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Essays on International Asset Allocation and Pricing

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Abstract

Essays on International Asset Allocation and Pricing

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My dissertation studies financial asset allocation and pricing in open economy framework. In the first chapter, I investigate why countries with more flexible exchange rate policies tend to hold more domestic bonds in their portfolios. First, I show that fewer domestic bond holdings under a pegged regime than under a floating regime is mainly because international bond position cannot hedge against real shocks when the exchange rate is pegged. Therefore, exchange rate regimes are non-neutral for asset holdings through changing the hedging characteristics of nominal assets. Second, I show that, under a floating regime, more domestic bond holdings by countries with more volatile nominal exchange rates can be explained by more volatile real shocks. I develop a two country DSGE model with endogenous portfolio choice in which nominal bonds are traded internationally and exchange rate regimes are characterized by interest rate rules. In the second chapter, I investigate how international equity mutual funds allocate their portfolios across countries and what factors determine their asset allocation decisions using micro-level data on mutual funds. I find that equity fund managers are actively engaged in a rebalancing strategy to manage their global portfolios and the motive behind this action is more related to equity market risk rather than to currency risk. I also show that the fund managers' degree of rebalancing is larger in times of higher global uncertainty and in equity markets that exhibit a stronger correlation with the global market, implying that global risk has asymmetric effect on international asset

allocation. In the third chapter, I expand a closed economy macro-finance model with a recursive preference into an open economy model, to better understand the determinants and co-movement of term premia across countries. I find that term premia are lower in an open economy setup than in a closed economy setup due to increased risk sharing across countries. In addition, I show that both underlying shocks and stochastic volatility shocks have to be highly correlated across countries to explain the cross-country co-movement of term premia, whereas the co-movement of yield spreads is more driven by correlated policy expectations rather than by correlated term premia. I build a two-country DSGE model with the Epstein-Zin preference and stochastic volatility shocks. The third chapter, as well as the second chapter, emphasizes the role of global common risk in an open economy.

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DEDICATION

to my parents

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Chapter 1

EXCHANGE RATE REGIMES AND HOME BIAS IN BONDS

1.1 Introduction

It has been a long-standing question in open economy literature whether nominal exchange regimes affect real variables. Theoretically, the answer depends on whether nominal rigidity exists in the economy. When prices are fully flexible and a country's exchange rate is fixed to a foreign currency, nominal prices can be adjusted instead of exchange rates in response to external shocks. Therefore, real variables should not be affected by the choice of exchange rate regimes. However, when prices are sticky, a country under the fixed exchange rate regime will be more restricted than a country with flexible exchange rate with regard to responding to external shocks. This is because price adjustment cannot completely absorb the adverse effect of external shocks immediately. Therefore, previous theoretical studies have focused on the role of price stickiness and firm's price setting behavior to explain the non-neutrality of exchange rate regimes. For example, Devereux and Engel (1998) examine the impact of price setting on the optimal choice of exchange rate regime. Monacelli (2004) investigates how the variability of real exchange rates differs across exchange rate regimes in the presence of nominal rigidities. However, empirical results on the non-neutrality of exchange rate regimes seem to be mixed. Baxter and Stockman (1989) find little evidence of systematic differences in macroeconomic aggregates across exchange rate regimes. Bastourre and Carrera (2004) demonstrate that the real volatility is greater for more rigid exchange rate regime.

This chapter takes a fresh look at the question by exploring financial markets; Are exchange rate regimes non-neutral for asset holdings? International investment and payoff from foreign assets are subject to exchange rate movement, which depends on the exchange rate

regime. Therefore, exchange rate regimes may matter for asset holdings. Furthermore, portfolio holdings may also affect other non-financial variables such as consumption; therefore, it may be interesting to explore how the previous results are affected if exchange rate regimes affect financial markets.

This question is also closely related to the literature on home bias in assets. Portfolio theory¹ implies that country-specific risks can be diversified away by holding foreign assets when returns are not perfectly correlated across countries. In reality, countries tend to hold more domestic assets in their portfolio relative to what pure diversification implies², exhibiting the well-known home bias (Tesar and Werner, 1995). In the existing literature, little attention has been paid to bond home bias whereas equity home bias has been a main interest (French and Poterba (1991), Ahearne, Grierer and Warnock (2004)). However, home bias is more prominent in bonds than in equities (Fidora, Thimann, and Fratzscher, 2007), and the global debt outstanding is much larger than the equity capitalization.

The most notable difference between nominal bonds³ and equities is that future bond returns in the local currency are already known at the time of the investment decision, whereas future equity returns are uncertain because they are subject to factors such as firm-specific performances and country-specific macroeconomic conditions. Therefore, the fixed income characteristic of bonds implies that exchange rates may play a very important role for international bond investors. For example, simple Markowitz type portfolio models⁴ can easily generate bond home bias by introducing exchange rate risk as an additional risk. Suppose that asset returns are uncorrelated and the variance of returns is the same across countries; therefore, the sole difference between a home and a foreign asset is the exchange

¹Lucas (1982) shows that it is optimal for a country to hold half of home asset for full risk sharing in a symmetric two-country model. Refer also to Markowitz (1952) and subsequent modern portfolio theory models.

²Pure diversification implies that investors hold market-capitalization-weighted portfolio.

³In this paper, we focus on nominal bonds rather than real bonds (e.g. TIPS) because the outstanding nominal bond market remains much larger. As of 2014, total U.S. treasury outstanding securities is 12,505 billion dollars, whereas total outstanding of U.S. TIPS is 1,078 billion dollars.

⁴Refer to Fidora, Thimann, and Fratzscher (2007) and Hau and Rey (2009).

rate risk. Then, investors have less incentive to invest in foreign bonds because the portfolio becomes riskier due to exchange rate risk. However, observed bond home bias cannot be explained simply by the consequence of avoiding exchange rate risk because investors would hold only domestic bonds if they wanted to avoid exchange rate risks.

A hedging motive may be more important for risk-averse investors who want to smooth consumption over their lifetime. If an asset position pays off in times of lower non-financial income, investors can hold financial assets to hedge against consumption risk. In the existing literature in which home bias is explained by a hedging motive, bonds are introduced in models to explain equity home bias and the role of bonds is usually to hedge against real exchange rate risk (for example, Engel and Matsumoto (2009), Coeurdacier and Gourinchas (2011)). In particular, Engel and Matsumoto (2009) show that, when prices are sticky, the hedging role of nominally denominated assets (i.e., a forward contract in foreign exchange) is closely related to exchange rate movement. Devereux and Sutherland (2008) also show that the relative return between home and foreign bonds is related to nominal exchange movement. Therefore, the exchange rate still plays an important role for investors who hold bond portfolios for hedging.

This chapter relates exchange rate movements to monetary policy regimes and therefore investigates how monetary policy regimes affect the hedging motive of international bond investors, leading to different degree of home bias in bonds. I show that exchange rate regimes are non-neutral for asset holdings by changing the hedging characteristics of nominal assets. First, I provide empirical evidence that countries under a pegged regime tend to hold fewer domestic bonds than countries under a floating regime and show this is mainly due to a nominal bonds' inability to hedge against real shocks. Under a floating regime, it is optimal for investors to take a long position in home bonds (i.e., overweight in home bonds) because it provides hedging against both real and nominal shocks. However, under a pegged exchange rate, the movement of nominal exchange rates is not responsive to relative real shocks between two countries because countries that peg exchange rates import foreign policies. This implies that an international bond position cannot provide a hedge against

real shocks; therefore, the incentive to hold domestic bonds is weaker under a pegged regime. This result has implications for international risk sharing. When a market is incomplete, there is less risk sharing between two countries when the exchange rate is pegged because the role of the international bond position is limited only to hedging against nominal shocks.

Second, I show that countries with higher nominal exchange rate volatility under a floating regime tend to hold more domestic bonds. This finding may be explained by tighter inflation targeting or by more volatile real shocks. Tighter inflation targeting makes relative consumption more volatile whereas relative equity returns become less effective in hedging against productivity shocks. Therefore, hedging against increased relative consumption risk requires more of a long position in home bonds as well as more foreign equity holdings. We can also explain the positive relationship between nominal exchange rate volatility and the home bias in bonds when countries are heterogeneous in the volatility of real shocks. I show that it is optimal for countries with more volatile real shocks to hold more domestic bonds whereas it is optimal for countries with more volatile nominal shocks to hold fewer domestic bonds. Both cases imply that bond holdings under a floating regime are more driven by real shocks. Once again, this finding is in contrast to bond holdings under a pegged regime in which real shocks have minimal effects.

I develop a two-country DSGE model with endogenous portfolio choice in which nominal bonds are traded internationally. I start with a model in which only nominal bonds are traded to highlight the different roles of nominal bonds across exchange rate regimes. The basic result from this model still holds in a model with equity trading introduced. An incomplete market is assumed to show that the limited role of nominal bonds under a pegged regime can lead to less international risk sharing when agents do not have sufficient means for full risk sharing. Exchange rate regimes are characterized by interest rate rules⁵, which enable me to investigate the effect of a monetary policy stance such as inflation- and output-stabilization on portfolio holdings.

⁵For example, see Benigno and Benigno (2008).

This chapter contributes to the literature on the non-neutrality of exchange rate regimes and on the international portfolio choice. First, the previous literature regarding the non-neutrality of exchange regimes focuses on non-financial sides of the economy. For example, Mussa (1986), Monacelli (2004) and Carrera and Vuletin (2013) investigate whether nominal exchange rate regimes affect real exchange rates. Bleaney and Fielding (2002) investigate how exchange rate regimes affect inflation and output volatility. In this paper, I show that exchange rate regimes are non-neutral for financial variables by affecting the hedging characteristics of nominal assets. Second, this paper considers a broader monetary policy framework other than inflation targeting in portfolio choice literature. Devereux and Sutherland (2008, 2013) and Paoli, Küçük-Tuğer, Søndergaard (2010) consider policy regimes such as inflation targeting and the money growth rule, but do not consider different exchange regimes using interest rate rules.

My work is not the first to investigate the relationship between exchange rate risk and home bias in bonds. Empirically, Fidora *et al.* (2007) find a positive relationship between real exchange rates volatility and home bias in bonds and equities. This paper is different from Fidora *et al.* (2007) in three ways. First, I use nominal exchange rate volatilities instead of real exchange rate volatilities. Second, this chapter regards the non-linear effect of nominal exchange rate regimes for asset holdings, whereas Fidora *et al.* (2007) regard the linear relationship between real exchange rate volatilities and home bias. Third, in my model, agents hold bonds for hedging motives in a general equilibrium framework instead of a mean variance framework in which there is no hedging motive.

Engel and Matsumoto (2009) and Coeurdacier and Gourinchas (2011) attempt to resolve the equity home bias puzzle by introducing bonds but do not address how different policy regimes affect portfolio holdings. In Engel and Matsumoto (2009), money is introduced in the model, but follows a random walk. Therefore, it is impossible to address how a monetary policy framework can affect portfolio holdings.

Devereux and Sutherland (2008, 2013) investigate how a policy rule in the form of inflation targeting can affect portfolio holdings in an open economy setting. However, they focus only

on a free floating regime and their main interest is to demonstrate how a policy stance on inflation affects portfolio holdings. I investigate asset holdings under different exchange rate regimes including a free floating regime. Furthermore, I show that a policy stance on output in addition to inflation can greatly affect portfolio holdings.

This chapter is organized as follows. Section 1.2 presents empirical evidence and Section 1.3 presents the two-country DSGE model with endogenous portfolio choice. Then, Section 1.4 discusses optimal bond choice across exchange regimes and across countries with different exchange rate volatilities. Concluding remarks are offered in Section 1.5.

1.2 Empirical Evidence

Recent bond home bias measures are newly estimated⁶, using a dataset from Arslanalp and Tsuda (2012, 2014) and Coordinated Portfolio Investment Survey (CPIS) data from IMF. The home bias for country j can be defined as the difference between the share of domestic bonds in country j 's bond portfolio and country j 's bond market share in the world, adjusted by market share. Adjusting home bias measures with market shares is usual in literature (for example, Bekaert and Wang, 2009); this has effects on countries with a large market share, such as the US and the UK, but little effects on small countries.

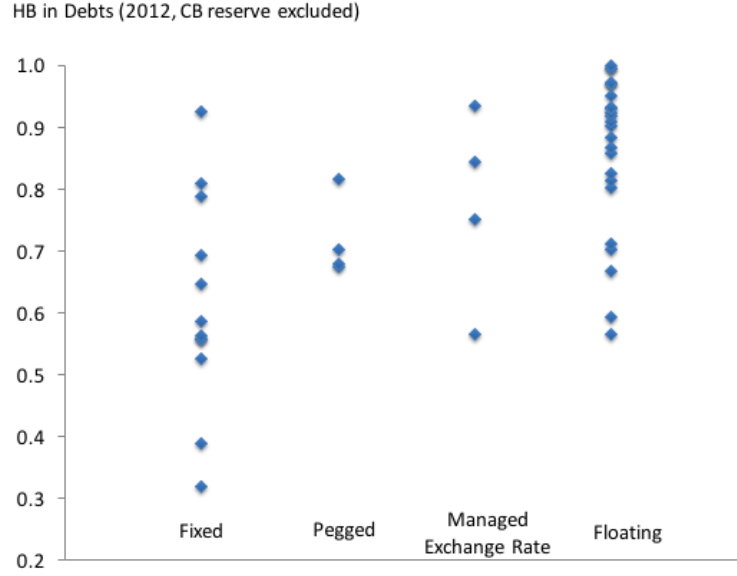
$$HB_j = \left[\frac{w_{j,\text{home}}}{w_{j,\text{home}} + w_{j,\text{foreign}}} - \text{market share}_j \right] / (1 - \text{market share}_j) \quad (1.1)$$

$w_{j,\text{home}}$ is country j 's investment in country j and $w_{j,\text{foreign}}$ is country j 's investment in foreign countries. Figure 1.1 shows that the degree of home bias in bonds tends to be higher for countries with a more flexible exchange rate regime.

Because exchange rates are pegged (or fixed) to a single currency or a currency basket, bilateral home bias measures need to be constructed, instead of aggregate country home bias measures in accordance with Fidora *et al.*(2007). The bilateral home bias measure of country i investing in country j is defined as

⁶Refer to the appendix for detailed data and country coverage.

Figure 1.1: Home bias in debts across exchange rate regimes (2012)



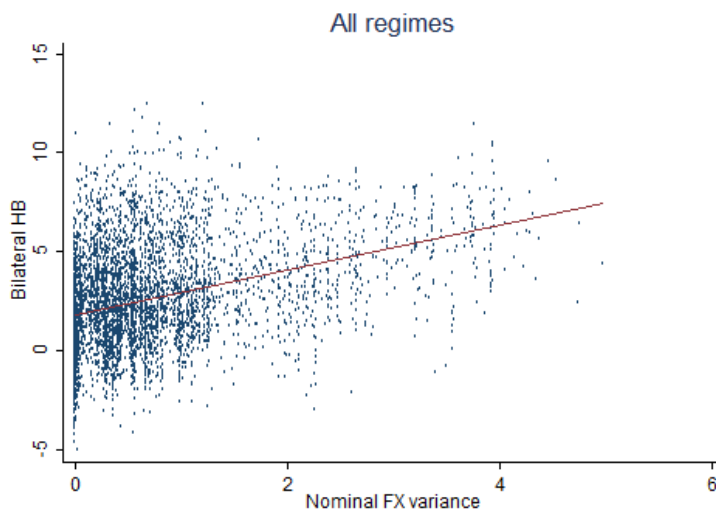
$$HB_{ij} = 1 - \frac{w_{i,j}}{\text{market share}_j} \quad (1.2)$$

$w_{i,j}$ is the share of investment in country j in country i 's portfolio. If country i 's investment in country j is relatively higher than the world market share of country j , HB_{ij} becomes lower. Figure 1.2 shows that bilateral home bias measures are positively related to the variance of nominal exchange rate variances.

Furthermore, if we regroup observations from Figure 1.2 according to whether the exchange rate of country i is bilaterally pegged to country j or not, we can see the clear difference in the level of bilateral home bias (See Figure 1.3). The degree of bilateral home bias in bonds is lower when a country's exchange rate is pegged to a foreign country.

Formally, consider a simple regression such as equation 1.3 to show that bilateral pegging itself affects home bias measures. The dependent variable, HB_{ij} , is defined as $\ln(w_{i,j}) - \ln(\text{market share}_j)$ following Fidora et al. (2007). Dummy variable takes a value of 1 if

Figure 1.2: Bilateral home bias (2011-2013)

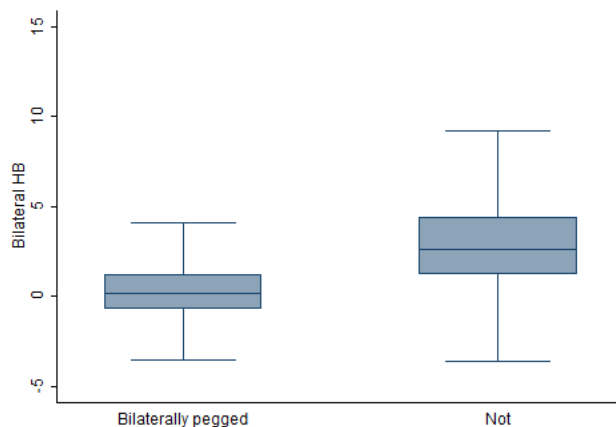


country i is bilaterally pegged to country j , otherwise 0. Nominal exchange rate variances are measured as the log of the variance of the daily exchange rate between two countries. The sample period is from 2010 to 2013.

$$HB_{ij} = \alpha_{ij} + \beta_1 FXvolatility_{ij} + \beta_2 dummy_{ij} + \epsilon_{ij} \quad (1.3)$$

Regression I in Table 1.1 shows that the variances of bilateral nominal exchange rates are positively related to bilateral home bias in bonds. However, the positive relation is most likely due to the non-linear effect of the exchange rate pegging rather than to the linear effect of nominal exchange rate variances on home bias. Regression II in Table 1.1 has a similar adjusted R-square to regression I, and the explanatory power of nominal exchange rate volatilities under a free floating regime is much lower than in a pooled regression. This evidence suggests that pegging to other currency tends to significantly reduce the degree of bond home bias. Another observation is that, under a floating regime, there remains a positive relation between the variances of nominal exchange rates and the degree of home

Figure 1.3: Bilateral pegging and bilateral home bias (2011-2013)



bias.

In the next section, I develop a model to explain two stylized facts. First, why countries under a pegged regime tend to hold fewer domestic bonds than countries under a floating regime is examined. Second, how the positive relation between the variances of the nominal exchange rate and the bond home bias measures under a floating regime can be explained by a hedging motive is examined.

1.3 The Model

I develop a two-country DSGE model⁷. There are home and foreign country trading goods and default-free nominal bonds internationally. Households maximize the expected lifetime utility, and firms produce differentiated goods using labor. In the baseline model, there are two shocks in each country; productivity and interest rate shocks. Nominal bonds are

⁷The model is developed on Devereux and Sutherland (2008); One of the main differences is that I introduce different exchange regimes, not only a free floating regime. Second, I also investigate the effect of output stabilization for asset choice. Third, productivity shocks are not a random walk as in Devereux and Sutherland (2008). The persistency of shocks are very important in asset choice. If productivity shock has a permanent effect as in Devereux and Sutherland (2008), policy stance does not matter for asset choice. Fourth, real exchange rate fluctuation is allowed in the model by introducing home bias in goods.

Table 1.1: Exchange rate regimes and bilateral home bias in bonds

<i>Regression</i>	<i>(I)Pooled</i>	<i>(II)Pooled</i>	<i>fixed_i</i>	<i>pegged_i</i>	<i>managed_i</i>	<i>floating_i</i>
<i>Nominal FX vol_{ij}</i>	1.14 *** (0.042)					0.63 *** (0.065)
<i>dummy_i^{fixed^j}</i>		-2.77*** (0.115)	-2.02*** (0.103)			
<i>dummy_i^{pegged^j}</i>		-2.18*** (0.182)		-1.53*** (0.256)		
<i>dummy_i^{managed^j}</i>		-0.94*** (0.275)			-1.58*** (0.338)	
<i>constant</i>	1.76 *** (0.045)	2.94 *** (0.038)	2.19 *** (0.055)	2.29 *** (0.138)	3.59 *** (0.159)	2.90 *** (0.074)
<i>adjusted R²</i>	0.13	0.12	0.18	0.05	0.05	0.04
<i>OBS</i>	4,994	4,994	1,767	644	364	2,219

Note : dummy = 1 if a country i 's currency is pegging to country j 's currency

denominated in each country's currency and pays off one unit of currency that they are issued in at next period. Therefore, the market is incomplete in the baseline model. Monetary authorities set nominal interest rates one period ahead.

1.3.1 Households

The representative agent in the home country maximizes her expected lifetime utility.

$$\max E_t \sum_{s=0}^{\infty} \beta^s \left(\frac{C_{t+s}^{1-\gamma}}{1-\gamma} - \psi \frac{L_{t+s}^{1+\eta}}{1+\eta} \right) \quad (1.4)$$

C_t and L_t are consumption and labor, respectively. γ is the risk aversion coefficient and β is the discount factor with $\eta, \psi > 0$. The home agent consumes composite goods consisting of domestic and foreign produced goods ($C_{H,t}, C_{F,t}$, respectively). θ is the elasticity of substitution between home and foreign goods. Domestic goods are aggregates of individual

goods ($C_{H,t}(i)$), and ϕ is the elasticity of substitution between individual goods. We assume home bias in consumption ($a \geq 1/2$) to allow fluctuation in real exchange rates. Then, aggregate consumption, domestic and foreign goods can be defined as equation (1.5) and (1.6).

$$C_t = \left(a^{\frac{1}{\theta}} C_{H,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} C_{F,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \frac{1}{2} \leq a < 1 \quad (1.5)$$

$$C_{H,t} = \left(\left(\frac{1}{a} \right)^{\frac{1}{\phi}} \int_0^{1/2} C_{H,t}(i)^{\frac{\phi-1}{\phi}} di \right)^{\frac{\phi}{\phi-1}}, C_{F,t} = \left(\left(\frac{1}{1-a} \right)^{\frac{1}{\phi}} \int_{1/2}^1 C_{F,t}(i)^{\frac{\phi-1}{\phi}} di \right)^{\frac{\phi}{\phi-1}} \quad (1.6)$$

At time t , home agents' nominal income include labor income ($w_t L_t$), profits ($P_t \Pi_t$) from the production and the payoff from bond portfolio ($B_{t-1}^H + S_t B_{t-1}^F$) chosen in the previous period. Nominal bonds are denominated in each country's currency and pays off one unit of currency that they are issued in the next period. There is a lump-sum tax (T_t) from the government. Home agents decide how much they consume (C_t) and invest in home and foreign nominal bonds (B_t^H, B_t^F , respectively). Q_t and Q_t^* are the nominal prices of home and foreign bond (at local currency), respectively. S_t is the nominal exchange rate, and an increase in S_t implies depreciation of home currency.

$$P_t C_t + Q_t B_t^H + S_t Q_t^* B_t^F = w_t L_t + P_t \Pi_t + B_{t-1}^H + S_t B_{t-1}^F - P_t T_t \quad (1.7)$$

The home budget constraint can be re-written in real terms as equation (1.8). The real return from home bond is defined as $r_t^H (= \frac{1}{Q_{t-1}} \frac{P_{t-1}}{P_t})$, and the real return in terms of home consumption from foreign bond is $r_t^F (= \frac{1}{Q_{t-1}^*} \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t})$.

$$\alpha_t^H + \alpha_t^F + C_t = \frac{w_t}{P_t} L_t + \Pi_t + \alpha_{t-1}^H r_t^H + \alpha_{t-1}^F r_t^F - T_t \quad (1.8)$$

Let W_t be the sum of home bond holding and foreign bond holding by home agents.

Furthermore, to reduce the number of variables, let real home bond holding be $\alpha_t \equiv \alpha_t^H$ and relative return between home and foreign bond as $r_{x,t} (\equiv r_t^H - r_t^F)$. Then, we can rewrite equation (1.8) like equation (1.9). Foreign budget constraint (equation (1.10)) can be derived in a similar way. Asterisk(*) implies foreign variable and RER_t is the real exchange rate defined as $\frac{S_t P_t^*}{P_t}$. The reason why the real exchange rate shows up in foreign budget constraint is that W_t^* and $\alpha_{t-1}^{*'}$ (home bond holding by foreign country) are expressed in terms of home consumption basket, and real exchange is not constant in our model due to the assumption of home bias in goods.

$$W_t + C_t = r_t^F W_{t-1} + \alpha_{t-1}' r_{x,t} + \frac{w_t}{P_t} L_t + \Pi_t - T_t \quad (1.9)$$

$$\frac{W_t^*}{RER_t} + C_t^* = \frac{r_t^F W_{t-1}^*}{RER_t} + \frac{\alpha_{t-1}^{*'} r_{x,t}}{RER_t} + \frac{w_t^*}{P_t^*} L_t^* + \Pi_t^* - T_t^* \quad (1.10)$$

1.3.2 Firms

Individual firms produce differentiated goods in monopolistic competition. These firms set optimal prices ($\tilde{P}_{H,t}$) to maximize discounted sum of expected profits according to equation (1.11). Λ_{t+s} is the stochastic discount factor defined as $\beta^s \left(\frac{C_{t+s}}{C_t} \right)^{-\gamma} \left(\frac{P_t}{P_{t+s}} \right)$, and $MC_{t+s}(i)$ implies the nominal marginal cost for producer i at time $t+s$. We assume a sticky price in the form of Calvo pricing in which κ is the probability that producers cannot set new prices each period. Producers adopt producer currency pricing (PCP); therefore, they do not set separate prices for goods sold in foreign countries. The production function is linear in labor ($Y_t(i) = A_t L_t(i)$) and no physical capital⁸ is used for production. Productivity in log terms follows AR(1) process (i.e. $\log A_t = \mu \log A_{t-1} + \varepsilon_{A,t}$) where $\varepsilon_{A,t}$ is *i.i.d.* process. $Y_{t+s}(i)$ is the demand for goods i , which can be expressed as $\left[\frac{\tilde{P}_{H,t}}{\tilde{P}_{H,t+s}} \right]^{-\phi} Y_{t+s}$.

⁸If we have physical capital in the production function, we cannot derive the analytical solution due to the law of the motion of capital which includes the lagged state variable. However, the intuition does not depend on the assumption of the production function.

$$\max_{\{\tilde{P}_{H,t}\}} E_t \sum_{s=0}^{\infty} \kappa^s \Lambda_{t+s} \left[\tilde{P}_{H,t}(i) - MC_{t+s}(i) \right] Y_{t+s}(i) \quad (1.11)$$

Optimal price ($\tilde{P}_{H,t}$) can be expressed like equation (1.12), which is the product of expected marginal cost and markup. Because individual firms may not be able to adjust prices every period due to the assumption of Calvo pricing, optimal price is forward-looking.

$$\tilde{P}_{H,t} = \frac{\phi}{\phi - 1} \frac{E_t \sum_{s=0}^{\infty} (\kappa\beta)^s \Lambda_{t+s} MC_{t+s}(i) Y_{t+s}(i)}{E_t \sum_{s=0}^{\infty} (\kappa\beta)^s \Lambda_{t+s} Y_{t+s}(i)} \quad (1.12)$$

The producer price and the consumer price in the home country can be expressed as equation (1.13). Because we assumed Calvo pricing with stickiness κ , it is easy to show that producer price ($P_{H,t}$) is the sum of the previous price ($P_{H,t-1}$) with weight κ and of the optimal price ($\tilde{P}_{H,t}$) with weight, $(1 - \kappa)$. ϕ is the substitutability between domestic goods. The consumer price (P_t) is the weighted sum of home and foreign producer price with weight, a and $1 - a$, respectively. Similarly, the producer and the consumer price in foreign country can be defined as equation (1.14).

$$P_{H,t} = \left((1 - \kappa)(\tilde{P}_{H,t})^{1-\phi} + \kappa(P_{H,t-1})^{1-\phi} \right)^{\frac{1}{1-\phi}}, \quad P_t = \left(a(P_{H,t})^{1-\theta} + (1 - a)(P_{F,t})^{1-\theta} \right)^{\frac{1}{1-\theta}} \quad (1.13)$$

$$P_{F,t}^* = \left((1 - \kappa)(\tilde{P}_{F,t}^*)^{1-\phi} + \kappa(P_{F,t-1}^*)^{1-\phi} \right)^{\frac{1}{1-\phi}}, \quad P_t^* = \left(a(P_{F,t}^*)^{1-\theta} + (1 - a)(P_{H,t}^*)^{1-\theta} \right)^{\frac{1}{1-\theta}} \quad (1.14)$$

1.3.3 Monetary Policy

Nominal interest rate rules⁹ are employed to characterize exchange rate regimes. There are three exchange regimes we consider. First is the pegged regime¹⁰ in which the home country's currency is pegged to a foreign country's currency, allowing temporary deviation from the target. Second is the free floating regime in which interest rate rules do not consider exchange rates. Third is the managed exchange regime in which a country's policy rule considers exchange rates, inflation and output at the same time.

