Do Term Premiums Matter? Transmission via Exchange Rate Dynamics

Koji Takahashi [1] Mitsuru Katagiri [2]

[1]Bank of Japan

[2]International Monetary Fund

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The views expressed here are those of the authors and do not necessarily reflect the official views of the Bank of Japan and the International Monetary Fund.

Motivation

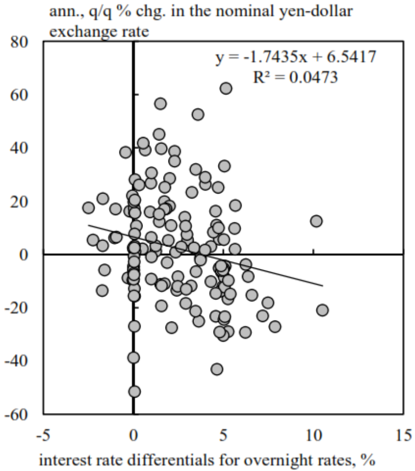
- A number of central banks have adopted a massive purchasing program of long-term bonds in the face of the zero lower bound of nominal interest rates.
- The macroeconomic effect of term premiums is a controversial issue both theoretically and quantitatively.

What We Do

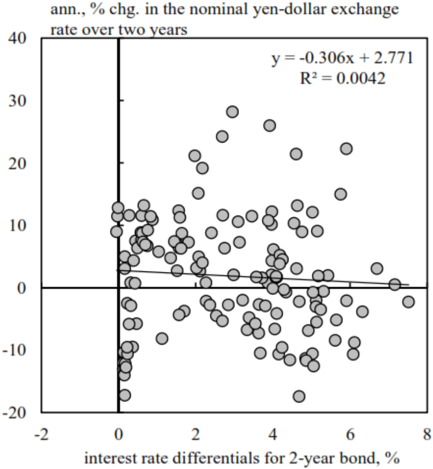
- By constructing a small open economy model with long-term bonds, this paper shows what assumptions are necessary for making term premiums relevant to the economy and quantifies the effect of reducing term premiums via the exchange rate channel consistently with data.
- We focus on the empirical finding that the Uncovered Interest Rate Parity (UIP) tends to hold for long-term bond yields.

Exchange Rates and Differential of Interest Rates(1)

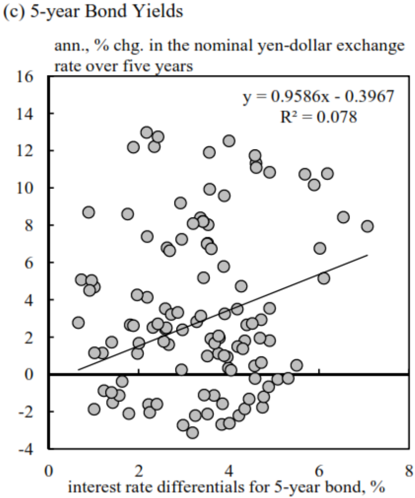
(a) Policy Rates (Overnight Rates)



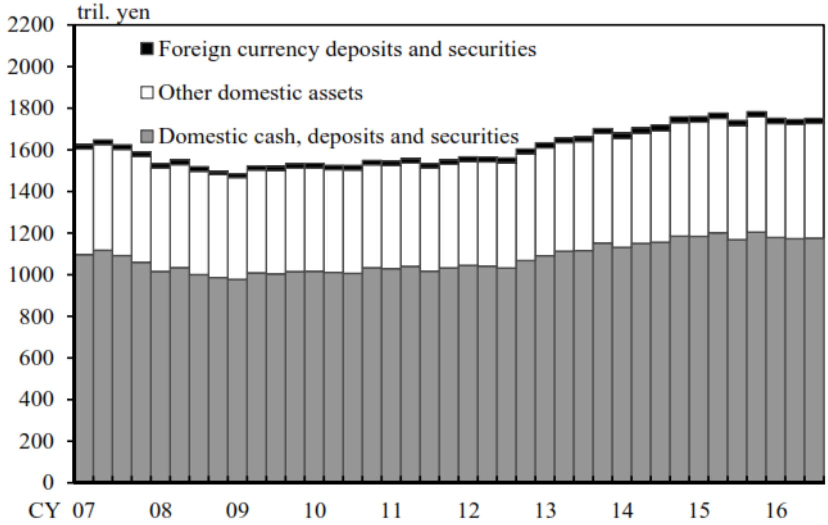
(b) 2-year Bond Yields



Exchange Rates and Differential of Interest Rates(2)

