ROLE OF RISK AVERSION IN COUNTRIES' PORTFOLIO CHOICES

A Master's Thesis

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July 2012

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ROLE OF RISK AVERSION IN COUNTRIES' PORTFOLIO CHOICES

Graduate School of Economics and Social Sciences
of
Bilkent University

by

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in

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ANKARA

July 2012

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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Supervisor

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ABSTRACT

ROLE OF RISK AVERSION IN COUNTRIES' PORTFOLIO CHOICES

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July 2012

This study aims to investigate the role of endogenously changing risk aversion in the portfolio decisions of the countries in a heterogeneous agents setting. Data shows that developed countries tend to hold more risky assets whereas developing countries hold more risk-free assets. This suggests developed countries to be less risk averse compared to the developing countries. This paper analyzes the role of risk aversion, which changes endogenously depending on the growth rate deviations from the expected growth rate, in the asset demands of countries. Therefore this paper seeks to answer how the asset demands change as the developed countries become more risk averse. In this study, developed countries are assumed to be less risk averse; however, their coefficient of risk aversion increases when their future endowments fall below their expectations, which is an exogenous factor affecting the demand for the assets of the developing countries.

Keywords: Asset Choice, Portfolio Compositions, Endogenous Risk Aversion

ÖZET

RİSKTEN KAÇINMANIN ÜLKELERİN PORTFÖY SEÇİMLERİ ÜZERİNDEKİ ROLÜ

ÖZCAN, Fulya
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Bu çalışma, heterojen ajanlar kullanarak, endojen olarak değişen riskten kaçınma katsayısının ülkelerin portföy kararlarındaki rolünü araştırmaktır. Verilere göre, gelişmekte olan ülkeler risksiz varlıklar tutmaktayken, gelişmiş ülkelerin portföylerinde riskli varlıklar daha çok yer kaplamaktadır. Ülkelerin finansal varlık seçimlerinde bu şekilde farklılaşmış olması, gelişmiş ülkelerin gelişmekte olan ülkelere kıyasla riskten daha az kaçındığını göstermektedir. Bu çalışmada, gelişmiş ülkelerin riskten daha az kaçındığı varsayılmaktadır; ancak, riskten kaçınma katsayısı onların gelecekteki büyüme beklentilerine göre değişmektedir; büyüme oranı beklentilerin altında gerçekleştiği takdirde, riskten kaçınma katsayıları artmaktadır. Riskten kaçınma katsayısı, gelişmekte olan ülkelerin varlıklarına olan talebi etkileyen dışsal bir faktördür. Bu sebeple, bu çalışmada içsel faktörlerin yanısıra yabancıların riskten kaçınmasının değişmesi gibi dışsal faktörlerin gelişmekte olan ülkelelerin varlıklarına olan talebi nasıl değiştireceği incelenmektedir.

Anahtar Kelimeler: Varlık Seçimi, Portföy Kompozisyonları, Endojen Değişen Riskten Kaçınma

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CHAPTER 1

INTRODUCTION

This paper investigates how the portfolio choices and hence the external balances of the countries change as a result of changes in risk aversion. Global imbalances have been raising a lot of concern for the last decades, with the United States being the leading contributor. The fact that the U.S. is running large current account deficits and the periphery economies are financing that deficit by running large current account surpluses has been worrying the policymakers. As seen in Figure-1, the current account position of the U.S. worsens over years. This pattern increases the concerns since the sustainability of external imbalances is doubtful and their correction will require corrections in the exchange rates as well.

One of the main explanations for the global imbalances is the 'savings glut hypothesis' put forward by Bernanke (2005), which suggests that the high savings propensity in 'emerging economies' and some industrialized countries (such as Germany and Japan) has resulted in a rush to U.S. equities due to lack of sufficient investment opportunities elsewhere. This even turned the net foreign asset position of the U.S. into a deficit during the 1990's and the first half of the 2000's (See Figure-2).

It is not only the size or the sign of the external balances but also their composition that has been worrisome for the policymakers. In addition to its highly

negative NFA position, the U.S. also has a critical portfolio composition: long in risky or illiquid assets and short in safe or liquid assets, whereas holdings of the rest of the world (investors of the U.S. securities) have the opposite composition (Gourinchas and Rey, 2007a)). This implies that US has a smaller coefficient of risk aversion compared to the rest of the world.

Risk aversion plays an important role in determining these patterns of foreign asset holdings. One of the main proxies that are used for risk aversion is the volatility perceptions of the investors; as the risk perception increases, this is reflected as higher volatility in the asset prices. Figure-4 plots VIX, Chicago Board

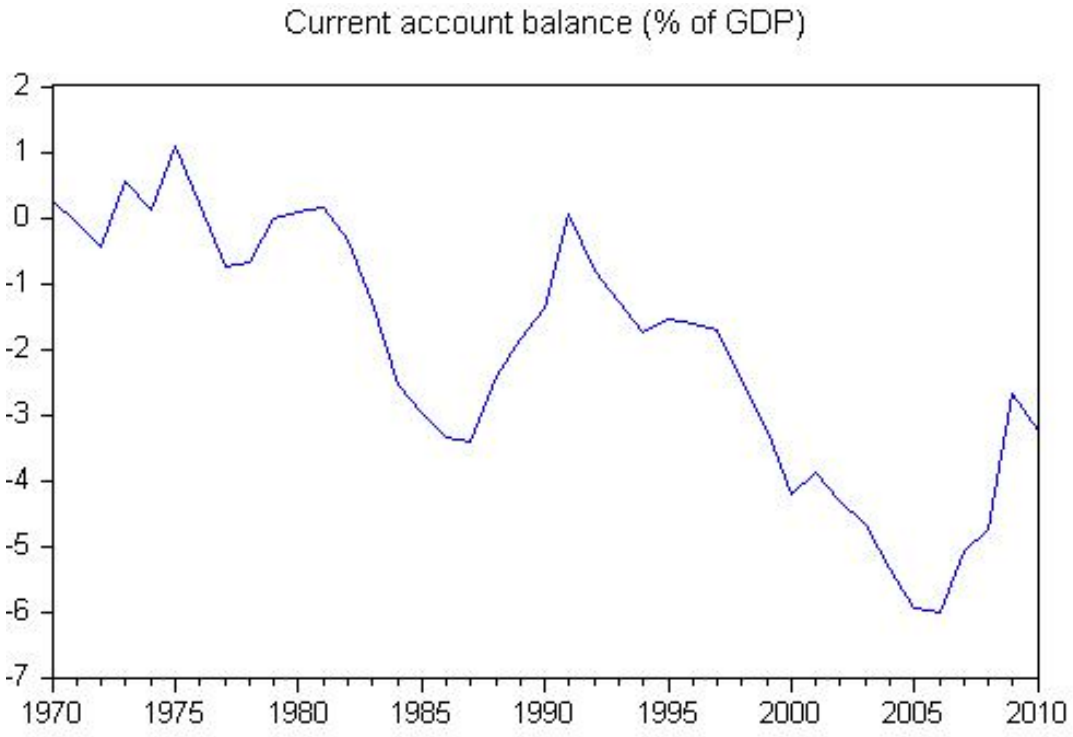

Figure 1: U.S. CA balance as a percentage of GDP - Source: World Bank World Development Indicators and Global Development Finance

Options Exchange Market Volatility Index, for the last two decades. VIX shows investors' risk expectations for the next 30-day period. A change in VIX is caused by a change in investors' risk perception. Therefore as VIX increases, this implies that the investors are perceiving the financial markets to be riskier, and when

the markets are perceived to be risky, investors shift from holding risky assets to holding less risky assets. (See Figure-3 Thus, the risk aversion of the investors is

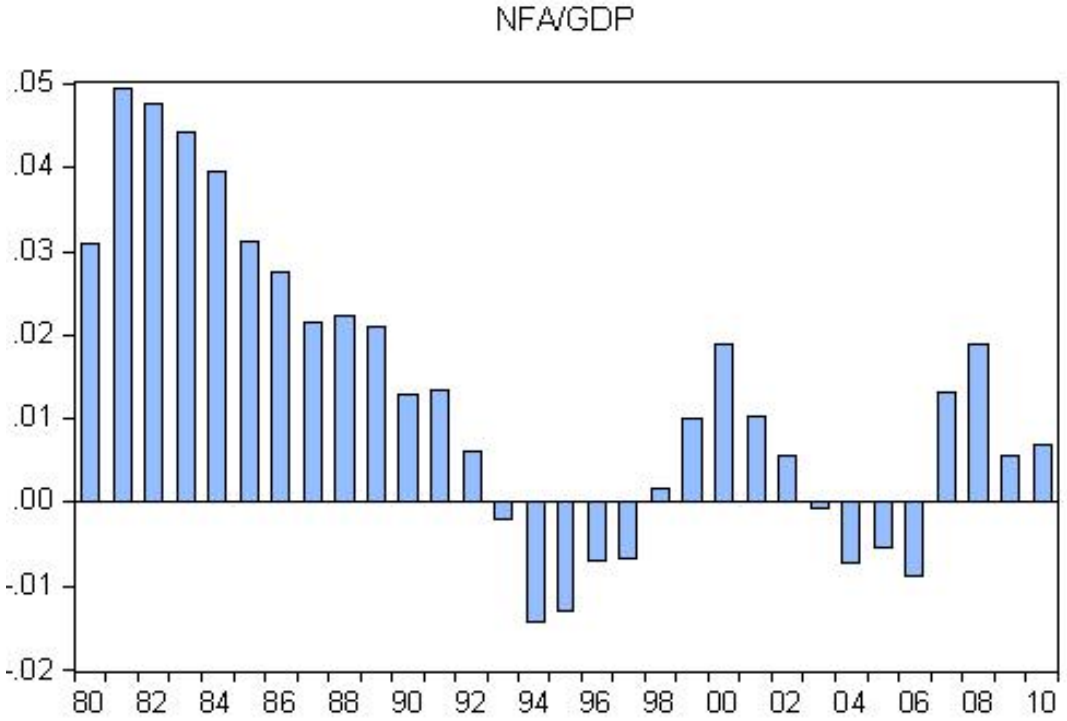

Figure 2: U.S. Net Foreign Asset as a ratio of GDP - Source: World Bank World Development Indicators and Global Development Finance

not constant over time but rather changes depending on the market's situation. The search for investment opportunities as put forward by savings glut hypothesis reveals itself as a very low volatility during the first half of the 2000's, which is then followed by a sudden spike during the global financial crisis. This is because a low risk perception, which reveals itself in a low level of VIX, results in higher asset demand whereas when people suddenly perceive more risk in the market - as in the case of global financial crisis- VIX rises and demand for risky assets falls.