Pegged regime

The foreign country follows the Taylor rule in reacting to producer price inflation¹¹ and output gap, whereas home currency is pegged to foreign currency, allowing temporary fluctuation from the target exchange rate (\bar{S}). Home and foreign bonds are not perfect substitutes despite pegging due to a temporary nominal shock (m_t^H) to a home country's interest rate. The coefficient on the exchange rate (ρ_s) must be greater than zero for equilibrium to exist, and the coefficient on inflation (ρ_π^F) must be greater than one to stabilize the inflation.

$$R_{t+1}^H = R_{t+1}^F \left(\frac{S_t}{\bar{S}} \right)^{\rho_s} \exp(m_t^H), \quad m_t^H \sim i.i.d.(0, \varepsilon_m^2), \rho_s > 0 \quad (1.15)$$

$$R_{t+1}^F = \left(\frac{P_{F,t}}{P_{F,t-1}} \right)^{\rho_\pi^F} \left(\frac{Y_{F,t}}{\bar{Y}} \right)^{\rho_y^F} \exp(m_t^F), \quad m_t^F \sim i.i.d.(0, \varepsilon_m^2), \rho_\pi^F > 1, \rho_y^F \geq 0 \quad (1.16)$$

⁹Refer to Benigno and Benigno (2008) for how interest rate rules can characterize exchange rate regimes.

¹⁰Pegged regime can be considered to be an approximated fixed regime in our model, and therefore, we do not deal with fixed regime separately. Technically, there exists an indeterminacy issue under fixed regime, and therefore, we allow small nominal shock in pegged regime to approximate fixed regime.

¹¹If consumption price inflation is used instead of producer's price inflation, there is an indeterminacy problem for some specific parameter values.

Free floating

Both home and foreign interest rate rules react to PPI inflation and output, but not to the exchange rate. Devereux and Sutherland (2008) address the case with $\rho_y^i = 0$ only and Devereux and Sutherland (2013) vary the value of ρ_π with a fixed ρ_y . However, I will consider the case in which the value of ρ_y^i varies as well.

$$R_{t+1}^i = \left(\frac{P_{i,t}}{P_{i,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{i,t}}{\bar{Y}} \right)^{\rho_y} \exp(m_t^i), \quad m_t^i \sim i.i.d.(0, \varepsilon_m^2), \rho_\pi > 1, \rho_y^i \geq 0, \quad i = H, F \quad (1.17)$$

Managed exchange rate regime

The only difference from a free floating regime is that the home interest rate rule reacts to the exchange rate.

$$R_{t+1}^H = \left(\frac{P_{H,t}}{P_{H,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{H,t}}{\bar{Y}} \right)^{\rho_y} \left(\frac{S_t}{S_{t-1}} \right)^{\rho_s} \exp(m_t^H), \quad m_t^H \sim i.i.d.(0, \varepsilon_m^2) \quad (1.18)$$

$$R_{t+1}^F = \left(\frac{P_{F,t}}{P_{F,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{F,t}}{\bar{Y}} \right)^{\rho_y} \exp(m_t^F), \quad m_t^F \sim i.i.d.(0, \varepsilon_m^2) \quad (1.19)$$

1.3.4 Government

Government supplies fixed nominal bonds (\bar{B}) and therefore, bond holding in the model is driven by demand. Government collects lump-sum tax from households in case the revenue from bond issuance cannot meet the amount of the payment to bond holders. There is no government spending in baseline model.

1.3.5 Aggregation

The demand for individual good i is given by $Y_t(i) = (P_{H,t}(i)/P_{H,t})^{-\phi}Y_t$. Therefore, firm-level equilibrium condition implies that

$$A_t L_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\phi} Y_t \quad (1.20)$$

If we sum across firms, we get

$$\int_0^1 A_t L_t(i) di = \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\phi} Y_t di \quad (1.21)$$

Since aggregate labor supply has to be equal to aggregate labor demand (i.e. $\int_0^1 L_t(i) di = L_t$), we get

$$Y_t = \frac{A_t L_t}{V_t} \quad (1.22)$$

where $V_t \equiv \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\phi} di$ measures price dispersion. With flexible price, individual firms' price is always equal to aggregate domestic price (i.e. $V_t = 1$). However, there is price dispersion¹² ($V_t \neq 1$) since we assumed Calvo pricing in which the κ portion of firms cannot adjust price whereas $(1 - \kappa)$ portion of firms can adjust prices. It is easy to show that the law of motion of price dispersion evolves as following.

$$V_t = (1 - \kappa) \tilde{\pi}_t^{-\phi} \pi_t^\phi + \kappa \pi_t^\phi V_{t-1} \quad (1.23)$$

1.3.6 Market Clearing

Equation (1.24) implies that home goods production is driven by total demand for home goods, which is typical in a monopolistic competition setup. Total demand for home goods consists of home demand and foreign demand. Equation (1.25) is world goods market clearing

¹²However, when the model is approximated at first order with zero steady state inflation, the price dispersion index disappears, not affecting the portfolio solution.

condition. Finally, equation (1.26) shows financial market clearing condition. We assume non-zero bond supply (\bar{B}) for each country. B_t^H implies demand for home bonds by home agents, whereas B_t^{H*} is demand for home bonds by foreign agents.

$$Y_t = a \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} C_t + (1 - a) \left(\frac{P_{H,t}^*}{P_t^*} \right)^{-\theta} C_t^* \quad (1.24)$$

$$C_t + C_t^* = Y_t + Y_t^* \quad (1.25)$$

$$B_t^H + B_t^{H*} = \bar{B}(\text{Home}), \quad B_t^F + B_t^{F*} = \bar{B}(\text{Foreign}) \quad (1.26)$$

1.4 Optimal Portfolio Choice

In this section, we derive the optimal portfolio. To obtain a general understanding of how financial assets can be used to hedge against non-financial income risk, we begin with a general expression of the optimal portfolio choice, which is not subject to a specific exchange rate regime. Then, we derive the optimal bonds choice under different exchange regimes to show how hedging property of bonds differs under each regime and therefore, generates different degrees of home bias. Thereafter, we allow equity trading in our model to observe whether our argument still holds. We also investigate the implication of international risk sharing and, finally, we investigate why countries with higher nominal exchange rate volatility tend to be more home biased under a floating regime.

1.4.1 General Expression

As is well known in the literature, full risk sharing between two countries implies that the marginal utility of one unit of currency spent by home agents must be equal to the marginal utility of the same currency spent by foreign agents. However, full risk sharing can be achieved only when agents have sufficient means to hedge against shocks. Because the

market is incomplete in our baseline model, full risk sharing cannot always be achieved. Therefore, relative consumption risk can be measured as the difference between the marginal utility of home and foreign country. Furthermore, we need to consider the real exchange rate because consumption baskets between home and foreign agents can be different due to the home bias in goods.

Relative consumption adjusted by real exchange rate can be derived by combining home and foreign budget constraint, Euler equations and transversality condition of financial wealth. Equation (1.27)¹³ tells us that relative consumption is affected by the discounted sum of relative future non-financial income, real exchange rate and asset holding (α). *Ex post* different realization of shocks across two countries will yield non-financial (labor) income difference, making relative consumption riskier. Without asset holding ($\alpha = 0$), there is no way to offset the effect of shocks on relative consumption. However, a properly chosen portfolio can partly offset the effects of shocks on relative consumption.

$$\begin{aligned} \widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{rer}_t &= \frac{(1-\beta)}{\beta} \widehat{w}_{t-1}^R + (1-\beta)(2\alpha - \bar{B}) \underbrace{\widehat{r}_{x,t}}_{\equiv r_t^H - r_t^F} \\ &+ (1-\beta) E_t \left[\sum_{j=0}^{\infty} \beta^j \left[\underbrace{(\widehat{y}_{t+j} - \widehat{y}_{t+j}^* + \widehat{\tau}_{t+j})}_{\text{non-financial income}} + \left(1 - \frac{1}{\gamma} - \frac{(1-\beta)\bar{B}}{\beta}\right) \underbrace{\widehat{rer}_{t+j}}_{\text{real exchange rate}} \right] \right] \end{aligned} \quad (1.27)$$

Devereux and Sutherland (2009) show that the optimal portfolio condition implies that relative consumption and relative return must be orthogonal as equation (1.28).

$$E_{t-1} \left[(\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{rer}_t) r_{x,t} \right] = 0 \quad (1.28)$$

Equation (1.27) and (1.28) together imply the general expression of the optimal home

¹³hat(\cdot) variables imply the log deviation from steady state value.

bond holding (α) as equation (1.29)¹⁴.

$$\alpha = \underbrace{\frac{\bar{B}}{2}}_{\text{pure diversification}} - \underbrace{\frac{1}{2} \frac{Cov_{t-1}(\Lambda_t - E_{t-1}\Lambda_t, r_{x,t})}{Var_{t-1}(r_{x,t})}}_{\text{non-financial income hedging}} - \underbrace{\frac{1}{2} \left[1 - \frac{1}{\gamma} - \frac{(1-\beta)\bar{B}}{\beta} \right] \frac{Cov_{t-1}(\Omega_t - E_{t-1}\Omega_t, r_{x,t})}{Var_{t-1}(r_{x,t})}}_{\text{real exchange rate hedging}} \quad (1.29)$$

We can express optimal bond holding as the combination of three parts. First, pure diversification part implies that home agents have to hold exactly half of home bonds' supply. This can be understood as the case where both countries fully share each country's risk when returns are uncorrelated. Second term is related to non-financial income hedging. Λ_t is defined as the discounted sum of current and future relative non-financial income (adjusted by terms of trade) *i.e.*, $\sum_{j=0}^{\infty} \beta^j [(\hat{y}_{t+j} - \hat{y}_{t+j}^*) + \hat{\tau}_{t+j}]$. If the relative home bond return ($r_{x,t} \equiv r_{H,t} - r_{F,t}$) is negatively correlated with the unexpected relative non-financial income ($\Lambda_t - E_{t-1}\Lambda_t$), holding home bonds provides hedging against non-financial income because it pays when labor income is low. Therefore, home agents have an incentive to hold home bonds instead of foreign bonds if the correlation is negative. The third term is related to hedging against a real exchange rate. Ω_t is defined as the discounted sum of the current and future exchange rate ($\sum_{j=0}^{\infty} \beta^j \widehat{r}e\widehat{r}_{t+j}$). If holding a home bond pays when the real exchange rate appreciates, holding a home bond provides hedging against the real exchange rate. The conditional variance of the relative asset return ($Var_{t-1}(r_{x,t})$) is related to the hedging effectiveness of assets. A higher conditional variance implies that the asset is more effective in hedging. (*i.e.*, fewer holdings are sufficient to hedge against the same amount of risk).

As pointed out by Devereux and Sutherland (2013), equation (1.29) is not a closed form solution because the variance and covariance expression on the right hand side also depends on optimal asset holding (α). In a simple endowment economy in which the labor income and the exchange rate is independent from asset holding, we can use equation (1.29) to

¹⁴Refer to the appendix for derivation.

obtain a solution. To solve for the optimal portfolio, we apply the Devereux and Sutherland method. First, we approximate equilibrium variables at first order and express those in a state space form as equation (1.30) and (1.31). The main variables in our interest include excess return ($\widehat{r}_{x,t}$) and risk sharing condition ($\widehat{c}_t - \widehat{c}_t^* - \frac{r\widehat{er}_t}{\gamma}$). Because the excess return is *i.i.d* variable, we do not have exogenous (x_{t-1}) and endogenous state variable (s_t) in state space representation. ξ_{t+1} is defined as $\widetilde{\alpha}'\widehat{r}_{x,t+1}$ and treated as *i.i.d.* shock temporarily.

$$\widehat{r}_{x,t} = R_1\xi_t + R_2\varepsilon_t + O(\varepsilon^2) \quad (1.30)$$

$$\widehat{c}_t - \widehat{c}_t^* - \frac{r\widehat{er}_t}{\gamma} = D_1\xi_t + D_2\varepsilon_t + D_3 \begin{bmatrix} x_{t-1} \\ s_t \end{bmatrix} + O(\varepsilon^2) \quad (1.31)$$

Then, using the optimal portfolio condition (1.28), the optimal portfolio holding can be constructed using R_1, R_2, D_1, D_2 and covariance matrix of shocks (Σ). D_3 is not used in deriving optimal portfolio because x_{t-1} and s_t are already known at the time of portfolio decision and therefore, irrelevant in hedging. The equilibrium portfolio holding ($\widetilde{\alpha}$) can be expressed as (1.32)¹⁵

$$\widetilde{\alpha} = \frac{\alpha}{\beta Y} = \left[R_2\Sigma D_2'R_1' - D_1R_2\Sigma R_2' \right]^{-1} R_2\Sigma D_2' \quad (1.32)$$

1.4.2 Pegged Regime

Interest rate rules modified from Benigno and Benigno (2008) are employed to characterize exchange rate regimes. Assume that the foreign interest rate rule follows the Taylor rule stabilizing producer price inflation and the output gap and that the home currency is pegged to the foreign currency, allowing temporary fluctuation from the target exchange rate (\overline{S}). The interest rate rules of home and foreign country can be expressed as equation (1.33)

¹⁵Refer to Devereux and Sutherland (2009) for detail

and (1.34), respectively. m_t^H can be interpreted as a shock to the exchange rate to which monetary authority cannot (or do not) react in real time. Benigno and Benigno (2008) show that ρ_s must be greater than zero for the existence of the equilibrium.

$$R_{t+1}^H = R_{t+1}^F \left(\frac{S_t}{\bar{S}} \right)^{\rho_s} \exp(m_t^H), \quad m_t^H \sim i.i.d.(0, \varepsilon_m^2), \rho_s > 0 \quad (1.33)$$

$$R_{t+1}^F = \left(\frac{P_{F,t}}{P_{F,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{F,t}}{\bar{Y}} \right)^{\rho_y} \exp(m_t^F), \quad m_t^F \sim i.i.d.(0, \varepsilon_m^2), \rho_\pi > 1, \rho_y \geq 0 \quad (1.34)$$

In this setup, the relative variables between home and foreign countries are not affected by foreign nominal shock (m_t^F) due to the one to one transmission of m_t^F to the home country. The unexpected exchange rate change is solely the function of home nominal shock (m_t^H) (Equation (1.35)). Because the relative return between the home and foreign nominal bond is unexpected exchange rate appreciation of the home currency, this implies that international bond position can only be used to hedge against nominal shock.

$$S_t - E_{t-1}S_t = -(r_t^H - r_t^F) = -\frac{1}{1 + \rho_s} m_t^H \quad (1.35)$$

Without international bond position, in response to m_t^H shock, relative consumption decreases, whereas the relative return from the portfolio with a long position in a home bond and a short position in a foreign bond pays a positive return. Therefore, it is optimal to take a long position in home bond (i.e., home bias in bonds). In equilibrium, m_t^H is completely hedged, whereas productivity shocks are not hedged at all. Optimal home bond holding under pegged regime can be expressed as (1.36).

$$\bar{\alpha}_{HH}^{pegged} \simeq \underbrace{\frac{\bar{B}}{2}}_{\text{pure diversification}} + \underbrace{(1-a) \left[(2a\theta - 1) - \frac{2a-1}{\gamma} \right]}_{>0 : \text{home bias due to } m_t^H} \quad (1.36)$$

In equilibrium, there is home bias in bonds purely to hedge against nominal exchange rate risk (m_t^H). Bond holding is not dependent on foreign country's policy stance and the exchange rate feedback coefficient (ρ_s) as long as $\rho_s > 0$, and the commitment is credible. In summary, the international bond position cannot hedge against real shocks when the exchange rate is pegged, because the relative return (i.e., unexpected exchange rate movement) does not respond to relative real shocks.

1.4.3 Floating Regime

Under free floating regime, I assume that both home and foreign monetary authorities do not react to the exchange rate, but stabilize PPI inflation and the output gap. Then, each country's nominal short-term interest rate rules can be expressed as equation (1.37)¹⁶. Interest rates are also subject to nominal shocks (m_t^i).

$$R_{t+1}^i = \left(\frac{P_{i,t}}{P_{i,t-1}} \right)^{\rho_\pi^i} \left(\frac{Y_{i,t}}{\bar{Y}} \right)^{\rho_y^i} \exp(m_t^i), \quad m_t^i \sim i.i.d.(0, \varepsilon_m^2), \rho_\pi^i > 1, \rho_y^i \geq 0, i = H, F \quad (1.37)$$

In contrast to a pegged regime, exchange rate dynamics are affected not only by nominal shocks but also by real shocks from each country. Suppose that there is a negative home productivity shock. A relative increase in home country's PPI inflation due to a negative home productivity shock makes the future return of a home nominal bond higher than the return of a foreign bond, when a monetary authority attempts to stabilize inflation. This behavior implies the contemporaneous appreciation of home currency because the expected currency return must be positive when no arbitrage condition holds. Given that payoff from the long position in home bonds with a short position in foreign bonds is equal to the unexpected appreciation of the home currency, a bond portfolio provides a hedge against productivity shocks because the relative consumption decrease in response to a negative

¹⁶We assume that target PPI inflation is zero, and the potential output is constant

productivity shock. In addition, it is easy to show that the long position in home bonds also provides hedging against nominal shocks as in a pegged regime case. Therefore, there is a home bias in bonds under a floating regime (i.e., holding home bond beyond pure diversification motive). However, it does not mean full home bias because the optimal holding will also depend on how effective each asset is and markets must clear.

Under a floating regime, exchange rate dynamics are affected by real shocks when short-term interest rate rules react to real shocks. This can occur in two channels. First, if monetary authorities respond to the output gap ($\rho_y^i \neq 0$), short-term nominal interest rate is directly affected by real shocks. Second, when prices are sticky, real shocks can affect the nominal interest rate through PPI inflation even when $\rho_y^i = 0$. The stickier prices are, the more real shocks affect nominal interest rates through inflation. Countries may place different emphasis on PPI inflation and output gap; therefore, which channel will be more dominant will differ across countries. However, what is important is that real shocks affect nominal interest rates whether this occurs through a policy stance coefficient (ρ_y^i) or PPI inflation under a free floating regime¹⁷.

Equation (1.38) is the expression¹⁸ for the optimal home bond holding by home agents. As previously discussed above, there is home bias in bonds due to a hedging motive. In contrast to an optimal bond holding under a pegged regime, the bias depends on the policy stance (ρ_π, ρ_y) in Taylor rules and depends on the variance of each shocks (σ_a^2, σ_m^2). The reason why variances of each shock appear is due to the assumption of an incomplete market. Because agents have a limited menu of assets with a larger set of shocks (i.e., 2 assets and 4 shocks), they must consider the relative importance of shocks, which corresponds to the magnitude of each shock¹⁹.

¹⁷We assume $\rho_y^i = 0$ to maintain a simple analytical solution simple. We will investigate the case when $\rho_y^i \neq 0$ at the end of this sub-section.

¹⁸Assumed $a = 1/2, \mu = 1, \rho_y = 0$ for simplification

¹⁹In complete markets, variances will not show up because all shocks can be hedged completely.

$$\bar{\alpha}_{HH}^{\text{floating}} \simeq {}^{20}\frac{\bar{B}}{2} + \frac{(\theta - 1) [(1 + \lambda\rho_{\pi})^2\sigma_a^2 + (1 - \beta)(\gamma(\theta - 1)(\lambda + \beta) + \lambda + 1)\sigma_m^2]}{\underbrace{2(1 - \beta) [(1 + \lambda\rho_{\pi})^2\sigma_a^2 + [\gamma(\theta - 1)(\lambda + \beta)(\lambda + 1) + (\lambda + 1)^2]\sigma_m^2]}_{>0}} \quad (1.38)$$

In previous section, we showed that there is home bias in bonds under a pegged regime as well. However, home agents tend to hold more home bonds under a free floating regime than under a pegged regime. First, nominal bonds are more versatile than under a pegged regime in that nominal bonds can be used to hedge against real shocks in addition to nominal shocks. Second, nominal bonds under a floating regime is less effective in hedging against nominal shocks than under a pegged regime because interest rates under a free floating regime are affected by real shocks. These two reasons together cause home agents to hold more home bonds than under a pegged regime.

$$var_{t-1}^{\text{floating}}(S_t) > var_{t-1}^{\text{pegging}}(S_t) \quad (1.39)$$

$$\bar{\alpha}_{HH}^{\text{floating}} > \bar{\alpha}_{HH}^{\text{pegging}} \quad (1.40)$$

Thus far, we assumed that monetary authority does react to inflation, solely for simplicity (i.e., $\rho_y^i = 0$). However, the monetary authority's stance on the outputgap also greatly affects the degree of home bias in bonds by affecting the hedging properties of nominal bonds. More emphasis on stabilizing output (higher ρ_y^i) relative to inflation makes nominal bonds more effective (i.e., more responsive to shocks) in hedging against real shocks but makes less effective in hedging against nominal shocks. Which effect will be dominant will depend on the persistency of each shock. For example, in a traditional model in which real shocks are persistent and interest shocks are temporary, real shocks matter more than nominal shocks. Therefore, less home bias usually is optimal for a higher ρ_y^i because nominal bonds are more effective in hedging against real shocks for higher ρ_y^i .

²⁰This is an approximated analytical solution: because we assume non-zero supply of bonds, it is impossible to derive an exact analytical solution. However, this expression is nearly quantitatively identical to a true solution.

1.4.4 Managed Floating Regime

Next is the case in which the home monetary authority cares about the exchange rate; however, it also cares about inflation and the outputgap, whereas the foreign monetary authority does not care about the exchange rate.

$$R_{t+1}^H = \left(\frac{P_{H,t}}{P_{H,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{H,t}}{\bar{Y}} \right)^{\rho_y} \left(\frac{S_t}{S_{t-1}} \right)^{\rho_s} \exp(m_t^H), \quad m_t^H \sim i.i.d.(0, \varepsilon_m^2) \quad (1.41)$$

$$R_{t+1}^F = \left(\frac{P_{F,t}}{P_{F,t-1}} \right)^{\rho_\pi} \left(\frac{Y_{F,t}}{\bar{Y}} \right)^{\rho_y} \exp(m_t^F), \quad m_t^F \sim i.i.d.(0, \varepsilon_m^2) \quad (1.42)$$

It is very straightforward to expect more home bias in bonds than under a pegged regime and a free floating regime (for the same parameter values of ρ_y and ρ_π). Nominal bonds can be used to hedge against both real and nominal shocks such as under a free floating regime. However, monetary authorities' asymmetric targeting cause bonds to be ineffective in hedging; therefore, more home bond holding is required than in previous cases.

1.4.5 Equity Trading Allowed

In a previous setup with nominal bonds alone, home agents had incentive to hold more home bonds under a free floating regime because they use nominal bonds mainly to hedge against real shocks despite the fact that nominal bonds are not effective for hedging against real shocks. Can we still observe more home bias under a free floating regime when equities are traded? With equities added, bonds may be used mainly to hedge against other shocks instead of against productive shocks under a free floating regime; therefore, bonds' role may be the same under the two regimes.

Equity returns in terms of the home consumption basket are defined as equation (1.43) where $Z_{H,t}$ and Π_t are the real price of home equity and profit, respectively. Government spending shocks are also added to the previous model to retain an incomplete market. I

assume that a government purchases domestic goods only, and government spending shocks follows AR(1) process, *i.e.*, $\log G_t = \mu^g \log G_{t-1} + \varepsilon_{g,t}$.

$$r_{H,t}^e = \frac{\Pi_t + Z_{H,t}}{Z_{H,t-1}}, \quad r_{F,t}^e = \frac{\Pi_t^* + Z_{F,t}}{Z_{F,t-1}} \frac{RER_t}{RER_{t-1}} \quad (1.43)$$

Whether there is more home bias in bonds under a floating regime depends on the monetary policy stance²¹. First, we investigate how the monetary policy stance on inflation stabilization affects the steady state home bond holdings under a floating regime²². Suppose that the central bank focuses more on the inflation stabilization (higher ρ_π); it will affect the home agents' home bond holding in two channels. First, focusing more on the inflation stabilization implies more volatile output, leading to more volatile non-financial income. To hedge against more volatile non-financial income risk, home agents have more incentive to hold foreign equity. However, more foreign equity position makes home agents more exposed to shocks other than productivity shocks. To undo this negative effect from holding more foreign equity and to hedge against productivity shocks, more home bond holding is required for home agents. Second, the stabilization of inflation affects the hedging effectiveness of financial assets. Relative equity returns between home and foreign countries become less responsive to both real and nominal shocks, whereas relative bond returns between home and foreign countries becomes less responsive to nominal shocks and more responsive to real shocks. Because the role of nominal bonds in the presence of equities is to undo negative effects from holding more foreign equity and to hedge against productivity shocks as well, more of a long position in home bonds with a short position in foreign bonds is required. Therefore, if the central bank focuses more on the inflation stabilization, home agents have incentive to hold more home bonds.

Next, what occurs if the central bank focuses more on output stabilization (*i.e.*, higher ρ_y)? More focus on output stabilization is similar to the case in which a central bank places

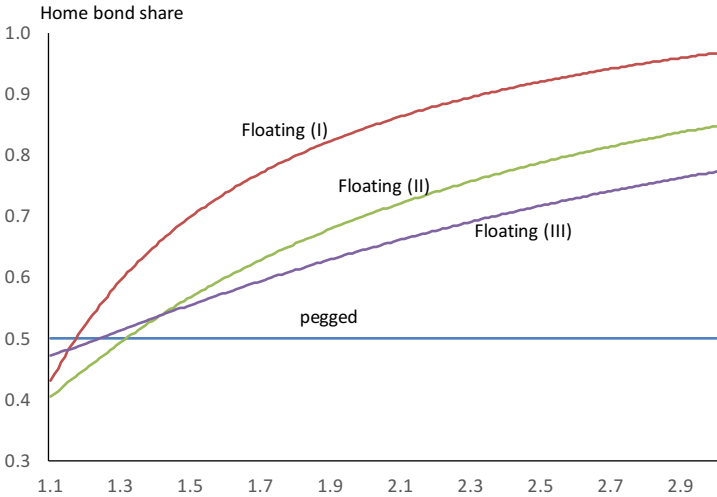
²¹Under a pegged regime, a foreign country's policy stance does not affect equilibrium bond holdings.

²²Refer to Devereux, Senay, and Sutherland (2013) for a similar result.

less focus on inflation stabilization; therefore, we can expect there will be less home bias in bonds with higher ρ_y . First, non-financial income is more stabilized and therefore, less need to take more of a long position in home bonds with a short position in foreign bonds to hedge against productivity shocks. Second, home agents have less incentive to hold foreign equity due to more stabilized non-financial income, implying that there is less negative effect from holding foreign equity.