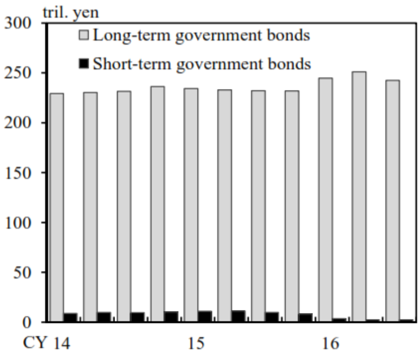


Composition of Japanese Household Assets

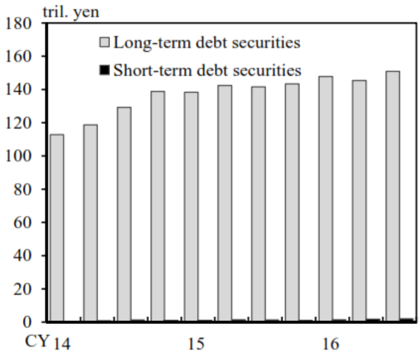


Bond Portfolios of Japanese Institutional Investors

(a) Domestic Government Bonds



(b) Foreign Debt Securities



Risk Premiums and Limited Bond Market Participations

- Two limited bond market participation assumptions are incorporated into the model.

Home Bias: Households cannot access foreign bonds and save only by domestic short-term and long-term bonds.

  - The share of foreign currency deposit and foreign securities in Japanese households' total assets is less than 1%.

Arbitrager: A risk-neutral arbitrager trades only long-term domestic and foreign bonds and does not trade short-term domestic and foreign bonds.

  - This assumption might be justified by the fact that most Japanese institutional investors tend to trade long-term bonds rather than short-term bonds.

- The exchange rate is determined by the UIP condition associated with long-term interest rates.

Literature

- Andrés, Lópes-Salido, and Nelson (2004), Chen, Curdia and Ferrero (2012), Wesolowski (2015), Alpanda and Kabaca (2015)
- Chinn and Meredith (2004), Chinn (2006), Engel (2014)
- Kano and Wada (2015)
- Adolfson et al. (2007, 2008)
- D'Amico et al. (2012), Ugai (2007), Curdia and Woodford (2011), Gertler and Karadi (2011), Vayanos and Vila (2009), Gagnon et al. (2011), Chodorow-Reich (2014), Hanson and Stein (2014)

Model

- A standard small open dynamic general equilibrium model with long-term bonds.
- The home economy consists of households, an arbitrager, and several types of firms, which produce consumption goods, intermediate goods, exported goods, and imported goods.
- In a spirit of a small open economy model, the foreign economy is assumed to be independent of the home economy, and it is described as a small-scale new Keynesian model.

Household

- The households choose their consumption C_t and short-term and long-term bonds, B_t and B_t^L, to maximize their lifetime utility,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log\left(C_t - \varkappa C_{t-1}\right) - \psi \frac{L_t(h)^{1+\nu}}{1+\nu} \right]$$

subject to a budget constraint.
The households allocate the income to the consumption basket, C_t, and savings. The consumption basket consists of domestic and foreign consumption goods,

$$C_t = \left[(1-\delta)^{\frac{1}{\eta}} C_{d,t}^{\frac{\eta-1}{\eta}} + \delta^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

where $C_{d,t}$ and $C_{f,t}$ are domestic and imported consumption goods, respectively.

Long-term Bonds

- The savings take two forms: nominal one-period domestic bonds, B_t, and long-term domestic bonds, B_t^L.
- Long-term bonds: perpetuities with a decaying coupon κ^s at $t+1+s$ as in Woodford (2001).
- Households pay time-varying transaction cost ζ_t per-unit of long-term bonds as in Chen et al. (2012) .
- The transaction cost is a source of term premiums, and follows the exogenous process,

$$\zeta_t - \zeta = \rho_\zeta \left(\zeta_{t-1} - \zeta\right) + \varepsilon_{\zeta,t}.$$

- In a quantitative analysis, we consider $\varepsilon_{\zeta,t}$ is a policy shock to change term premiums, and examine the response of inflation rates as well as exchange rates to this shock.

