Global Risk, Risk Aversion and Japan's Exorbitant Duty (Very Preliminary and Not for Circulation) *

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Abstract.

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> "It was quite a paradox that a country with Japan's level of public sector debt turned into a haven in a global market storm, but that was the case in the first quarter of 2016. The sharp appreciation of the yen against the dollar, despite negative policy interest rates, reversed the normal currency market laws of gravity." – *Financial Times*, April 6, 2016

1. Introduction It is believed that rising currencies are associated with a low debt-to-gross domestic product (hereafter, GDP) ratio. As of 2016, the Swiss franc is an example of a currency that is likely to remain well supported due to the low debt-to-GDP ratio of 34.40. As for the national debt of Japan, it has continued to grow since the early 1990s and reached more than twice the annual GDP of Japan (see Figure 1). In the continued expansionary fiscal policy, since 1999, the Bank of Japan (hereafter, BOJ) has developed its so-called unconventional monetary policy by setting short-term nominal interest rates to almost 0%. Until the European debt crisis in 2009-2012 led to negative interest rates in Swiss and northern European countries closely linked to the Euro, nominal interest rates in Japan have continued to stay at the lowest level since the late 1990s. In the coexistence of the huge national debt and the extremely low nominal interest rates in Japan, the Japanese yen has been regarded, not only as one of the most useful funding currencies, but also as one of the safest haven currencies during risk-off periods.

Rogoff and Tashiro (2015) empirically demonstrated that while the yen has enjoyed the safe haven effect, albeit with its sharp appreciation in a financial turmoil, Japan has received highly positive excess returns as the world's largest creditor nation in the extremely low interest rate period since the late 1990s. They conceptualized such bright side of the creditor nation as "Japan's exorbitant privilege", while stating that Japan simultaneously has played a critical role in providing its safe haven currency with sharp appreciation during risk-off periods.[1] In this paper, we propose a risk-based model of exchange rate and then empirically examine why and how the yen sharply appreciates as the safest haven currency

[1] We can observe that the yen sharply appreciated in accordance with the increase in global financial risks and after disaster shocks, for example, induced by the bankruptcy of Lehman Brothers in September 2008, the Tohoku earthquake in March 2011, the concern about China's economic slowdown in August 2015, the Brexit in June 2016, and the concern about the Italian banking problem in July 2016.

in a financial turmoil, whereas Japan receives positive excess returns for the extremely low interest rate period, albeit its huge natinal debt.

The risk-based view of exchange rate determination focuses on determination of currency risk premiums in currency carry trading. This analytical framework of currency risk premiums pays attention to each country's exposure to the common global financial risk, or the carry trade risk. From this analytical view, Lusting et al. (2011) empirically demonstrated that exchange rates are determined systematically depending on each country's exposure to the common global financial risk. Following this finding, previous literature has attempted to explain why the countries' exposures are different in terms of country's economic scale, policy preferences of currency authorities, and global economic disaster shocks.

Martin (2011) and Hassan (2013) proposed theoretical models in which a super power with larger nontradable sectors utilizes more risk diversification than a small power with smaller nontradable sectors; thus, the super power receives more positive currency risk premiums in compensation for its exposing more to the global financial risk. Given that the economic scale of Japan (and also Swiss) is smaller than that of the U.S. and the EU., however, this story cannot well explain why the Japanese yen (and also the Swiss Franc) earns more highly positive currency risk premiums in currency carry trading.

Backus et al. (2013) provided other theoretical explanation in which a central bank's preference subject to the Taylor rule is the key determination of currency risk premiums. More concretely, if a central bank pays more attention to inflation in the Taylor rule, nominal interest rates would stay at low levels and consequently, a positive currency risk premium is generated. However, this model is not valid for explaining why the yen appreciates during risk-off periods because the Taylor rule cannot explain the behavior of the Bank of Japan (hereafter, BOJ) facing the zero lower bound since the late 1990s.

Gourio et al. (2013) and Fahri and Gabaix (2016) offered the most insightful approach to elucidate why the yen earns highly positive currency risk premiums from foreign investment among currencies of developed countries. Their real business cycle models introduced a global volatility risk as an economic disaster that leads to collapse in each country's fundamental. Their approach opens the path to examine the mechanism in which a particular currency receives risk premiums in response to the disaster shock. However, because their theoretical models did not explain what economic structure in each country makes countries' exposures to the disaster risks differentiated, we cannot make straightforward use of their model to investigate the key determinant of risk premiums of the Japanese yen.