Figure 1.4²³ compares the share of home bonds in a bond portfolio under different policy regimes. In the case of a pegged regime, it is clear that a foreign country’s monetary policy stance (ρ_π, ρ_y) has no effects on an equilibrium asset holding as is the case in the previous baseline model without equities. Any home bond share beyond pure diversification (*i.e.*, 0.5) is solely related to nominal shocks. We can observe that there tends to be more home bias under a floating regime for most policy parameter values. Therefore, having equities in the model does not change the main result from the baseline model without equities.

Figure 1.4: Home bond share in the presence of equities



Note : x-axis : ρ_π , floating (I) : $\rho_y = 0$, floating (II) : $\rho_y = 0.1$, floating (III) : $\rho_y = 0.3$

²³Parameter values : $a = 0.85, \beta = 0.99, \gamma = 3, \psi = 9.7, \eta = 1.49, \theta = 1.5, \phi = 10, \kappa = 0.75, \mu = 0.9, \mu^g = 0.9, \bar{B} = 1.26, \sigma^a = 0.009, \sigma^m = 0.001, \sigma^g = 0.003$

1.4.6 Implication for International Risk Sharing

The previous section showed that the exchange rate is non-neutral for asset holdings by changing the hedging characteristics of nominal assets. This finding also has implications for international risk sharing. When the market is incomplete, risk sharing is more limited under a pegged regime because international bond position cannot hedge against any types of real shocks.

For simplicity, consider the baseline model with nominal bonds alone. As a measure of international risk sharing, we use the conditional variance of relative consumption between home and foreign country adjusted by the real exchange rate because full risk sharing implies the conditional variance is zero. Under a pegged regime, nominal shocks are completely hedged, whereas real shock is not hedged at all because nominal bonds cannot be used to hedge against real shocks under a pegged regime. As observed in equation (1.44), the conditional variance of relative consumption under a pegged regime is affected by the variance of productivity shock (σ_a^2) only, but not by the variance of nominal shock (σ_m^2). However, under a floating regime, either real or nominal shocks are not perfectly hedged, but productivity shocks which are the major source of relative consumption fluctuation can be partly hedged using nominal bonds²⁴. This argument still holds in a model with equities because any real shocks other than productivity shocks cannot be hedged with international bond position under a pegged regime.

$$Var_{t-1}^{\text{pegged}}\left(\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t\right) = \left[\frac{(1 - \beta)\mu\lambda [\gamma(1 - 2a\theta) + (2a - 1)]}{(1 - \beta\mu)\gamma [\gamma(1 - 2a\theta) + 2(a - 1)] [\beta\mu(1 - \mu) + \mu(1 + \lambda) - 1]} \right]^2 \sigma_a^2 \quad (1.44)$$

$$Var_{t-1}^{\text{pegged}}\left(\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t\right) > Var_{t-1}^{\text{floating}}\left(\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t\right) \quad (1.45)$$

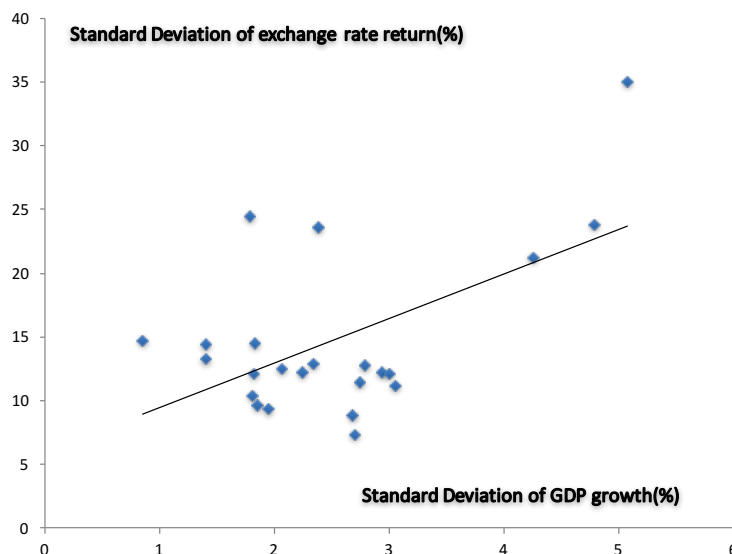
²⁴We do not show the expression of condition variance under a floating regime because it is very messy. The variance is expressed as a weighted average of σ_a^2 and σ_m^2 .

1.4.7 Exchange Rate Variances and Home Bias under a Floating Regime

Thus far, we have investigated how exchange rate regimes affect the degree of home bias in bonds. In this section, we restrict our focus to a free floating regime to investigate why countries with higher exchange rate variances tend to be more home biased. First, we need to explain why countries are heterogeneous in the variance of nominal exchange rates. One possibility is that countries may have different policy stances. As already shown in previous sections, when countries focus more on inflation stabilization relative to output stabilization, there is more home bias in bonds with a more volatile nominal exchange rate.

Another possibility is that countries are heterogeneous in the variance of underlying shocks. Figure 1.5 shows a cross-sectional relation between exchange rate variances and GDP growth variances (as a proxy of the volatility of real shocks) for floating regime countries. The figure shows a positive relation, implying that the cross-sectional distribution of exchange rate variances may be driven by real shocks.

Figure 1.5: The variances of nominal exchange rate and GDP growth rates (1999 - 2013)



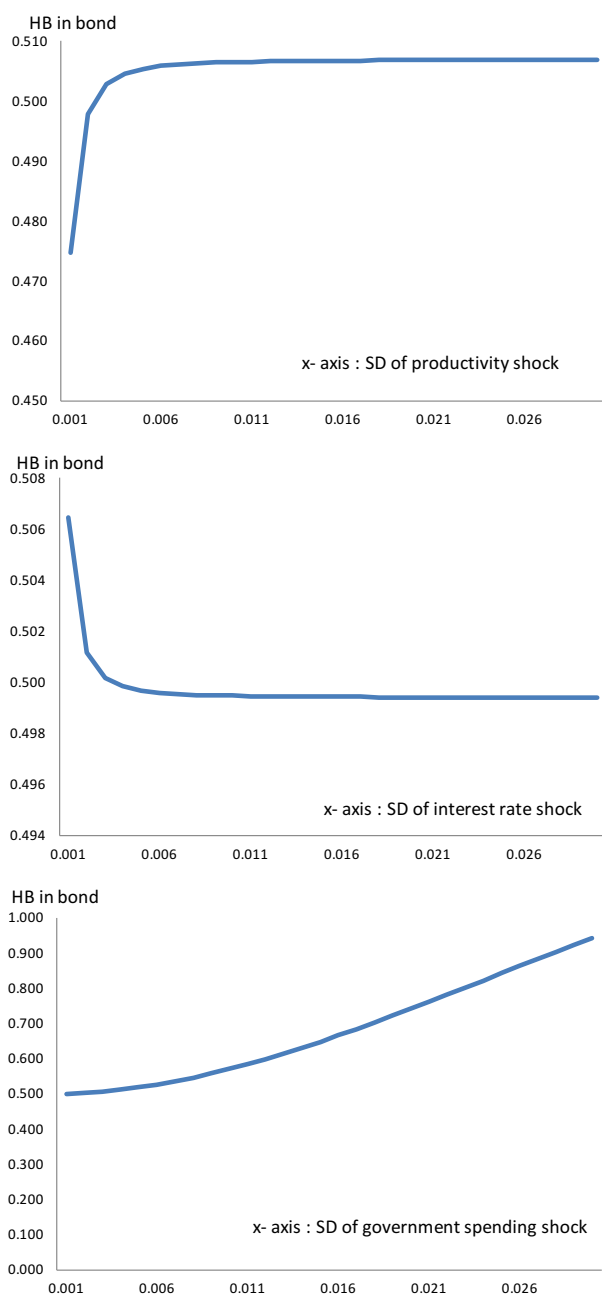
Holding other variances of underlying shocks fixed²⁵, we vary the variances of each shock to understand how different levels of underlying shock affects the home bias in bonds. Figure 1.6 shows that, the higher variance of real shocks, the stronger home bias is, whereas the variance of the interest rate shock is negatively related to home bias. This finding implies that the positive relation between the variance of the nominal exchange rate and the degree of home bias under a floating regime is more related to real shocks rather than nominal shocks. This result emphasizes that domestic bond holding under a floating regime is more driven by real shocks, whereas real shocks play a minimal role in bond holdings under a pegged regime which we previously showed.

1.5 Conclusion

In this chapter, I investigated how monetary policy frameworks can affect optimal domestic bond demands in two-country DSGE frameworks. First, I showed that the hedging characteristics of nominal bonds are fundamentally different across exchange rate regimes, implying the non-neutrality of exchange rate regimes for asset holdings. Agents under a floating regime tend to hold more home bonds to hedge against both real and nominal shocks, whereas home bias in bonds under a pegged regime is disconnected from real shocks. Second, I showed that the positive relation between the volatility of the nominal exchange rates and the degree of home bias under a floating regime is driven by real shocks, which re-emphasizes the heterogeneous role of nominal bonds across exchange rate regimes. Consequently, international risk sharing in an incomplete market is more limited when a country adopts a pegged regime, due to the restricted role of nominal bonds.

²⁵Default variances of productivity shock, interest rate shock and government spending shock are $(0.009)^2$, $(0.001)^2$, $(0.003)^2$, respectively

Figure 1.6: The effect of each shock's variances on bond home bias



Chapter 2

GLOBAL RISK AND INTERNATIONAL EQUITY PORTFOLIO REBALANCING

2.1 Introduction

Foreign equity portfolio investment has accounted for a growing proportion of cross-border capital flows in the last couple of decades. With its critical effect on the dynamics of host equity markets and more broadly domestic investment activities, understanding forces that influence the country allocation decision of foreign investors becomes an important research topic in international finance. While recent works, notably Hau and Rey (2004, 2006, 2008) and Curcuru et al. (2011, 2014), find that U.S. investors actively reallocate¹ away from equity markets that recently performed well, a motive behind this rebalancing action has been controversial and still remains an open question in the literature. In this chapter, we ask two questions: First, what is the dominant risk factor in driving portfolio rebalancing for international equity fund managers? Hau and Rey (2006, 2008) emphasize stabilizing international portfolio holders' exposure to foreign exchange risk. Under a two-country (home and foreign) framework, when a foreign share of international portfolios gains in value, the exchange rate risk associated with the higher foreign share inevitably rises if not rebalanced. However, the international portfolio risk also involves unexpected return changes in the underlying equity markets. We first examine if portfolio rebalancing is motivated by the risk of total return, the combination of the equity return evaluated in a local currency and the exchange rate return. Then, we test if the rebalancing action is driven mainly by currency risk or by local equity market risk. Second, how do the local market return's correlations with the global market

¹Regarding the rebalancing action in practice, risk-averse fund managers (or investors) reallocate away from a market whose relative weight in their portfolio deviates from a target allocation by a certain pre-specified threshold level, or on a regular basis, simply once every six or twelve months.

affect the equity portfolio rebalancing behavior? Financial market liberalization around the world has enabled investors to have an easy access to foreign markets but it has also made local markets more vulnerable to external shocks. Depending on the underlying equity market return's co-movement with the global return, which is heterogeneous across countries, we would expect to see very different reactions of the fund managers to local equity market innovations.

Earlier research, based on the bilateral capital flows data, documented that U.S. investors chase returns instead of rebalancing their foreign portfolios invested in OECD countries (Bohn and Tesar, 1996; Brennan and Cao, 1997)². However, recent portfolio-holdings data approach predominantly reports the opposite results: portfolio rebalancing characterizes U.S. residents' international investment strategies (Hau and Rey, 2004, 2006, 2008; Curcuru et al., 2011, 2014)³. Hau and Rey (2006, 2008)'s currency risk rebalancing hypothesis, however, does not always get empirical support. Gyntelberg et al. (2014) use stock market and foreign exchange data from Thailand and document the presence of portfolio rebalancing by nonresident investors in the Thai equity market when the local market outperforms relative to a reference market. However, they find no evidence that such rebalancing is driven by exchange rate fluctuations. Moreover, Ülkü and Karpova (2014) document that foreign investors from non-Eurozone countries do not necessarily rebalance more to local equity market return shocks in Greece than European investors.⁴

²Empirical analysis based on the bilateral capital flows data may suffer from an inference problem associated with the wealth effect and reserve causality. Detail discussions regarding these issues are provided in section 2.2.1.

³The same strategy, however, does not always characterize foreign equity investments. For example, Chaban (2009) looks at three commodity-exporting countries (Australia, Canada and New Zealand) and finds that the correlation between the equity return and currency return is not as strong as non-commodity-dependent countries, suggesting a weaker portfolio rebalancing motive for commodity-producing countries. The reason provided in the paper is that when the equity prices rise in the U.S. due to the high income shock, commodity prices as well as equity prices in commodity-exporting countries increase as well, reducing the need to rebalance globally-diversified portfolios.

⁴The determinants of portfolio rebalancing at the household-level are also discussed in Calvet et al. (2009). They find more active rebalancing behavior from sophisticated households in Sweden characterized by holding higher levels of education and wealth with better diversified portfolios.

While rebalancing may provide an efficient way for international investors to adjust their asset allocation in case a future adverse shock raises risk exposure of their portfolio, it may hurt their overall returns by selling winners and buying losers. In light of this concern, Curcuru et al. (2011, 2014) argue that the rebalancing may be a result of the tactical allocation that is determined by a returns-seeking preference rather than by risk-mitigating; U.S. investors sell off equities that recently exhibited high returns and subsequently buy equities just before their strong performance. The mean-reverting behavior of the equity returns is the key assumption of the Curcuru et al. (2011, 2014)'s results, implying that the equity returns should be predictable to take advantage of the returns-seeking strategy.

As seen from the literature summarized above, there is no consensus regarding the main rebalancing motive of the international investors. Indeed, the empirical results in the literature seem to be sensitive to the characteristics of data (aggregate vs. micro-level), choice of sample countries and periods, and underlying assumptions of asset returns⁵. In addition, the standard approach in the literature focuses on the country-specific dynamics of asset returns or risks and ignores the global common factors that may have an asymmetric effect on underlying equity markets. With the greater globalization in goods and capital markets and increasing volume of equity trading, stock returns exhibit a high degree of co-movement worldwide, indicating that the portfolio risk may come not only from the local equity market but also from its link with the global market.

The main goal of this chapter is to provide a finer understanding of international equity fund managers' portfolio management and the motives behind their actions⁶. To this end, we employ the fund-level micro data that come from Emerging Portfolio Fund Research

⁵While we do not test this explicitly in this chapter, the extent to which investors rebalance their foreign portfolios may also depend on their risk preferences. In general, risk-averse investors are more likely to engage in rebalancing strategies than risk-tolerant investors because they are more sensitive to the expected risk of their portfolios.

⁶We focus on the risk channel rather than the return-seeking channel as a rebalancing motive because we do not find strong evidence for the equity return predictability in our sample. The estimated autoregressive coefficients for total returns are significant in less than a half of our sample countries. Excluding the recent global crisis periods (2008-09), we find that the AR(1) coefficients remain significant in less than a third of our sample countries. See Table A1 in Appendix for details.

(EPFR) database. The database tracks country allocation information of equity mutual funds domiciled mostly in advanced countries over the period 1998-2012. Unlike most studies in the literature that focus on the advanced country investor's asset holdings in a small number of OECD countries for a relatively short-time period, we use comprehensive international portfolio holdings data; the EPFR data set contains broad geographic coverage of equity investment destinations and investor domiciles around the world and over long time periods⁷.

Taking advantage of the microstructure data, our analysis proceeds as follows: First, we measure a time-varying equity market variance shock and use it to test a risk-rebalancing hypothesis. We consider the rebalancing action not just between home and foreign countries but also between foreign countries. This is plausible with the rich portfolio allocation data set which gives us information about capital flows across various country-pairs. Second, instead of relying on the survey evidence of Levich et al. (1999) that the unhedged foreign exchange exposure of portfolio investments is a main motive behind international equity portfolio rebalancing as in Hau and Rey (2006), we directly test this exchange rate driven risk-rebalancing hypothesis using the Eurozone funds' allocation information. If the foreign exchange risk hedging is behind fund managers' rebalancing strategy, we would expect to observe a more negative response of Eurozone investors' portfolio holdings to the stock market shocks in non-Eurozone areas than in Eurozone areas. Lastly, we provide new empirical evidence on how the correlation of the local equity return with the global return affects rebalancing decisions. To explore the theoretical implications, we also present a simple mean-variance portfolio balance model in section 2.4 whose prediction is consistent with the main empirical findings on the effect of global risk.

Our results confirm risk-rebalancing behavior of international equity fund managers and demonstrate the importance of underlying equity market risk, rather than exchange rate

⁷Note that EPFR Global database includes over 1100 international equity mutual funds that invest in over 120 countries around the world. However, the required data screening process, described in section 2.2.1, leaves 799 equity funds with 43 investment destination countries in our sample.

risk, as a main motive behind the portfolio rebalancing action, corroborating the earlier empirical findings (Gyntelberg et al., 2014; Ülkü and Karpova, 2014). This is not surprising as volatility of equity returns is almost always bigger than that of currency returns across countries and the risk-averse investor’s hedging motive is more sensitive to the higher risk. In addition, global fund managers tend to show a higher degree of rebalancing in equity markets that exhibit a stronger correlation with the global market. This result helps understand why the rebalancing coefficient associated with the United Kingdom’s excess equity return is significantly high although the level of equity risk is fairly low in the United Kingdom. This is due in part to the common shock in the form of correlation with the global return which adds to overall portfolio risk of the fund manager. Intuitively, equity markets that are more sensitive to global factors are considered riskier due to reduced diversification benefits of the fund managers, a majority of which reside in advanced countries.

The rest of this chapter is organized as follows. Section 2.2 describes the data and the empirical model specification. Section 2.3 reports and discusses empirical results. Section 2.4 presents brief theoretical interpretations of main results using a mean-variance portfolio balance model. Section 2.5 concludes this chapter.

2.2 Empirical Methodology

2.2.1 Data and sources

This chapter employs a micro-level data set provided by the Emerging Portfolio Fund Research (EPFR) Global database, which collected country allocation information directly from fund managers or administrators of 799 international equity mutual funds over the period from January, 1998 to December, 2012. The EPFR database reports each fund’s total net assets (TNA) denominated in U.S. dollars, country allocation weights as a percentage share of the fund assets and funds’ portfolio returns⁸. The latter two sources are used in our empirical

⁸Total net assets in our sample amount to 624 billion US dollars as of the end of 2012, approximately 2.4% of the worldwide mutual fund total net assets of 26 trillion US dollars. Source: 2013 Investment Company Fact Book, ICI. As for another evidence of the representativeness of our data, Jotikasthira et

analysis. The database also provides information about fund domiciles that are primarily located in advanced market jurisdictions including United States, United Kingdom, and the EU area. Funds are different in investment scopes and are sorted by the market segments as shown in Table 2.1. For example, 142 funds from all domiciles invest more than 95% of their portfolio in Asia, primarily in China and India. The table also shows the US dollar value of total net assets at the end of our sample period⁹.

Table 2.1: Number of equity funds and their total net assets by target region, 1998-2012

Target region	# of funds	Total net assets in Dec., 2012
Asia excluding Japan	142	72
BRIC	15	10
Emerging Europe, Middle East, Africa	98	14
Europe	139	74
Global	160	226
Global Emerging	153	196
Latin America	58	22
Pacific	34	10
Total	799	624 billion US dollars

Source: Emerging Portfolio Fund Research; Note: Europe, Global and Pacific include both developed and emerging markets while all other regions include emerging markets only. Europe funds invest most of their assets in Germany and U.K., Global funds mostly in the U.S., U.K., Japan and Germany, Global Emerging funds mostly in Brazil, China, India, and Russia, Latin America funds mostly in Brazil, and Pacific funds mostly in Japan, China, and India.

al. (2012) confirm similar patterns for portfolio flows data provided by EPFR and the data on the net foreign transactions of U.S. investors reported in the Treasury International Capital System (TIC) by the U.S. Treasury department.

⁹EPFR data have also been used by Broner et al. (2006), Forbes et al. (2016), Fratzscher (2012), Gelos and Wei (2005), Jotikasthira et al. (2012), Raddatz and Schmukler (2012), and Wei et al. (2010), but they address different questions from ours.

In order for our empirical results to be immune to the outliers or inconsistency resulting from the emergence or disappearance of funds during the sample period, we drop funds whose total number of observations is less than 12 months. Moreover, small funds whose initial net asset value is less than 15 million U.S. dollars are also excluded as they often report the data at less frequent intervals. Applying these data screening procedures leaves 23 developed and 20 emerging countries of portfolio investment recipients in our sample. All the major equity markets around the world are included in our sample and therefore our empirical results are unlikely to be sensitive to the data screening procedure. Table 2.2 lists a full set of countries.

Table 2.2: Investment host countries in the sample

Region	Developed markets	Emerging markets
Americas	Canada, United States	Brazil, Chile, Colombia, Mexico, Peru
Europe, Middle East & Africa	Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom	Czech Republic, Greece, Hungary, Poland, Russia, South Africa, Turkey
Asia & Pacific	Australia, Hong Kong, Japan, New Zealand, Singapore	China, India, Indonesia, Korea, Malaysia, Philippines, Taiwan, Thailand

Note: Countries are sorted based on the 2015 MSCI (Morgan Stanley Capital International) market classification

The data for the equity market returns in both daily and monthly frequency for each country, region and world are from MSCI index. Country j 's return r_{jt} is defined as $r_{jt} = \ln(\frac{MSCI_{jt}}{MSCI_{jt-1}})$. The daily spot exchange rates are from Bloomberg and these are recorded in the way that a higher exchange rate means the local currency appreciation against the

currency of the fund domicile. In our empirical procedure, we use extreme caution to precisely measure the total return from a country's equity market because the currency return has to reflect the exchange rates between the host country and the fund domicile. For example, the U.S. domiciled funds' total return from the equity investment in Germany is a combination of euro-denominated local equity market return in Germany and the changes in exchange rate between the U.S. and Germany in a given time period.

Our micro-level data offer a couple of identification advantages in an empirical procedure. With bilateral flows data, it is difficult to figure out if any change in bilateral capital flow is induced by the wealth effect or by the effect of other economic variables. For example, a U.S. fund manager who recently experiences an increase in her wealth may distribute the excess wealth to all assets in her portfolio but lower the share of her portfolio for a particular country's asset that recently performed well. By observing an increase in aggregate capital inflows to the host country and a rise in the underlying equity market return, one may incorrectly conclude that the U.S. investor chases returns, while a portfolio data-based approach precisely points to portfolio rebalancing (Curcuro et al., 2011). Furthermore, when the foreign equity return increases due to changes in either local equity prices or currency values, the foreign share of the fund manager's portfolio automatically rises. By removing this valuation effect from the current period's portfolio weight for a country, the portfolio allocation data allow us to measure the active portfolio management that reflects the investor's net demand for the country's assets. Lastly, a regression model involving aggregate capital flows between two countries on one side and the market return differentials on the other side may suffer from an endogeneity problem due to reverse causality. This is not an issue with the micro-level fund's allocation data because the direction of causality is clear from a country's equity market return change to the fund's country weight change and not vice versa.

2.2.2 Dependent variable

In order to measure an active change in the weight of country j in a fund manager's portfolio, we follow Curcuru et al. (2011) and use the expression below as our dependent variable in empirical models. Formally, the change in the fund i 's country j weight or portfolio share at time t is defined as follows:

$$\Delta w_{ij,t} = w_{ij,t} - w_{ji,t-1} \underbrace{\left(\frac{1 + r_{jt}}{1 + r_{it}} \right)}_{\text{valuation effect}} \quad (2.1)$$

where r_{jt} is the equity return in country j from period $t - 1$ to t ; r_{it} is fund i 's weighted average portfolio return at time t defined as $r_{it} = \sum_{j=1}^J w_{ij,t-1} r_{ij,t}$. When country j 's equity market outperforms fund i 's average portfolio return at time t , country j weight in fund i 's portfolio at time t automatically rises due to the valuation effect. So, the second term in the right-hand-side of equation 2.1 is often called a buy-and-hold weight or passive holding. Under the passive buy-and-hold strategy, $\Delta w_{ij,t} = 0$. By eliminating the valuation effect from the observed country weight at time t , we can track a global fund manager's *active* portfolio shifting behavior.

2.2.3 Regression model specification

Fund managers are heterogeneous: They trade assets at different times. Moreover, they have different minimum thresholds for portfolio reallocation, inducing some to rebalance their portfolios but keeping others inactive even when exposed to the same return changes. For this reason, our empirical procedure based on a panel dataset tries to discover the average tendency of fund managers' reaction to return changes and other risk factors. To empirically test the risk-rebalancing hypothesis, we use the following panel fixed-effect regression model: For fund i , country j and time t ,

$$\Delta w_{ij,t} = \alpha_{ij} + \beta_1 \Delta r_{ij,t} + \beta_2 X_{ij,t} + \beta_3 \Delta r_{ij,t} X_{ij,t} + u_{ij,t} \quad (2.2)$$

where $\Delta w_{ij,t}$ is the active change of the portfolio weight as defined in equation 2.1; α_{ij} controls for a time-invariant fund-country specific fixed effect; $\Delta r_{ij,t}(= r_{jt} - r_{it})$ is country j 's equity market return over the fund i 's portfolio average return; $X_{ij,t}$ is a country-specific market risk measure that will be specified later; and $u_{ij,t}$ is a disturbance term. Our primary objective in the empirical analysis is to estimate and interpret the coefficients β_1 and β_3 from equation 2.2 in order to see the marginal effect of excess returns as follows:

$$\frac{\partial(\Delta w_{ij,t} | \Delta r_{ij,t}, X_{ij,t})}{\partial \Delta r_{ij,t}} = \beta_1 + \beta_3 X_{ij,t} \quad (2.3)$$

Equation 2.3 shows that the fund manager's portfolio reallocation in response to return changes depends on the conditional factor X . A significant and negative coefficient β_1 would confirm the rebalancing hypothesis (return chasing hypothesis if $\beta_1 > 0$) given X is equal to zero, and a significant and negative β_3 would signify that the higher the value of the conditional factor X , the greater the degree of portfolio rebalancing for fund i 's equity holdings in country j .

2.3 Estimation Results

2.3.1 Risk and reallocation

In this subsection, we test the risk-rebalancing hypothesis by looking at how the risk associated with total return changes affects fund managers' reallocation decisions. To measure risk of returns, we first calculate the monthly variance of total return for each country using the daily return data. Then, we define variance shock for each country as a deviation of the current month's variance from the average of past three months, generating a time-varying variance shock of return over the sample period¹⁰. The variance of total return differs substantially across countries with the higher variance generally observed in emerging economies than in advanced economies. For this reason, using the *level* of variance for each country in

¹⁰The choice of three months is arbitrary. Our results are robust to the longer periods of 6 or 12 months.

our panel data analysis would capture a difference in income levels rather than idiosyncratic market risks. Therefore, we employ a variance *shock* instead of its level as a country-specific portfolio risk of fund managers.

In testing the rebalancing hypothesis, Hau and Rey (2008) take a two-country approach by aggregating foreign countries into one group and assuming each fund to allocate between two countries only, home and foreign. What's ignored in their analysis is that fund managers may substitute away from country j holdings towards another foreign asset instead of the home asset. Ignoring this possibility, the simple two-country approach overemphasizes the role of currency risk and exaggerate home bias. In this chapter, we allow portfolio shifts between foreign countries as well:

$$\Delta w_{ij,t} = \alpha_{ij} + \beta_1 \Delta r_{ij,t} + \beta_2 \Delta r_{ij,t} \Delta V_{ij,t} + \beta_3 \Delta V_{ij,t} + u_{ij,t} \quad (2.4)$$

In equation 2.4, the *relative* variance shock of country j ($\Delta V_{ij,t}$) is now defined as a deviation of the country's variance shock $V_{jt}(= \text{var}(r_{jt}) - (\{\sum_{k=1}^3 \text{var}(r_{j,t-k})\}/3))$ from the fund average variance shock $V_{it} (= \sum_{j=1}^J w_{ij,t-1} V_{jt})$ ¹¹. Likewise, $\Delta r_{ij,t} (= r_{jt} - r_{it})$ is the excess return of country j from the fund average return.