Household B.C.

- Households are owners of all types of firms and arbitragers in the economy and obtain their aggregate profits, D_t.
- B.C. of households:

$$P_t C_t + B_t + (1+\zeta_t) P_t^L B_t^L = R_{t-1} B_{t-1} + P_t^L R_t^L B_{t-1}^L + W_t(h) L_t(h) + D_t \tag{2}$$

  where P_t^L is the price of long-term bonds and $R_t^L = \frac{1}{P_t^L} + \kappa$ is the long-term interest rate.
- The households cannot invest in foreign bonds but invest only in domestic bonds.

Arbitrager

- The arbitrager can trade only domestic and foreign *long-term* bonds and cannot trade domestic and foreign short-term bonds.
- Their optimization problem is formulated as,

$$\max_{B_t^L, B_t^{L*}} E_t \left[\beta_{A,t} \left\{ \left(R_{t+1}^{L*} + \phi_{t+1}\right) \frac{P_{t+1}^{L*}}{Q_{t+1}} B_t^{L*} + R_{t+1}^L P_{t+1}^L B_t^L \right\} - \left(\frac{P_t^{L*}}{Q_t} B_t^{L*} + P_t^L B_t^L \right) \right], \quad (3)$$

where P_t^{L*}, R_{t+1}^{L*}, and B_t^{L*} are the price, the return and the amount of foreign long-term bonds, respectively. $\beta_{A,t}$ is a discount factor for the arbitrager.

Foreign Bonds

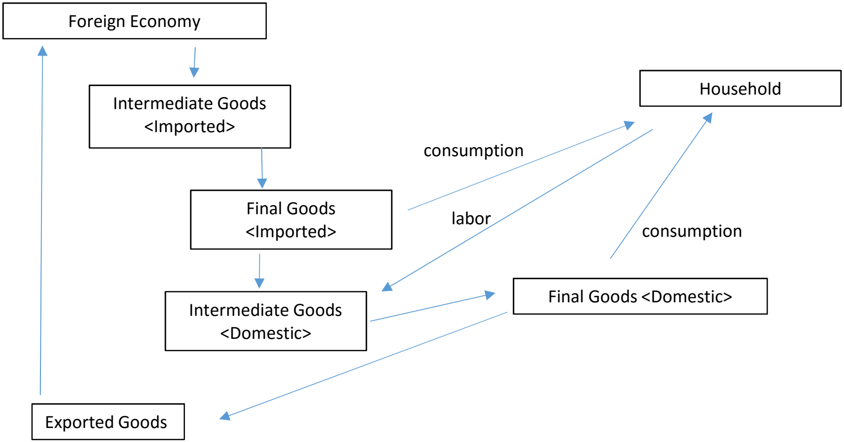
- To ensure the existence of the steady-state in the small open economy, it is assumed that there exists a tiny time varying risk-premium on foreign bonds, ϕ_t, which is determined by the following rule,

$$\phi_t - \phi = -\Phi \left(B_t^{L*} - B^{L*} \right) + v_{q,t}.$$

- By combining the arbitrager's first order conditions with respect to B_t^L and B_t^{L*}, and deleting the discount factor $\beta_{A,t}$, the following UIP condition with respect to long-term interest rates is derived,

$$E_t \left[\frac{P_{A,t+1}^{L*}}{P_{A,t}^{L*}} \left(R_{t+1}^{L*} + \phi_{t+1} \right) \frac{Q_t}{Q_{t+1}} \right] = E_t \left[\frac{P_{t+1}^{L}}{P_t^{L}} R_{t+1}^{L} \right]. \tag{4}$$

Exported, Imported and Domestic Goods Firms



Labor and Wage

- There are competitive labor agencies who aggregate labor services by each household h into a homogeneous labor L_t using the following CES aggregator,

$$L_t = \left(\int_0^1 L_t(h)^{\frac{1}{\lambda_w}} dh \right)^{\lambda_w},$$

where $\lambda_w > 1$ is a markup parameter.