These previous research indeed suggests that countries' exposures to the common global financial risk could be attributed to some kind of difference in economic structure of each country; however, it cannot answer our question of why Japan earns most highly positive currency risk premiums among developed countries during risk-off periods, because it did not specify the key driver, that could induce the difference in Japan's and other countries' exposures to the common global risk, from among differences in their economic structure. In this paper, we focus on the difference in risk aversion of Japanese and foreign investors, each facing common global risks such as global economic recession and the increase in global financial-market volatility. Thus, we attempt to explain why the Japanese yen sharply appreciates during risk-off periods, while it depreciates during risk-on periods.

Our analysis of the Japanese yen in terms of different risk aversions also contributes to understanding the forward discount puzzle, which interest rate differentials between domestic and foreign currencies are positively associated with excess returns from investment on the foreign currency.[2] Verdelhan (2013) ran Fama regression for 13 currencies of developed countries, and his estimation results suggest that the forward discount puzzle is the most severe in the Japanese yen to US dollar exchange rate. This is consistent with the finding of Fahri et al. (2014) that the Japanese yen is the currency that has the most highly negative (positive) currency risk premium for foreign (Japanese) investors. Our theoretical model to explain the yen's currency risk premiums also can produce the forward discount puzzle.

Our theoretical model focuses on the difference in Japanese and foreign investors' risk aversion as a source of Japan's excess returns and the currency risk premium of the yen. Hence, our empirical strategy is to establish the difference in Japanese and foreign investors' risk aversion. To this end, we adopt the following estimation method.

[2] The forward discount puzzle has been explained in terms of the habit formation (Verdelhan (2010)), heterogeneity in investors (Alvarez et al. (2009), Bacchetta and van Wincoop (2010)), country's economic scale (Martin (2011) and Hassan (2013)), the long-run risks (Bansal and Shaliastovich (2013)), and the economic disaster risks (Gourio et al. (2013) and Fahri and Gabaix (2014)).

2. A Risk-based Model of Exchange Rate As discussed above, Rogoff and Tashiro (2015) showed that Japan would earn an average excess return on foreign bonds at an annual rate of 0.99% from 1996 to 2015 and thereby they stated the average excess return as "Japan's exobitant privilage". In this section, we consider what duty Japan undertakes in compensation for the Japan's exorbitant privilege, in particular, in terms of the issue of why the yen becomes a haven asset in the increase in global financial risks. To this end, we propose a simple risk-based model of exchange rate. [3]

2.1. **Carry Trade Risk and Excess Currency Return** Until negative interest rates emerged in Swiss and northern European countries closely linked to the Euro after the European debt crisis in 2009-2012, nominal interest rates in Japan continued to stay at the lowest level in the world from the late 1990s. Accordingly, the Japanese yen has been regarded as one of the most useful funding currency for currency carry trading and it is well known that the yen drastically appreciated in risk-off periods.[4] In order to explain why the yen appreciates (depreciates) in risk-off (risk-on) periods, we focus on the carry trade risk in the global currency market and thus the currency risk premium. By doing so, we provide a simple model of the currency risk premium.[5]

For simplicity, we assume that two countries–home (Japan) and foreign countries–produce only nontradable goods and consume them; that is, the two countries do not trade goods, and consumers in each country have a perfect home bias. This implies that a real exchange rate is determined as the relative price of the nontradable goods in each country. [6] On the other hand, the international capital market is complete and hence investors in the two countries carry out financial transactions through currency carry trading.

Through the following theoretical analysis, we use a superscript $*$ to denote a foreign variable. R_t and R_t^* denote risk-free gross real interest rates and Q_t is the real exchange

[3] See Lusting and Verdelhan (2012) and Engle (2014) for theoretical surveys on the risk-based model of exchange rate.

[4] The yen appreciated in accordance with the increase in global risks, for example, induced by the bankruptcy of Lehman Brothers in September 2008, the concern about China's economic slowdown in August 2015, the Brexit in June 2016, and the concern about the Italian banking problem in July 2016.

[5] See Lusting et al. (2011) for the carry trade risk in the currency market.

[6] This assumption of the perfect home bias is not necessarily unreasonable because real exchange rates depend much on the relative prices of nontradable goods (see Fahri and Gabaix (2016)).

rates defined as domestic good per foreign good. M_{t+1} and M^*_{t+1}) denote the stochastic discount factor (hereafter, SDF) of the domestic and foreign investors: the marginal rate of intertemporal substitution in consumption of each country. Thus, investor's intertemporal optimization and arbitrage trading make the following three conditions satisfied in the international complete market:

$$E_t[M_{t+1}R_t] = 1, \tag{1}$$

$$E_t[M^*_{t+1}R^*_t] = 1, \tag{2}$$

$$\frac{Q_{t+1}}{Q_t} = \frac{M^*_{t+1}}{M_{t+1}}, \tag{3}$$

where $E[\cdot]$ denotes the expectation operator. Equations (1) and (2) indicate the Euler condition for consumptions of the domestic and foreign countries. Equation (3) is the no-arbitrage condition for contingent claims in the international complete market.[7] If we have the SDF, we can obtain the three asset price, R, R^*, Q, from the three conditions. Note that we define the change in nominal exchange rates in a similar fashion, using the ratio of two nominal pricing kernels.