Table 2.3 reports the estimated coefficients of equation 2.4. Looking at columns (1) to (3) in Table 2.3, we first observe that there is a significant and negative relationship between the return differential and the change in portfolio share for country j ; our panel regressions confirm the rebalancing hypothesis with robust empirical evidence in both advanced and emerging host countries. It is interesting to note that the equity holdings in advanced economies respond more negatively to the equity market return shocks than they do in emerging economies. In general, the risk associated with the equity and currency markets is

¹¹Precisely speaking, the relative variance shock included in equation 2.4 should be based not on the realized variance but on the expected variance which is then to affect a reallocation decision for country weights at time t . However, we find that the variance is highly persistent in our monthly data (evidence shown in Appendix A.1.) and use the variance of contemporaneous returns as a proxy for the expected future variance in our empirical analysis.

Table 2.3: Time varying variance shock and rebalancing

Dependent variable: $\Delta w_{ij,t}$	Advanced countries	Emerging markets	All countries	(full sample)
	(1)	(2)	(3)	(4)
$\Delta r_{ij,t}$	-0.88*** (0.041)	-0.55*** (0.021)	-0.62*** (0.019)	-0.61*** (0.019)
$\Delta r_{ij,t} \Delta V_{ij,t}$				-1.96*** (0.165)
$\Delta V_{ij,t}$				-0.14*** (0.032)
F-statistics				632.95***
Observations	229,107	333,494	562,601	559,151

Note: All specifications include fund-country fixed effects. Newey-West standard errors are reported in parentheses. F-statistic and its significance level are reported to test the joint significance of return coefficients and interaction terms. *** indicates statistical significance at 1 percent level.

lower in developed economies than in emerging economies, indicating that the idiosyncratic market risks alone may not fully account for the higher rebalancing coefficient in column (1) than in column (2) in Table 2.3. This is one of the reasons why we look into the impact of global return later. Returning to the pooled sample in columns (3) and (4), we see the greater degree of rebalancing in response to a higher variance shock in country j 's local equity market, verifying that the rebalancing is motivated by managing the risk of asset returns. One can look at the joint F-test between return differential and interaction terms in order to infer the significance of the conditional impact of return differential on the portfolio weight changes for country j . Table 2.3 shows that the p-value for the F-statistic is below 1%, and we conclude that excess return and interaction terms are jointly significant and informative in explaining the active portfolio reallocation.

Estimation results in Table 2.3 emphasize portfolio rebalancing as an equity portfolio management strategy and the role of time-varying risk on the rebalancing decision. One thing that is impossible to infer from results in Table 3 is a distinctive role of currency risk or equity risk in portfolio allocation. In fact, those two risk concepts are embedded in our total return variance shock measure. Thus, the following subsection explores the total return variance in greater detail to test the Hau and Rey (2006, 2008)'s foreign exchange risk driven rebalancing hypothesis.

2.3.2 Is the exchange rate risk the dominant risk factor in rebalancing?

The relative variance shock in the earlier subsection was introduced as a measure of market specific risk. If the risk matters in accounting for a negative relationship between returns and reallocation, what kind of risk is important? Hau and Rey's earlier works (2006, 2008) stress exposure to foreign exchange risk as a driving force behind rebalancing between home and foreign countries. Their argument is as follows: When a foreign country's equity return rises, the foreign share of the fund's portfolio automatically increases due to the valuation effect. This high foreign share brings greater exposure to the foreign exchange risk to risk-averse investors and induces them to pull out their outperforming assets. By doing so, the investors restore their original portfolio allocation, which reflects their risk preferences.

Since the total return r_{jt} from country j 's equity market is a sum of the equity market return evaluated at a local currency and the local currency's appreciation rate against the investor's currency from time $t - 1$ to t , we can decompose conditional variance of excess (total) return of country j over home country h as follows:

$$\text{var}(r_{jt} - r_t^h) = \text{var}(s_{jt} - s_t^h) + \text{var}(e_{jt}) + 2\text{cov}(s_{jt} - s_t^h, e_{jt}) \quad (2.5)$$

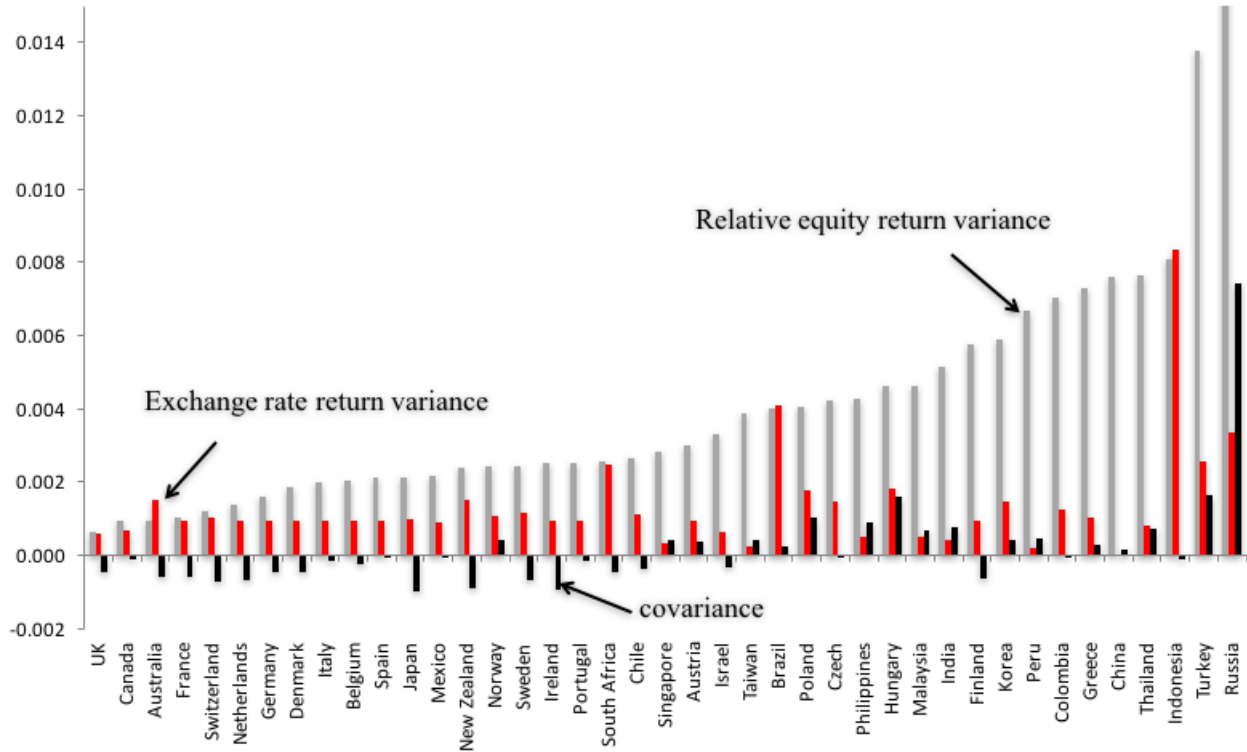
where s_{jt} and e_{jt} are the realized stock and exchange rate returns of country j , respectively. We assume that s_{jt} includes both dividends and stock index changes. The United States is chosen to be the home country for now. There are three factors determining the

risk of excess return when investing in a foreign country over the home country. First, investing in foreign country j is riskier when there exists much fluctuation in return differentials between home and foreign equity markets measured by the relative equity return variance ($var(s_{jt} - s_t^h)$). Second, the exchange rate risk $var(e_{jt})$ also contributes to the excess risk of foreign country j investment. Third, the covariance $cov(s_{jt} - s_t^h, e_{jt})$ between the stock and exchange rate returns can either amplify or dampen the excess risk of foreign investment depending on its sign. In general, the sign of covariance is negative in markets where the currency return variance constitutes a relatively large share of total return variance (with a couple of exceptions) as displayed in Figure 2.1¹². In a symmetric model as in Hau and Rey (2008) where home and foreign equity returns follow exactly the same distribution, the relative equity return variance is set to zero, leaving the variance of exchange rate return as the only source of foreign investment uncertainty. However, as seen from Figure 2.1, the relative equity return variance is not trivial at all and far exceeds the currency return variance in most countries. Furthermore, we observe the great variation in relative equity return variance across countries and generally lower volatility in equity returns in the advanced economies than emerging economies. However, we do not see such a volatility pattern from the exchange rate returns across countries.

Although decomposing the variance of total return into equity and exchange rate components is not a difficult task in theory, it is empirically challenging to distinguish between the two without knowing the exact contribution of the common risk. Such decomposition is inevitable to introduce substantial degrees of errors and bias into the linear regression analysis. For this reason, we rely on a sub-sampling approach to test an exchange rate risk-driven rebalancing hypothesis. In this exercise, we choose funds that invest in countries which involve the exchange rate risk if different currencies are used between the fund's domicile and investment recipient countries and no such risk otherwise. The best candidate for this

¹²This negative covariance is also consistent with the empirical findings in the literature (Cappiello and De Santis, 2005; Peltonen, 2005). Note that the exchange rate is defined as the value of local currency against the U.S. dollar. Covariance for all countries in the graph is multiplied by two to illustrate its actual contribution to the overall variance. Sample period covers from 1998 to 2012.

Figure 2.1: Variance of equity and currency returns and their covariance, 1998-2012



exercise is Eurozone funds. To test an exchange risk driven rebalancing hypothesis, we run the following regression to see if the rebalancing coefficient is stronger in the presence of exchange rate risk:

$$\Delta w_{ij,t} = \alpha_{ij} + \beta_1 \Delta r_{ij,t} + \beta_2 \Delta r_{ij,t} \cdot D + u_{ij,t} \quad (2.6)$$

where $\Delta r_{ij,t}$ is defined as a deviation of country j 's total return from fund i 's average return ($=r_{jt} - r_{it}$) and D is a binary variable taking the value of unity for host countries that use currencies other than the funds' domicile currencies.

Table 2.4 shows the estimated coefficients and from equation 2.6. As shown in the results,

Table 2.4: Rebalancing coefficients for Eurozone funds

Dependent variable: $\Delta w_{ij,t}$	Eurozone funds' allocation
$\Delta r_{ij,t}$	-0.61*** (0.207)
$\Delta r_{ij,t} \cdot D$	-0.01 (0.248)
F-statistics	14.17***
Observations	26,803

Note: D is a binary variable taking the value of unity for non-Eurozone host countries. Eurozone host countries include Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. Fund-country fixed effect is included. Newey-West standard errors are reported in parentheses. *** indicates statistical significance at 1 percent level.

we verify the rebalancing hypothesis for European fund managers. In fact, the estimated rebalancing coefficient β_1 is very close to the estimation results in columns (3) and (4) of Table 2.3. This finding makes sense as a large fraction of our EPFR data comes from funds located in the Eurozone area¹³. Next, we examine if the exchange rate risk places an additional rebalancing motive to fund managers. The insignificant coefficient of the interaction term $\Delta r_{ij,t} \cdot D$ reflects that the Eurozone fund managers are not necessarily more sensitive to currency risk. The currency risk may be hedged elsewhere already and therefore it may not serve as a risk factor in portfolio reallocation decisions. Therefore, we find no definitive evidence that rebalancing is driven by the motive of managing foreign exchange exposure as stressed in Hau and Rey (2006, 2008)¹⁴. In other words, the underlying equity market risk rather than currency risk may be a driving force of risk rebalancing of international fund managers. These results are broadly consistent with the earlier empirical

¹³In our sample, 351 out of 799 funds are domiciled in the Eurozone area such as Germany and France.

¹⁴We also find consistent evidence from US domiciled funds whose international portfolio includes a rigid US dollar peg country, Hong Kong.

findings of Gyntelberg et al. (2014) and Ülkü and Karpova (2014) in that expected exchange rate fluctuations are not the main cause of portfolio reallocation decisions; underlying asset market risk may play a bigger role.

2.3.3 *Correlation with the global market and its impact on rebalancing*

One empirical challenge to address the risk-rebalancing hypothesis comes from the fact that the global equity market integration may obscure the exact identification of the cross-country return differentials and their effect on the foreign investors' portfolio allocation. In fact, the results in Table 2.3 show that the estimated rebalancing coefficient associated with the excess equity return in advanced economies is larger in absolute value than in emerging economies, while the risk levels in local equity and currency markets are generally much lower in advanced markets. This suggests that the idiosyncratic market risk alone cannot explain the international fund managers' portfolio shifting decisions. Hence, in this subsection, we explore the new possibility that global risk is an important source of portfolio risk and examine its effect on portfolio allocations.

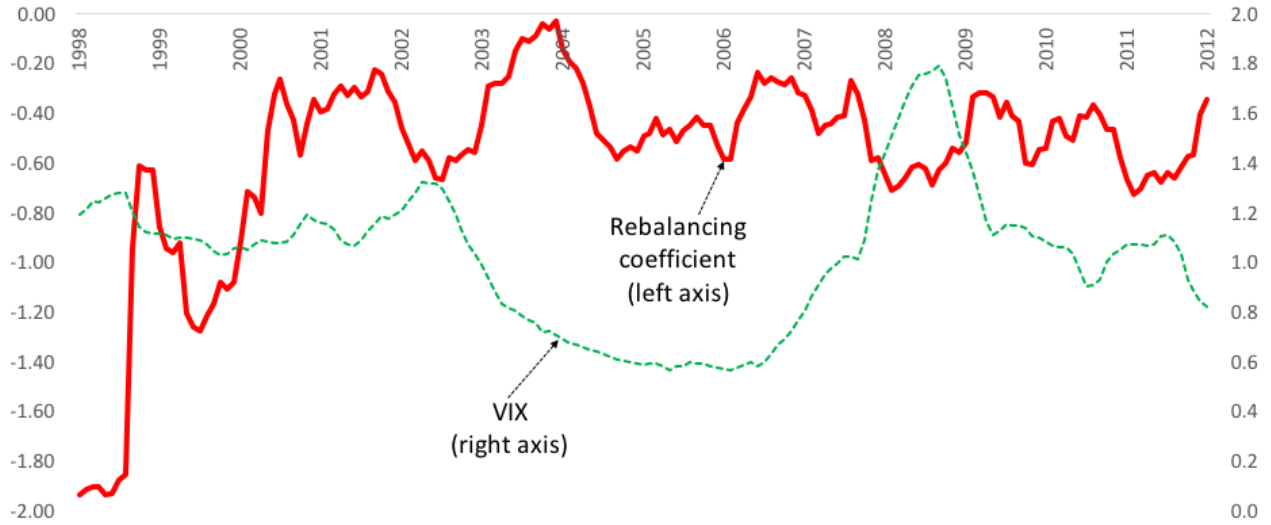
As a preliminary step to understand whether the rebalancing coefficient is related with global risk, we first estimate the time-varying rebalancing coefficients by a rolling regression with a window size of 12 months over the sample period¹⁵. The patterns observed in Figure 2.2¹⁶ reflect that the lower the global equity market risk, the less likely the international investors engage in active portfolio rebalancing behavior¹⁷.

¹⁵Given that the U.S. equity market is the largest in the world and has significant spillover effect on other countries, we use the VIX index as a proxy for the world equity market uncertainty. The VIX index is a measure of the implied volatility of S&P 500 index options and better serves as a measure of the expected risk. On the other hand, the variance of MSCI world return is a measure of the realized volatility of the global return. Both implied and realized volatility measures tend to move closely together.

¹⁶Rebalancing coefficients (β_1) are estimated from a rolling regression ($\Delta w_{ij,t} = \alpha_{ij} + \beta_1 \Delta r_{ij,t} + u_{ij,t}$) with a window size of 12 months. For example, the estimate as of Jan. 2005 includes the data from Jan. 2005 to Dec. 2005. Accordingly, the VIX index is measured as a 12 month moving average and normalized using the sample average.

¹⁷One concern that arises in a rolling-window regression is that the number of funds included in each window may change over the sample period, which may cause an inference issue by observing estimation results from an unstable sample. We also run a rolling-window regression with a balanced panel including

Figure 2.2: Degree of rebalancing and global risk indicator



However, the degree of rebalancing may be different across countries. In order to investigate the heterogeneous effect of correlation with the global return on the host country's market risk, we partition investment recipient countries in our sample into three groups according to their strength of correlation with the global equity return (MSCI world return). Group 1 (G_1) includes countries whose equity markets are most strongly correlated with the global market while group 3 (G_3) includes countries with the least correlation. Return correlations are calculated recursively using monthly data from January, 1998 with initial time coverage of 12 months and a wider range thereafter. Therefore, β_1 in equation 2.7 measures how strongly, on average, international investors respond to country j 's excess equity market returns, and β_3 , β_4 and β_5 measure the additional degree of rebalancing conditional on the excess return for groups 1, 2, and 3, respectively¹⁸:

121 funds and find a very close co-movement of rebalancing coefficient estimates from the unbalanced panel (full-sample) and balanced panel. See Appendix Figure A.3.

¹⁸Whether a country is classified as one of G_1 , G_2 or G_3 at time t is determined by a recursive correlation up to time t . Because each country's return correlation with the global return often changes, the country

$$\Delta w_{ij,t} = \alpha_{ij} + \left(\beta_1 + \beta_2 X_t + \sum_{k=1}^3 \beta_{2+k} G_{kt} \right) \Delta r_{ij,t} + \beta_6 X_t + \sum_{k=1}^3 \beta_{6+k} G_{kt} + u_{ij,t} \quad (2.7)$$

where α_{ij} controls fund-country fixed effects and X_t is the global risk measured by the variance of MSCI world returns.

Table 2.5 shows a clear difference in the degree of rebalancing across groups (See also Figure B.4). As displayed in columns (1)-(2) in Table 2.5, conditional on the excess return, global uncertainty X_t makes the degree of rebalancing larger on average, consistent with time-series evidence in Figure 2.2. Moreover, countries have heterogeneous exposures to global equity market conditions and we find that the degree of rebalancing is greater for a group of countries whose equity return moves more closely with the global return. We reach this conclusion by combining coefficient estimates of excess return and interaction terms for each group. Indeed, countries included in group 1 (G_1) are mostly advanced markets such as Australia, Canada, Germany, the United Kingdom, and the United States. And, fund managers in our sample, the majority of which reside in advanced economies, perceive a strong stock market correlation of their own with the global market as an additional source of risk. This covariance risk puts pressure on the funds' portfolio allocation and leads to a more sensitive rebalancing action. One of the reasons for this finding may be that the return changes in advanced markets are strongly associated with the global factors that are easy to access and evaluate compared to the country-specific factors.

On the other hand, markets around the world tend to fall together during the global crisis which may also work as a common shock to every country. To control for the potentially unusual market movements worldwide during the peak of recent global crisis, we include crisis dummy variables between January 2008 and December 2009 in our alternative specifications¹⁹. Robust results with controlling crisis dummies are presented in columns (3)

list in each group varies over time.

¹⁹The exact start and end dates of the recent crisis may be controversial. In our analysis, we consider the years 2008- 2009 because we observe excessive volatility in equity returns during that period.

Table 2.5: Global risk and rebalancing

Dependent variable: $\Delta w_{ij,t}$	(1)	(2)	(3)	(4)
$\Delta r_{ij,t}$	-2.37*** (0.084)	-2.27*** (0.084)	-2.37*** (0.084)	-2.28*** (0.084)
$\Delta r_{ij,t} \cdot X_t$		-2.64*** (0.550)		-2.67*** (0.600)
$\Delta r_{ij,t} \cdot G_{1t}$	1.41*** (0.097)	1.37*** (0.098)	1.43*** (0.098)	1.37*** (0.098)
$\Delta r_{ij,t} \cdot G_{2t}$	1.66*** (0.089)	1.61*** (0.089)	1.66*** (0.089)	1.61*** (0.089)
$\Delta r_{ij,t} \cdot G_{3t}$	2.12*** (0.088)	2.08*** (0.054)	2.13*** (0.088)	2.08*** (0.088)
X_t		0.09 (0.060)		-0.66*** (0.142)
G_{1t}		-0.15*** (0.014)		-0.15*** (0.014)
G_{2t}		-0.14*** (0.014)		-0.14*** (0.014)
G_{3t}		-0.11*** (0.014)		-0.11*** (0.014)
Crisis dummies	No	No	Yes	Yes
F-statistics	444.60***	349.02***	433.20***	350.25***
Observations	562,601	562,601	562,601	562,601

Note: $\Delta r_{ij,t}$ ($= r_{j,t} - r_{i,t}$) is country j 's excess equity market return over fund i 's portfolio average return. X_t measures variance of MSCI world returns. Groups are classified by the degree of correlation of local equity market with the global market. Correlations are calculated recursively using monthly data from January, 1998 with initial time coverage of 12 months and a wider range thereafter. G_{1t} includes top 33% countries whose equity markets show the strongest correlation with the global market. G_{2t} includes countries whose correlation with the global market ranges between 34 and 66% and G_{3t} includes bottom 67-100% countries. Crisis time dummies control the peak of recent global crisis periods between January, 2008 and December, 2009. All specifications include fund-country fixed effects. Newey-West standard errors are reported in parentheses.

and (4) in Table 2.5, where we see little change from the results without crisis controls. In contrast to the previous regression, the global risk (X_t) is now statistically significant and the negative sign implies that fund managers lower their portfolio holdings when the level of global uncertainty is high. Moreover, we do a robustness check for the results in Table 2.5 by partitioning our sample countries into four groups instead of three. A further segmentation does not alter the main conclusion as demonstrated by the results in Appendix Table A.2.²⁰

In this subsection, we show that how strongly fund managers reallocate away from a country's equity market depends on the correlation between the local market return and the global return. This result complements the existing literature emphasizing that global common (or push) factors are partly responsible for cross-border capital flows (Cerutti et al., 2014; Forbes and Warnock, 2012; Fratzscher, 2012). Lastly, the intuition behind our empirical result is that equity markets that are more sensitive to global market conditions are considered riskier due to reduced diversification benefits of the fund managers, a majority of which are located in advanced countries.

2.4 Theoretical Interpretation of Empirical Results

In this section, we present a minimal model to explore the theoretical implication of the effect of a country's equity market correlation with the global market on the optimal asset allocation decision. In our mean-variance portfolio balance model, a representative fund manager holds equity mutual funds that are invested in multiple countries with uncertain returns²¹.

²⁰One could have used equity returns instead of total returns as an explanatory variable in regression. We would get the similar results because indirect evidence in Appendix shows that correlation of total returns with the global equity market comes mostly from the correlated equity markets other than correlated currency markets.

²¹The model can be applied to a case when both equities and bonds are available as an asset class. Since our empirical procedure is based on the equity funds data, we assume that fund managers invest only in risky securities.

2.4.1 Optimal portfolio weight determination

We assume that fund managers are risk-averse mean-variance investors whose utility function takes the following quadratic form:

$$\max_w L = w' E[r] - \frac{\lambda}{2} w' \Sigma w \quad (2.8)$$

$$s.t. \quad w' I = 1 \quad (2.9)$$

where w is a $(J \times 1)$ vector of country weight where w_j is the j th element, $E[\cdot]$ is the standard expectation operator, r is a $(J \times 1)$ vector of country asset returns in an investor's currency, λ is the coefficient of risk aversion, Σ is the covariance matrix of expected asset returns, and I is a unity column vector. The constraint means all wealth is allocated in risky securities of J countries. Setting up the Lagrangian and solving the corresponding first-order conditions, the optimal portfolio weight for country j , which represents the investor's optimal allocation of wealth to each of J risky assets, is as follows:

$$w_j = \frac{E[r_j] - E[r_{-j}] + \lambda\{var(r_{-j}) - cov(r_j, r_{-j})\}}{\lambda\{var(r_j) + var(r_{-j}) - 2cov(r_j, r_{-j})\}} \quad (2.10)$$

where we denote by r_{-j} the weighted average of returns of all other countries in the fund's portfolio other than country j . Equation 2.10 implies that the optimal portfolio weight of country j increases when its return is expected to be higher than the average return of other countries or its equity market is expected to involve less risk, given other things constant. By linking our empirical results in favor of portfolio rebalancing (i.e., excess return coefficient $\beta_1 < 0$) in the previous section with equation 2.10, we postulate that the dominating channel for the portfolio reallocation between countries j and $-j$ conditional on the excess return realization is through the variance (or risk) effect rather than the return effect. In other words, the higher expected variance of country j 's equity return induces the risk-averse fund manager to lower her portfolio weight of the country whose equity market performs better

than the average of other countries in her portfolio to restore the original portfolio allocation.

2.4.2 Global factor in equity returns

We now assume that country j 's total return (r_j) is driven by the global common factor (G), country-specific factor (X_j) and a shock to the country j 's equity return (ε_j) that is not explained by G and X_j as follows:

$$r_j = a_j G + b_j X_j + \varepsilon_j \quad (2.11)$$

where parameters a_j and b_j capture a country j 's return correlation with the global factor and country-specific factor, respectively. We exclude time subscripts for a notational convenience. Equation 2.11 attempts to capture that total return r_j is correlated across countries due to the common factor G that has a worldwide impact. We also assume that ε_j is an idiosyncratic shock and uncorrelated among each other. In order for the variable G to fully capture the common factor across countries, X_j is assumed to be uncorrelated across countries as well. Note that since the total return is a combination of equity and currency returns, the global factor may have a common effect on equity or currency market (or both markets) across countries. Nevertheless, we do not separate the total return into those two returns in this subsection to keep our expressions simple²².

2.4.3 Effect of return correlation with the global market on portfolio allocation

If all countries are equally sensitive to a global return shock (i.e., $a_j = a \forall j$), equation 2.10 is reduced to

²²One may ask what is a dominating channel through which global factor influences the country's total return. Empirical evidence is hard to obtain because of the absence of global index for currencies. Nevertheless, we conjecture that it is mainly through the equity return because, on average, about 90 percent of the correlation between a country's total return and global return is explained by the correlation between the underlying equity market return and global return. See Figure A.4. in Appendix for details

$$(w_j|a_j = a \forall j) = \frac{E[r_j] - E[r_{-j}] + \lambda var(r_{-j})}{\lambda\{var(r_j) + var(r_{-j})\}} \quad (2.12)$$

where $C_j = b_j X_j + \varepsilon_j$ from equation 2.11, which is a pure country-specific component of equity return; and $-j$ refers to the weighted average of all other countries in the fund's portfolio other than country j .

In practice, local equity returns are highly correlated with the global return and the size of this correlation varies across countries, as reported in Table A3 in the appendix. To reflect this observation in our model, we now allow different sensitivity (a_j) to the global common factor across countries. Then, equation 2.10 becomes

$$(w_j|a_j \neq a_{-j}) = \frac{(a_j - a_{-j})E[G] + E[C_j - C_{-j}] + \lambda\{a_{-j}(a_{-j} - a_j)var(G) + var(C_{-j})\}}{\lambda\{(a_j - a_{-j})^2 var(G) + var(C_j) + var(C_{-j})\}} \quad (2.13)$$

Equation 2.13 shows that the optimal portfolio allocation also depends on the degree of a country's return correlation with the global factor. Suppose country j 's return is more sensitive to the global factor than that of other countries included in the fund's portfolio, that is, $a_j > a_{-j} > 0$. Since $a_j > a_{-j}$, global uncertainty $var(G)$ has a stronger negative effect on the optimal weight for country j due to the negative term, $a_{-j}(a_{-j} - a_j)var(G)$, in the numerator. On the other hand, $(a_j - a_{-j})^2 var(G)$ in the denominator does not influence the reallocation between countries j and $-j$ because it would also appear in country $-j$'s optimal weight with exactly the same magnitude and the same sign²³.

