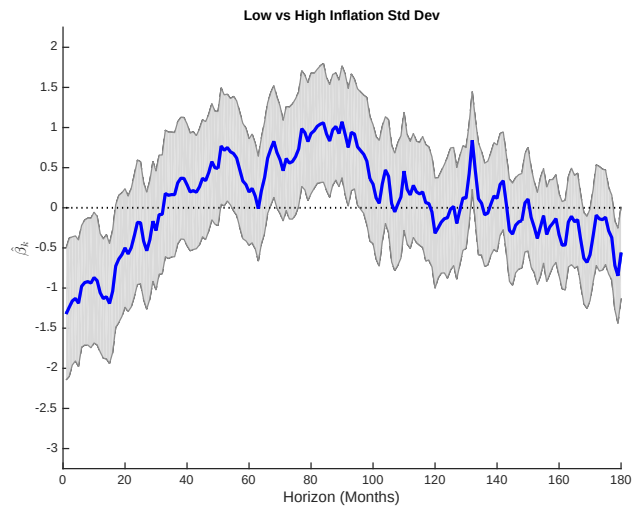
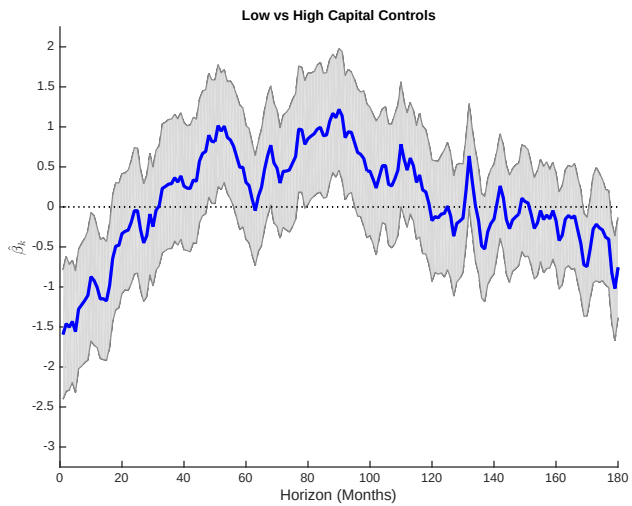
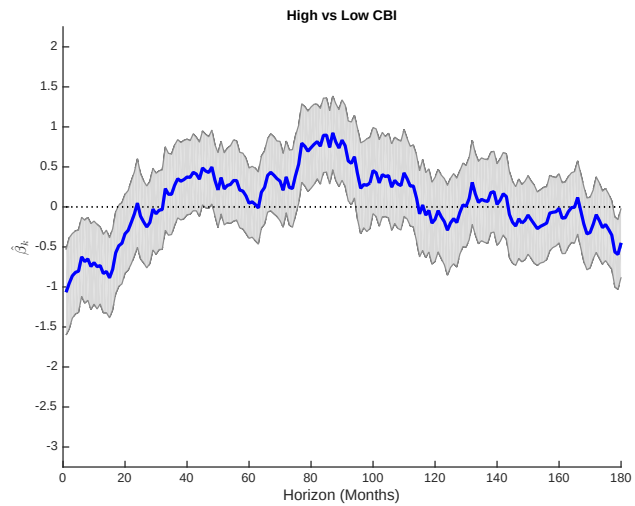
High vs Low









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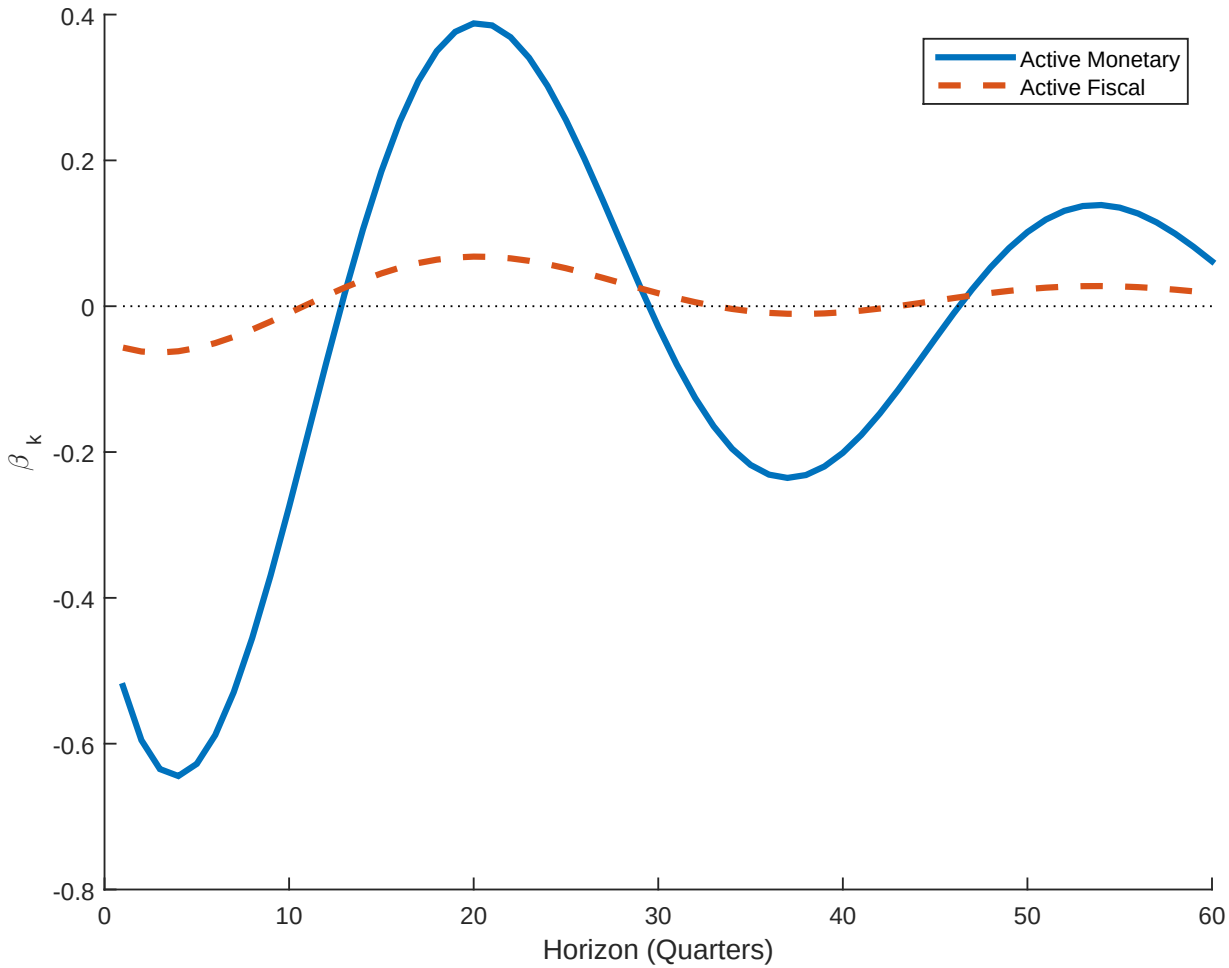
Active Fiscal / Passive Monetary Policy in Foreign Country



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