- The demand function for each household's labor service is then derived as a result of profit maximization of the labor agencies,

$$L_t(h) = \left(\frac{W_t(h)}{W_t} \right)^{\frac{\lambda_w}{1-\lambda_w}} L_t. \tag{5}$$

- The households monopolistically supply differentiated labor forces $L_t(h)$ and set wages $W_t(h)$ on a staggered basis à la Calvo (1983) with partial indexation.

Consumption Goods Firms

- The consumption good firm produces the final good, $Y_{d,t}$, by aggregating the intermediate goods, $Y_{d,t}(i)$, using the CES aggregator.

$$Y_{d,t} = \left(\int_0^1 Y_{d,t}(i)^{\frac{1}{\lambda_c}} di \right)^{\lambda_c},$$

where $\lambda_c > 1$ is a markup parameter.

- The demand of intermediate goods is described as a result of profit maximization of the representative consumption good firm:

$$Y_{d,t}(i) = \left(\frac{P_{d,t}(i)}{P_{d,t}} \right)^{\frac{\lambda_c}{1-\lambda_c}} Y_{d,t}. \quad (6)$$

Intermediate Goods Firms

- A continuum of intermediate good firms, i, produces differentiated intermediate goods using labor, $L_t(i)$, and imported intermediate inputs, $Z_t(i)$ as follows:

$$Y_{d,t}(i) = [Z_t(i)]^{\alpha} [A_t L_t(i)]^{1-\alpha}, \tag{7}$$

  A_t: productivity .

- Under monopolistic competition, intermediate good firm i faces demand, $Y_{d,t}(i) = (P_{d,t}(i)/P_{d,t})^{\frac{\lambda_c}{1-\lambda_c}} Y_{d,t}$, and maximizes its discounted profits by setting the price of its differentiated products on a staggered basis à la Calvo (1983).
- A fraction $1-\xi_d \in (0,1)$ of intermediate good firms reoptimizes prices, while the remaining fraction ξ_d indexes prices to a weighted average of past and steady-state inflation $(\pi_{d,t-1})^{\iota_d} \pi^{1-\iota_d}$.

Imported Goods Firms

- i) intermediate goods firms and ii) final goods firms.
- A continuum of intermediate good firms f purchases foreign goods from abroad at the foreign price P_t^*, and sell them to the domestic final good firm as differentiated foreign goods $Y_{f,t}(f)$ at the price of $P_{f,t}(f)$.
- The demand for intermediate imported goods:

$$Y_{f,t}(f) = \left(\frac{P_{f,t}(f)}{P_{f,t}}\right)^{\frac{\lambda_f}{1-\lambda_f}} Y_{f,t}. \tag{8}$$

- Market clear condition for the final imported good:

$$Y_{f,t} = C_{f,t} + Z_t \tag{9}$$

  $C_{f,t}$: Consumption, Inputs for domestic intermediate good firms: Z_t
- The imported goods firms set the prices in the home currency on a staggered basis with partial indexation.

Exported Goods Firms

- The exported good firms purchase domestic consumption goods $Y_{d,t}$, and sell them to foreign customers at the price of $P^*_{x,t}$ in a foreign currency basis.
- The demand function for exported goods $Y_{x,t}$:

$$Y_{x,t} = A_t \left(\frac{P^*_{x,t}}{P^*_t} \right)^{\frac{\lambda_x}{1-\lambda_x}} \left(y^*_t \right)^{\theta} \exp\left(v_{x,t} \right). \tag{10}$$

  where λ_x and θ are parameters for elasticity of demand to relative price of exported goods and foreign output gap, respectively.
- The exported firms set the exported prices *in the foreign currency* on the staggered basis with partial indexation, and maximize their profits *in the home currency*.

Central Bank

- Taylor Rule:

$$R_t = (R_{t-1})^{\rho_R} \times \tag{11}$$

$$\left[R \left(\frac{\left[\Pi_{j=1}^{4} \pi_{t-j+1}\right]^{1/4}}{\bar{\pi}_t} \right)^{1+\phi_\pi} \left(\frac{\left[\Pi_{j=1}^{4} g^{y}_{t-j+1}\right]^{1/4}}{e^{\gamma}} \right)^{\phi_y} \right]^{1-\rho_R} v_{m,t} \tag{12}$$

where $g_t^y = Y_{d,t}/Y_{d,t-1}$ and $\bar{\pi}_t$ is the target inflation rate.