This risk panic is also reflected in the US net foreign asset holdings as a shift from negative to positive position. Table-1 shows the US net securities flows before and during the global financial crisis. During these different phases, changes in risk perception (as can be seen in VIX) affects not only the amount of the

securities but also the composition of the holdings. For instance, at the peak of the crisis -Phase 2- (which also corresponds to the peak of the VIX at 2008), foreign investors of the US securities shift their US holdings from risky to riskless assets, i.e., they increase their holdings of treasury bonds and bills and decrease their holdings of private assets to a great extent. This period is when the highest amount of US official assets are held by the foreigners during crisis. This 'safe haven' or 'flight to quality' affect can be considered as one of the consequences of changes in risk aversion on portfolio holdings. This table therefore exemplifies how changes in risk aversion affects the portfolio compositions.

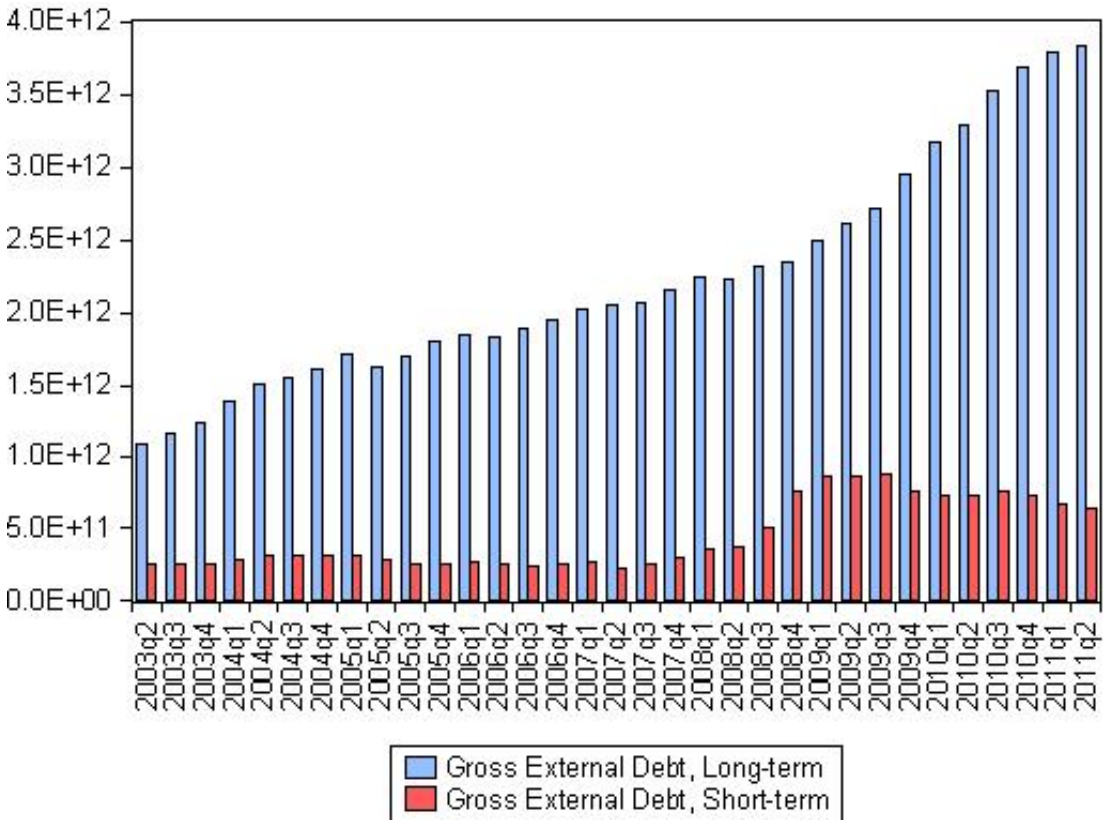

Figure 3: Us Gross Long and Short Term External Debt Position - Source: World Bank Quarterly External Debt Statistics

The aim of this paper is to explore the relationship between changes in risk aversion and portfolio compositions through factors affecting the developed (foreign) country.The effects of changes in mean returns or variance of returns of

domestic assets on foreigners' demand for domestic assets is trivial; as the domestic asset yields increase, holding the variance constant, foreigners increase their demand for domestic asset. In the case where the variance of the domestic assets increase, holding the returns constant, domestic assets become riskier and hence foreigners demand less of the domestic asset. These changes occur due to factors endogenous to the domestic economy. However, there are also factors exogenous to the developing country, but still affect the foreign demand for their assets. For instance, a negative shock to the developed country may result in

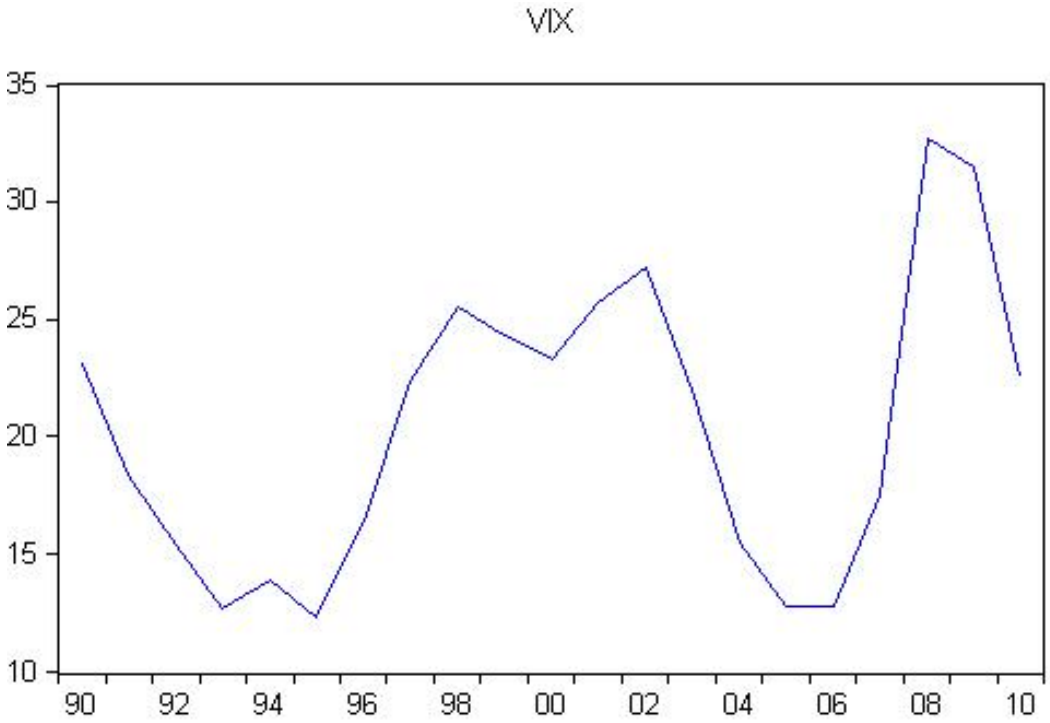

Figure 4: VIX Chicago Board Options Exchange Market Volatility Index - Source: Daily data from CBOE, annual average: author's calculation

the residents of the developed country turning more risk averse than usual and therefore they end up reducing the share of the domestic asset in their portfolios, regardless of the situation in the domestic country. Thus, in this paper, developed country is assumed to be less risk averse and therefore holds more risky assets compared to the developing country. Moreover, since the developed country has a more stable economy than the developing, a negative shock to the

fundamentals in the developed country has a greater impact on the economy, which results in foreigners becoming more risk averse. To relate the patterns observed in the external balances to the changes in the risk aversion, this paper develops an asymmetric open economy DSGE model of two countries, where foreigners, who are originally less risk averse, become more risk averse and eventually change their portfolio compositions. Modelling the effects of the factors exogenous to an economy on the foreign demand for their assets and hence on countries' portfolio compositions is the contribution of this paper to the literature.

This paper is organized as follows: Section-II elaborates more on the literature about global imbalances and risk aversion. In Section-III a DSGE model of two countries with heterogeneous countries is developed. In Section-IV a simplified version of this model is solved, obtaining a closed form solution. In Section-V using data for developing countries and the US, different cases that change the countries' portfolio compositions are analyzed and Section-VI does a robustness check. Section VII concludes.