Our simple model shows that the global common factor generates a heterogeneous effect on the portfolio reallocation across countries depending on the host country's equity market sensitivity to the global return shocks. In particular, a fund manager has an incentive to reallocate further away from a country whose equity market exhibits a stronger co-movement

²³We focus on the variance channel here because, as mentioned earlier, the risk rebalancing requires the variance effect outweigh the return effect in making a portfolio allocation decision.

with the global market. This theory view is consistent with our empirical results presented earlier.

2.5 Conclusion

The main purpose of this chapter is to provide a finer understanding of international equity fund managers' portfolio management and the motive behind their actions. To this end, we examine the impact of time-varying country-specific stock market risks and the underlying equity market return's correlation with the world market on portfolio reallocation decisions using the fund-level equity portfolio allocation data covering a large number of countries. Our empirical results confirm risk-rebalancing behavior of international equity fund managers and demonstrate the importance of the underlying equity market risk, rather than exchange rate risk, as a main motive of portfolio rebalancing behavior. In addition, global fund managers tend to have a higher degree of rebalancing in equity markets that are more strongly correlated with the global market. Taken together, these results suggest the need to look into both the local equity market risk and covariance risk arising from the underlying market's correlation with the global market to understand the motive behind mutual funds' portfolio allocations.

Chapter 3

COMOVEMENT OF TERM PREMIA IN AN OPEN ECONOMY

3.1 Introduction

The yield curve has been widely used for understanding real economic activities. For example, the yield spread between ten-year Treasury bonds and three-month Treasury Bills is known to have predictive power for U.S. recessions (Estrella and Mishkin, 1996). However, understanding the yield curve in the general equilibrium framework has been challenging because it is difficult to generate upward-sloping yield curve in a traditional macroeconomic model. Rational expectation models with expected utility generate a flat yield curve¹ at the first order approximation since there is no term premium. Furthermore, rational expectation models with higher order approximation generate a downward-sloping yield curve if the preference is non-recursive.

It is relatively easy to generate an upward-sloping yield curve in the partial equilibrium model with an endowment economy². The coefficients on shocks in policy function of inflation and consumption can be set arbitrarily since there is no restriction on those coefficients. However, when it comes to general equilibrium within a production economy, inflation and consumption processes are fully endogenized, leading to very small yield spreads. Recent macro-finance literature tries to fill this gap by introducing recursive preference and higher order approximation (for example, Rudebusch and Swanson 2012). In addition, long-run risks such as time-varying inflation targets, regime switching and growth risks are often

¹For example, Kulish and Rees (2011) build small open economy model to investigate why long-term yields are more correlated across countries than short-term yields. However, the yield curve in their model is flat.

²See Campbell and Cochrane (1999) and Piazzesi and Schneider (2007).

introduced to amplify results. However, those additional mechanisms are effective only with recursive preference and higher order approximation and therefore, recursive preference with higher order approximation can be considered as the main mechanism to generate a sizeable term premium in general equilibrium model.

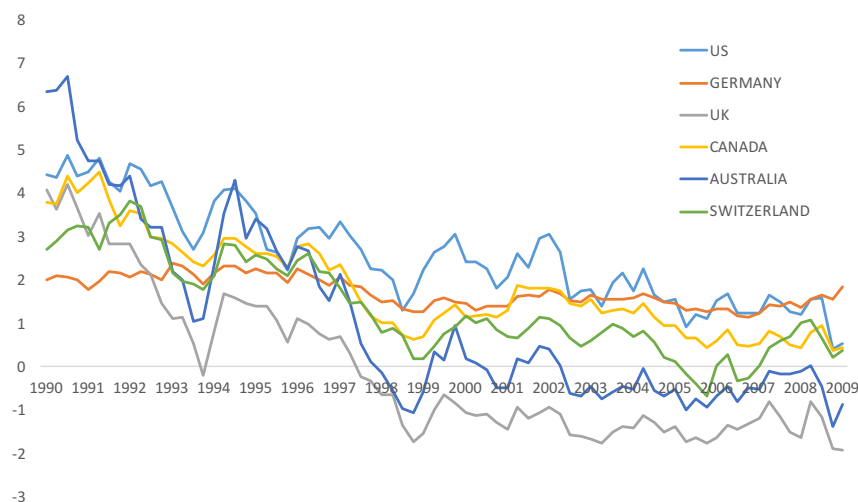
In this chapter, I expand recent macro-finance term structure model into an open economy model to explain several stylized facts which cannot be explained in a closed economy model. First, term premia have steadily declined globally. Figure 3.1 shows term premium estimates generated from the affine model used in Wright (2011)³. Term premia are often understood as the compensation for bearing risks from holding long-term bonds instead of rolling over short-term bonds. Since ex-post real returns from nominal long-term bonds are subject to inflation realization, inflation uncertainty is usually considered to be the most important factor in explaining term premia. Wright (2011)'s main conclusion is that the steady decline in global term premia is related to a global decline in inflation uncertainty. However, global inflation has been already stabilized since 1990 and, therefore, it is likely that other factors are also playing a role. In this chapter, I present an alternative explanation for this: increased risk sharing can lower term premia by stabilizing consumption. To characterize different level of risk sharing of individual economies, I consider three models; autarky, financial autarky with international good trading and fully open economy with international good and asset trading.

Second, yield spreads tend to co-move across countries. Figure 3.2 shows that yield spreads between ten-year government bonds and three-month bonds tend to move together: the correlation coefficient of yield spreads between advanced countries after 2000 is over 0.7⁴. Furthermore, the comovement is more prominent among countries with more economic integration. Figure 3.3 shows that yield spreads of France is more synchronized with Germany

³Term premia are not directly observable and therefore, it has to be estimated. The estimates may be subject to the estimation method or model. However, Wright (2011) also provides results from various estimation methods and model-free estimates from survey, which confirm the global decline in term premia.

⁴U.S.-UK: 0.72, U.S.-France: 0.70, U.S.-Germany: 0.72, France-Germany: 0.83

Figure 3.1: Global decline in term premia



Source: Wright (2011)

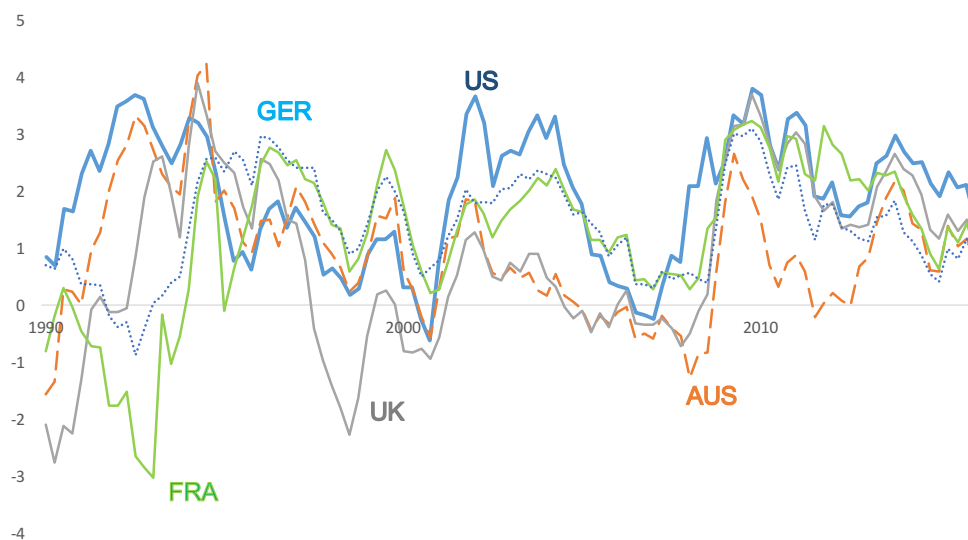
than UK⁵. This implies that there are common or global factors behind the movement of countries' yield spreads and the common factors have heterogeneous effect on the comovement across time and countries.

Third, term premia in addition to yield spreads tend to comove across countries as in Figure 3.1. Yield spreads and term premia are related concepts, but they differ in that term premia are purely risk-correlated components whereas yield spreads contain information about expected short-term rate paths. Jotikasthira et al. (2015) empirically find that risk compensation channels account for 42-90% of cross-country covariance of 5-year bond yields while policy channels accounts for 10-58%. In this chapter, I show that correlated stochastic volatility shocks together with correlated underlying shocks can explain this.

I build a two-country New Keynesian DSGE model to better understand the determinants and the comovement of term premia in open economy framework. To generate sizeable term

⁵UK is more correlated with the U.S. than other Euro countries.

Figure 3.2: Comovement of government bond yield spreads (10 year - 3 month)

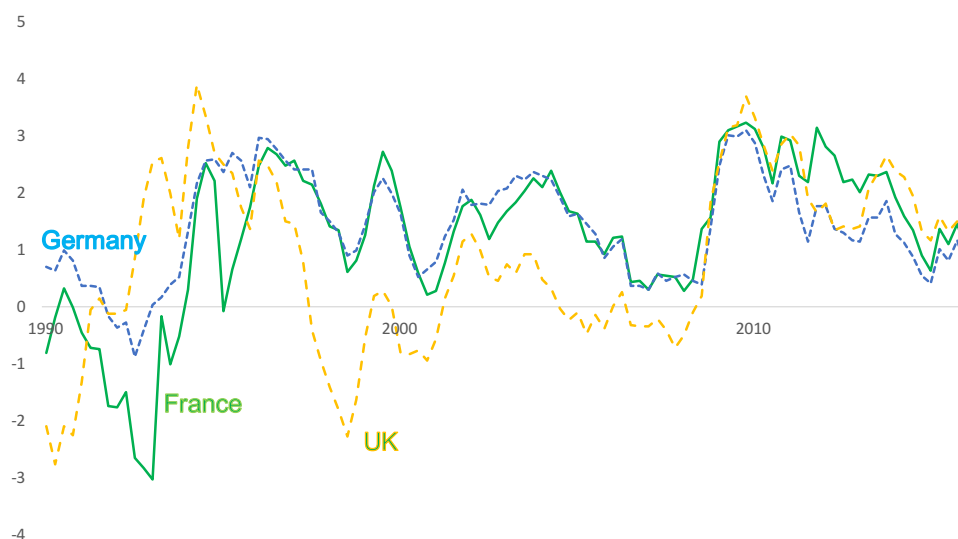


premia, it is essential to have recursive preference (*i.e.* the Epstein-Zin preference) in the model. I assume a two-country model rather than a small open economy model to explore the interaction between countries. In the baseline model, home agents can hold foreign bonds with different maturities in addition to home bonds and, therefore, foreign assets can provide hedging against country-specific shocks. I assume non state-contingent bonds⁶ whereas the macro-finance literature usually assumes state-contingent bonds. However, in the model, agents can achieve complete risk sharing⁷ between countries because there are multiple bonds in the economy and the number of shocks is relatively smaller than the number of financial assets. Stochastic volatility shocks are introduced to generate time-varying term premia. It is well-known that term premia are constant at second order approximation and therefore,

⁶Even in incomplete market setup in which stochastic discount factor is pinned down only with one-period bonds, the results remains similar.

⁷In a first order approximated model with constant asset holdings, agents can achieve complete risk sharing as long as the number of assets are the same as the number of shocks. However, in higher order approximated model in which portfolio holdings are time-varying, there should be additional assets to achieve complete risk sharing. In the baseline model, there are 40 domestic bonds and 40 foreign bonds, which are enough to achieve complete risk sharing even with higher order approximation.

Figure 3.3: Comovement of yield spreads (10 year - 3 month) among European countries



more than second order approximation is required to generate time-varying risk premia. I simplify the menu of shocks by considering only productivity shocks⁸ and stochastic volatility shocks in productivity. Adding other shocks such as interest rate and government spending shocks may help to increase term premia; however, the main results do not change and the main goal of this paper is to investigate how the degree of risk sharing and the correlation of shocks affect term premia and comovement of term premia.

This chapter is not the first study to investigate the yield curve in an open economy setup. Kulish and Rees (2011) study why long-term yields are more correlated across countries than are short-term yields in a small open economy setup. However, their model has a flat yield curve without term premia, since the model is approximated at the first order. Chin et al. (2015) study the same topic as Kulish and Rees (2011) but in a DSGE model with term premia. However, their model does not have sizeable term premia, since they do not introduce recursive preference. In this chapter, we focus on different topics such as the decrease in term

⁸Productivity shocks are usually the most important source of term premia. See Rudebusch and Swanson (2012) and Croce (2014).

premia, comovement of yield spreads and term premia with recursive preference. There are already several closed economy studies with the Epstein-Zin preference and higher order approximation (Ferman 2011, Rudebusch and Swanson 2012, Andreasen 2012, Gourio 2012). Gourio et al. (2013) build a two-country model with recursive preference, but they study equity and currency risk premia in an RBC framework in which countries are actually in an autarky.

This chapter is organized as follows. Section 3.2 presents the two-country DSGE model with recursive preference and stochastic volatility shocks. Then, Section 3.3 discusses how yields, term premia and yield spreads are determined in the DSGE framework. Section 3.4 presents the main results from the simulation and concluding remarks are offered in Section 3.5.

3.2 The Model

I develop a two-country New Keynesian DSGE model in which yield spreads are upward-sloping and term premia comove across countries. Instead of standard expected utilities, recursive preferences (Epstein-Zin, 1989) are introduced to generate sizeable term premia. The model will use third order approximation to generate time-varying term premia. In the baseline model⁹, agents in both countries can trade goods and nominal bonds with different maturities¹⁰ internationally. Financial market is assumed to be complete¹¹ domestically and internationally and therefore, there is complete international risk sharing between the two countries. For simplicity, I assume that there are only shocks related to productivity in the model: home and foreign productivity shocks and stochastic volatility shocks. Other agents in the model include final, intermediate good producers with sticky price and monetary

⁹We will also investigate the case of autarky and financial autarky. In these cases, financial assets are not traded internationally.

¹⁰This is a quarterly model. Therefore, nominal bonds with maturities up to 40 periods are assumed to exist to generate 10 year bond yield.

¹¹We also tried incomplete market case in which stochastic discount factor is pinned down only with one-period bond. However, the main result is similar. In addition, it may be reasonable to assume complete market if agents can use multiple bonds with different maturities to hedge against shocks.

authorities which set the nominal interest rate to stabilize inflation and the output gap.

3.2.1 Households

The model deviates from a standard open economy model by introducing recursive preference. In a standard model with expected utility and rational expectation, the yield curve is either flat¹² (at first order approximation) or down-ward sloping (at higher order approximation). Therefore, it is difficult for models with non-recursive preference to address any stylized facts related to term premia or yield spreads.

In general, the value function of a representative home agent can take two forms as in equation (3.1) (See Rudebusch and Swanson, 2012). With the assumption of the utility function as in equation (3.2), the value function takes negative values globally and, therefore, the value function in this model is defined as the second one in equation (3.1). The Epstein-Zin coefficient, α , is related to the degree of risk aversion to an uncertain value of V_{t+1} and reflects how much agents prefer earlier resolution of uncertainty. α is jointly determined by the risk aversion coefficient and the inverse of elasticity of intertemporal substitution ($1/\gamma$). More specifically, α is calculated as $1 - (1 - \text{risk aversion})/(1 - \gamma)$. When α is zero, the value function collapses to the usual expected utility.

$$V_t = \left\{ \begin{array}{ll} u(C_t, N_t) + \beta [E_t V_{t+1}^{1-\alpha}]^{\frac{1}{1-\alpha}} & \text{if } u(C_t, N_t) \geq 0 \\ u(C_t, N_t) - \beta [E_t (-V_{t+1}^{1-\alpha})]^{\frac{1}{1-\alpha}} & \text{if } u(C_t, N_t) \leq 0 \end{array} \right\} \quad (3.1)$$

$$u(C_t, N_t) = \frac{C_t^{1-\gamma}}{1-\gamma} - \frac{N_t^{1+\psi}}{1+\psi} \quad (3.2)$$

The budget constraint for a representative home agent can be expressed as equation (3.3). In a financially open economy, home agents can hold both domestic and foreign nominal bonds whereas, in the case of a financial autarky case, it is assumed that home

¹²For example, Kulish and Rees (2011) investigate why long-term yields are more correlated across countries than short-term yields. However, the yield curve in their model is flat.

agents cannot hold foreign bonds. $B_t^{(\tau)}$ is the amount of home bond of maturity τ held by home agents and $B_t^{(\tau)*}$ is the foreign bond of maturity τ held by home agents. $Q_t^{(\tau)}$ is the nominal price of home bond of maturity τ at time t and S_t is the nominal exchange rate. $Q_t^{(0)}$ and $Q_t^{(0)*}$ are the price of home and foreign bonds with zero maturity and are equal to 1 since nominal bonds pay off 1 unit of local currency at maturity. The maximum maturity of bonds, T , is assumed to be 40, which implies a 10-year bond. I_t is the investment¹³ in capital defined as $K_{t+1} - (1 - \delta)K_t$ with δ implying the depreciation rate.

$$C_t + I_t + \sum_{\tau=1}^T \frac{Q_t^{(\tau)} B_t^{(\tau)}}{P_t} + \sum_{\tau=1}^T \frac{S_t Q_t^{(\tau)*} B_t^{(\tau)*}}{P_t} = Y_t + \sum_{\tau=1}^T \frac{Q_t^{(\tau-1)} B_{t-1}^{(\tau)}}{P_t} + \sum_{\tau=1}^T \frac{S_t Q_t^{(\tau-1)*} B_{t-1}^{(\tau)*}}{P_t} \quad (3.3)$$

The home consumption basket is the CES aggregate of domestic and foreign produced goods ($C_{H,t}, C_{F,t}$, respectively) with the degree of home bias, a . ϕ is the elasticity of the substitution between home and foreign goods.

$$C_t = \left(a^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi-1}{\phi}} + (1-a)^{\frac{1}{\phi}} C_{F,t}^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}}, \quad \frac{1}{2} \leq a < 1 \quad (3.4)$$

All goods are assumed to be tradable. Therefore, when both home and foreign agents allocate resources optimally, the demand for home and foreign final goods by the home agent is determined as in equation (3.5) in which $P_{H,t}$ and $P_{F,t}$ are the price for domestic and foreign final goods at home currency, respectively.

$$\begin{aligned} C_{H,t} &= a \left(\frac{P_{H,t}}{P_t} \right)^{-\phi} C_t \\ C_{F,t} &= (1-a) \left(\frac{P_{F,t}}{P_t} \right)^{-\phi} C_t \end{aligned} \quad (3.5)$$

¹³I assume there is no adjustment cost in capital for simplicity. The assumption has little effect on the result.

The price of a unit of consumption basket (*CPI*) of home and foreign country is determined as

$$P_t = \left[aP_{H,t}^{1-\phi} + (1-a)P_{F,t}^{1-\phi} \right]^{\frac{1}{1-\phi}} \quad (3.6)$$

$$P_t^* = \left[aP_{F,t}^{*1-\phi} + (1-a)P_{H,t}^{*1-\phi} \right]^{\frac{1}{1-\phi}} \quad (3.7)$$

3.2.2 Producers

There are two types of producers in each country: intermediate good producers and a final good producer. Intermediate good producers (i) produce differentiated intermediate goods in monopolistic competition to maximize the discounted sum of expected profits (equation (3.8)). The stochastic discount factor (M_{t+j}) in the model with recursive preference has the additional term ($[V_{t+1}/(E_t V_{t+1}^{1-\alpha})]^{-\alpha}$), compared to standard SDF. It depends not only on the marginal utility growth but also on risk aversion to V_{t+1} . The Rotemberg price adjustment cost $\left(\frac{\xi}{2} \left(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} \frac{1}{\pi_{ss}} - 1 \right)^2 Y_{t+j} \right)$ is assumed to introduce price stickiness. Whenever an intermediate good producer changes prices deviating from steady state inflation (π_{ss}), it incurs the adjustment cost proportional to output. The parameter, ξ , is related to the penalty cost and governs the degree of price stickiness. It can be shown that one can map ξ to the price stickiness in Calvo type price stickiness¹⁴. I assume Rotemberg price adjustment cost instead of Calvo pricing, since there would be additional state variable (i.e. price dispersion) if I assume Calvo pricing. W_t is the wage and N_t is the amount of labor used in production.

$$\max_{P_t(i)} E_t \sum_{j=0}^{\infty} M_{t+j} \left[\frac{P_{t+j}(i)}{P_{t+j}} Y_{t+j}(i) - W_{t+j} N_{t+j}(i) - r_{t+j} K_{t+j}(i) - \frac{\xi}{2} \left(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} \frac{1}{\pi_{ss}} - 1 \right)^2 Y_{t+j} \right] \quad (3.8)$$

¹⁴ $\xi = \varphi(1 - \theta + \theta\lambda)(\lambda - 1)/((1 - \varphi)(1 - \varphi\beta)(1 - \theta))$ where φ : Calvo stickiness, θ : coefficient on capital in production function, λ : price elasticity of the demand for differentiated good i

$$M_{t+j} = \beta \left[\frac{V_{t+j}}{(E_t V_{t+j}^{1-\alpha})^{\frac{1}{1-\alpha}}} \right]^{-\alpha} \left(\frac{C_{t+j}}{C_t} \right)^{-\gamma} \quad (3.9)$$

Production ($Y_t(i)$) is the function of labor and physical capital. We assume endogenous capital in production function instead of fixed capital formation¹⁵. The demand for a differentiated intermediate good (i) is determined as in equation (3.11) in which η is the elasticity of substitution between differentiated intermediate goods. Following Andreasen (2012), we assume that productivity follows the AR(1) process as in equation (3.12) and volatility ($\sigma_{A,t}$) is time-varying. The conditional volatility of productivity shocks follows the AR(1) process as in equation (3.13). This implies that an increase in $\sigma_{A,t}$ makes the effect of a productivity shock ($\varepsilon_{A,t}$) more uncertain and therefore, can be understood as uncertainty shock. In the baseline model, productivity shocks and volatility shocks are uncorrelated across countries (equation (3.14) and (3.15)). We will relax the assumption about correlation of shocks later.

$$Y_{t+j}(i) = A_{t+j} K_{t+j}(i)^\theta N_{t+j}(i)^{1-\theta} \quad (3.10)$$

$$Y_{t+j}(i) = \left(\frac{P_{t+j}(i)}{P_{t+j}} \right)^{-\eta} Y_{t+j} \quad (3.11)$$

$$\log\left(\frac{A_t}{A_{ss}}\right) = \rho_A \log\left(\frac{A_{t-1}}{A_{ss}}\right) + \sigma_{A,t} \varepsilon_{A,t} \quad (3.12)$$

$$\log\left(\frac{\sigma_{A,t}}{\sigma_{ss}}\right) = \rho_\sigma \log\left(\frac{\sigma_{A,t-1}}{\sigma_{ss}}\right) + \varepsilon_{\sigma,t} \quad (3.13)$$

$$\text{cov}(\varepsilon_{A,t}, \varepsilon_{A,t}^*) = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad (3.14)$$

¹⁵Previous studies (Rudebusch and Swanson (2012), Andreasen (2012), Ferman (2011)) assume fixed capital formation in production function for simplicity. If endogenous time-varying capital is assumed, there is additional state variables in the model, making hard to solve the model. In the appendix, I show that the assumption of fixed capital does not change the main intuition.

$$\text{cov}(\varepsilon_{\sigma,t}, \varepsilon_{\sigma,t}^*) = \begin{pmatrix} \sigma_{ss}^2 & 0 \\ 0 & \sigma_{ss}^2 \end{pmatrix} \quad (3.15)$$

A final good producer combines intermediate goods to produce a single final good to maximize profit every period as in equation (3.16). This process can be understood as repackaging intermediate goods and the process is as shown in equation (3.17). We assume that the final good is produced with domestic goods only.

$$\max_{Y_t(i)} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di \quad (3.16)$$

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}} \quad (3.17)$$

3.2.3 Monetary Policy

The monetary authority sets the short-term nominal interest rate to stabilize CPI inflation and the output gap.

$$\frac{i_t}{\bar{i}} = \left(\frac{i_{t-1}}{\bar{i}} \right)^{\rho_i} \left[\left(\frac{\pi_t}{\bar{\pi}} \right)^{\rho_\pi} \left(\frac{Y_t}{\bar{Y}} \right)^{\rho_y} \right]^{1-\rho_i}$$

3.2.4 Market Clearing

The market clearing conditions for home and foreign goods can be expressed as equation (3.18) and (3.19), respectively. Equations (3.20) and (3.21) show the bond market clearing conditions. $B_{ij}^{(\tau)}$ is the τ maturity bond holding of country i by country j . Bond market clearing conditions have to hold for each $\tau = 1, \dots, 40$. A zero net supply of bond for each maturity was assumed.

$$Y_t = a \left(\frac{P_{H,t}}{P_t} \right)^{-\phi} C_t + (1-a) \left(\frac{P_{H,t}^*}{P_t^*} \right)^{-\phi} C_t^* + I_t + \frac{\xi}{2} \left(\frac{\pi_t^H}{\pi_{ss}^H} - 1 \right)^2 Y_t \quad (3.18)$$

$$Y_t^* = a \left(\frac{P_{F,t}^*}{P_t^*} \right)^{-\phi} C_t^* + (1-a) \left(\frac{P_{F,t}}{P_t} \right)^{-\phi} C_t + I_t^* + \frac{\xi}{2} \left(\frac{\pi_t^{F^*}}{\pi_{ss}} - 1 \right)^2 Y_t^* \quad (3.19)$$

$$B_{HH}^{(\tau)} + B_{FH}^{(\tau)} = 0 \quad (3.20)$$

$$B_{FF}^{(\tau)} + B_{HF}^{(\tau)} = 0 \quad (3.21)$$

3.3 Bond Pricing and Term Premia

In this section, we discuss the general properties of term structure in a DSGE framework. This will help explain the simulation results in the next section, since we do not have an analytical solution when the recursive preference is introduced. First, we discuss how bonds with different maturities are priced and then present how term premia and yield spreads are determined.

3.3.1 Bond Pricing

The Euler equation for home bond holdings of maturity τ can be written as equation (3.22) whereas equation (3.23) shows the Euler equation for foreign bonds. M_{t+1} is the stochastic discount factor defined as equation (3.24) and $Q_t^{(\tau)}$ is the nominal price of bond of maturity τ known at time t . Since the maturity τ at time t becomes $\tau - 1$ at time $t + 1$, $Q_{t+1}^{(\tau-1)}/Q_t^{(\tau)}$ can be interpreted as a one-period nominal return (*i.e.* capital gain) from holding the home bond of maturity τ from t to $t + 1$. Bond prices at the next period are not known at the current moment except one-period bonds (*i.e.* $Q_{t+1}^0 = 1$). Exchange rate movement matters for real returns from the foreign nominal bonds as in (3.23). Equation (3.22) and (3.23) together imply that the UIP holds for all maturities.

$$1 = E_t \left[M_{t+1} \underbrace{\frac{Q_{t+1}^{(\tau-1)}}{Q_t^{(\tau)}}}_{\text{nominal holding return}} \frac{1}{\pi_{t+1}} \right] \quad \text{for } \tau = 1, \dots, 40 \quad \text{with } Q_{t+1}^0 = 1 \quad (3.22)$$

$$1 = E_t \left[M_{t+1} \underbrace{\frac{Q_{t+1}^{*(\tau-1)}}{Q_t^{*(\tau)}}}_{\text{nominal holding return}} \frac{S_{t+1}}{S_t} \frac{1}{\pi_{t+1}} \right] \quad \text{for } \tau = 1, \dots, 40 \quad \text{with } Q_{t+1}^{*0} = 1 \quad (3.23)$$

$$M_{t+1} = \beta \left[\frac{V_{t+1}}{(E_t V_{t+1}^{1-\alpha})^{\frac{1}{1-\alpha}}} \right]^{-\alpha} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \quad (3.24)$$

Equation (3.22) also implies that expected one-period real bond holding returns are the same for all maturities ($\tau = 1, \dots, 40$) at the first approximation when rational expectation holds.

$$E_t \left[\frac{1}{Q_t^{(1)}} \frac{1}{\pi_{t+1}} \right] = E_t \left[\frac{Q_{t+1}^{(1)}}{Q_t^{(2)}} \frac{1}{\pi_{t+1}} \right] = \dots = E_t \left[\frac{Q_{t+1}^{(39)}}{Q_t^{(40)}} \frac{1}{\pi_{t+1}} \right] \quad (3.25)$$

Once we can pin down the stochastic discount factor (M_{t+1}), we can price no-arbitrage riskless bonds. In other words, if we apply the above equations recursively, the nominal bond yield with τ -period maturity ($i_t^{(\tau)}$) can be determined as in equation (3.26); bond yield is jointly determined by the expected stochastic discount factor and inflation.

$$(i_t^{(\tau)})^{-\tau} = E_t \left[M_{t+1} M_{t+2} \dots M_{t+\tau} \frac{1}{\pi_{t+1}} \frac{1}{\pi_{t+2}} \dots \frac{1}{\pi_{t+\tau}} \right] \quad (3.26)$$

3.3.2 Nominal Term Premia and Yield Spreads

The yield curve is, on average, upward-sloping. If agents hold a one-period bond, the nominal value they receive at the next period is already predetermined, implying there is no uncertainty in nominal terms. However, if agents hold a long-term bond, the market value of the bond at the next period is uncertain and, therefore, they want to be compensated for bearing risks by continuing to hold long-term bonds instead of rolling over short-term bonds. Therefore, the upward-sloping yield curve is usually considered to be related to risk premia.