We use a lower case variable to denote the natural logarithm of the corresponding uppercase variable (for example, $r = \log R$), and we use Δ to denote the first difference operator as $\Delta X_{t+1} = X_{t+1} - X_t$. Thus, we can transform equations (1)-(3) as in the following:

$$r_t = -E_t[m_{t+1}] - L(M_{t+1}), \tag{4}$$

$$r^*_t = -E_t[m^*_{t+1}] - L(M^*_{t+1}), \tag{5}$$

$$\Delta q_{t+1} = m^*_{t+1} - m_{t+1}. \tag{6}$$

$L(\cdot)$ is an uncertainty measure called as the "entropy", which measures the randomness and volatility of a stochastic variable (see e.g. Alvarez and Jermann (2005), Backus et al. (2014) and Campbell (2014) for the application of the entropy to asset pricing). The

[7] Chari et al. (2002) derived the three conditions by specifying money and contingent claims in modeling a household optimization problem. Burnside and Graveline (2012) demonstrated that equation (3) is not satisfied in an incomplete market.

entropy of the domestic investor's SDF is defined as follows:

$$L(M_{t+1}) = \log E_t[M_{t+1}] - E_t[\log M_{t+1}] > 0. \tag{7}$$

The increase in the entropy is ascribed to the increase in the randomness and volatility of the SDF: the uncertainty about future consumption facing by the domestic investor.[8] We can also define the entropy of the foreign investor's SDF, $L(M^*_{t+1})$, in the same manner.

Thus, we can derive the excess return of the domestic investor from investment on foreign bonds using the entropy:

$$rp_t = r^*_t + E_t[\Delta q_{t+1}] - r_t = L(M_{t+1}) - L(M^*_{t+1}). \tag{8}$$

This shows that the excess return from foreign investment equals to the currency risk premium paid for investor's risk taking in carry trading (the first equality), and the excess return is represented as a difference in the entropy, or the uncertainty about future consumption, faced by the domestic and foreign investors (the second equality). In other words, the excess return and the currency risk premium is ascribed to how differently the domestic and foreign investors evaluate the uncertainty about their future consumption expressed in the entropy.

Now, let us assume that the home and foreign countries face the increase in a common global risk such as global economic recession and the increase in global financial-market volatility, and consider the issue of how the excess return responds to the increase in the global risk. We also assume that investors of carry trading take short positions of a lower interest rate currency and long positions of a higher interest rate currency. In this setting, if the relative risk aversion of the domestic investor is larger than that of the foreign investor, the entropy of the home country, $L(M_{t+1})$, would become larger than that of the foreign country, $L(M^*_{t+1})$, in response to the increase in the global risk.

This is because the relative risk aversion determines variability in investor's future

[8] The logarithmic function $\log(\cdot)$ is a strictly concave function; hence, from Jensen's inequality, we can show that the entropy $L(\cdot)$ takes a positive value as far as the SDF does not degenerate to one number. Alvarez and Jermann (2005) and Backus et al. (2014) focused on the entropy as a uncertainty measure defining the upper bound of an expected excess return on a risk asset.

marginal utility with respect to one-percent future change in consumption and hence the domestic investor's SDF, M_{t+1}, increases more that the foreign investor's SDF, M^*_{t+1}, does because change in the SDF reflects change in investor's future marginal utility. The domestic investor therefore receives a positive excess return and a positive currency risk premium in response to the increase in the global risk if she is more risk averse than her foreign counterpart. This insight does not depend on the functional form of investor's preference, but we formalize below this insight through developing the above theoretical model with the recursive preference suggested in Epstein and Zin (1989; 1991).

2.2. **Global Risk and Risk Aversion** Without specifying households', or investors', preference, we have described that the domestic investor would obtain a positive excess return on foreign bonds if she is more risk averse than the foreign investor in risk-off periods. In this subsection, we extend the theoretical model introduced above using the recursive preference and thereby analyze whether or how Japan's larger risk aversion can induce the following characteristics of the Japanese yen as a low interest rate currency:

1. the Japanese yen earns positive currency excess returns on foreign bonds, as demonstrated in Rogoff and Tashiro (2015),

2. the yen is more likely to sharply appreciate as a haven asset in global financial turmoil, while it is more likely to depreciate in global financial stability.