	Pre-Crisis	**Phase 1**	**Phase 2**	**Phase 3**
	2006-Q2 2007	**Q3 2007-Q2 2008**	**Q3 2008-Q4 2008**	**Q1 2009-Q2 2009**
Securities, total by private investors	368.8	-36.0	358.4	-244.6
Foreign purchases of US securities	765.0	189.9	60.0	12.7
Treasury	-19.7	73.2	323.1	62.0
Coupon securities	-22.9	-10.3	49.9	73.5
Bills	2.1	83.5	273.0	-11.6
Agencies	20.9	-107.4	-183.0	-98.8
Corporate bonds	572.8	82.5	-78.5	-34.3
Equities	191.0	141.6	-1.6	83.8
US purchases of foreign securities	-396.1	-225.9	298.4	-257.2
Bonds	-247.7	-113.3	200.7	-179.1
Equities	-148.5	-112.6	97.7	-78.1
Memo heightForegin official assets in the US	494.7	614.3	199.1	391.8
of which: Treasury bonds	194.2	172.1	103.9	275.9
of which: Treasury bills	-27.2	66.4	486.9	207.7
US official assets abroad	5.0	-62.1	-1,048.7	875.9

Table 1: Net securities flows in the US balance of payments (in billions of US dollars, annual rate) - Source: McCauley and McGuire (2009) - During the second phase of the crisis, which corresponds to the peak point of the VIX, both foreign and U.S. investors shift from holding equities and stocks to holding treasury bills and bonds. This suggests that as the volatility perception increases, investors turn more risk averse and hence move towards holding less risky assets.

CHAPTER 2

RELATED LITERATURE

There are two major channels aiming to explain the current account adjustments. The conventional theory is the intertemporal approach to the current account (Obstfeld and Rogoff, 1995), where the current account deficits are suggested to arise from expected current account surpluses and hence they imply trade surpluses in the future. However, Gourinchas and Rey (2007b) argue that this trade channel is insufficient to explain the current account dynamics as it ignores the capital gains and losses on the external accounts; as a complementary channel, they propose the valuation channel where the adjustment takes place through expectations in foreign portfolio returns. In this study, external balance adjustments happen due to the deviations from the expected endowments, which affect risk aversion. Since risk aversion changes, consequently the portfolio compositions will be affected.

Changes in risk aversion due to endowment shocks in this paper leads the foreign country to require higher returns from the domestic assets, which will be endogenously solved in the model. Therefore there will be an endogenous risk premium for the assets of the developing country. Neumeyer and Perri (2005) models the interest rate of an emerging economy as a function of the world interest rate for risky assets and a country risk where they analyze the role of interest rate fluctuations in determining the output volatility in emerging markets. In their paper, the world interest rate can change due to external factors, whereas there are two sources for the country risk. The country risk can change either

due to external factors (which change the world interest rate without affecting the default risk) or due to fundamentals (which directly affect the default risk). The external factors that they consider are foreign events, contagion or political factors that are independent of the fundamentals of the domestic country. Fundamentals directly affect the default risk as they model the default risk component as a decreasing function of expected productivity. Therefore both changes in the world interest rate and the country's endogenous default risk change the interest rate that country faces. In this paper, risk premium is related to what they refer to as the "foreign events". As foreigners become more risk averse due to their own endowment shocks, they require more premium from the domestic country regardless of the economic conditions of the domestic country. Since this paper incorporates the risk aversion factor into risk premium endogenously, it can be considered as an improvement in the risk premium as risk premium should also capture the changes in risk aversion.

In the general model developed in this paper, risk aversion of the country depends on the realization of their expected future endowments. If their endowment next period is at least as much as their expectation, their risk taking behavior does not change. However since they are not used to negative endowment shocks, once their endowment next period falls below the expected level, they become more risk averse and hence require more return from the assets of the developing country. The negative deviation from the future expectations is incorporated into the foreigner's utility, which is one source of heterogeneity in the model. This formulation of utility is related but not exactly similar to the habit formation models [1]. These models look at the deviations from the past consumption levels (habit). Agents in those models try to improve their consumption levels upon their consumption history. However in this model, agents (foreigners) get disutility once their endowment falls below what they had expected instead of their

[1] See Ferson and Constantinides (1991), Campbell and Cochrane (1999), Ravn et. al. (2006), Verdelhan (2010), for the habit formation models where agents get lower utility as their consumption reduces closer to the habit or subsistence level of consumption. In Borri and Verdelhan (2011), sovereign defaults and bond prices are shown to be depending not only on the economic conditions of the borrower but also on the time-varying risk aversion of the lenders, using external habit preferences for the lenders only.

habit level. This deviation factor in the utility also changes the risk aversion. Since deviation factor is forward-looking, it is another contribution of this paper.

Another source of heterogeneity in this model is that, foreign country is assumed to be less risk averse than the domestic country. This follows from the differences in the portfolio compositions observed in the data. Arslan et. al. (2012) and Gourinchas et. al. (2011a) analyze the portfolio compositions with the ex-ante assumption that the developed countries are less risk averse, and show that both risk premia and portfolio composition can be explained with this difference. However in those papers coefficients of risk aversion do not change as a result of shocks. Guvenen (2009) sets up a model where heterogeneous preferences are caused by the differences in intertemporal elasticity of substitution, using Epstein-Zin preferences which disentangles elasticity of substitution from risk aversion. Again, in that paper risk aversion does not change with endowment shocks.

The changes in size and the composition of external balances are analyzed in two directions in the literature. One strand does the analysis in the demand side of the financial markets, whereas the other analyzes the effect of the asset supplies. The major demand side explanations used in this paper are Mendoza (2009), Mendoza and Quadrini (2009), Kraay and Ventura (1999), Kraay et. al (2005) and Tille and van Wincoop (2009). This study closely follows that of Mendoza et. al. (2009), where the global imbalances are suggested to arise from financial integration of economies with different levels of financial market developments. They assert that these differences also effect the portfolio compositions where financially developed countries end up having a negative net foreign asset position with positive net holdings of risky assets. They set up a DSGE model with incomplete financial markets with shocks to endowment and investment. Their model explains the current patterns and compositions of the foreign asset portfolios. In this study, however, changes in foreigners' risk aversion will be incorporated into the context of heterogeneous endowment processes with a DSGE model to analyze the effects on the composition of external balances as well as their magnitude.

Mendoza and Quadrini (2009), observing the fact that the financial crises in emerging economies having arisen from not only the fundamentals and having spread to many more countries coincided with a "widening period" of global imbalances, analyze the relationship between global financial crisis and financial globalization. In their paper the central role is played by the financial intermediaries, whose net worth is hit by the credit shocks and the heterogeneity of financial markets results in different reactions in portfolio compositions. Their model explains the movements observed in asset holdings prior to global financial crisis and finds that the global contagion and large changes in asset prices can be attributed to the shocks to financial intermediaries. Kraay and Ventura (1999) find that when there is high investment risk compared to diminishing returns to domestic assets, countries have an incentive not to change their foreign to domestic asset compositions in their portfolios whereas when investment risk is low compared to diminishing returns to domestic assets, transitory income shock is always reflected as an investment in the foreign assets. Kraay et. al. (2005) show that size and composition of external balances depend on diminishing returns, production risk and sovereign risk. In a more extended model, Tille and van Wincoop (2009) using a two country DSGE analysis with incomplete financial markets and show that there are three main factors that drive capital flows: portfolio growth, portfolio reallocation associated with time-varying expected returns and risk, and portfolio reallocation associated with time-varying second moments. This paper will contribute to the literature as changes in risk aversion is considered as a factor that changes the portfolio compositions, in addition to the ones presented in the previous studies.

The two major studies with a supply side analysis where incomplete financial markets with different levels of financial deepness are developed are Caballero et. al. (2008a) and (2008b). Caballero et. al. (2008a) suggest that the heterogeneity in financial developments across countries result in discrepancy in asset supplies, and show that global imbalances as well as low interest rates are equilibrium outcomes of this heterogeneity. In Caballero et. al. (2008b), the global financial crisis is attributed to the burst of the asset bubble which was created by the global asset scarcity that had led to a rush to U.S. securities.

CHAPTER 3

GENERAL MODEL

This paper seeks to explore the consequences of a change in the risk aversion of the developed country, caused by its own fundamentals, on the demand for the developing country's assets and the risk premium on those assets. Developed and developing country differ from each other in terms of their risk aversion. Whereas the risk aversion of investors in the developing country is constant at a high level, risk aversion of the investors in the developed country is subject to change depending on the performance of the economy. When the economy performs poorly compared to the expectations, investors in the developed country change their portfolio compositions and/ ir they require a higher premium form the domestic assets. This in turn affects the external balances of both countries.

This paper sets up a dynamic stochastic general equilibrium model with heterogeneous countries. There are two countries in consideration: domestic and foreign. Each country has a continuum of identical households and hence their preferences admit a representative household. However, there is one representative agent in each country as they differ in their risk preferences. Domestic and foreign interest rates differ from each other by the amount of the risk premium. The risk premium for the domestic assets arises from the fact that domestic country is less developed compared to foreign country. For the sake of simplicity, countries are endowment economies with no production. Utility of the domestic agents are not affected by the deviations in their endowments. However, once the foreigners receive a lower endowment than they had expected, they turn more risk

averse. Therefore, endowment fluctuations are incorporated into their utility. Investors becoming more risk averse changes the interest rate through risk premium, as they require higher return from the domestic assets. Consequently, expected returns and hence asset demands also change, which then leads to adjustments in the portfolio decisions. The adjustments in portfolio decisions can take form in a magnitude change (positive or a negative portfolio growth) or a composition change (allocation between foreign and domestic holdings, as well as allocation between risky and safe assets). These changes eventually affect external balances.