- The monetary policy shock in period t consists of two parts: a temporary interest rate shock in period t and an interest rate news shock in $t-12$. That is,

$$\log(v_{m,t}) = \rho_m \log(v_{m,t-1}) + \varepsilon_{m,t}$$
$$\varepsilon_{m,t} = \hat{\varepsilon}_{m,t} + \tilde{\varepsilon}_{m,t-12}$$

where $\hat{\varepsilon}_{m,t}$ and $\tilde{\varepsilon}_{m,t}$ are independent iid shocks.

Foreign Economy

- The foreign economy is described as a simple New Keynesian economy with long-term bonds.
- Following the spirit of small open economy model, the foreign economy is assumed to be not influenced by the foreign economy while it influences the home economy through import/export and exchange rates.

Calibrated Parameters

Table: Calibration

Parameter	Value or target
Discount factor, β and β^*	0.998
Decaying coupon, κ	$1-\frac{1}{40}$
Productivity growth (Japan γ and the U.S. γ^*)	$1.01^{\frac{1}{4}}$ and $1.02^{\frac{1}{4}}$
Target inflation rate (Japan $\bar{\pi}$ and the U.S. $\bar{\pi}^*$)	$1.01^{\frac{1}{4}}$ and $1.02^{\frac{1}{4}}$
Sensitivity of risk premium, Φ	0.001
Elasticity between domestic and foreign goods, η	1.076
Calvo parameter, ξ_w, ξ_f, and ξ_x,	0.8
Wage markup, λ_w	1.2
Wage indexation, ι_w	0.5
Share of imported consumption goods, δ	$P_{f,t}C_{f,t}/\left(P_tC_t\right)=0.063$
Share of imported intermediate goods, α	$P_{f,t}Z_t/\left(P_{d,t}Y_{d,t}\right)=0.1$

Estimated Parameters

- The rest of parameters are estimated by a Bayesian method using the following 12 data sequences in Japan and the U.S. from 1987Q1 to 2016Q3: Japanese GDP growth, core CPI inflation, call rate, 3-year Japanese government bond yield, 10-year government bond yield , import price index inflation, percent changes in Yen-dollar exchange rate, net export-GDP ratio, the US GDP growth, the US core CPI inflation, FF rate, 10-year US government bond yield.
- In the model, there are 22 parameters for the domestic economy,, 11 parameters for the foreign economy, and the variance of 14 structural shocks.

Term Premium

- The term premium is defined by the model variables. The F.O.C. for the domestic households with respect to the long-term bond B_t^L gives,

$$1 + \zeta_t = \beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t \pi_{t+1}} e^{-\gamma_{t+1}} \frac{P_{t+1}^L R_{t+1}^L}{P_t^L} \right]. \tag{13}$$

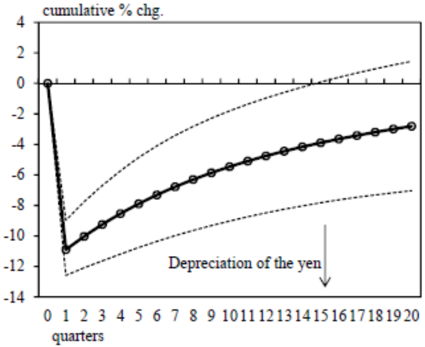
Considering that the transaction cost is the only source of term premiums in this model, fictitious long-term interest rates *without term* premiums, $\tilde{R}_t^L$, can be computed by,

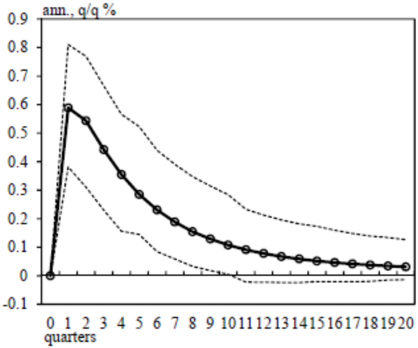
$$1 = \beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t \pi_{t+1}} e^{-\gamma_{t+1}} \frac{\tilde{P}_{t+1}^L \tilde{R}_{t+1}^L}{\tilde{P}_t^L} \right]$$

where $\tilde{R}_t^L = 1/\tilde{P}_t^L + \kappa$, and the term premium is defined by $R_t^L - \tilde{R}_t^L$.