We assume that the utility of home and foreign households follows the recursive preferences suggested in Epstein and Zin (1989; 1991) and the growth rate of home consumption, g_t, follows the stochastic process:

$$g_{t+1} = g - \sigma_u v_t^{1/2} u_{t+1} \quad (g \geq 0, \sigma_u > 0), \tag{9}$$

$$v_{t+1} = v + \sigma_w w_{t+1} \quad (v > 0, \sigma_w > 0), \tag{10}$$

where $u_{t+1}, w_{t+1} \sim i.i.d\, \mathrm{N}(0,1)$.[9] In equation (9), u_{t+1} indicates the global recession shock arising at time $t+1$. In equation (9), v_{t+1} and w_{t+1} indicate the global financial-market

[9] Even if we incorporate autoregressive terms for g_{t+1} and v_{t+1} into equations (9) and (10), our theoretical conclusion does not change. Bansal and Yaron (2004), Colacito and Corse (2011), Bansal et al. (2012), and Bansal and Shaliastovich (2013)

volatility and the global volatility shock at time $t+1$, respectively. Hence, the two equations show that the domestic country is exposed to the global recession risk $\sigma_u v_t^{1/2} u_{t+1}$, in which the global recession shock u_{t+1} increases through a given global volatility $v_t^{1/2}$.[10] The growth rate of foreign consumption, g_t^*, can be describe in the same manner. Thus, under the assumption that the domestic investor evaluates the global recession risk $\sigma_u v_t^{1/2} u_{t+1}$ and the global volatility risk $\sigma_w w_t$, we obtain the following SDF in the home country:

$$
\begin{aligned}
E_t[m_{t+1}] &= -m_0 - \lambda_u E_t[\sigma_u (v_t)^{1/2} u_{t+1}]^2 - \lambda_w E_t[\sigma_w w_{t+1}]^2, && (11) \\
m_{t+1} - E_t[m_{t+1}] &= \theta_u \sigma_u (v_t)^{1/2} u_{t+1} + \theta_w \sigma_w w_{t+1}, && (12)
\end{aligned}
$$

where each parameter is defined as follows:

$$
\begin{aligned}
m_0 &= -\log\beta - \phi^{-1} g > 0, && (13) \\
\lambda_u &= \frac{1}{2}(\phi^{-1} - \gamma)(1-\gamma) > 0 \quad \text{if } \gamma > 1 > \phi^{-1}, && (14) \\
\lambda_w &= \frac{1}{2}(\phi^{-1} - \gamma)(1-\gamma)(A_2)^2 > 0 \quad \text{if } \gamma > 1 > \phi^{-1}, \text{ where } A_2 = \frac{1}{2}k(1-\gamma)\sigma_u^2, && (15) \\
\theta_u &= \gamma, && (16) \\
\theta_w &= (\phi^{-1} - \gamma)A_2 = \frac{1}{2}k(\phi^{-1} - \gamma)(1-\gamma)\sigma_u^2 > 0 \quad \text{if } \gamma > 1 > \phi^{-1}, && (17)
\end{aligned}
$$

where β, γ, and ϕ denote the discount factor, the relative risk aversion coefficient, and the elasticity of the intertemporal substitution in consumption, respectively. We suppose that the relative risk aversion coefficient, γ, is larger than the elasticity of the intertemporal substitution in consumption, ϕ, and both the parameters are larger than one, indicating that the domestic household prefers dispelling uncertainly as soon as possible.[11] k denotes a parameter for the linear approximation of the utility function with the recursive preference (see Hansen et al. (2008), Backus et al. (2013) and Backus et al. (2014)). Note that

[10] When the global volatility shock w_t follows the normal distribution, the global volatility v_t does not necessarily take a positive value. However, as shown in Backus et al. (2014), it does not essentially matter whether the global volatility takes positive or negative values in deriving our theoretical implications below. We proceed theoretical analysis by assuming that v_t takes a positive value for simplicity. In contrast to our analysis, Bansal and Shaliastovich (2013) assume v_t follows the gamma distribution and v_t does not takes any negative values.

[11] Bansal et al. (2012) Bansal and Shaliastovich (2013)

parameters λ_u, λ_w, θ_u and θ_w, which is the so-called factor loading, depend on the relative risk aversion coefficient γ.