This paper does not regard domestic country as a small open economy as country size is not an issue here. Instead, the two countries differ from each other in terms of their development levels. Investing in domestic economy is riskier than in foreign economy as the domestic country is a developing country. Foreign bonds on the other hand, are considered as risk-free assets, which earn the risk free interest rate. This drives a wedge between foreign and domestic interest rates. This wedge is the risk premium which is a function of the deviation from the expected foreign endowment. In this sense, the interest that the foreign bonds pay can be considered as the world interest rate. Given these, foreign economy can be considered to represent U.S. whereas the domestic economy represents the periphery countries as a whole, i.e., the financial counterparts of the U.S. financial account imbalance.

3.1 Households

Throughout this paper, households are utility maximizers from consumption of domestic and foreign goods only. The utility function depends on the risk aversion of the households. Their income constraint depends on their endowments and returns from asset holdings. Domestic and foreign agents trade with each other, so they maximize their utility from the consumption of the both domestic and foreign goods.

3.1.1 Type of the Utility Function

Since the aim of this paper is to determine the effect on the portfolio choices resulting from the changes in risk aversion depending on endowment shocks, choosing the appropriate type of utility function is crucial for the analysis. The two candidates are the usual CRRA (constant relative risk aversion) utility and non-expected/ recursive utility. In CRRA utility, intertemporal elasticity of substitution and coefficient of relative risk aversion are reciprocals of each other. Therefore, this requires an a priori belief that high risk aversion comes along with low intertemporal elasticity of substitution[2]. Moreover, it may not be possible to determine the sole effect of changes in risk aversion if risk aversion is related to thee intertemporal elasticity of substitution.

One alternative to overcome this problem is to use Epstein and Zin preferences instead of CRRA utility (Epstein and Zin, 1989). By using recursive and non-expected utility, authors are able to disentangle the sole effect of risk aversion from the intertemporal elasticity of substitution. In order to conclude that this class of utility functions are suitable for the portfolio choice analysis, it is important to compare the asset choices using both non-expected recursive utility and CRRA utility. One study that does so is that of Giuliano and Turnovsky (2003), where authors show that using CRRA utility causes biased results in portfolio weights[3]. However, their analysis is on choosing different parametric values for risk aversion and intertemporal elasticity of substitution and comparing the results on portfolio choices. Since this is a parametric exercise on coefficient of risk aversion, whose true value is almost impossible to determine, arguing that CRRA brings about biased results might also be a biased conclusion.

The utility function that would suit the exercise in this paper should allow the coefficient of relative risk aversion to increase as there is a negative endowment shock. This idea leads to finding a "risk vulnerable" utility function. By incorporating another risk ("background risk") to an agent's wealth, Gollier and

[2]See Hall (1988) and Weil (1990) for a separation between risk aversion and intertemporal elasticity of substitution.

[3]For more work in asset choice literature using non-expected recursive utility, see Obstfeld (1994) and Bhamra and Uppal (2006).

Pratt (1996) show that the agent becomes more risk averse for another independently risky alternative. This paper would like to show that as foreigners receive a negative endowment shock, their risk aversion for the domestic assets, which has no correlation with their endowment process, increases; which is very similar to the risk vulnerability idea. Gollier and Pratt (1996) determine the conditions for a type of utility function to be risk vulnerable and find that CRRA utility is among many other classes that are risk vulnerable. Therefore CRRA utility would be sufficient for the analysis in this paper.

3.1.2 Domestic Households

Domestic agents consume both foreign and domestic goods. Two types of goods are aggregated using a CES (constant elasticity of substitution) utility function with CRRA preferences. The relevant utility function for the representative risk averse household for domestic country with a constant coefficient of relative risk aversion is as follows:

$$U(c_t^d, c_t{*}^d) = \frac{\left[(c_t^d)^{\eta_d}(c_t{*}^d)^{(1-\eta_d)}\right]^{(1-\alpha_d)} - 1}{1-\alpha_d} \tag{3.1}$$

(3.1)

The corresponding RRA coefficient:

$$\phi_d = \alpha_d \tag{3.2}$$

Total per capita consumption in period t equals:

$$c_t = c_t^d + c_t{*}^d \tag{3.3}$$

where c_t^d is the per capita domestic good consumption by domestic agents at period t,$c_t{*}^d$ is the per capita foreign good consumption by domestic agents at period t, and $1/\alpha_d$ is the coefficient of intertemporal elasticity of substitution for domestic country, and η_d is the constant elasticity of substitution between domestic and foreign goods.

3.1.3 Foreign Households

Foreign households are assumed to be less risk averse, and their utility depends on the deviations of their endowments from their expectations, as well as their consumption[4]. In modelling the utility function which incorporates deviations of wealth, this paper adopts the hyperbolic absolute risk aversion utility function in the following form, again using CES aggregation for both types of goods:

$$U(c_t{*}^f, c_t^f) = \frac{\left[(c_t\,{*}^f - \gamma_t)^{\eta_f} (c_t^f)^{(1-\eta_f)}\right]^{(1-\alpha_f)} - 1}{1-\alpha_f} \tag{3.4}$$

The corresponding RRA coefficient:

$$\phi_f = \alpha_f \left(\frac{c_t}{c_t - \gamma_t}\right) \tag{3.5}$$

Total per capita consumption in period t equals:

$$c_t{*} = c_t\,{*}^f + c_t^f \tag{3.6}$$

Here, γ_t is considered as a preference parameter that governs the relationship between wealth level and RRA, and defined as a function of the deviations from the expected endowment:

$$\gamma_{t+1} = -\frac{1}{2}\{(y_{t+1}^* - E_t[y_{t+1}^*]) - |y_{t+1}^* - E_t[y_{t+1}^*]|\} \tag{3.7}$$

There are two possible cases for γ. If foreigners receive at least as much endowment as they had expected i.e., if $y_{t+1}^* \geq E_t[y_{t+1}^*]$, then $\gamma_{t+1} = 0$; so the risk aversion coefficient does not change. However, once they receive less endowment i.e., $y_{t+1}^* \leq E_t[y_{t+1}^*]$, then γ becomes positive and hence foreigners turn more risk averse.

[4]Borri and Verdelhan (2011) also introduces a heterogeneity between agents in terms of their preferences. In their model borrowers have a CRRA utility with constant RRA whereas lenders exhibit external habit preferences with CRRA utility, which results in lenders having a varying risk aversion coefficient.

3.2 Endowment

The sources of income of the household depends on the type of the economy. In the endowment economy, households receive stochastic endowments each period and due to this uncertainty, they buy foreign and domestic bonds.

Assume that domestic and foreign economy are endowed with income y_t and y_t^* respectively. Since domestic economy represents the surplus countries as a whole, evolution of y_t is chosen to be mean-reverting at the level, whereas for the foreign economy this process is mean-reverting at the growth rate and hence endowment process is explosive so that foreign economy runs CA deficits[5]. These processes are chosen in order to mimic the patterns observed in the data. The country that runs the CA deficits represents the developed country, which in fact represents the U.S., whereas the country that runs CA surplus is a representative developing country. The path y_t follows therefore is given by:

$$(y_{t+1} - \bar{y}) = \rho_d(y_t - \bar{y}) + u_{t+1} \tag{3.8}$$

The path for y_t* follows therefore is given by:

$$(y_{t+1}^* - y_t^*) = \rho_f(y_t^* - y_{t-1}^*) + v_{t+1} \tag{3.9}$$

where u and v are white noise processes and $0 < \rho_d < 1$ and $0 < \rho_f < 1$ so that the process itself is not explosive.
Then, the budget constraint for the domestic representative household is given by:

$$A_{t+1} + S_{t+1} + C_t - R_t^s S_t - R_t^* A_t = y_t \tag{3.10}$$

For the foreign household:

$$A_{t+1}^* + S_{t+1}^* + C_t^* - R_t^s S_t^* - R_t^* A_t^* = y_t^* \tag{3.11}$$

where

- A_t : one period risk-free bonds issued by foreign country and held by domestic country

[5]This follows from Obstfeld and Rogoff (1996).

- S_t : one period risky bonds issued by domestic country and held by domestic country
- C_t : total consumption of domestic household in period t
- R_t^* : gross return on foreign assets in period t, (R_{t+1}^* is known today)
- R_t^s : gross return on domestic assets in period t
- A_t^* : one period risk-free bonds issued by foreign country and held by foreign country
- S_t^* : one period risky bonds issued by domestic country and held by foreign country
- C_t^* : total consumption of foreign household in period t

In Neumeyer and Perri (2005), it is assumed that the US interest rate follows an AR(1) process. In their study, they use real yield on an index on non-investment grade domestic bonds and find the AR(1) coefficient. In this paper, it is also assumed that the risk-free interest rate follows an AR(1) process.However, shocks to interest rate at time t happen one period ahead so that the interest rate next period is known with certainty ie., $E_t[R_{t+1}^*] = R_{t+1}^*$:

$$R_t^* = \rho_r R_{t-1}^* + w_{t-1} \tag{3.12}$$

The relation between risk-free and risky rate is as follows:

$$R_t^s = \theta_t + R_t^* \tag{3.13}$$

where θ is the risk premium which will be explained in more detail in the following section.