To better understand yield spreads, we first need to understand what determines term premia. The τ -period nominal term premium can be defined as the difference between the yield from holding τ period bond and the investing sequence of short-term bonds as in equation (3.27).

$$NTP_t^{(\tau)} \equiv i_t^{(\tau)} - \frac{1}{\tau} \sum_{j=0}^{\tau-1} E_t i_{t+j}^{(1)} \quad (3.27)$$

Ferman (2011) shows that the nominal term premium can be decomposed as three parts; the real term premium, convexity, and the covariance between stochastic discount factor and inflation. Among the three components, the last one, covariance between stochastic discount factor and inflation, is the most important¹⁶. Therefore, we can rewrite the term premium as in equation (3.28). The nominal term premium is basically determined by the degree of covariance between the stochastic discount factor and inflation. Higher $Cov_t(\widehat{m}_{t+\tau}, \widehat{\pi}_{t+\tau})$ implies that the bond loses more of its (real) value when agents are in need of more income and, therefore, long-term bond holders need to be compensated more when conditional covariance is higher. We can further decompose the covariance into correlation and variances of the stochastic discount factor and inflation. Later, we will see that the covariance will depend on the degree of risk sharing.

¹⁶See Ferman (2011)

$$NTP_t^{(\tau)} = \underbrace{\frac{1}{\tau} Cov_t(\hat{m}_{t+\tau}, \hat{\pi}_{t+\tau})}_{Corr_t(\hat{m}_{t+\tau}, \hat{\pi}_{t+\tau}) \sqrt{var(\hat{m}_{t+\tau})} \sqrt{var(\hat{\pi}_{t+\tau})}} + other\ terms \quad (3.28)$$

Nominal term premia are closely related to yield spreads and, empirically, historical average of both are similar. However, they are not the same conceptually. As equation (3.29) shows, the comovement of yield spread can be decomposed into the comovement of term premia and of the expected short rate path. In next section, we will investigate how much each of these two components contributes to the correlation of yield spread and what determines it.

$$Yield\ spread(10yr - 3m) \equiv i_t^{(40)} - i_t^{(1)} = \underbrace{NTP_t^{(40)}}_{risk\ premium} + \underbrace{\frac{1}{\tau} \sum_{j=0}^{39} E_t i_{t+\tau}^{(1)} - i_t^{(1)}}_{expected\ short\ rate\ path} \quad (3.29)$$

3.4 Simulation

In this section, we present simulation results to understand what determines term premia and comovement in an open economy setup. A third order perturbation method is used and empirical moments presented here are based on 200,000 simulations. First, we show how the openness of the economy affects the term premium level. The previous macro-finance literature has studied term premia only in a closed economy setup. However, the result from an open economy may be different from the result from a closed economy, since domestic agents can engage in international good trading and asset trading to hedge against country-specific shocks which cannot be hedged in a closed economy setup. This enhanced risk sharing may change the volatility of conditional covariance between the stochastic discount factor and inflation, which, in turn, affects the term premium level. We consider three types of economy: autarky, financial autarky, and fully open economy. Second, we explore how the correlation of productivity shocks across countries affects the term premium level and

comovement. Third, we investigate the effect of correlated volatility shocks on term premia and comovement.

3.4.1 Calibration

The model is a quarterly model. The discount factor, β , is set as 0.99. The inverse of the elasticity of intertemporal substitution, γ , is 2, which is standard. Risk aversion is set to be 110 as is common in other macro-finance literature. This implies that the Epstein-Zin coefficient, α , is -108. Inverse Frisch elasticity, ψ , is 1/2.5. The share of capital in the production function, θ , is 1/3. The price elasticity of a differentiated good, η , is set to be 10. The Rotemberg cost adjustment parameter, ζ , is 629, which is equivalent to 0.75 in Calvo stickiness, as is standard in the New Keynesian model. ξ has a one-to-one relationship with Calvo stickiness in which ζ can be equal to $\varphi(1 - \theta + \theta\lambda)(\lambda - 1)/((1 - \varphi)(1 - \varphi\beta)(1 - \theta))$ ¹⁷. The degree of home bias in goods is 0.75 from Coeurdacier and Gourinchas (2011). The depreciation rate, δ , is 0.02. The yearly capital stock, $\bar{K}/(4\bar{Y})$, is 2.5 from U.S. data. The elasticity of the substitution between home and foreign goods is 1.2. The persistence parameter in Taylor rule, ρ_i , is 0.73 from Rudebusch and Swansson (2012). The coefficient on inflation and output in the Taylor rule are set to be 1.5 and 0.3, respectively. The persistence of productivity, ρ_A , is 0.98 while the mean of variance of productivity shock, σ_A^2 , is $(0.005)^2$. The steady state inflation, $\bar{\pi}$, is 1.00615 from U.S. data. The persistence of volatility shock is 0.9.

3.4.2 Financial Openness

We consider three cases to characterize different degrees of openness. In autarky, there are two symmetric countries which are disconnected from each other. In a financial autarky, countries can trade goods internationally, but do not hold each other's financial assets. In an open economy, countries can freely invest in foreign bonds and also trade goods inter-

¹⁷ φ : Calvo stickiness, θ : coefficient on capital in production function, λ : price elasticity of the demand for differentiated good i

nationally (i.e. the baseline model). We keep parameter values the same over these three types of economy. It may be true that structural parameters may change when the economy opens up more, but we do not consider this endogenous structural change in this paper. This exercise is simply to investigate whether previous results in a closed economy still hold in an open economy setup which may be more realistic.

First, table 3.1 shows that the level of term premia¹⁸ gets lower when the economy is more open. In particular, the effect is more prominent when moving from financial autarky to open economy than it is from autarky to financial autarky. This can be understood as a result of international risk sharing. As already seen in equation (3.28), the nominal term premium is determined by the conditional covariance between the stochastic discount factor and inflation. When the economy is more open, there is more international risk sharing to smooth consumption more, which lowers the conditional covariance between the stochastic discount factor and inflation. More specifically, the conditional variance of the stochastic discount factor (or consumption) and the correlation between stochastic discount factor and inflation is lowered when the economy is more open, whereas the conditional variance of inflation goes up. This implies that generating sizeable term premia in a DSGE model may be still challenging in an open economy setup.

Second, nominal term premia in an open economy are negatively correlated, whereas yield spreads are positively correlated in the baseline model in which no correlation between shocks across countries is assumed. Yield spreads are positively correlated, since the co-movement of yield spreads across countries is mainly driven by the expected short-term rate rather than by term premia. In an open economy model in which domestic output is determined by foreign demands in addition to home demands and agents hold foreign assets to smooth consumption, the short-term yield set by central bank is affected by foreign shocks. Therefore, expected short-term rates are correlated across countries even when underlying

¹⁸Yield spread is slightly lower than term premia, since expected short rate declines as long as the persistency of shocks is smaller than 1. The movement of yield spread and term premia is quite similar. Therefore, the explanation will focus on term premia.

shocks are not correlated. However, nominal term premia, which are mainly determined by higher moments, are not positively correlated in an open economy model. This result may suggest the importance of global (or common) risk in explaining asset prices, since we cannot generate a positive correlation of term premia across countries when countries' shocks are fully idiosyncratic. Therefore, we explore how the degree of correlation of productivity shocks and stochastic volatility shocks affects the correlation of term premia across countries in the next two subsections.

Table 3.1: Openness and term premium

<i>Unconditional mean</i>	<i>data</i>	<i>Autarky</i>	<i>Financial autarky</i>	<i>Open Economy</i>
$Mean[Yield\ Spread^{10yr-3m}]$	1.93	1.30	1.25	1.11
$Mean[NTP^{10yr-3m}]$	2.57	1.17	1.10	0.93
$Corr[YieldSpread^{10yr-3m}]$	0.60	0.00	0.13	0.42
$Corr[NTP^{10yr-3m}]$	0.91	0.00	-0.07	-0.32

Note: Data is the quarterly U.S. data from 1990 to 2015. Correlation is between U.S. and UK. For the correlations of other pairs of countries, see the appendix. Yield spread data are from Global Financial Data and term premium data are from Wright (2011).

I considered only three forms of openness in the representative agent model to highlight the effect of risk sharing on term premia; autarky, financial autarky, and fully open economy. However, we can consider more complicated forms of openness in heterogeneous model. For example, some agents may hold foreign assets for hedging whereas other agents do not hold financial assets. By varying the portion of agents who hold foreign assets, we may investigate how the degree of openness can affect term premia in a more realistic environment. In sum, it is likely that term premium level may be affected when the degree of risk sharing among agents differs.

3.4.3 Correlated Shocks

From now on, we focus on a financially open model to investigate how correlated productivity shocks across countries affect term premia level and the comovement of term premia. Table 3.2 shows that the level of term premia and yield spreads increases when shocks are more correlated across countries. Again, this is related to risk sharing as already discussed in previous section. Cross-country correlated shocks cannot be hedged by international trading or asset holdings. Therefore, the existence of such shocks makes each country's consumption more volatile, implying higher conditional covariance between the stochastic discount factor and inflation. When shocks are highly correlated (i.e. 0.9), the mean level of term premia is similar to that in a closed economy (See table 3.1).

Second, the correlation of term premia across countries increases as productivity shocks are more correlated across countries. However, it takes a negative value when the correlation of productivity shocks is lower than 0.5. Furthermore, even when the correlation of productivity shocks are very highly correlated (i.e. 0.9), the correlation of term premia is still lower than data. It is interesting to note that the correlation of yield spread across countries decreases as productivity shocks are more correlated across countries. This is due to the decrease in expected short rates.

Table 3.2: Correlated shocks across countries

<i>Unconditional mean</i>	<i>data(U.S.)</i>	<i>corr = 0</i>	<i>corr = 0.3</i>	<i>corr = 0.5</i>	<i>corr = 0.9</i>
$Mean[Yield\ Spread^{10yr-3m}]$	1.93	1.11	1.18	1.22	1.29
$Mean[NTP^{10yr-3m}]$	2.57	0.93	1.01	1.05	1.15
$Corr[Yield\ Spread^{10yr-3m}]$	0.60	0.42	0.39	0.36	0.27
$Corr[NTP^{10yr-3m}]$	0.91	-0.32	-0.11	0.02	0.18

Note: Data (U.S.) is quarterly data from 1990 to 2015. Correlation is between U.S. and UK. For the correlations of other pairs of countries, see appendix. Yield spread data are from Global Financial Data and term premium data are from Wright (2011).

In sum, introducing correlated shocks helps to increase the level of term premia and the correlation of term premia across countries. However, they are still low even with very highly correlated productivity shocks. This incentivizes introducing stochastic volatility shocks, as shown in the next subsection.

3.4.4 Common Factor in Stochastic Volatility Shocks

In this subsection, I relax the assumption that stochastic volatility shocks in the baseline model are purely idiosyncratic. Table 3.3 shows that the degree of correlation of stochastic volatility shocks has no effect on the level of term premia. This is because stochastic volatility shocks in the model have no skewness and are mean-preserving. Theoretically, we can show that third order approximation of any risk premia around the deterministic steady state can be expressed as in equation (3.30)¹⁹ in which $TP_{\sigma\sigma\sigma}$ implies the partial derivative of term premium with respect to σ third times and x_t stands for state variables.

$$TP_t = \frac{1}{2}TP_{\sigma\sigma}\sigma^2 + \frac{1}{6}TP_{\sigma\sigma\sigma}\sigma^3 + \frac{3}{6}TP_{\sigma\sigma x}\sigma^2x_t \quad (3.30)$$

Third order approximation does not affect the level of term premium when there is no skewness ($\sigma^3 = 0$). Furthermore, the degree of correlation of the stochastic discount factor does not affect any terms in equation (3.30). Note that equation (3.30) is only for risk premia which is the difference between two asset returns. For other variables, the degree of correlation affects the unconditional mean. For example, the unconditional mean of the yield slope slightly decreases as the correlation of stochastic volatility shocks increases. Where the yield slope is different from term premia is that it also contains information of expected short-term interest rates. Therefore, the degree of correlation of stochastic volatility affects the level of yield slope but very slightly.

Second, cross-country correlation of yield slope and nominal term premia increases as the correlation of stochastic volatility shocks increases. Theoretically, time-varying term premia is related to the third term in equation (3.30) (i.e. $\frac{3}{6}TP_{\sigma\sigma x}\sigma^2x_t$) and the introduction

¹⁹See Andreasen (2012) for derivation.

of correlated stochastic volatility shocks makes the correlation of this term across countries positive. Cross-country correlation of nominal term premia is more affected by the correlation of stochastic volatility shocks than the correlation of yield slope as can be seen in table 3.3.

In summary, we can generate a sizeable positive correlation of term premia across countries when stochastic volatility shocks are correlated across countries with correlated productivity shocks. However, the term premia level is still lower than data. Introducing correlated skewness and kurtosis across countries may help to have higher term premia level without affecting the correlation as can be seen in equation (3.30), which I leave for future research.

Table 3.3: Correlated stochastic volatility shocks

<i>correlation of productivity shock = 0.0</i>						
<i>stochastic volatility</i>	<i>data(U.S.)</i>	<i>corr = 0.0</i>	0.3	0.5	0.7	0.9
<i>Mean[Yield slope^{10yr-3m}]</i>	1.93	1.11	1.11	1.11	1.11	1.11
<i>Mean[NTP^{10yr-3m}]</i>	2.57	0.93	0.93	0.93	0.93	0.93
<i>Corr[Yield slope^{10yr-3m}]</i>	0.60	0.42	0.45	0.47	0.49	0.51
<i>Corr[NTP^{10yr-3m}]</i>	0.91	-0.32	-0.15	-0.02	0.10	0.24
<i>correlation of productivity shock = 0.5</i>						
<i>stochastic volatility</i>	<i>data(U.S.)</i>	<i>corr = 0.0</i>	0.3	0.5	0.7	0.9
<i>Mean[Yield slope^{10yr-3m}]</i>	1.93	1.22	1.21	1.21	1.21	1.21
<i>Mean[NTP^{10yr-3m}]</i>	2.57	1.05	1.05	1.05	1.05	1.05
<i>Corr[Yield slope^{10yr-3m}]</i>	0.60	0.36	0.45	0.51	0.57	0.63
<i>Corr[NTP^{10yr-3m}]</i>	0.91	0.02	0.25	0.41	0.58	0.74

Note: Data (U.S.) is quarterly data from 1990 to 2015. Correlation is between U.S. and UK. For the correlations of other pairs of countries, see appendix. Yield spread data are from Global Financial Data and term premium data are from Wright (2011).

3.5 Conclusion

In this chapter, I built a two-country New Keynesian model to explain several stylized facts about the yield curve. First, I showed that a steady decrease in term premia globally can be related to increased risk sharing. This explanation is different from traditional views which relate the phenomenon only to inflation uncertainty. Furthermore, this result has implications for the recent macro-finance literature focused on closed economy setups. In an open economy setup in which agents can hedge against country-specific shocks by trading goods and assets, it is more difficult to generate sizeable term premia. Second, the comovement of yield spreads and term premia across countries can be explained when stochastic volatility shocks are correlated across countries with correlated underlying shocks. This result emphasizes the importance of global (or common) shocks in asset pricing literature.

BIBLIOGRAPHY

- [1] Andreasen, M., 2012. On the effects of rare disasters and uncertainty shocks for risk premia in non-linear DSGE models. *Review of Economic Dynamics* Vol 15, 295-316.
- [2] Barro, R., Jin, T., 2015. Rare events and long-run risks. Working Paper.
- [3] Bekaert, G., Wang, X., 2009. Home bias revisited. Columbia business school Working Paper.
- [4] Benigno, G., Benigno, P., 2008. Exchange rate determination under interest rate rules. *Journal of International Money and Finance* Volume 27, Issue 6, 971-993.
- [5] Binsvergen, J., Fernández-Villaverde, J., Koijen, R., Rubio-Ramírez, J., 2012. The term structure of interest rates in a DSGE model with recursive preferences. *Journal of Monetary Economics* Vol 59, 634-648.
- [6] Bohn, H., Tesar, L., 1996. US equity investment in foreign markets: portfolio rebalancing or return chasing? *Am. Econ. Rev.* 86 (2), 77-81.
- [7] Brennan, M., Cao, H., 1997. International portfolio investment flows. *J. Finan.* 52 (5), 1851-1880.
- [8] Broda, C., 2002. Terms of trade and exchange rate regimes in developing countries. FRB of New York Staff Report NO. 148.
- [9] Broner, F, Gelos, G., Reinhart, C., 2006, When in peril, retrench: Testing the portfolio channel of contagion. *J. Int. Econ.* 69 (1), 203-230.
- [10] Calvet, L., Campbell, J., Sodini, P., 2009. Fight or flight? Portfolio rebalancing by individual investors. *Q. J. Econ.* 124, 301-348.
- [11] Campbell, J., Cochrane, J., 1999. By force of habit: a consumption-based explanation of aggregate stock market behavior. *The Journal of Political Economy* Vol 107, Issue 2, 205-251.
- [12] Carrera, J., Vuletin, G., 2013. The effects of alternative exchange rate regimes on real exchange rate volatility: Evidence based on a new dataset Volume 31, Issue 1, 212-234.

- [13] Cerutti, E., Claessens, S., Ratnovski, L., 2014. Global liquidity and drivers of cross-border bank flows. IMF Working Paper 14/69.
- [14] Chaban, M., 2009. Commodity currencies and equity flows. *J. Int. Money Finan.* 28 (5), 836-852.
- [15] Chin, M., Filippeli, T., Theodoridis, K., 2015. Cross-country co-movement in long-term interest rates: a DSGE approach. Bank of England Working Paper No. 530.
- [16] Coeurdacier, N., Kollmann, R., Martin, P., 2007. International Portfolios with supply, demand and redistributive shocks. NBER Working Paper No. 13424.
- [17] Coeurdacier, N., Gourinchas, P., 2011. When bonds matter: home bias in goods and assets. NBER Working Paper No. 17560.
- [18] Croce, M., 2014. Long-run productivity risk: A new hope for production-based asset pricing?. *Journal of Monetary Economics* Vol 66, 13-31.
- [19] Curcuru, S., Thomas, C., Warnock, F., Wongswan, J., 2011. US international equity investment and past and prospective returns. *Am. Econ. Rev.* 101 (7), 3440-3455.
- [20] Curcuru, S., Thomas, C., Warnock, F., Wongswan, J., 2014. Uncovered equity parity and rebalancing in international portfolios. *J. Int. Money Finan.* 47, 86-99.
- [21] Dahlquist, M., Hasseltoft, H., 2013. International bond risk premia. *Journal of International Economics* Vol 90, 17-32.
- [22] De Santis, R., 2006. The geography of international portfolio flows, international CAPM and the role of monetary policy frameworks. ECB Working Paper No. 678.
- [23] Devereux, M., Sutherland, A., 2008. Financial globalization and monetary policy. *Journal of Monetary Economics* 55, 1363-1375.
- [24] Devereux, M., Sutherland, A., 2010. Country portfolio dynamics. *Journal of Economic Dynamics & Control* 34, 1325-1342.
- [25] Devereux, M., Senay, O., Sutherland, A., 2014. Nominal stability and financial globalization. *Journal of Money, Credit and Banking* Volume 46, Issue 5, 921-959.
- [26] Duffee, G., 2012. Bond pricing and the macroeconomy. Working Paper.
- [27] Engel, C., Hakkio, S., 1996. The distribution of exchange rates in the EMS. *International Journal of Finance and Economics* Volume 1(1), 55-67.

- [28] Engel, C., Matsumoto, A., 2009. The international diversification puzzle when goods prices are sticky: It's really about exchange-rate hedging, not equity portfolios. *American Economic Journal: Macroeconomics* 1:2, 155-188.
- [29] Ferman, M., 2011. Switching monetary policy regimes and the nominal term structure. *Dynare Working Papers Series*.
- [30] Fernández-Villaverde, J., Levintal, O., 2016. Solution methods for models with rare disasters. *NBER Working Paper No 21997*.
- [31] Fidora, M., Thimann, C., Fratzscher, M., 2007. Home bias in global bond and equity markets: the role of real exchange rate volatility. *Journal of International Money and Finance* 26, 631-655.
- [32] Forbes, K., Fratzscher, M., Kostka, T., Straub, R., 2016. Bubble thy neighbor: portfolio effects and externalities from capital controls. *J. Int. Econ.* 99, 85-104.
- [33] Forbes, K., Warnock, F., 2012. Capital flow waves: Surges, stops, flight, and retrenchment. *J. Int. Econ.* 88 (2), 235-251.
- [34] Fratzscher, M., 2012. Capital flows, push versus pull factors and the global financial crisis. *J. Int. Econ.* 88 (2), 341-356.
- [35] Gelos, G., Wei, S., 2005, Transparency and international portfolio holdings. *J. Finan.* 60 (6), 2987-3020.
- [36] Gourio, F., 2012. Disaster risk and business cycles. *American Economic Review* 102(6), 2734-2766.
- [37] Gourio, F., Siemer, M., Verdelhan, A., 2013. International risk cycles. *Journal of International Economics* 89, 471-484.
- [38] Gyntelberg, J., Loretan, M., Subhanij, T., Chan, E., 2014. Exchange rate fluctuations and international portfolio rebalancing. *Emerg. Mark. Rev.* 18, 34-44.
- [39] Hau, H., Rey, H., 2004. Can portfolio rebalancing explain the dynamics of equity returns, equity flows, and exchange rates? *Am. Econ. Rev.* 94 (2), 126-133.
- [40] Hau, H., Rey, H., 2006. Exchange rates, equity prices, and capital flows. *Rev. Finan. Stud.* 19, 273-317.

- [41] Hau, H., Rey, H., 2008. Global portfolio rebalancing under the microscope. NBER Working Paper 14165.
- [42] Hördahl, P., Tristani, O., Vestin, D., The yield curve and macroeconomic dynamics. *The Economic Journal* Vol 118, 1937-1970.
- [43] Jotikasthira, C., Lundblad, C., Ramadorai, T., 2012. Asset fire sales and purchases and the international transmission of funding shocks. *J. Finan.* 67 (6), 2015-2050.
- [44] Jotikasthira, C., Le, A., Lundblad, C., 2015. Why do term structures in different currencies co-move? *Journal of Financial Economics* Vol 115, Issue 1, 58-83.
- [45] Kulish, M., Rees, D., 2011. The yield curve in a small open economy. *Journal of International Economics* Vol 85, 268-279.
- [46] Levich, R., Hayt, G., Ripston, B., 1999. 1998 Survey of derivatives and risk management practices by US institutional investors. Survey conducted by the NYU Salomon Center, CIBC World Markets, and KPMG, available at <http://www.stern.nyu.edu/rlevich/>.
- [47] Miranda-Agrippino, S., Rey, H., 2015. World asset markets and the global financial cycle. NBER Working paper 21722.
- [48] Mussa, M., 1986, Nominal exchange rate regimes and the behavior of real exchange rates: Evidence and implications, *Carnegie-Rochester Conference Series on Public Policy* 25, 117-214.
- [49] Paoli, B., Scott, A., Weeken O., 2010. Asset pricing implications of a New Keynesian model. *Journal of Economic Dynamics & Control* Vol 34. 2056-2073.
- [50] Paoli, B., Küçük-Tuğer, H., SØndergaard, J., 2010. Monetary policy rules and foreign currency positions. *Bank of England Working Paper* No. 403.
- [51] Piazzesi, M., Schneider, M., 2006. Equilibrium yield curves. NBER Working Paper 12609.
- [52] Raddatz, C., Schmukler, S., 2012. On the international transmission of shocks: Micro-evidence from mutual fund portfolios. *J. Int. Econ.* 88 (2), 357-374.
- [53] Rey, H., 2013. Dilemma not trilemma: the global financial cycle and monetary policy independence. *Federal Reserve Bank of Kansas City Economic Policy Symposium*.

- [54] Rudebusch, G., Wu, T., 2008. A macro-finance model of the term structure, monetary policy and the economy. *The Economic Journal* Vol 118, 906-926.
- [55] Rudebusch, G., Swanson, E., 2008. Examining the bond premium puzzle with a DSGE model. *Journal of Monetary Economics* Vol 55, S111-S126.
- [56] Rudebusch, G., Swanson, E., 2012. The bond premium in a DSGE model with long-run real and nominal risks. *American Economic Journal: Macroeconomics* 4(1), 105-143.
- [57] Sutton, G., 2000. Is there excess comovement of bond yields between countries?. *Journal of International Money and Finance* Vol 19, 363-376.
- [58] Swanson, E., 2012. Risk aversion and the labor margin in dynamic equilibrium models. *American Economic Review* Vol 102(4), 1663-1691.
- [59] Uhlig, H., 2010. Easy EZ in DSGE. Working Paper.
- [60] Ülkü, N., Karpova, Y., 2014. Do international equity investors rebalance to manage currency exposure? A study of Greece foreign investor flows data. *J. Int. Finan. Mark., Inst. Money* 29, 150-169.
- [61] Wei, S., Zhang, Z., Du, Q., 2010, Does the global fireman inadvertently add fuel to the fire? New evidence from institutional investors' response to IMF program announcements. *J. Int. Money Finan.* 29 (4), 728-741.
- [62] Wright, J., 2011. Term premia and inflation uncertainty: empirical evidence from an international panel dataset. *American Economic Review* Vol 101, 1514-1534.

Appendix A

APPENDIX FOR CHAPTER 1

A.1 Estimation of home bias measures

A.1.1 Data

We estimate home bias measure in bonds using dataset by Arslanalp and Tsuda(2012, 2014) and Coordinated Portfolio Investment Survey (CPIS) data from IMF. Arslanalp and Tsuda (2012, 2014)'s dataset provide information on government debt outstanding of 24 emerging and 24 advanced countries by investor groups (i.e. foreign, domestic, central bank etc) and world market share of each country from 2004Q1 to 2014Q2. The most challenging part of estimating bond home bias is that total debt outstanding data is difficult to get, while international transaction part is relatively easier to get. Earlier study used BIS data for total debt outstanding, which is no longer available for most countries. That is why we use Arslanalp and Tsuda dataset. However, Arslanalp and Tsuda dataset do not provide information about how much domestic investors invest in foreign countries. Therefore, we combine Arslanalp and Tsuda dataset with Coordinated Portfolio Investment Survey(CPIS) data from IMF. We adjust CPIS data rather than using original CPIS data, since the common information in both dataset provide (i.e. total debt holdings by foreigners) is little bit different for some countries due to coverage issue. We calculate the ratio between domestic investors' foreign investment and foreign investor's domestic investment from CPIS data and apply this ratio to foreign investor's domestic investment from Arslanalp and Tsuda to get domestic investors' foreign investment consistent with Arslanalp and Tsuda data.