λ_u and λ_w in equation (11) is the "market price of risk". The market price of risk measures how negatively the domestic investor evaluates the global recession risk $\sigma_u v_t^{1/2} u_{t+1}$ and the global volatility risk $\sigma_w w_t$ because the two global risks decrease her future marginal utility and thus decrease the SDF. Equation (14) shows to what extent that the realization of the two global risk at time $t+1$ increases investor's marginal utility and SDF at that time because of the resolution of uncertainty. The above analysis for the SDF is also applicable to the foreign investor.

Supposing that all variables are i.i.d log-normally distributed, we can simplify the entropy $L(M_{t+1})$ as:

$$L(M_{t+1}) = \log E_t[\exp m_{t+1}] - E_t[m_{t+1}] = (1/2)\text{Var}[m_{t+1}]. \tag{18}$$

Hence, we can write out the entropy in our setting as follows:

$$L(M_{t+1}) = \frac{1}{2}\lambda_u E_t[\sigma_u (v_t)^{1/2} u_{t+1}]^2 + \frac{1}{2}\lambda_w E_t[\sigma_w w_{t+1}]^2 \tag{19}$$

Using equation (11), we can derive the following closed form of equation for the currency excess return on foreign bonds, or the currency risk premium:

$$\begin{aligned} rp_t &= r_t^* + E_t[\Delta q_{t+1}] - r_t, \\ &= \frac{1}{2}(\theta_u^2 - \theta_u^{*2}) E_t[\sigma_u (v_t)^{1/2} u_{t+1}]^2 + \frac{1}{2}(\theta_w^2 - \theta_w^{*2}) E_t[\sigma_w w_{t+1}]^2. \end{aligned} \tag{20}$$

This shows how the difference between the home and foreign countries' risk aversions produces the difference between the home and foreign countries' exposures to the global economic fluctuation. If the domestic investor is more risk averse than the foreign investor, it follows that $\theta_u^2 - \theta_u^{*2} > 0$ and $\theta_w^2 - \theta_w^{*2} > 0$; thus the domestic investor receives a positive currency excess return from foreign investment as the global recession and volatility are expected to be imminent.

From no-arbitrage condition (3) and equation (12), we have the following equation for exchange rate dynamics:

$$\Delta q_{t+1} - E_t[\Delta q_{t+1}] = (\theta_u^* - \theta_u^2)\sigma_u(v_t)^{\frac{1}{2}} u_{t+1} + (\theta_w^* - \theta_w^2)\sigma_w w_{t+1}. \tag{21}$$

This shows that if the domestic investor is more risk averse than the foreign investor, the exchange rate unexpectedly appreciates in response to the global recession and volatility shocks. We can infer that Japan's larger risk aversion is responsible for granting the Japanese yen the status of a haven currency, particularly, during global recession and financial turmoil.

The spread between the domestic and foreign real interest rates, which is a key driver of currency carry trading, is given by:

$$r_t^* - r_t = \{\delta_u(\gamma) - \delta_u(\gamma^*)\} E_t[\sigma_u(v_t)^{1/2} u_{t+1}]^2 - \{\delta_w(\gamma) - \delta_w(\gamma^*)\} E_t[\sigma_w(w_{t+1})]^2, \tag{22}$$

where parameters $\delta_u(\gamma)$ and $\delta_w(\gamma)$ are determined depending on the relative risk aversion coefficient, γ, in the following:

$$\delta_u(\gamma) = \frac{\theta_u^2}{2} - \lambda_u = \frac{1}{2}\left\{\gamma + \phi^{-1}(\gamma - 1)\right\} > 0, \quad \delta_u'(\gamma) > 0 \tag{23}$$

$$\delta_w(\gamma) = \frac{\theta_w^2}{2} - \lambda_w = \frac{1}{2}(\gamma + \phi^{-1})(1 - \phi^{-1})(A_2)^2 > 0, \tag{24}$$

where $A_2 = \frac{1}{2}k(1-\gamma)\sigma_u^2$ and $\delta_w'(\gamma) > 0$ for $\gamma > 1$. This equation implies that the real interest rate in the home country with higher risk aversion becomes lower than that in the foreign country with lower risk aversion in response to the increase in the global recession and volatility risks. Accordingly, from equation (20), we can see that the low interest rate country, which is the home country with higher risk aversion, receives positive excess currency returns, as the global economy is expected to become unstable.

2.3. **Insight on Japan's Exorbitant Duty and Privilege** Our simple model shows that if the domestic investor is more risk averse than the foreign investor, she receives positive excess currency returns on foreign bonds, while the exchange rate appreciates, during the period when global recession and volatility become severe. The backdrop of this process is that the increase in global recession and volatility risks induces increasing the market price of risk, λ_u and λ_w in equation (11), due to larger variability in the marginal utility and the SDF of the domestic investor with larger relative aversion (see equations (8) and (18)). Such increase in the market price of risk leads to buying the home currency and selling the foreign currency.