3.3 Risk Premium

Risk premium for the domestic assets has two components; domestic and foreign. Domestic risk premium component, θ_t^d is a function of the domestic

endowment whereas foreign risk premium component θ_t^f depends not only on the foreign endowment but also on the deviation form the expected endowment, γ_t. Thus, the relationship between risk-free and risky rates can be separated in the following form:

$$R_{t+1}^s = R_{t+1}^* + \theta_{t+1}^d + \theta_{t+1}^f \tag{3.14}$$

where $\theta_t = \theta_t^d + \theta_t^f$

At time t, the domestic premium for the next period, θ_{t+1}^d is known by the domestic agents, but this information is not available to the foreigners. This can be considered as a one-period information lag between the two countries. Therefore the expected return from the domestic assets for the domestic agents is as follows:

$$E_t[R_{t+1}^s]^d = R_{t+1}^* + \theta_{t+1}^d + E_t[\theta_{t+1}^f] \tag{3.15}$$

In the similar manner, at time t, foreigners know how much the foreign premium, θ_{t+1}^f will be next period, but domestic agents do not know this. Then, expected return from the domestic assets for the foreigners is as follows:

$$E_t[R_{t+1}^s]^f = R_{t+1}^* + \theta_{t+1}^f + E_t[\theta_{t+1}^d] \tag{3.16}$$

These premiums will be calculated endogenously from the optimization problems from the domestic and foreign households.

3.4 External Balances

Financial account in both economies is defined as the differences in the changes in domestic and foreign holdings of for both countries.

$$FA_t = [S_t^* - S_{t-1}^*] - [A_t - A_{t-1}] \tag{3.17}$$

$$FA_t^* = [A_t - A_{t-1}] - [S_t^* - S_{t-1}^*] \tag{3.18}$$

3.5 Market Clearance Conditions

In each economy, endowment at time t is either consumed by the households in that country or traded with the agents in the other country in return for assets which are purchased by both residents and non-residents of that country. Thus, the market clearance conditions are as follows:

$$y_t = c_t^d + c_t^f \tag{3.19}$$

$$y_t^* = c_t *^f + c_t *^d \tag{3.20}$$

3.6 First Order Conditions

In both countries, representative agents solve the same maximization problem with respect to the same constraint. Therefore for the beginning it suffices to solve for the maximization problem of the domestic household to save from notation:

$$max \sum_0^\infty \beta^t U(c_t^d, c_t^{*d}) \text{ subject to (3.10)}$$

Unconstrained Bellman: Representative domestic agent will choose how much to allocate between risky and risk free bonds and to the domestic good. First the agent allocates between assets given c_t^d and c_t^{*d}:

$$V(S_t, A_t; c_t^d, c_t^{*d}) = \max_{\{S_t, A_t\}} \{U(c_t^d, y_t + R_t^s S_t + R_t^* A_t - A_{t+1} - S_{t+1} - c_t^d) + \\ + \beta E_t V[S_{t+1}, A_{t+1}; c_{t+1}^d {c_{t+1}^*}^d]\} \tag{3.21}$$

First Order Conditions:

$$S_{t+1} : (1-\eta_d)\Big[(c_{t+1}^d)^{\eta_d}({c_{t+1}^*}^d)^{(1-\eta_d)}\Big]^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}*^d)^{-\eta_d} = \beta E_t[V_{St+1}] \tag{3.22}$$

$$A_{t+1} : (1-\eta_d)\Big[(c_{t+1}^d)^{\eta_d}(c_{t+1}*^d)^{(1-\eta_d)}\Big]^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}*^d)^{-\eta_d} = \beta E_t[V_{At+1}] \tag{3.23}$$

Envelope Conditions:

$$S_t : V_{St} = R_t^{s(1-\eta_d)}(1-\eta_d)\Big[(c_t^d)^{\eta_d}(c_t*^d)^{(1-\eta_d)}\Big]^{-\alpha_d}(c_t^d)^{\eta_d}(c_t*^d)^{-\eta_d} \tag{3.24}$$

$$A_t : V_{At} = R_t^{*(1-\eta_d)}(1-\eta_d)\Big[(c_t^d)^{\eta_d}(c_t{*}^d)^{(1-\eta_d)}\Big]^{-\alpha_d}(c_t^d)^{\eta_d}(c_t{*}^d)^{-\eta_d} \tag{3.25}$$

Then the resulting first order conditions for the domestic household are as follows: Iterating 3.24 and 3.25 one period, taking expectations and substituting back into 3.22 and 3.23 yield:

$$\beta E_t\left[R_{t+1}^s\Big\{(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{-\eta_d}\right] =$$

$$\Big\{(c_t^d)^{\eta_d}(c_t{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_t^d)^{\eta_d}(c_t{*}^d)^{-\eta_d} \tag{3.26}$$

$$\beta E_t\left[R_{t+1}^*\Big\{(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{-\eta_d}\right] =$$

$$\Big\{(c_t^d)^{\eta_d}(c_t{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_t^d)^{\eta_d}(c_t{*}^d)^{-\eta_d} \tag{3.27}$$

Following the similar steps for the foreign household yields the following set of equations:

$$\beta E_t\left[R_{t+1}^s\Big\{(c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(1-\eta_f)}\Big\}^{-\alpha_f}(c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{-\eta_f}\right] =$$

$$\Big\{(c_t*^f-\gamma_t)^{\eta_f}(c_t^f)^{(1-\eta_f)}\Big\}^{-\alpha_f}(c_t*^f-\gamma_t)^{\eta_f}(c_t^f)^{-\eta_f} \tag{3.28}$$

$$\beta E_t\left[R_{t+1}^*\Big\{(c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(1-\eta_f)}\Big\}^{-\alpha_f}(c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{-\eta_f}\right] =$$

$$\Big\{(c_t*^f-\gamma_t)^{\eta_f}(c_t^f)^{(1-\eta_f)}\Big\}^{-\alpha_f}(c_t*^f-\gamma_t)^{\eta_f}(c_t^f)^{-\eta_f} \tag{3.29}$$

Equating the Euler Equations for the domestic agents:

$$\beta E_t\left[R_{t+1}^s\Big\{(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{-\eta_d}\right] =$$

$$\beta E_t\left[R_{t+1}^*\Big\{(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{(1-\eta_d)}\Big\}^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{*}^d)^{-\eta_d}\right] \tag{3.30}$$

Substituting 3.15 yields the domestic risk premium:

$$\theta^d_{t+1} = -\frac{E_t\left[\theta^f_{t+1}\left\{(c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{(1-\eta_d f)}\right\}^{-\alpha_d}(c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{-\eta_d}\right]}{E_t\left[\left\{(c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{(1-\eta_d)}\right\}^{-\alpha_d}(c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{-\eta_d}\right]} \tag{3.31}$$

Following the similar steps for the foreigner and substituting 3.16 yields the foreign risk premium:

$$\theta^f_{t+1} = -\frac{E_t\left[\theta^d_{t+1}\left\{(c_{t+1}{*^f} - \gamma_{t+1})^{\eta_f}(c^f_{t+1})^{(1-\eta_f)}\right\}^{-\alpha_f}(c_{t+1}{*^f} - \gamma_{t+1})^{\eta_f}(c^f_{t+1})^{-\eta_f}\right]}{E_t\left[\left\{(c_{t+1}{*^f} - \gamma_{t+1})^{\eta_f}(c^f_{t+1})^{(1-\eta_f)}\right\}^{-\alpha_f}(c_{t+1}{*^f} - \gamma_{t+1})^{\eta_f}(c^f_{t+1})^{-\eta_f}\right]} \tag{3.32}$$

After choosing the asset holdings, agents decide how much to consume from each type of good (domestic and foreign). Due to CES utility, the ratio of home goods to imported goods are as follows:

$$\frac{c^d_t}{c_t{*^d}} = \frac{\eta_d}{(1-\eta_d)} \tag{3.33}$$

$$\frac{(c_t{*^f} - \gamma_t)}{c^f_t} = \frac{\eta_f}{(1-\eta_f)} \tag{3.34}$$

3.7 Euler Equations

Euler equations for domestic and foreign households are as follows:

$$\beta E_t[R^*_{t+1}]E_t\{\frac{\left[\left((c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{(1-\eta_d)}\right)^{-\alpha_d}(c^d_{t+1})^{\eta_d}(c_{t+1}{*^d})^{-\eta_d}\right]}{\left[\left((c^d_t)^{\eta_d}(c_t{*^d})^{(1-\eta_d)}\right)^{-\alpha_d}(c^d_t)^{\eta_d}(c_t{*^d})^{-\eta_d}\right]}\} = 1 \tag{3.35}$$

$$\beta E_t[R^*_{t+1}]E_t\{\frac{\left[\left((c^*_{t+1}{}^f-\gamma_{t+1})^{\eta_f}(c^f_{t+1})^{(1-\eta_f)}\right)^{-\alpha_f}(c^*_{t+1}{}^f-\gamma_{t+1})^{\eta_f}(c^f_{t+1})^{-\eta_f}\right]}{\left[\left((c_t*^f-\gamma_t)^{\eta_f}(c^f_t)^{(1-\eta_f)}\right)^{-\alpha_f}(c_t*^f-\gamma_t)^{\eta_f}(c^f_t)^{-\eta_f}\right]}\}=1 \tag{3.36}$$

From Euler equations, consumption paths are also related as follows:

$$E_t\{\frac{\left[\left((c^d_{t+1})^{\eta_d}(c_{t+1}*^d)^{(1-\eta_d)}\right)^{-\alpha_d}(c^d_{t+1})^{\eta_d}(c_{t+1}*^d)^{-\eta_d}\right]}{\left[\left((c^d_t)^{\eta_d}(c_t*^d)^{(1-\eta_d)}\right)^{-\alpha_d}(c^d_t)^{\eta_d}(c_t*^d)^{-\eta_d}\right]}\}=$$

$$E_t\{\frac{\left[\left((c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c^f_{t+1})^{(1-\eta_f)}\right)^{-\alpha_f}(c_{t+1}*^f-\gamma_{t+1})^{\eta_f}(c^f_{t+1})^{-\eta_f}\right]}{\left[\left((c_t*^f-\gamma_t)^{\eta_f}(c^f_t)^{(1-\eta_f)}\right)^{-\alpha_f}(c_t*^f-\gamma_t)^{\eta_f}(c^f_t)^{-\eta_f}\right]}\} \tag{3.37}$$

The model is summarized in Table-2

An analytical solution for this model could not be obtained due to time constraints. Therefore next chapter introduces a simplified version of this model with parametric results.