A.1.2 Exchange rate regime

In this paper, fixed regime countries are defined as countries without exchange rate risk (*i.e.* countries with currency board or sharing common currencies with other countries like Euro). In our sample, those countries include Greece, Ireland, Finland, Portugal, Austria, Germany, France, Slovenia, Belgium, Netherlands, Spain and Italy. Soft pegging countries are countries with exchange rate anchor, but not perfectly pegged. Those countries in our sample are Latvia, Bulgaria, Lithuania, Denmark. Managed floating countries include Argentina, Switzerland, Indonesia, Russia, Malaysia¹. Free floating countries include Uruguay, UK, Japan, New Zealand, US, Mexico, Sweden, Czech Republic, Australia, Phillipines, Romania, Thailand, South Africa, Canada, Colombia, Chile, Poland, Korea, Hungary, Brazil, Turkey and India.

A.1.3 Estimates of home bias in bond

We tried to exclude central bank's reserve holding whenever the data is available. Below is the estimates for the year 2012.

Finland(0.32), Ireland(0.39), Greece(0.53), Austria(0.56), Belgium(0.56), Germany(0.56), Switzerland(0.56), Uruguay(0.56), France(0.59), Japan(0.59), Portugal(0.65), New Zealand(0.67), Bulgaria(0.67), Lithuania(0.68), Slovenia(0.69), Norway(0.70), Latvia(0.70), UK(0.71), Argentina(0.75), Netherlands(0.79), Chile(0.80), Italy(0.81), Mexico(0.81), Denmark(0.81), USA(0.82), Russia(0.84), Czech(0.86), Thailand(0.87), South Africa(0.88), Sweden(0.90), Canada(0.91), Indonesia(0.92), Colombia(0.92), Spain(0.92), Phillipines(0.93), Australia(0.93), Malaysia(0.93), Romania(0.95), Hungary(0.97), Korea(0.97), Poland(0.97), Brazil(0.99), Turkey(1.00), India(1.00)²

¹Switzerland is monitoring Euro and Malaysia is monitoring US dollar while Russia monitors currency basket, usually Euro and US dollar.

²For foreign asset holding, we used CPIS data as reported by countries. Therefore, it is possible that home bias measure here might be little overestimated if a country under-reported foreign asset holding

A.2 Log-linearized equilibrium conditions for benchmark model

1. New Keynesian Phillips Curve(Home)

$$\widehat{\pi}_{H,t} = \beta E_t \widehat{\pi}_{H,t+1} + \frac{(1-\kappa)(1-\beta\kappa)}{\kappa} (\eta(\widehat{y}_t - \widehat{a}_t) + \gamma \widehat{c}_t - \widehat{a}_t - (1-a)\widehat{\tau}_t) \quad (\text{A.1})$$

2. New Keynesian Phillips Curve(Foreign)

$$\widehat{\pi}_{F,t}^* = \beta E_t \widehat{\pi}_{F,t+1}^* + \frac{(1-\kappa)(1-\beta\kappa)}{\kappa} (\eta(\widehat{y}_t^* - \widehat{a}_t^*) + \gamma \widehat{c}_t^* - \widehat{a}_t^* + (1-a)\widehat{\tau}_t) \quad (\text{A.2})$$

3. Demand for home goods

$$\widehat{y}_t = a\widehat{c}_t + (1-a)\widehat{c}_t^* - 2\theta a(1-a)\widehat{\tau}_t \quad (\text{A.3})$$

4. Demand for foreign goods

$$\widehat{y}_t^* = a\widehat{c}_t^* + (1-a)\widehat{c}_t + 2\theta a(1-a)\widehat{\tau}_t \quad (\text{A.4})$$

5. Euler Equation(Home) + Euler Equation(Foreign)

$$\gamma(E_t \widehat{c}_{t+1} - \widehat{c}_t) = \gamma(E_t \widehat{c}_{t+1}^* - \widehat{c}_t^*) + (1-2a)[E_t \widehat{\tau}_{t+1} - \widehat{\tau}_t] \quad (\text{A.5})$$

6. Euler Equation(Home) + Interest rate rule(Home)

$$\gamma(E_t \widehat{c}_{t+1} - \widehat{c}_t) = \rho_\pi \widehat{\pi}_{H,t} + \rho_y \widehat{y}_t + m_t - E_t \widehat{\pi}_{H,t+1} - (1-a)[\widehat{\tau}_t - E_t \widehat{\tau}_{t+1}] \quad (\text{A.6})$$

7. Euler Equation(Foreign) + Interest rate rule(Foreign)

$$\gamma(E_t \widehat{c}_{t+1}^* - \widehat{c}_t^*) = \rho_\pi \widehat{\pi}_{F,t}^* + \rho_y \widehat{y}_t^* + m_t^* - E_t \widehat{\pi}_{F,t+1}^* + (1-a)[\widehat{\tau}_t - E_t \widehat{\tau}_{t+1}] \quad (\text{A.7})$$

8. Relative real return between home and foreign nominal bond

$$\widehat{r}_{x1,t+1} = \widehat{r}_{H,t+1}^{(1)} - \widehat{r}_{F,t+1}^{(1)} \quad (\text{A.8})$$

$$= (\widehat{r}_{H,t+1}^{(1)} - E_t \widehat{r}_{H,t+1}^{(1)}) - (\widehat{r}_{F,t+1}^{(1)} - E_t \widehat{r}_{F,t+1}^{(1)}) \quad (\text{A.9})$$

$$= (-\widehat{q}_{(1),t} - \widehat{\pi}_{t+1} - E_t(-\widehat{q}_{(1),t} - \widehat{\pi}_{t+1})) - (-\widehat{q}_{(1),t}^* + (\widehat{s}_{t+1} - \widehat{s}_t) - \widehat{\pi}_{t+1}) \quad (\text{A.10})$$

$$- E_t(-\widehat{q}_{(1),t}^* + (\widehat{s}_{t+1} - \widehat{s}_t) - \widehat{\pi}_{t+1}) \quad (\text{A.11})$$

$$= -(\widehat{s}_{t+1} - E_t \widehat{s}_{t+1}) \quad (\text{A.12})$$

$$= -(\widehat{\pi}_{H,t+1} - E_t \widehat{\pi}_{H,t+1}) + (\widehat{\pi}_{F,t+1}^* - E_t \widehat{\pi}_{F,t+1}^*) + (\widehat{\tau}_{t+1} - E_t \widehat{\tau}_{t+1}) \quad (\text{A.13})$$

9. Relative budget constraint

$$\widehat{w}_t^R = \frac{1}{\beta} \widehat{w}_{t-1}^R - (\widehat{c}_t - \widehat{c}_t^*) + (\widehat{y}_t - \widehat{y}_t^* + \widehat{\tau}_t) + \left(1 - \frac{(1-\beta)\overline{W}}{\beta \overline{Y}^*}\right) (1-2a)\widehat{\tau}_t + (2\alpha' - \overline{B})r_{x,t} \quad (\text{A.14})$$

A.3 Derivation of general expression of optimal portfolio

Linearized home and foreign budget constraints³ are

$$\widehat{w}_t = \frac{1}{\beta}\widehat{w}_{t-1} + \frac{\overline{W}}{\beta\overline{Y}}\widehat{r}_{N,t} + \alpha' r_{x,t} + \widehat{y}_t - \widehat{c}_t + (1-a)\widehat{\tau}_t \quad (\text{A.15})$$

$$\widehat{w}_t^* = \frac{1}{\beta}\widehat{w}_{t-1}^* + \frac{\overline{W}^*}{\beta\overline{Y}^*}\widehat{r}_{N,t} + \frac{(1-\beta)\overline{W}}{\beta\overline{Y}^*}\widehat{r}\widehat{e}r_t + (\overline{B} - \alpha')\widehat{r}_{x,t} + \widehat{y}_t^* - \widehat{c}_t^* - (1-a)\widehat{\tau}_t \quad (\text{A.16})$$

Combine these two to get (Let $\widehat{x}_t^R \equiv \widehat{x}_t - \widehat{x}_t^*$)

$$\begin{aligned} \widehat{w}_t^R &= \frac{1}{\beta}\widehat{w}_{t-1}^R + (\widehat{y}_t - \widehat{y}_t^*) - (\widehat{c}_t - \widehat{c}_t^*) + 2(1-a)\widehat{\tau}_t - \frac{(1-\beta)\overline{W}}{\beta\overline{Y}^*}\widehat{r}\widehat{e}r_t + (2\alpha' - \overline{B})r_{x,t} \quad (\text{A.17}) \\ &= \frac{1}{\beta}\widehat{w}_{t-1}^R - (\widehat{c}_t - \widehat{c}_t^*) + (\widehat{y}_t - \widehat{y}_t^* + \widehat{\tau}_t) + (1 - \frac{(1-\beta)\overline{W}}{\beta\overline{Y}^*})\widehat{r}\widehat{e}r_t + (2\alpha' - \overline{B})r_{x,t} \end{aligned}$$

Therefore, (\overline{B} = bond supply normalized by steady state output)

$$\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma}\widehat{r}\widehat{e}r_t = \frac{1}{\beta}\widehat{w}_{t-1}^R - \widehat{w}_t^R + (2\alpha' - \overline{B})r_{x,t} + (\widehat{y}_t - \widehat{y}_t^* + \widehat{\tau}_t) + (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta})\widehat{r}\widehat{e}r_t \quad (\text{A.18})$$

Rearrange and impose transversality condition for NFA

$$\widehat{w}_t^R = \beta\widehat{w}_{t+1}^R + \beta(\widehat{c}_{t+1} - \widehat{c}_{t+1}^* - \frac{1}{\gamma}\widehat{r}\widehat{e}r_{t+1}) - \beta(2\alpha' - \overline{B})r_{x,t+1} - \beta(\widehat{y}_{t+1} - \widehat{y}_{t+1}^* + \widehat{\tau}_{t+1}) \quad (\text{A.19})$$

$$- \beta(1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta})\widehat{r}\widehat{e}r_{t+1} \quad (\text{A.20})$$

$$= \beta E_t(\widehat{c}_{t+1} - \widehat{c}_{t+1}^* - \frac{1}{\gamma}\widehat{r}\widehat{e}r_{t+1}) + \beta^2 E_t(\widehat{c}_{t+2} - \widehat{c}_{t+2}^* - \frac{1}{\gamma}\widehat{r}\widehat{e}r_{t+2}) + \dots \quad (\text{A.21})$$

$$- \beta E_t(\widehat{y}_{t+1} - \widehat{y}_{t+1}^* + \widehat{\tau}_{t+1}) - \beta^2 E_t(\widehat{y}_{t+2} - \widehat{y}_{t+2}^* + \widehat{\tau}_{t+2}) - \dots \quad (\text{A.22})$$

$$- \beta(1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta})E_t\widehat{r}\widehat{e}r_{t+1} - \beta^2(1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta})E_t\widehat{r}\widehat{e}r_{t+2} + \dots \quad (\text{A.23})$$

³Hat(\widehat{x}) variables imply deviation of log-linearized variable from their steady state

We can rewrite relative consumption using above expression

$$\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t = \frac{1}{\beta} \widehat{w}_{t-1}^R - \beta E_t(\widehat{c}_{t+1} - \widehat{c}_{t+1}^* - \frac{1}{\gamma} \widehat{r}er_{t+1}) - \beta^2 E_t(\widehat{c}_{t+2} - \widehat{c}_{t+2}^* - \frac{1}{\gamma} \widehat{r}er_{t+2}) - \dots \quad (\text{A.24})$$

$$+ (\widehat{y}_t - \widehat{y}_t^* + \widehat{\tau}_t) + \beta E_t(\widehat{y}_{t+1} - \widehat{y}_{t+1}^* + \widehat{\tau}_{t+1}) + \beta^2 E_t(\widehat{y}_{t+2} - \widehat{y}_{t+2}^* + \widehat{\tau}_{t+2}) + \dots \quad (\text{A.25})$$

$$+ (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) \widehat{r}er_t + \beta (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) E_t \widehat{r}er_{t+1} \quad (\text{A.26})$$

$$+ \beta^2 (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) E_t \widehat{r}er_{t+2} - \dots + (2\alpha' - \overline{B}) r_{x,t} \quad (\text{A.27})$$

Since $E_t(\widehat{c}_{t+1} - \widehat{c}_{t+1}^* - \frac{1}{\gamma} \widehat{r}er_{t+1}) = \widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t$, we can simplify above expression as

$$E_t \sum_{j=0}^{\infty} \beta^j (\widehat{c}_{t+j} - \widehat{c}_{t+j}^* - \frac{1}{\gamma} \widehat{r}er_{t+j}) = \frac{1}{\beta} \widehat{w}_{t-1}^R + (2\alpha' - \overline{B}) r_{x,t} + E_t \sum_{j=0}^{\infty} \beta^j (\widehat{y}_{t+j} - \widehat{y}_{t+j}^* + \widehat{\tau}_{t+j}) \quad (\text{A.28})$$

$$+ (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) E_t \sum_{j=0}^{\infty} \beta^j \widehat{r}er_{t+j} \quad (\text{A.29})$$

Express above equation in terms of $\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t$

$$\frac{1}{1-\beta} (\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t) = \frac{1}{\beta} \widehat{w}_{t-1}^R + (2\alpha' - \overline{B}) r_{x,t} + E_t \sum_{j=0}^{\infty} \beta^j (\widehat{y}_{t+j} - \widehat{y}_{t+j}^* + \widehat{\tau}_{t+j}) + (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) E_t \sum_{j=0}^{\infty} \beta^j \widehat{r}er_{t+j} \quad (\text{A.30})$$

Simplify further to get

$$\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r}er_t = \frac{(1-\beta)}{\beta} \widehat{w}_{t-1}^R + (1-\beta)(2\alpha' - \overline{B}) r_{x,t} + (1-\beta) E_t \sum_{j=0}^{\infty} \beta^j (\widehat{y}_{t+j} - \widehat{y}_{t+j}^* + \widehat{\tau}_{t+j}) \quad (\text{A.31})$$

$$(1-\beta) (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) E_t \sum_{j=0}^{\infty} \beta^j \widehat{r}er_{t+j} \quad (\text{A.32})$$

$$= \frac{(1-\beta)}{\beta} \widehat{w}_{t-1}^R + (1-\beta)(2\alpha' - \overline{B}) r_{x,t} + \quad (\text{A.33})$$

$$(1-\beta) E_t \left[\sum_{j=0}^{\infty} \beta^j \left[(\widehat{y}_{t+j} - \widehat{y}_{t+j}^* + \widehat{\tau}_{t+j}) + (1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta}) \widehat{r}er_{t+j} \right] \right] \quad (\text{A.34})$$

Optimality portfolio condition (from second order approximation of home and foreign Euler equations) is

$$E_{t-1} \left[(\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r} \widehat{e} r_t) r_{x,t} \right] = 0 \quad (\text{A.35})$$

Apply equation the expression of $\widehat{c}_t - \widehat{c}_t^* - \frac{1}{\gamma} \widehat{r} \widehat{e} r_t$ to optimal portfolio condition to get

$$(2\alpha' - \overline{B}) \text{Var}_{t-1}(r_{x,t}) + \text{Cov}_{t-1} \left[(\Lambda_t - E_{t-1}\Lambda_t) + \left[1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta} \right] (\Omega_t - E_{t-1}\Omega_t), r_{x,t} \right] = 0 \quad (\text{A.36})$$

Solve for α

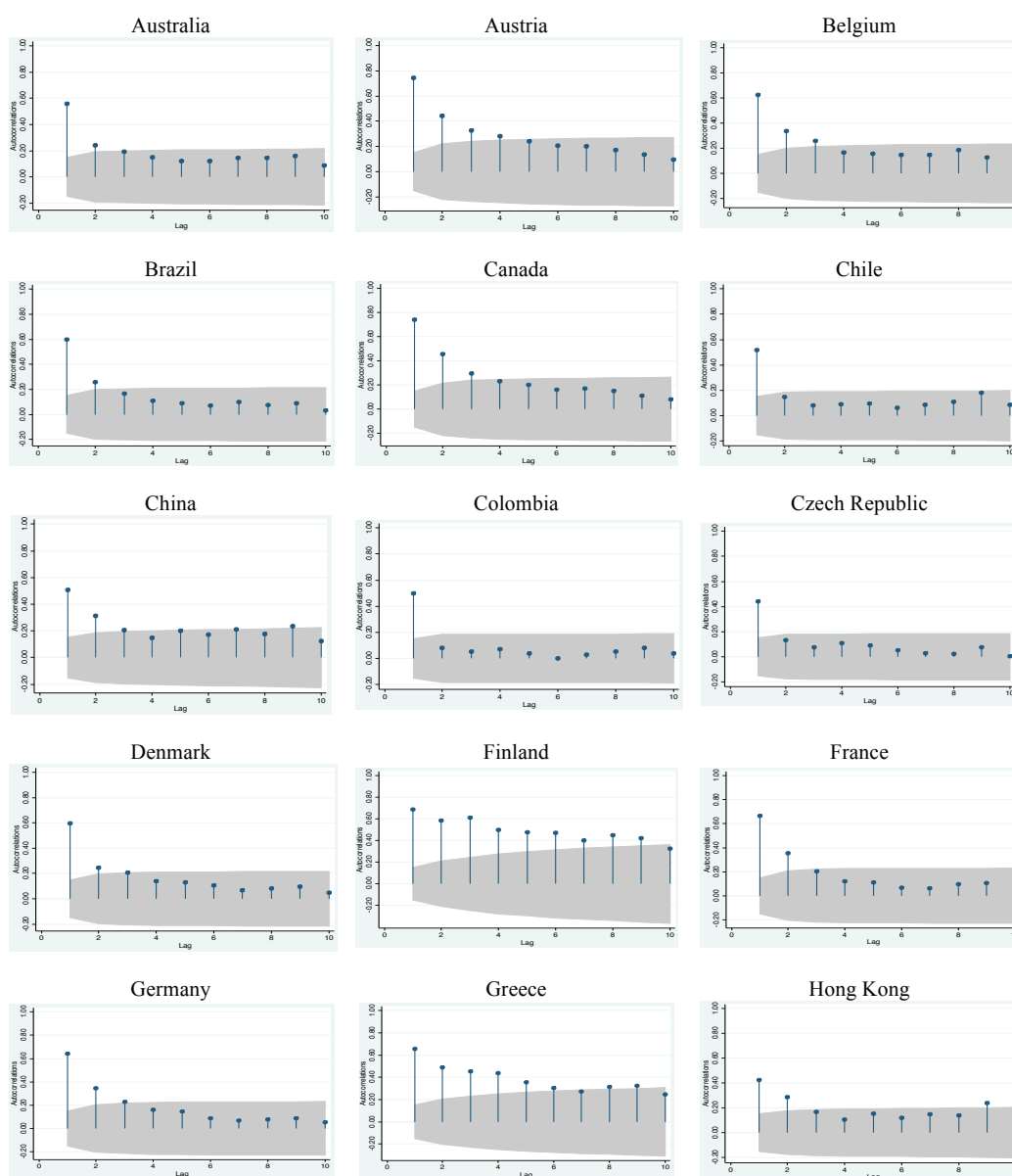
$$\alpha = \frac{\overline{B}}{2} - \frac{1}{2} \frac{\text{Cov}_{t-1}(\Lambda_t - E_{t-1}\Lambda_t, r_{x,t})}{\text{Var}_{t-1}(r_{x,t})} - \frac{1}{2} \left[1 - \frac{1}{\gamma} - \frac{(1-\beta)\overline{B}}{\beta} \right] \frac{\text{Cov}_{t-1}(\Omega_t - E_{t-1}\Omega_t, r_{x,t})}{\text{Var}_{t-1}(r_{x,t})} \quad (\text{A.37})$$

where $\Lambda_t = \sum_{j=0}^{\infty} \beta^j [(\widehat{y}_{t+j} - \widehat{y}_{t+j}^*) + \widehat{\tau}_{t+j}]$, $\Omega_t = \sum_{j=0}^{\infty} \beta^j \widehat{r} \widehat{e} r_{t+j}$

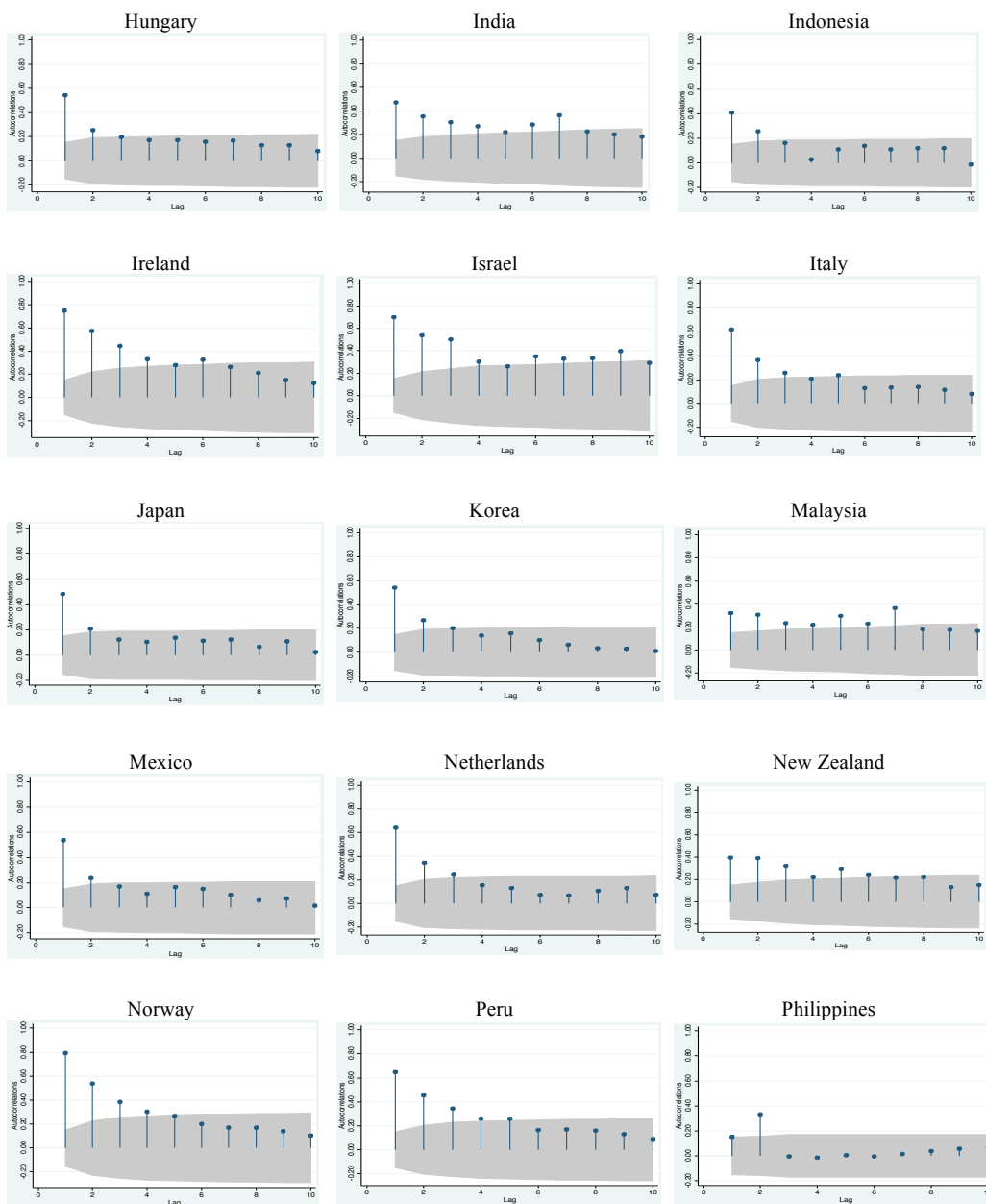
Appendix B

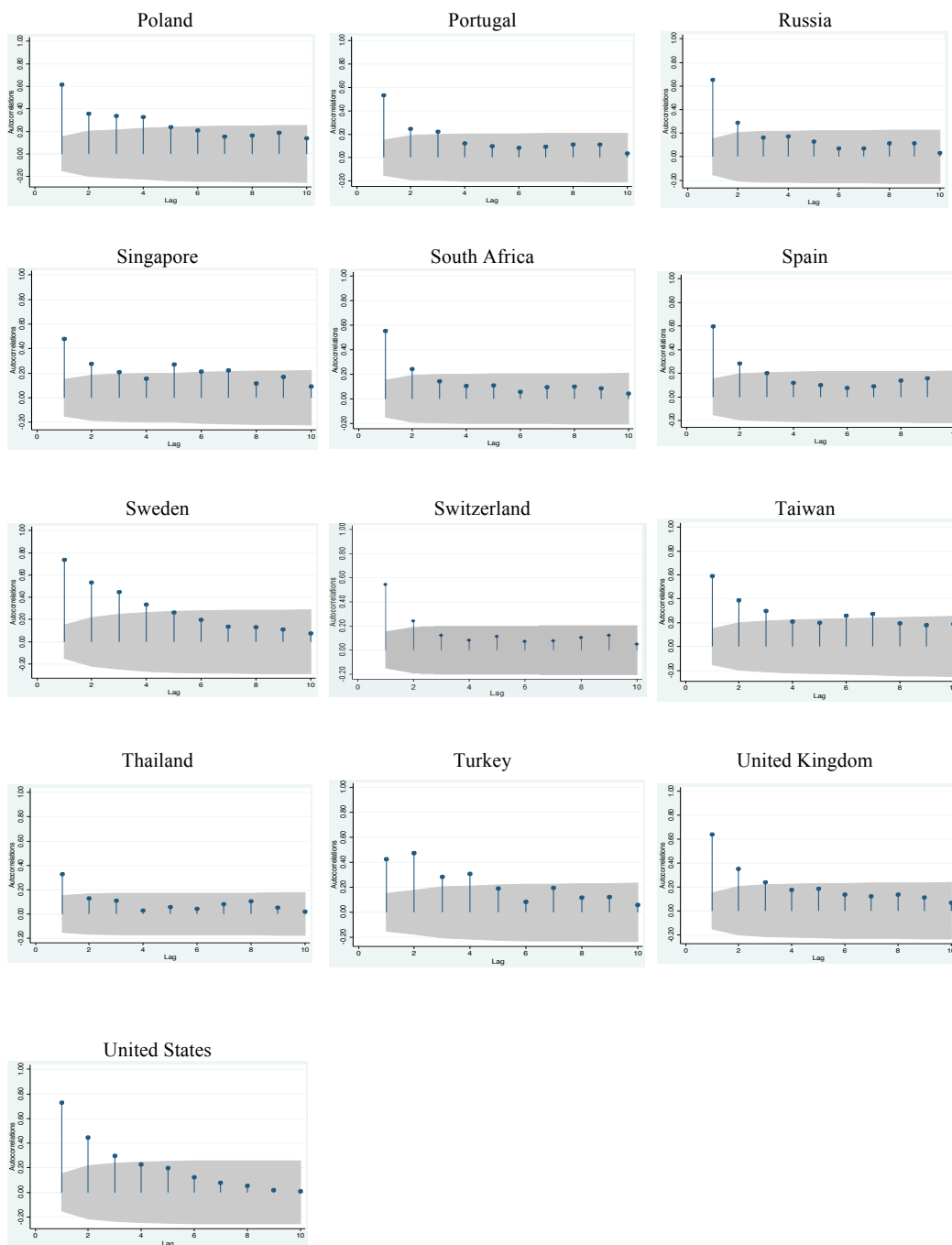
APPENDIX FOR CHAPTER 2

Figure B.1: Autocorrelations of monthly variance of contemporaneous returns



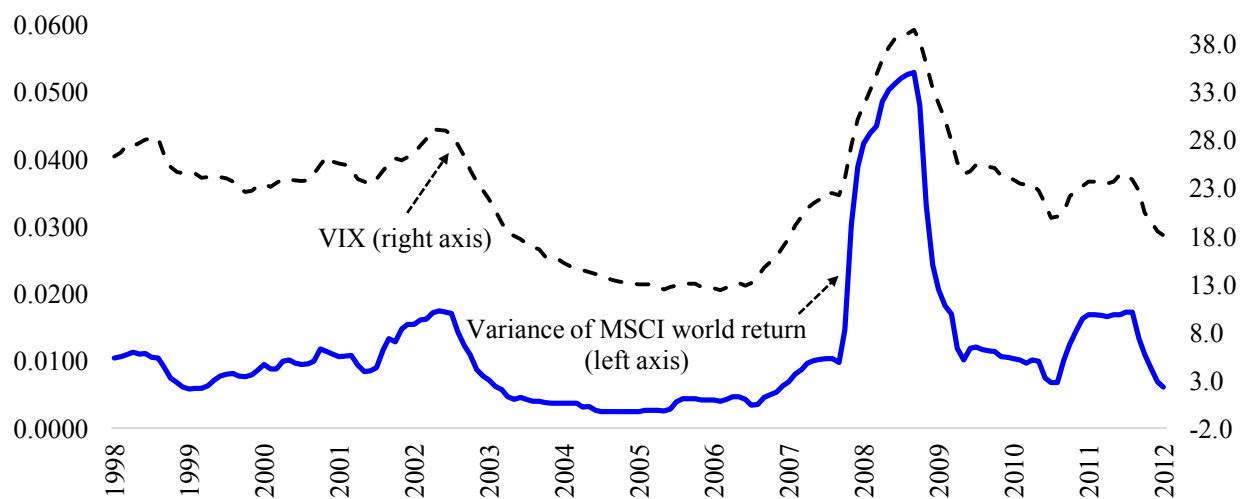
Daily MSCI index (in U.S. dollars) from 2000 to 2013 are used to calculate the monthly variance in each market. 95 percent confidence bands are obtained from the Bartlett's formula for MA(q) processes.