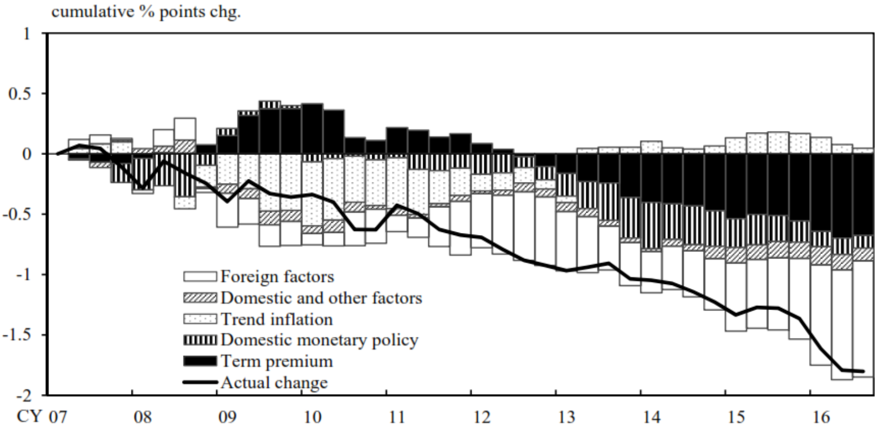
Impulse Response Functions to Term Premium Shock (1%)

Exchange Rate and CPI Inflation Rate

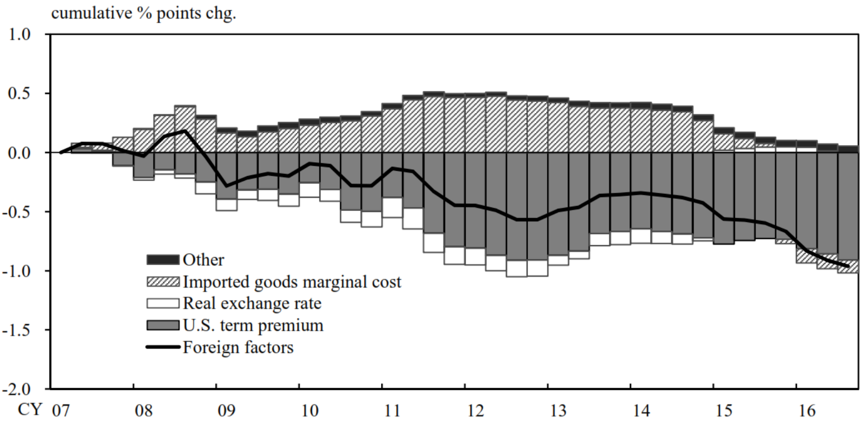




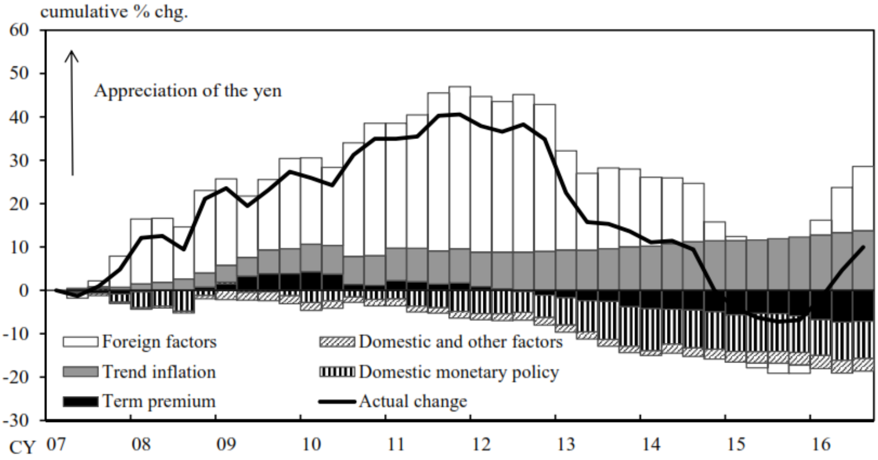
Decomposition of Japanese 10-year Bond Yields