Table 2: Model Summary

Equation Specifications	
Domestic Consumption	$C_t = y_t - A_{t+1} - S_{t+1} + R_t^s S_t + R_t^* A_t$
Foreign Consumption	$C_t^* = y_t^* - A_{t+1}^* - S_{t+1}^* + R_t^s S_t^* + R_t^* A_t^*$
Wealth Parameter	$\gamma_{t+1} = -\frac{1}{2}\{(y_{t+1}^* - E_t[y_{t+1}^*]) - \lvert y_{t+1}^* - E_t[y_{t+1}^*]\rvert\}$
Foreigners' RRA coefficient	$\phi_f = \alpha_f(\frac{c_t}{c_t - \gamma_t})$
Domestic Endowment	$(y_{t+1} - \bar{y}) = \rho_d(y_t - \bar{y}) + u_{t+1}$
Foreign Endowment	$(y_{t+1}^* - y_t^*) = \rho_f(y_t^* - y_{t-1}^*) + v_{t+1}$
Domestic Financial Account	$FA_t = [S_t^* - S_{t-1}^*] - [A_t - A_{t-1}]$
Foreign Financial Account	$FA_t^* = [A_t - A_{t-1}] - [S_t^* - S_{t-1}^*]$
Risk Free Rate	$(R_t^* - \bar{R}) = \rho_r(R_{t-1}^* - \bar{R}) + w_{t-1}$
Risky Rate	$R_t^s = R_t^* + \theta_t^d + \theta_t^f$
Domestic Risk Premium	$\theta_{t+1}^d = -\frac{E_t\left[\theta_{t+1}^f\left((c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(1-\eta_d f)}\right)^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(-\eta_d)}\right]}{E_t\left[\left((c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(1-\eta_d)}\right)^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(-\eta_d)}\right]}$
Foreign Risk Premium	$\theta_{t+1}^f = -\frac{E_t\left[\theta_{t+1}^d\left((c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(1-\eta_f)}\right)^{-\alpha_f}(c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(-\eta_f)}\right]}{E_t\left[\left((c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(1-\eta_f)}\right)^{-\alpha_f}(c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(-\eta_f)}\right]}$
Euler Eq. for Domestic	$\beta E_t[R_{t+1}^*]E_t\{\frac{\left[\left((c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(1-\eta_d)}\right)^{-\alpha_d}(c_{t+1}^d)^{\eta_d}(c_{t+1}{}^{*d})^{(-\eta_d)}\right]}{\left[\left((c_t^d)^{\eta_d}(c_t{}^{*d})^{(1-\eta_d)}\right)^{-\alpha_d}(c_t^d)^{\eta_d}(c_t{}^{*d})^{(-\eta_d)}\right]}\} = 1$
Euler Eq. for Foreigner	$\beta E_t[R_{t+1}^*]E_t\{\frac{\left[\left((c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(1-\eta_f)}\right)^{-\alpha_f}(c_{t+1}{}^{*f} - \gamma_{t+1})^{\eta_f}(c_{t+1}^f)^{(-\eta_f)}\right]}{\left[\left((c_t{}^{*f} - \gamma_t)^{\eta_f}(c_t^f)^{(1-\eta_f)}\right)^{-\alpha_f}(c_t{}^{*f} - \gamma_t)^{\eta_f}(c_t^f)^{(-\eta_f)}\right]}\} = 1$
Mean, Domestic Endowment	$\bar{y} = \sum_{s=1}^{t} y_{t-s}$
Domestic Market Clearance	$y_t = c_t^d + c_t^f{}*$
Foreign Market Clearance	$y_t^* = c_t{}^{*f} + c_t{}^{*d}$

CHAPTER 4

SIMPLIFIED MODEL

In order to obtain a closed form solution for the analysis, this chapter introduces a simplified version of the general model. The static model in this chapter closely follows from Giuliano and Turnovsky (2003) where they develop open economy models and analyze portfolio choices and their effects on growth[6].

In this model, domestic representative agent maximizes a standard intertemporal recursive utility function given U(t) defined as:

$$f([1-\phi_d]U(t)) = \left(\frac{1-\phi_d}{1-1/(1-\epsilon)}\right) C(t)^{1-(1/\epsilon)h} + e^{-\rho h} f([1-\phi_d]E_t U(t+h)) \quad (4.1)$$

where

- $C(t) > 0$ is period t consumption
- $\rho > 0$ is the rate of time preference
- $\phi_d > 0$ is the coefficient of relative risk aversion
- $\epsilon > 0$ is the intertemporal elasticity of substitution
- $h > 0$ is the time interval (following Giuliano and Turnovsky (2003), $h \to 0$)

[6]Their methodology is closely related to the one in Svensson (1989) and their framework follows from Obstfeld (1994).

There are again two types of assets, domestic and foreign. There are no endowments or any other sources of income other than the asset yields[7]. Hence, the agent's problem is to determine how much to allocate to consumption, and to domestic and foreign assets.

Domestic asset has a stochastic rate of return R_d over the time interval (t,t+dt):

$$dR_d = r_d dt + dd \tag{4.2}$$

where dd is a Brownian motion with zero mean and $\sigma_d^2 dt$ variance. The same process is also valid for the foreign asset with a Brownian motion process df having a variance $\sigma_f^2 dt$:

$$dR_f = r_f dt + df \tag{4.3}$$

The wealth constraint of the agent is then:

$$W = D + F \tag{4.4}$$

where D denotes the domestic asset holdings and F denotes the foreign asset holdings. Domestic agent maximizes the utility given in 4.1 subject to the stochastic wealth accumulation equation choosing the portfolio shares of domestic and foreign assets ω_d and ω_f:

$$dW = W[\omega_d dR_d + \omega_f dR_f] - Cdt \tag{4.5}$$

Then, the equilibrium conditions as in Giuliano and Turnovsky (2003) are:

$$\omega_d = \frac{r_d - r_f}{\phi_d(\sigma_d^2 + \sigma_f^2)} + \frac{\sigma_f^2}{(\sigma_d^2 + \sigma_f^2)} \tag{4.6}$$

$$\omega_f = 1 - \omega_d \tag{4.7}$$

$$g = \left[\left(\frac{1+\epsilon}{2\phi_d}\right)(r_d - r_f)^2 + \epsilon(r_d\sigma_f^2 + r_f\sigma_d^2) + (1-\epsilon)\frac{\phi_d}{2}\sigma_f^2\sigma_d^2\right]\frac{1}{(r_d\sigma_f^2 + r_f\sigma_d^2)} - \epsilon\rho \tag{4.8}$$

where g is the mean growth rate. For the agents residing in the foreign country, the equilibrium conditions are symmetric:

$$\omega_f^* = \frac{r_f - r_d}{\phi_f(\sigma_f^2 + \sigma_d^2)} + \frac{\sigma_d^2}{(\sigma_f^2 + \sigma_d^2)} \tag{4.9}$$

[7]For models with other sources of income included, see Brunnermeier and Nagel (2008) and Liu (2012).

$$\omega_d^* = 1 - \omega_f^* \tag{4.10}$$

$$g^* = \left[\left(\frac{1+\epsilon}{2\phi_f}\right)(r_f - r_d)^2 + \epsilon(r_f\sigma_d^2 + r_d\sigma_f^2) + (1-\epsilon)\frac{\phi_f}{2}\sigma_d^2\sigma_f^2\right]\frac{1}{(r_f\sigma_d^2 + r_d\sigma_f^2)} - \epsilon\rho \tag{4.11}$$

What differs in this model from that of Giuliano and Turnovsky (2003) is that here domestic and foreign countries have different coefficients of risk aversion. Moreover, in order to obtain CRRA preferences, letting $\epsilon = 1/\phi$ for both countries, growth rates are obtained as:

$$g = \left[\left(\frac{1+1/\phi_d}{2\phi_d}\right)(r_d - r_f)^2 + \frac{1}{\phi_d}(r_d\sigma_f^2 + r_f\sigma_d^2) + (1 - \frac{1}{\phi_d})\frac{\phi_d}{2}\sigma_f^2\sigma_d^2\right]\frac{1}{(r_d\sigma_f^2 + r_f\sigma_d^2)} - \frac{\rho}{\phi_d} \tag{4.12}$$

$$g^* = \left[\left(\frac{1+1/\phi_f}{2\phi_f}\right)(r_f - r_d)^2 + \frac{1}{\phi_f}(r_f\sigma_d^2 + r_d\sigma_f^2) + (1 - \frac{1}{\phi_f})\frac{\phi_f}{2}\sigma_d^2\sigma_f^2\right]\frac{1}{(r_f\sigma_d^2 + r_d\sigma_f^2)} - \frac{\rho}{\phi_f} \tag{4.13}$$