(a)

Figure B.2: VIX index and variance of MSCI world return



Note: The VIX index (measured on the right axis) is an original series in a 12 month moving average and the variance of MSCI world return (measured on the left axis) is rescaled by multiplying the original series by 100 before taking a moving average.

Figure B.3: Rolling-window rebalancing coefficients from unbalanced vs. balanced panel

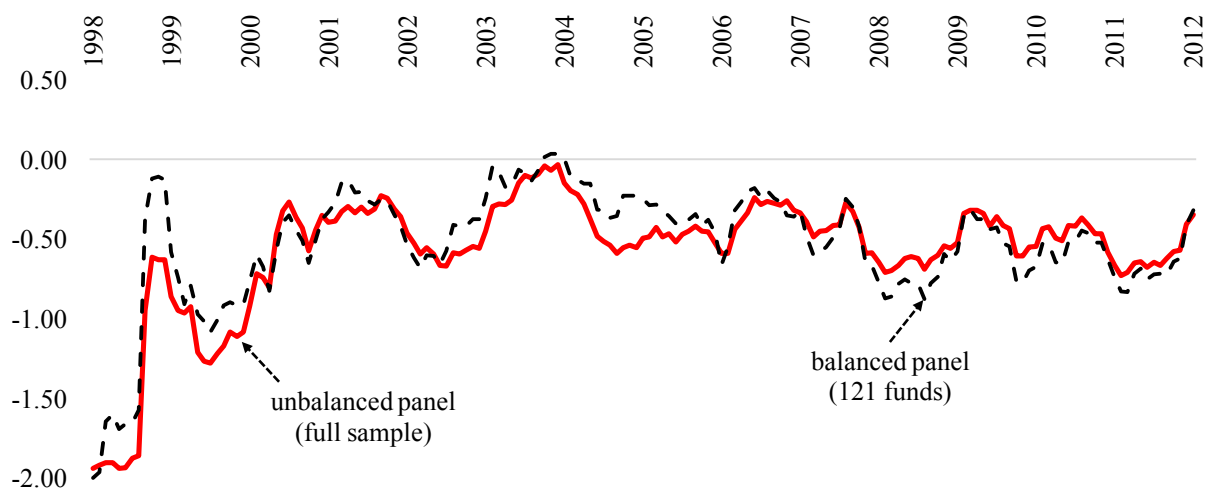


Figure B.4: Rolling-window rebalancing coefficients by country groups

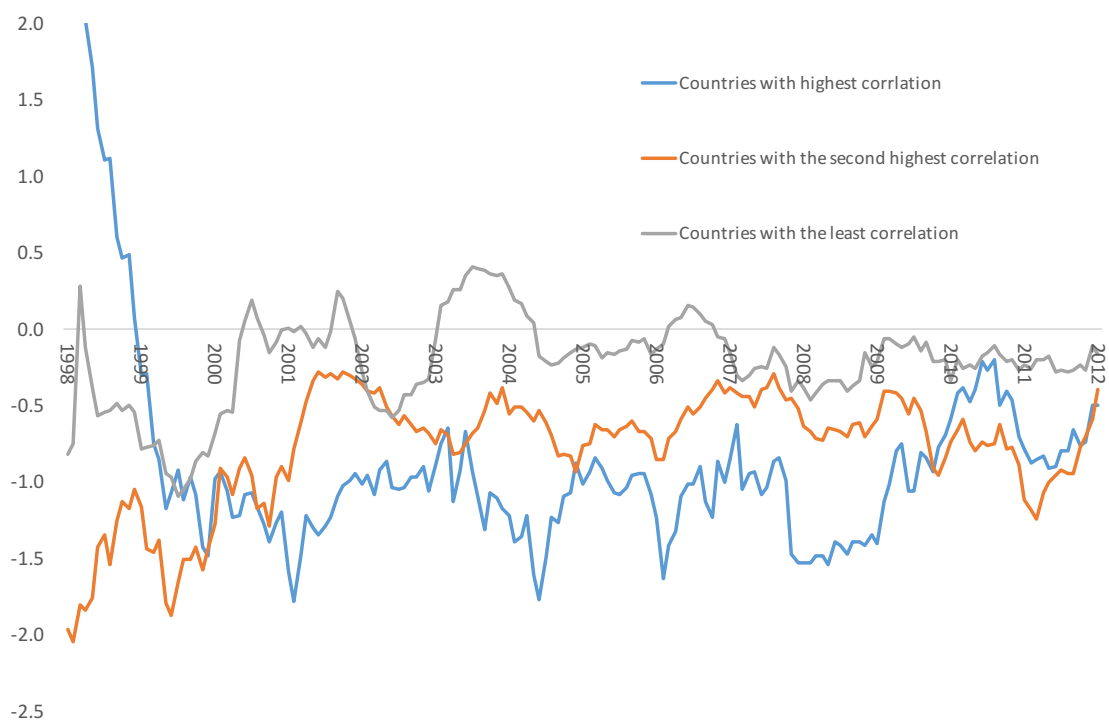


Figure B.5: Strong correlation between global and local equity returns

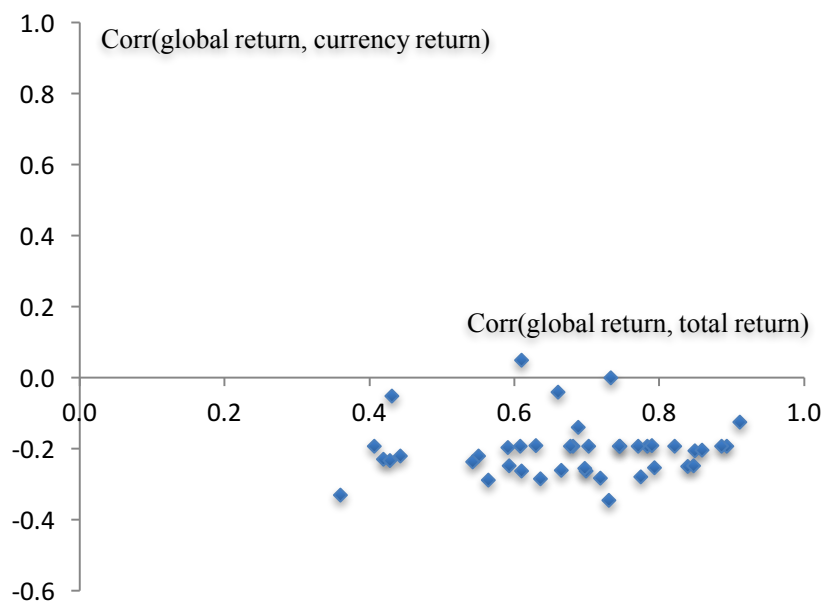
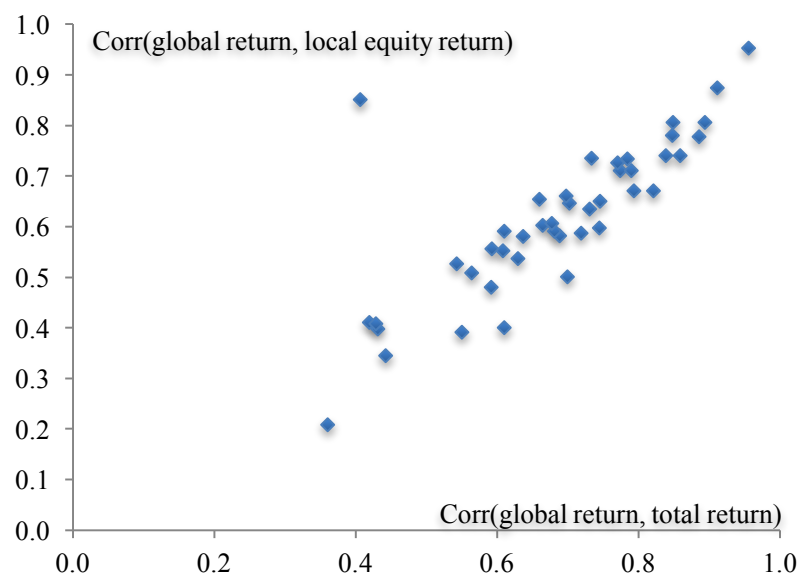


Table B.1: AR(1) coefficient for total returns

Country	Coefficient (SE)	Country	Coefficient (SE)
Australia	0.116 (0.075)	Brazil	-0.007 (0.077)
Austria	0.321***(0.071)	Chile	-0.006 (0.075)
Belgium	0.321***(0.071)	China	0.074 (0.073)
Canada	0.228***(0.073)	Colombia	0.150**(0.074)
Denmark	0.092 (0.075)	Czech Republic	0.041 (0.075)
Finland	0.206***(0.074)	Greece	0.147*(0.072)
France	0.159**(0.074)	Hungary	0.126*(0.075)
Germany	0.111 (0.075)	India	0.114 (0.074)
Hong Kong	0.180**(0.073))	Indonesia	0.163**(0.073)
Ireland	0.229***(0.073)	Korea	0.092 (0.072)
Israel	0.038 (0.075)	Malaysia	0.223***(0.074)
Italy	0.042 (0.075)	Mexico	-0.021 (0.074)
Japan	0.239***(0.073)	Peru	-0.065 (0.075)
Netherlands	0.148**(0.074)	Philippines	0.139*(0.074)
New Zealand	-0.073 (0.075)	Poland	-0.052 (0.076)
Norway	0.159**(0.074)	Russia	0.194***(0.073)
Portugal	0.128*(0.074)	South Africa	-0.035 (0.076)
Singapore	0.1 (0.073)	Taiwan	0.058 (0.075)
Spain	0.081 (0.075)	Thailand	0.053 (0.072)
Sweden	0.082 (0.075)	Turkey	-0.148**(0.075)
Switzerland	0.238***(0.072)		
United Kingdom	0.07 (0.074)		
United States	0.149**(0.075)		

Note: Monthly returns considered over the period 1998-2012 are total returns from equity holdings in a host country evaluated in an investor currency. Newey-West standard errors are reported in parentheses.

Table B.2: Global risk and rebalancing: four group approach

Dependent variable: $\Delta w_{ij,t}$	(1)	(2)	(3)	(4)
$\Delta r_{ij,t}$	-2.37*** (0.084)	-2.28*** (0.084)	-2.37*** (0.084)	-2.28*** (0.084)
$\Delta r_{ij,t} \cdot X_t$		-2.56*** (0.551)		-2.53*** (0.602)
$\Delta r_{ij,t} \cdot G_{1t}$	1.15*** (0.108)	1.11*** (0.109)	1.16*** (0.109)	1.11*** (0.109)
$\Delta r_{ij,t} \cdot G_{2t}$	1.54*** (0.093)	1.52*** (0.094)	1.56*** (0.094)	1.51*** (0.094)
$\Delta r_{ij,t} \cdot G_{3t}$	1.80*** (0.090)	1.75*** (0.090)	1.80*** (0.090)	1.74*** (0.090)
$\Delta r_{ij,t} \cdot G_{4t}$	2.19*** (0.089)	2.15*** (0.090)	2.20*** (0.090)	2.16*** (0.090)
X_t		0.08 (0.060)		-0.67*** (0.142)
G_{1t}		-0.15*** (0.016)		-0.15*** (0.016)
G_{2t}		-0.13*** (0.014)		-0.14*** (0.014)
G_{3t}		-0.13*** (0.014)		-0.13*** (0.014)
G_{4t}		-0.12*** (0.014)		-0.12*** (0.014)
Crisis dummies	No	No	Yes	Yes
F-statistics	452.95***	353.97***	442.56***	355.65***
Observations	562,601	562,601	562,601	562,601

Note: Groups are classified by the degree of correlation of local equity market with the global market. Correlations are calculated recursively using monthly data from January, 1998 with initial time coverage of 12 months and a wider range thereafter. Dummy variable $G_1 = 1$ for top 25 percent countries whose equity markets show the strongest correlation with the global market; $G_2 = 1$ for upper 26-50 percent countries; $G_3 = 1$ for 51-75 percent countries; and $G_4 = 1$ for bottom 76-100 percent countries. All specifications include fund-country fixed effects. Newey-West standard errors are reported in parentheses.

Appendix C

APPENDIX FOR CHAPTER 3***C.1 Cross correlation matrix of term premia***

Cross-correlation matrix of term premia other than U.S.-UK is presented in this appendix. The estimates of term premia is based on Wright (2011). Wright (2011) build discrete-time affine term structure model employed by Ang and Piazzesi (2003) and Cochrane and Piazzesi (2008), using quarterly data from 1990 to 2009.

Table C.1: Cross-correlation of term premia

	U.S.	Japan	Germany	UK	Canada	Norway	Sweden	Australia
U.S.	1.00							
Japan	0.88	1.00						
Germany	0.77	0.83	1.00					
UK	0.91	0.94	0.79	1.00				
Canada	0.94	0.89	0.83	0.95	1.00			
Norway	0.79	0.03	0.42	0.61	0.79	1.00		
Sweden	0.88	0.88	0.91	0.95	0.95	0.73	1.00	
Australia	0.91	0.92	0.79	0.98	0.95	0.67	0.96	1.00

C.2 Equilibrium conditions

* implies foreign variables.

- Value function

$$V_t = - \left(\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{N_t^{1+\psi}}{1+\psi} \right) + \beta Q_t \quad (\text{C.1})$$

$$V_t^* = - \left(\frac{C_t^{*1-\gamma}}{1-\gamma} - \frac{N_t^{*1+\psi}}{1+\psi} \right) + \beta Q_t^* \quad (\text{C.2})$$

- Auxiliary variables 1¹

$$Q_t = V_{ss}(X_t)^{\frac{1}{1-\alpha}} \quad (\text{C.3})$$

$$Q_t^* = V_{ss}(X_t^*)^{\frac{1}{1-\alpha}} \quad (\text{C.4})$$

- Auxiliary variables 2

$$X_t = \left(\frac{E_t V_{t+1}}{V_{ss}} \right)^{1-\alpha} \quad (\text{C.5})$$

$$X_t^* = \left(\frac{E_t V_{t+1}^*}{V_{ss}^*} \right)^{1-\alpha} \quad (\text{C.6})$$

- Euler equation for 1 period bond

$$1 = \beta E_t \left(\frac{V_{t+1}}{Q_t} \right)^{-\alpha} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \frac{i_t}{\pi_{t+1}} \quad (\text{C.7})$$

$$1 = \beta E_t \left(\frac{V_{t+1}^*}{Q_t^*} \right)^{-\alpha} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\gamma} \frac{i_t^*}{\pi_{t+1}^*} \quad (\text{C.8})$$

- Euler equation for τ -period bond

$$1 = \beta E_t \left(\frac{V_{t+1}}{Q_t} \right)^{-\alpha} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \frac{Q_{t+1}^{(\tau-1)}}{Q_t^{(\tau)}} \frac{1}{\pi_{t+1}} \quad \text{for } \tau = 1, \dots, 40 \quad (\text{C.9})$$

$$1 = \beta E_t \left(\frac{V_{t+1}^*}{Q_t^*} \right)^{-\alpha} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\gamma} \frac{Q_{t+1}^{*(\tau-1)}}{Q_t^{*(\tau)}} \frac{1}{\pi_{t+1}^*} \quad \text{for } \tau = 1, \dots, 40 \quad (\text{C.10})$$

- Euler equation for the return from capital investment

$$1 = \beta E_t \left(\frac{V_{t+1}}{Q_t} \right)^{-\alpha} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} (A_{t+1} K_{t+1}^{\theta-1} L_{t+1}^{1-\theta} + 1 - \delta) \quad (\text{C.11})$$

$$1 = \beta E_t \left(\frac{V_{t+1}^*}{Q_t^*} \right)^{-\alpha} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\gamma} (A_{t+1}^* K_{t+1}^{\theta-1*} L_{t+1}^{1-\theta*} + 1 - \delta) \quad (\text{C.12})$$

¹Defining auxiliary variables make numerical solution more accurate

- International risk sharing

$$C_t^{-\gamma} = C_t^{*-\gamma}/rer_t \quad \text{for perfect risk sharing} \quad (\text{C.13})$$

$$\left(\frac{P_{F,t}}{P_t}\right)^{-\phi} C_t = \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\phi} C_t^* Tot_t \quad \text{for financial autarky} \quad (\text{C.14})$$

- Stochastic discount factor

$$M_{t+1} = \beta E_t \left(\frac{V_{t+1}}{Q_t}\right)^{-\alpha} \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \frac{1}{\pi_{t+1}} \quad (\text{C.15})$$

- Terms of trade

$$\frac{Tot_t}{Tot_{t-1}} = \frac{\pi_{H,t}}{\pi_{F,t}} \quad (\text{C.16})$$

- Real exchange rate

$$rer_t = \frac{P_t^* S_t}{P_t} \quad (\text{C.17})$$

- Definition of price ratio

$$P_{HH} = \frac{P_{H,t}}{P_t} \quad (\text{C.18})$$

$$P_{FH} = \frac{P_{F,t}}{P_t} \quad (\text{C.19})$$

$$P_{FF} = \frac{P_{F,t}^*}{P_t^*} \quad (\text{C.20})$$

$$P_{HF} = \frac{P_{H,t}^*}{P_t^*} \quad (\text{C.21})$$

- Relationship between price ratios

$$1 = aP_{HH}^{1-\phi} + (1-a)P_{FH}^{1-\phi} \quad (\text{C.22})$$

$$1 = aP_{FF}^{1-\phi} + (1-a)P_{HF}^{1-\phi} \quad (\text{C.23})$$

- Optimal price setting

$$mc_t = \frac{\eta-1}{\eta} + \frac{\xi}{\eta} \left(\frac{\pi_{H,t}}{\bar{\pi}_H} - 1\right) \frac{\pi_{H,t}}{\bar{\pi}_H} - \frac{1}{\eta} E_t M_{t+1} \left[\xi \left(\frac{\pi_{H,t+1}}{\bar{\pi}_H} - 1\right) \frac{\pi_{H,t+1}}{\bar{\pi}_H} \frac{Y_{t+1}}{Y_t} \right] \quad (\text{C.24})$$

$$mc_t^* = \frac{\eta-1}{\eta} + \frac{\xi}{\eta} \left(\frac{\pi_{F,t}^*}{\bar{\pi}_F} - 1\right) \frac{\pi_{F,t}^*}{\bar{\pi}_F} - \frac{1}{\eta} E_t M_{t+1} \left[\xi \left(\frac{\pi_{F,t+1}^*}{\bar{\pi}_F} - 1\right) \frac{\pi_{F,t+1}^*}{\bar{\pi}_F} \frac{Y_{t+1}^*}{Y_t^*} \right] \quad (\text{C.25})$$

- Real marginal cost of labor

$$mc_t = \frac{W_t}{(1-\theta)A_t K_t^\theta N_t^{-\theta}} \quad (\text{C.26})$$

$$mc_t^* = \frac{W_t^*}{(1-\theta)A_t^* K_t^{*\theta} N_t^{*-\theta}} \quad (\text{C.27})$$

- Labor supply

$$\frac{N_t^\psi}{C_t^{-\gamma}} = W_t \quad (\text{C.28})$$

$$\frac{N_t^{*\psi}}{C_t^{*-\gamma}} = W_t^* \quad (\text{C.29})$$

- Production function

$$Y_t = A_t K_t^\theta N_t^{1-\theta} \quad (\text{C.30})$$

$$Y_t^* = A_t^* K_t^{*\theta} N_t^{*1-\theta} \quad (\text{C.31})$$

- The law of the motion of capital

$$K_{t+1} = (1-\delta)K_t + I_t \quad (\text{C.32})$$

$$K_{t+1}^* = (1-\delta)K_t^* + I_t^* \quad (\text{C.33})$$

- Goods market clearing

$$Y_t = a \left(\frac{P_{H,t}}{P_t} \right)^{-\phi} C_t + (1-a) \left(\frac{P_{H,t}^*}{P_t^*} \right)^{-\phi} C_t^* + I_t + \frac{\xi}{2} \left(\frac{\pi_t^H}{\pi_{ss}} - 1 \right)^2 Y_t \quad (\text{C.34})$$

$$Y_t^* = a \left(\frac{P_{F,t}^*}{P_t^*} \right)^{-\phi} C_t^* + (1-a) \left(\frac{P_{F,t}}{P_t} \right)^{-\phi} C_t + I_t^* + \frac{\xi}{2} \left(\frac{\pi_t^{*F}}{\pi_{ss}} - 1 \right)^2 Y_t^* \quad (\text{C.35})$$

- Monetary policy rule

$$\frac{i_t}{\bar{i}} = \left(\frac{i_{t-1}}{\bar{i}} \right)^{\rho_i} \left[\left(\frac{\pi_t}{\bar{\pi}} \right)^{\rho_\pi} \left(\frac{Y_t}{\bar{Y}} \right)^{\rho_y} \right]^{1-\rho_i} \quad (\text{C.36})$$

$$\frac{i_t^*}{\bar{i}^*} = \left(\frac{i_{t-1}^*}{\bar{i}^*} \right)^{\rho_i} \left[\left(\frac{\pi_t^*}{\bar{\pi}^*} \right)^{\rho_\pi} \left(\frac{Y_t^*}{\bar{Y}^*} \right)^{\rho_y} \right]^{1-\rho_i} \quad (\text{C.37})$$

- Productivity shock

$$\log A_t = \rho_A \log A_{t-1} + \sigma_{A,t} \varepsilon_t \quad (\text{C.38})$$

$$\log A_t^* = \rho_A \log A_{t-1}^* + \sigma_{A,t}^* \varepsilon_t^* \quad (\text{C.39})$$

- Stochastic volatility shock

$$\log \sigma_{A,t} = (1 - \rho_\sigma) \log \sigma_{SS} + \rho_\sigma \log \sigma_{A,t-1} + \sigma_A \varepsilon_{\sigma t} \quad (\text{C.40})$$

$$\log \sigma_{A,t}^* = (1 - \rho_\sigma) \log \sigma_{SS}^* + \rho_\sigma \log \sigma_{A,t-1}^* + \sigma_A^* \varepsilon_{\sigma t}^* \quad (\text{C.41})$$

- Nominal yield for maturity τ ($=1, \dots, 40$)

$$(i_t^{(\tau)})^{-\tau} = E_t \left[M_{t+1} M_{t+2} \dots M_{t+\tau} \frac{1}{\pi_{t+1}} \frac{1}{\pi_{t+2}} \dots \frac{1}{\pi_{t+\tau}} \right] \quad (\text{C.42})$$

$$(i_t^{*(\tau)})^{-\tau} = E_t \left[M_{t+1}^* M_{t+2}^* \dots M_{t+\tau}^* \frac{1}{\pi_{t+1}^*} \frac{1}{\pi_{t+2}^*} \dots \frac{1}{\pi_{t+\tau}^*} \right] \quad (\text{C.43})$$

- Nominal term premium for maturity τ

$$NTP_t^{(\tau)} = i_t^{(\tau)} - \frac{1}{\tau} \sum_{j=0}^{\tau-1} E_t i_{t+j} \quad (\text{C.44})$$

$$NTP_t^{*(\tau)} = i_t^{*(\tau)} - \frac{1}{\tau} \sum_{j=0}^{\tau-1} E_t i_{t+j}^* \quad (\text{C.45})$$

C.3 Model with fixed capital

In benchmark model, I assumed endogenous capital in production function. This appendix shows the results from the model with fixed capital in production function (i.e. $Y_{t+j}(i) = A_{t+j} \bar{K}^\theta N_{t+j}(i)^{1-\theta}$) as previously studied by Rudebusch and Swanson (2012), Andreasen (2012) and Ferman (2011). Basically, the intuition of the main result does not change.

Table C.2: Openness and term premium

<i>Unconditional mean</i>	<i>Autarky</i>	<i>Financial autarky</i>	<i>Open Economy</i>
$Mean[Yield\ Spread^{10yr-3m}]$	1.03	0.97	0.84
$Mean[NTP^{10yr-3m}]$	1.09	1.03	0.87
$Corr[Yield\ Spread^{10yr-3m}]$	0.00	0.08	0.32
$Corr[NTP^{10yr-3m}]$	0.00	-0.08	-0.42

Table C.3: Correlated shocks across countries

<i>Unconditional mean</i>	<i>corr = 0</i>	<i>corr = 0.3</i>	<i>corr = 0.5</i>	<i>corr = 0.9</i>
$Mean[Yield\ Spread^{10yr-3m}]$	0.84	0.92	0.98	1.07
$Mean[NTP^{10yr-3m}]$	0.87	0.94	0.98	1.06
$Corr[Yield\ Spread^{10yr-3m}]$	0.32	0.32	0.30	0.22
$Corr[NTP^{10yr-3m}]$	-0.42	-0.17	-0.02	0.16

Table C.4: Correlated stochastic volatility shocks

correlation of productivity shock = 0.0

<i>stochastic volatility</i>	<i>corr = 0.0</i>	0.3	0.5	0.7	0.9
<i>Mean</i> [Yield slope ^{10yr-3m}]	0.84	0.82	0.80	0.79	0.77
<i>Mean</i> [NTP ^{10yr-3m}]	0.87	0.87	0.87	0.87	0.87
<i>Corr</i> [Yield slope ^{10yr-3m}]	0.32	0.38	0.41	0.45	0.48
<i>Corr</i> [NTP ^{10yr-3m}]	-0.42	-0.26	-0.15	-0.03	0.09

correlation of productivity shock = 0.5

<i>stochastic volatility</i>	<i>corr = 0.0</i>	0.3	0.5	0.7	0.9
<i>Mean</i> [Yield slope ^{10yr-3m}]	0.98	0.95	0.94	0.92	0.91
<i>Mean</i> [NTP ^{10yr-3m}]	0.98	0.98	0.98	0.98	0.98
<i>Corr</i> [Yield slope ^{10yr-3m}]	0.30	0.39	0.45	0.51	0.57
<i>Corr</i> [NTP ^{10yr-3m}]	-0.02	0.23	0.39	0.57	0.74