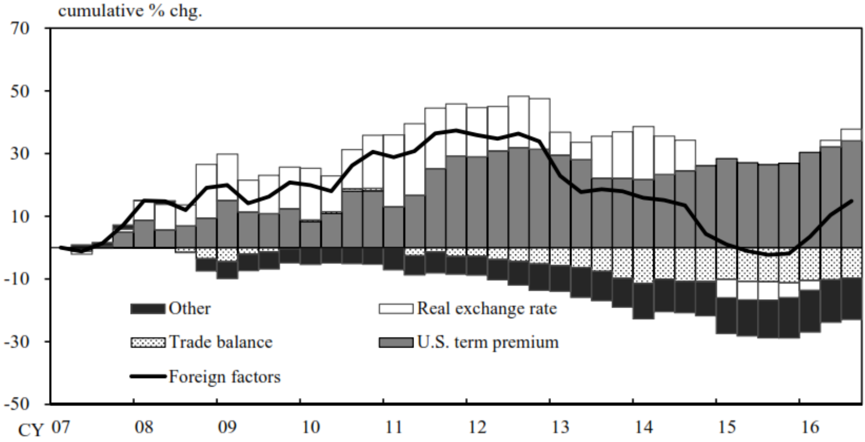
Decomposition of Japanese 10-year Bond Yields: Foreign Factors



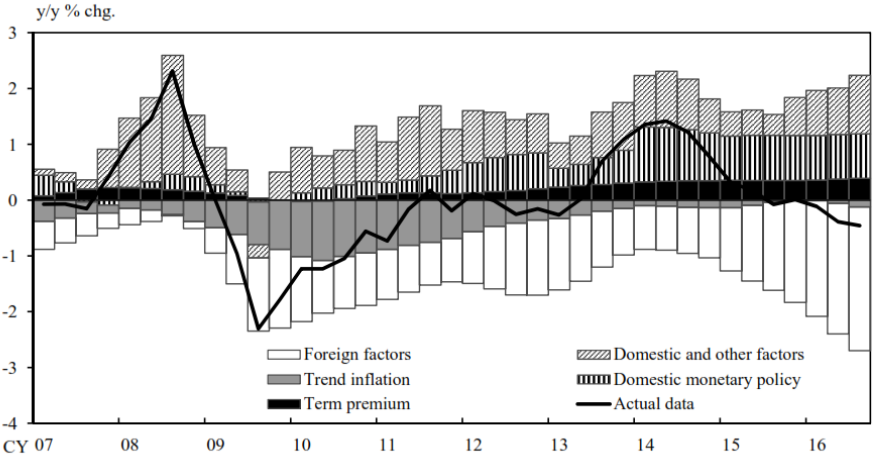
Decomposition of Dollar-Yen Exchange Rate