The capital accounts for both domestic and foreign countries are obtained by the following equations:

$$KA_d = \triangle\, \omega_d^* - \triangle\, \omega_f \tag{4.14}$$

$$KA_f = \triangle\, \omega_f - \triangle\, \omega_d^* \tag{4.15}$$

Heterogeneity between the two countries comes from their coefficients of relative risk aversion. It is assumed that the domestic agents have a constant RRA, i.e., $\phi_d = \overline{\phi}_d$.However, foreign agents are assumed be more risk averse while their risk aversion changes with the deviations from their mean growth rate expectations. In order to make sure that such relation exists, VIX is regressed on the US growth rate for the period 1990-2010 (See Figure-5). This regression reveals a negative relationship, very close to unity, between growth rate and the volatility perceptions of the agents. Since this relationship implies that as the economy experiences a lower growth rate the volatility increases; in this model growth rate is considered as a factor that affects risk aversion. For the purpose of explaining the effects of the external factors on portfolio choices, this paper only considers negative shocks to growth rate, which makes a less risk averse agent become

more risk averse, and eventually change his/her portfolio choice. Next chapter calibrates the coefficients of risk aversion for domestic and foreign country given the portfolio weights and then analyzes the how a negative growth shock changes these weights and hence the external balances.

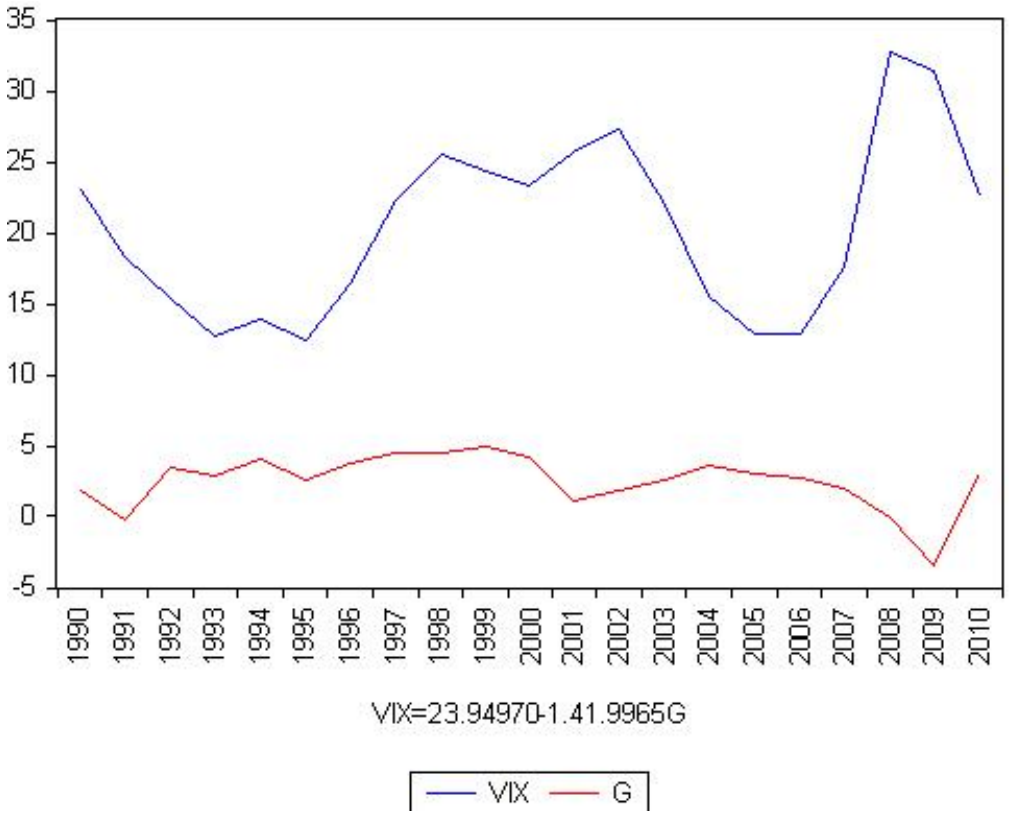

Figure 5: VIX yearly averaged close values and US growth rate. Source: CBOE, World Bank - Investors perceive the financial markets to be riskier when the growth rate is low; whereas as growth rate increases, investors perceive a lower volatility. -

CHAPTER 5

CALIBRATION

Domestic country in this model represents the developing countries whereas foreign country refers to the US. Country size or population rates are neglected as the concern is to determine the sole effect of a change in risk aversion of the less risk averse country on the external balances. Throughout this exercise, the rate of time reference, ρ equals 0.04.

From Gourinchas and Rey (2011a), the ratio of net foreign asset position to gross domestic product for the US is taken and averaged for the period 1990-2010, and is found to be -0.15, which leads to the following equality:

$$NFA_f = \omega_d^* - \omega_f = -0.15 \tag{5.1}$$

Since $NFA_d = -NFA_f$ and that $\omega_d + \omega_f = \omega_d^* + \omega_f^* = 1$, total demands for domestic and foreign assets are obtained to be respectively:

$$\omega_d + \omega_d^* = 0.85 \tag{5.2}$$

$$\omega_f + \omega_f^* = 1.15 \tag{5.3}$$

Next, from World Bank World Data Bank database, mean returns and variance of returns for US and a set of developing countries are obtained for the period 1990-2010, using the real interest rate variable. These countries are chosen as in Mendoza et. al. (2009) and are listed as: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hong Kong, Hungary, Indonesia, Israel, Jordan, Korea, Malaysia, Morocco, Pakistan, Peru, Philippines, Poland,

Russia, Singapore, Saudi Arabia, South Africa, Thailand and Turkey. The values obtained are: $r_d = 0.0821$, $r_f = 0.0437$, $\sigma_d^2 = 0.0065$, and $\sigma_f^2 = 0.000377$. From the External Wealth of Nations-II data set of Lane and Milesi-Ferretti (2006), domestic to foreign holdings ratio of the developing countries listed above and the US are calculated and from these the portfolio weights are found as: $\omega_d = 0.318$ (domestic holdings of the domestic country), $\omega_f = 0.682$ (foreign holdings of the domestic country), $\omega_f^* = 0.3737$ (foreign holdings of the foreign country), and $\omega_d^* = 0.6268$ (domestic holdings of the foreign country). With these values at hand, the coefficient of risk aversion for the domestic and foreign countries can be calibrated. This calibration exercise proves that the residents of the US are less risk averse compared to the ones in the developing countries since $\phi_d = 21.23$ and $\phi_f = 9.77$. However, the reader should note that these portfolio values are initial values for the exercise in this chapter and are used to calibrate the risk aversion coefficients (See Table-3). Domestic representative agent have a constant coefficient of relative risk aversion, whereas the RRA found for the foreign representative agent is only the staring value for the analysis and is not constant.

The following step is to find a relationship between the foreign growth rate and foreigners' risk aversion. For that, a relationship similar to the one in 3.7 is obtained:

$$\phi_f = \overline{\phi}_f + \gamma \tag{5.4}$$

where $\overline{\phi}_f = 9.77$ is the initial value of RRA for the foreign agent, γ is the preference parameter:

$$\gamma = \delta \frac{1}{2}\{(g^* - \overline{g}^*) - |g^* - \overline{g}^*|\} \tag{5.5}$$

where $\overline{g}^* = 0.4\%$ is the initial and hence the expected mean growth rate for the foreign economy. If the economy experiences a growth rate higher than $\overline{g}^*$, risk aversion stays constant at $\overline{\phi}_f$ as $\gamma = 0$. However, if the growth rate is lower than the initial level, then γ becomes positive and ϕ_f increases by the magnitude of γ, which also depends on δ.

The idea of incorporating the deviations from the mean growth rate of wealth in Equation 5.5 follows from the observation that as agents experience a reduction in their wealth, they become more risk averse and hence decrease the weight

Variables	Domestic	Foreign
Coefficient of relative risk aversion	21.23	9.77
Weight of domestic asset	0.318	0.6268
Weight of foreign asset	0.682	0.3737
Mean growth rate	0.24	0.4

Table 3: Initial Values

of the risky domestic asset in their portfolios[8]. What is critical in this analysis is finding a plausible value for δ. In order to do that, firstly one needs to find how changes in growth rate affect the portfolio allocations. For that, data from Calvet et. al. (2009) is taken and the relationship between the changes in wealth and portfolio shares of risky and riskless assets is estimated. According to this regression, as wealth increases by 1 unit, agents decrease the share of riskless asset by 0.7297 units. Supposing that the wealth the representative foreign agent declines by 0.01, the new portfolio weights become: $\omega_f* = 0.381$ and $\omega_d* = 0.612$. The coefficient of risk aversion that implies these new weight is $\phi_f = 9.9$. Thus a 0.01 units decline in wealth causes the coefficient of relative risk aversion of the foreigner to increase by 0.13 units. This exercise is repeated for various changes in wealth and the results are reported at Table 4. With these data, γ values are regressed on the wealth changes and the coefficient from this regression is found as -15.59. Using this value, δ is set to be $\delta = -15.59$.

Once δ is also calibrated, it is able to proceed to study the countries' portfolio decisions. The remainder of this chapter analyzes different cases that affect the portfolio choices of the representative agents of the countries.