The insight of our model into Japan's excess returns from foreign investment and the dynamics of the yen is that Japan's risk aversion plays the critical role in determining them. According to our model, Japan's larger risk aversion would be responsible for the Japanese yen's status of a haven currency during global recession and financial turmoil. Japanese economy experienced a banking crisis in the late 1990s, and since then it has faced a continuing stagnation and a pressure to reconstruct bank and firm balance sheets. If the stagnation since the late 1990s increase Japan's risk aversion, such increase in its risk aversion would make the yen one of the most utilized low interest rate currencies for the currency carry trading (see equation (22)). As a consequence, Japan has received positive excess returns on foreign investment since the late 1990s, and the yen has has the characteristic that makes it appreciate during global recession and financial turmoil.[12]

Therefore, due to Japan's larger risk aversion, the international currency market would require Japan playing a role in becoming a provider of a haven asset during global recession and financial turmoil. This role would be "Japan's exorbitant duty", as pointed out by Gouricnhas et al. (2010), while the reward of this duty would be "Japan's exorbitant privilege", as pointed out by Rogoff and Tashiro (2015). In the next section, we will empirically examine the theoretical implication derived in this section.

3. Empirical Analysis

3.1. Proxies for Global Risk and Risk Aversion

3.2. Impulse Response of The Yen to Global Financial Shock

[12] More precisely, the yen has a cycle in which it appreciates during global recession and financial turmoil, while it depreciates during global booming and financial stability, due to Japan's relatively larger risk aversion.

3.3. Global Risk and Japan's Exorbitant Duty

4. Conclusions

Appendix I: Procedure for Deriving the Stochastic Discount Factor In this appendix, we explain a procedure for deriving the closed form of the SDF discussed in subsection 2.2. We assume that the home and foreign households have the same utility function except for a risk aversion coefficient:

$$U_t = \left\{(1-\beta)C_t^{1-1/\phi} + \beta[\mu_t(U_{t+1})^{1-1/\phi}]\right\}^{1-1/\phi}, \tag{A-1}$$

$$\mu_t(U_{t+1}) = \left\{E_t[(U_{t+1})]^{1-\gamma}\right\}^{1-1/\gamma}, \tag{A-2}$$

where β denotes the subjective discount factor and C_t denotes consumption. Equation (A-2) describes the certainty equivalence of the expected utility. γ denotes the relative risk aversion parameter and ϕ denotes the elasticity of the intertemporal substitution in consumption. Thus, the SDF is given by:

$$M_{t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-1/\phi}\left(\frac{U_{t+1}}{\mu_t(U_{t+1})}\right)^{1/\phi-\gamma}. \tag{A-3}$$

The difference in the SDFs of the home and foreign households only lies in the risk aversion parameter γ.

We prepare for the ratio of the utility to consumption as $Z_t = U_t/C_t$ and then define the following variable:

$$x_t = \log\mu_t\left\{(C_{t+1}/C_t)Z_{t+1}\right\} = (1-\gamma)^{-1}\log E_t[\exp(1-\gamma)(g_{t+1}+z_{t+1})]. \tag{A-4}$$

Thus, following Hansen et al. (2008), Backus et al. (2013) and Backus et al. (2014), we can derive a linear approximation of the household recursive utility expressed in equations (A-1) and (A-2) as follows:

$$z_t \simeq z_0 + kx_t \ (0 < k < 1), \tag{A-5}$$

where parameters z_0 and k are not dependent on the risk aversion parameter γ. The logarithmic transformation of the SDF in equation (A-3) can be expressed in the following:

$$m_{t+1} = \log\beta - \phi^{-1}g_{t+1} + (\phi^{-1} - \gamma)(g_{t+1} + z_{t+1} - x_t). \tag{A-6}$$

Thus, we below express the SDF as a linear function of an underlying risk factor. To this end, we seek a guess solution of the utility-consumption ratio z_t in the following function of a state variable v_t:

$$z_t = A_1 + A_2 v_t. \tag{A-7}$$

We substitute this equation into equation (A-4) and then, given equations (9) and (10), we have the following equation:

$$\begin{aligned} x_t &= E_t[g_{t+1} + z_{t+1}] + \frac{1}{2}(1-\gamma)\mathrm{Var_t[g_{t+1} + z_{t+1}]} \\ &= (g + A_1 + A_2 v) + \frac{1}{2}(1-\gamma)\left\{\sigma_u^2 v_t + (A_2)^2\sigma_w^2\right\}. \end{aligned} \tag{A-8}$$