Decomposition of Dollar-Yen Exchange Rate: Foreign Factors

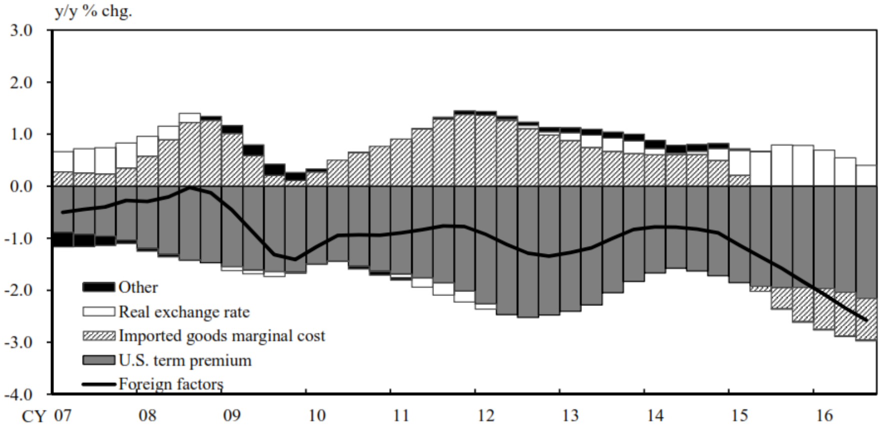


Decomposition of CPI Inflation Rate



Decomposition of CPI Inflation Rate: Foreign Factors

(b) Details on the Contribution of Foreign Factors to the Inflation Rate



Conclusion

- We construct a small open economy model with limited bond market participation assumptions, and estimate parameters using Japan and the U.S. data.
- An impulse response analysis shows that changes in the term premium have sizable effects on inflation rates via the exchange rate.
- The decomposition of the CPI inflation rate shows that although decreasing domestic term premiums increased Japan's inflation rates via the exchange rate channel, it is almost equally influenced by foreign factors such as a rise in the U.S. term premium.

Estimation Results (1)

Table: Parameter Values for Japan

parameter	posterior mean	prior dist.	prior mean	prior stdev
$\varkappa$	0.37	Beta	0.4	0.1
ν	1.14	Gamma	1.0	0.5
θ	1.16	Gamma	1.0	0.5
ζ	0.0019	Beta	0.01	0.005
λ_d	2.29	Gamma	1.2	0.5
λ_f	3.39	Gamma	1.2	0.5
λ_x	2.04	Gamma	1.2	0.5
ξ_d	0.95	Beta	0.66	0.1
ι_d	0.12	Beta	0.5	0.2
ι_f	0.13	Beta	0.5	0.2
ι_x	0.47	Beta	0.5	0.2
ϕ_π	0.32	Gamma	0.5	0.25
ϕ_y	0.19	Gamma	0.5	0.15
ρ_{tp}	0.99	Beta	0.97	0.02
ρ_m	0.68	Beta	0.5	0.2
ρ_R	0.87	Beta	0.8	0.05
ρ_γ	0.66	Beta	0.5	0.2
ρ_d	0.19	Beta	0.5	0.2
ρ_f	0.92	Beta	0.5	0.2
ρ_x	0.92	Beta	0.5	0.2
ρ_q	0.88	Beta	0.5	0.2
ρ_ς	0.93	Beta	0.5	0.2

Estimation Results (2)

Table: Parameter Values for the U.S.

parameter	posterior mean	prior dist.	prior mean	prior stdev
$\varkappa^*$	0.36	Beta	0.4	0.1
ϖ^*	0.009	Beta	0.1	0.05
ϕ_π^*	1.55	Gamma	0.5	0.2
ϕ_y^*	1.10	Gamma	0.5	0.2
ζ^*	0.0054	Beta	0.016	0.008
ρ_{tp}^*	0.99	Beta	0.97	0.02
ρ_m^*	0.60	Beta	0.5	0.2
ρ_R^*	0.72	Beta	0.8	0.1
ρ_γ^*	0.96	Beta	0.5	0.2
ρ_p^*	0.39	Beta	0.5	0.2
ρ_ζ^*	0.97	Beta	0.5	0.2

Estimation Results (3)

Table: Parameter Values for Standard Deviation

parameter	posterior mean	prior dist.	prior mean	prior stdev
σ_γ	0.76	Inv. Gamma	0.50	inf.
σ_d	54.10	Inv. Gamma	0.50	inf.
σ_f	4.56	Inv. Gamma	0.50	inf.
σ_x	0.13	Inv. Gamma	0.50	inf.
σ_q	0.16	Inv. Gamma	0.50	inf.
σ_ζ	0.15	Inv. Gamma	0.25	inf.
σ_{tp}	0.02	Inv. Gamma	0.05	inf.
$\tilde{\sigma}_m$	0.07	Inv. Gamma	0.50	inf.
$\hat{\sigma}_{m12}$	0.05	Inv. Gamma	0.25	inf.
σ^*_γ	0.17	Inv. Gamma	0.50	inf.
σ^*_p	0.10	Inv. Gamma	0.50	inf.
σ^*_ζ	0.13	Inv. Gamma	0.25	inf.
σ^*_{tp}	0.03	Inv. Gamma	0.05	inf.
σ^*_m	0.10	Inv. Gamma	0.75	inf.