We substitute this equation into equation (A-5). Thus, by comparing the resultant equation with equation (A-7), we have equations for A_1 and A_2:

$$A_1 = (1-k)^{-1}z_0 + k(1-k)^{-1}[g + A_2 + \frac{1}{2}(1-\gamma)(A_2^2\sigma_w^2], \tag{A-9}$$

$$A_2 = \frac{1}{2}k(1-\gamma)\sigma_u^2. \tag{A-10}$$

Given that $g_{t+1} + z_{t+1} - E_t[g_{t+1} + z_{t+1}] = -\sigma_u(v_t)^{1/2}u_{t+1} + A_2\sigma_w w_{t+1}$, we can derive the expectation of the SDF in equation (A-6) as equation (11) in the maintext.

Appendix II: Computing Proxies for Global Risk and Relative Risk Aversion

REFERENCES

[1] Alvarez, F., and Jermann, U., 2005. "Using Asset Prices to Measure the Persistence of the Marginal utility of Wealth." Econometrica 73(6), November: 1977-2016.

[2] Bacchetta, P. and van Wincoop, E., 2010. Infrequency Portfolio Decisions: A Solution to the Forward Discount Puzzle. American Economic Review 100(3), June: 870-904.

[3] Backus, D., Gavazzoni, F., Telmer, C., and Zin, S., 2013. "Monetary Policy and the Uncovered Interest Rate Parity Puzzle." Mimeo., March. [First publicized in NBER Working Paper No.16218, July 2010.]

[4] Backus, D., Chernov, M., and Zin, S., 2014. "Sources of Entropy in Representative Agent Models." Journal of Finance 69(1), February: 51-99.

[5] Backus, D., Coleman, C., Ferriere, A., and Lyon S., 2015. "Pareto Weights as Wedges in Two-Country Models." NBER Working Paper No.21773, December.

[6] Bansal, R., Kiku, D., and Yaron A., 2012. "Risks for the Long Run: Estimation with Time Aggregation." Mimeo, July. [first version ppeared in June 2006 as titled "Risks for the long run: Estimation and inference.".]

[7] Bansal R., and Shaliastovich, I., 2013. "A Long-run Risks Explanation of Predictability Puzzles in Bond and Currency Markets." Review of Financial Studies 26(1), January: 1-33.

[8] Bénétrix, A., Lane, P., and Shambaugh, J., 2015. "International Currency Exposures, Valuation Effects and the Global Financial Crisis." Journal of International Economics 96, Supplement 1, July: S98-S109.

[9] Bekaert, G., Engstrom, E., and Xing, Y., 2009. "Risk, Uncertainty, and Asset Prices." Journal of Financial Economics 91, 59-82.

[10] Bekaert G., and Hoerova, M., 2014. "The VIX, the Variance Premium and Stock Market Volatility." Journal of Econometrics 183, December: 181-192.

[11] Bekaert, G., and Hoerova, M., 2016. "What Do Asset Prices Have to Say About Risk Appetite and Uncertainty?" Journal of Banking and Finance 67, June: 103-118.

[12] Bekaert G., Hoerova, M., and Lo Duca, M., 2013. "Risk, Uncertainty, and Monetary Policy." Journal of Monetary Economics 60, October: 771-788.

[13] Burnside, C., and Graveline, J., 2012. "Exchange Rate Determination, Risk Sharing and the Asset Market View." NBER Working Paper No.18646, December.

[14] Campbell, J., 2014. "Empirical Asset Pricing: Eugene Fama, Lars Peter Hansen, and Robert Shiller." Mimeo, May.

[15] Campbell, J., Giglio, S., Poilk, C., and Turley, R., 2016. "An Intertemporal CAPM with Stochastic Volatility." Mimeograph, February.

[16] Chari, V., Kehoe, P., and Mcgrattan, E., 2002. "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?" Review of Economic Studies 69(3), July: 533-563.

[17] Curcuru, S., Thomas, C., and Warnock, F., 2013. "On Return Differentials." Journal of International Money and Finance 36, September: 1-25.

[18] Engel, C., 2014. "Exchange Rates and Interest Parity." In Gopinath, G., Helpman, E., and Rogoff, K. (eds.), Handbook of International Economics, Chapter 8, Elsevier; Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney and Tokyo: 453-522.

[19] Engel, C., 2016. "Exchange Rates, Interest Rates, and the Risk Premium." American Economic Review 106(2), February: 436-474.

[20] Epstein, L., and Zin, S., 1989. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework." Econometrica 57(4), July: 937-969.

[21] Epstein, L., and Zin, S., 1991. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: An Empirical Analysis." Journal of Political Economy 99(2), April: 263-286.

[22] Fahri, E., Fraiberger, S., Gabaix, X., Ranciere, R., and Verdelhan, A., 2014. "Crash Risk in Currency Markets." Mimeo., June.

[23] Farhi, E., and Gabaix, X., 2016. "Rare Disasters and Exchange Rates." Quarterly Journal of Economics 131(1), February: 1-52.

[24] Gavaix, X., and Maggiori, M., 2015. "International Liquidity and Exchange Rate Dynamics." Quarterly Journal of Economics 130(3), August: 1369-1420.

[25] Gohrband, C., and Howell, K., 2015. "U.S. International Financial Flows and U.S. Net Invetment Position: New Perspectives Arising from New International Standards." In C.R. Hulten and M.B. Reinsdorf (eds.), Measuring Wealth and Financial Intermediation and Their Links to the Real Economy, University of Chicago Press; Chicago, Chapter 8: 231-270.

[26] Gourinchas, P.-O., and Rey, H., 2007. "From World Banker to World Venture Capitalist: U.S. External Adjustment and the Exorbitant Privilege." In Clarida, R.H. (ed.), G7 Current Account Imbalances: Sustainability and Adjustment, University of Chicago Press; Chicago: 11-55.

[27] Gourinchas, P.-O., Rey, H., and Givillot, N., 2010. "Exorbitant Privilege and Exorbitant Duty." Mimeo., December.

[28] Gourinchas, P.-O., and Rey, H., 2014. "External Adjustment, Global Imbalances, Valuation Effects." In Gopinath, G., Helpman, E., and Rogoff, K., (eds.), Handbooks of International Economics, Volume 4, Noth-Holland; Amsterdam and others: 585-645.

[29] Gourio, F., Siemer, M., and Verdelhan, A., 2013. "International Risk Cycles." Journal of International Economics 89(2), March: 471-484.

[30] Duffee, G., 2005. "Time Variation in the Covariance between Stock Returns and Consumption Growth. Journal of Finance 60(4), August: 1673-1712.

[31] Habib, M., 2010. "Excess Returns on Net Foreign Assets: The Exorbitant Privilege from a Global Perspective." European Central Bank Working Paper Series No.1158, Feburuary.

[32] Hansen, L, Heaton, J., and Li, N., 2008. "Consumption Strikes Back? Measuring Long-run Risk." Journal of Political Economy 116(2), April: 260-302.

[33] Hassan, T., 2013. ”Country Size, Currency Unions, and International Asset Returns.” Journal of Finance 68(6), December: 2269-2308.

[34] Ivashina, V., Scharfstein, D., and Stein, J., 2015. ”Dollar Funding and the Lending Behabior of Global Banks.” Quarterly Journal of Economics 130(3), August: 1241-1281.

[35] Lusting, H., Roussanov, N., and Verdelhan, A., 2011. ”Common Risk Factors in Currency Markets.” Review of Financial Studies 24(11), November: 3731-3777.

[36] Lusting, H., Roussanov, N., and Verdelhan, A., 2014. ”Countercyclical Currency Risk Premia.” Journal of Financial Economics 111(3), March: 527-553

[37] Lusting, H., and Verdelhan, A., 2012. ”Exchange Rates in a Stochastic Discount Factor Framework.” In James, J., Marsh, I. and Sarno, L. (eds.), Handbook of Exchange Rates, John Wiley&Sons Inc., Chapter 14: 391-420.

[38] Maggiori, M., 2013, ”The U.S. Dollar Safety Premium,” mimeo.

[39] Martin, I., 2011. ”The Forward Premium Puzzle in a Two-country World. ”NBER Working Paper No.17564, November.

[40] Menkhoff, L., Sarno, L., Schmeling, M., and Schrimpf, A., 2012. ”Carry Trades and Global Foreign Exchange Volatility.” Journal of Finance 67(2), April: 681-718.

[41] Plender, J. 2016. ”Central Bank Paralysis Prevails as Currency Wars Get Complicated” Financial Times Insight, April 6: 22

[42] Rogoff, K., and Tashiro, T., 2015. ”Japan’s Exorbitant Privilege.” Journal of the Japanese and International Economies 35: 43-61.

[43] Verdelhan, A., 2010. ”A Habit-based Explanation of the Exchange Rate Risk Premium.” Journal of Finance 65(1), February: 123-146.

[44] Verdelhan, A., 2013. ”The Share of Systematic Variation in Bilateral Exchange Rates.” Mimeo, February.