[8]With a questionnaire survey data on the clients of a brokerage firm, Cohn et. al. (1975) show that as wealth of the investors increase, their portfolio shares on risky assets also increase. Using data from the Swedish households, Calvet et. al. (2009) show that as the wealth of the households decrease, they allocate a lower share of their wealth to risky assets. Campbell and Cochrane (1999) find risk aversion to be countercyclical using a habit formation model. However, micro-studies by Brunnermeier and Nagel (2008) and Chiappori and Paiella (2008) find risk aversion to be constant with respect to changes in wealth.

5.1 Yield on Domestic Asset Falls by Half

When the yield on the domestic asset falls by half, i.e., $r_d = 0.04105 < r_f$, demand for the domestic asset by both the domestic and the foreign agent falls while the demand for the foreign asset increases: $\omega_d = 0.0368$, $\omega_f = 0.963$, $\omega_f^* = 0.985$ and $\omega_d^* = 0.015$. Notice that both countries still hold a little portion of their wealth in the risky domestic asset although it has a lower return compared to the foreign asset, which is also less risky. This arises from the hedging behavior of the representative agents, which is given from Equation-4.6 by σ_j^2 $(\sigma_i^2 + \sigma_j^2)$ for the agent in country i. This relative ratio of the variances in the portfolio weights determines how the agents diversify their portfolio whereas $(r_i - r_j)/\phi_i(\sigma_i^2 + \sigma_f^2)$ is the speculative behavior[9].

The change in the capital accounts are: $\triangle\ KA_d = -0.892$ and $\triangle\ KA_f = 0.892$, that is, the external position of the domestic country worsens while it improves for the foreign country. This is caused by a factor endogenous to the domestic economy, which supports the trivial argument that the conditions in an economy affects the foreign demand for its assets.

5.2 Growth Rate Reduces by Half

In addition to the factors endogenous to an economy,some external factors might also affect the demand for the assets of that country. If, for instance, the growth rate is observed at 0.2 % instead of 0.4%, it is obtained that $\gamma = 3.118$. Then the coefficient of risk aversion increases to $\phi_f = 12.888$. Keeping the mean and variance of returns constant, this causes foreigners to increase the weight of their own assets in their portfolios while decreasing the weight of the domestic country's asset: $\omega_f* = 0.512$, $\omega_d^* = 0.488$. The the total demand for domestic assets falls as $\omega_d + \omega_d^* = 0.8065$, and demand for foreign assets increases as $\omega_f + \omega_f^* = 1.194$. Then the change in the capital accounts are given as: $\triangle\ KA_d = -0.1388$ and $\triangle\ KA_f = 0.1388$, that is, when foreign agents become more risk averse due to a negative growth shock, they reduce their demand for the risky domestic asset and hence improve their external position. However, due

[9]See Giuliano and Turnovsky (2003) for the discussion of the speculative and hedging behavior.

to this exogenous change, the demand for the domestic assets falling worsens the domestic capital account although the mean returns and variances are unchanged. This example shows how the external factors, such as changes in risk aversion of the foreigners, affects the demand for the assets of the country in consideration and hence its capital account.

5.3 Foreigners Asking for Higher Premium

The last case analyzed in this chapter is foreigners asking for higher risk premium from the domestic assets after experiencing a lower growth rate than they had expected. Following from Section 5.2, suppose that the growth rate is observed at 0.2 % and consequently the coefficient of risk aversion of foreigners increases to $\phi_f = 12.888$. In order for foreigners to continue holding the same portion of their wealth on the domestic asset, i.e., $\omega_d^* = 0.6268$, they require higher return from the domestic asset. Keeping everything else constant, the return on the domestic asset should increase to $r_d = 0.0943$, with a risk premium of $\theta = 0.0122$. With this increase, domestic agents adjust their portfolio choices accordingly and hence allocate $w_d = 0.402$ of their wealth to their own assets. The resulting change in the capital accounts are: $\triangle\ KA_d = 0.084$ and $\triangle\ KA_f = -0.084$, which shows that as the premium on the domestic assets increase holding the variance constant, total demand for the domestic asset increases and hence the external balance of the domestic country is improved. This is another example that shows how the changes in growth rate of the foreign country results in higher risk premium for the domestic assets and hence changes the portfolio allocations. The results of this chapter is summarized at Table- 5.

$\triangle W_f$	ω_f^*	$\triangle \omega_f^*$	ϕ_f	γ
-0.01	0.381176	0.007476	9.900301949	0.130301949
-0.015	0.3848245	0.0111245	9.964763377	0.194763377
-0.02	0.388473	0.014773	10.03006973	0.260069732
-0.025	0.3921215	0.0184215	10.09623773	0.326237733
-0.03	0.39577	0.02207	10.16328455	0.393284548
-0.035	0.3994185	0.0257185	10.2312278	0.4612278
-0.04	0.403067	0.029367	10.30008559	0.530085591
-0.045	0.4067155	0.0330155	10.36987651	0.59987651
-0.05	0.410364	0.036664	10.44061965	0.670619654
-0.055	0.4140125	0.0403125	10.51233464	0.742334645
-0.06	0.417661	0.043961	10.58504165	0.815041648
-0.065	0.4213095	0.0476095	10.65876139	0.88876139
-0.07	0.424958	0.051258	10.73351518	0.963515179
-0.075	0.4286065	0.0549065	10.80932493	1.039324925
-0.08	0.432255	0.058555	10.88621316	1.116213162
-0.085	0.4359035	0.0622035	10.96420307	1.194203069
-0.09	0.439552	0.065852	11.04331849	1.273318494
-0.095	0.4432005	0.0695005	11.12358398	1.353583978
-0.1	0.446849	0.073149	11.20502478	1.435024783
-0.105	0.4504975	0.0767975	11.28766691	1.517666913
-0.11	0.454146	0.080446	11.37153715	1.601537147
-0.115	0.4577945	0.0840945	11.45666307	1.686663066
-0.12	0.461443	0.087743	11.54307308	1.773073081
-0.125	0.4650915	0.0913915	11.63079647	1.860796469
-0.13	0.46874	0.09504	11.7198634	1.949863403
-0.135	0.4723885	0.0986885	11.81030499	2.040304987
-0.14	0.476037	0.102337	11.90215329	2.132153293
-0.145	0.4796855	0.1059855	11.9954414	2.225441397
-0.15	0.483334	0.109634	12.09020342	2.320203423

Table 4: Values for γ- In order to find a relationship between wealth changes and the preference parameter γ, firstly, the portfolio shares to foreign asset by the foreigner is calculated for every 0.5% reduction in the wealth. Then from equation 4.6, the corresponding value for the ϕ_f is calculated. With the values of ϕ_f and wealth changes, using equation 5.5, γ values for each level of wealth is calculated, which finally helps to estimated the other preference parameter, δ. Throughout this exercise, returns and variances are taken at their initial levels.

	Initial Case	**Case-I**	**Case-II**	**Case-III**
	$r_d = 0.0821$ $r_f = 0.0437$ $\sigma_d^2 = 0.0065$ $\sigma_f^2 = 0.000377$ $\gamma = 0$	$r_d = 0.04105$ $r_f = 0.0437$ $\sigma_d^2 = 0.0065$ $\sigma_f^2 = 0.000377$ $\gamma = 0$	$r_d = 0.0821$ $r_f = 0.0437$ $\sigma_d^2 = 0.0065$ $\sigma_f^2 = 0.000377$ $\gamma = 3.118$	$r_d = 0.0943$ $r_f = 0.0437$ $\sigma_d^2 = 0.0065$ $\sigma_f^2 = 0.000377$ $\gamma = 3.118$
ϕ_d	21.23	21.23	21.23	21.23
ϕ_f	9.77	9.77	12.888	12.888
ω_d	0.318	0.0368	0.318	0.402
ω_d^*	0.6268	0.015	0.488	0.6268
ω_f	0.682	0.963	0.682	0.598
ω_f^*	0.3737	0.985	0.512	0.3737
$\triangle\ KA_d$	0	-0.892	-0.1388	0.084
$\triangle\ KA_f$	0	0.892	0.1388	-0.084

Table 5: Results Summary- The values in the initial case come directly from data. Case-I is when the return on domestic assets fall by half, holding other things constant, which results in a reduction in the demand for domestic assets and hence worsens the capital account of the domestic country. Case-II is when the growth rate in the foreign country is realized as half of the expectation, and hence foreigners become more risk averse, shifting their risky domestic holdings to less risky foreign assets, which again worsens the capital account of the domestic country as the total demand for the domestic assets fall. In Case-III, when the foreigners become more risk averse due to the deviation of their growth rate from their expectation, instead of decreasing their risky domestic holdings, they ask for a higher premium for keeping the same portion of their wealth in the domestic asset, which increases the total demand for the domestic asset since the return is increased and hence improves the capital account of the domestic country.

CHAPTER 6

ROBUSTNESS CHECK

This chapter provides a robustness check by analyzing the three cases in Chapter-5 by modifying the preference parameter, γ. Referring back to Figure 4.1, it can also be argued that the foreigners not only become more risk averse when the growth rate is lower but they also become less risk averse when the growth rate is higher, since VIX and growth rate seem to be almost perfectly negatively correlated. Thus, this chapter takes the relationship between growth rate deviation and preference parameter γ symmetric and modifies equation 5.5 by dropping the absolute value terms. So, the new γ becomes:

$$\gamma = \delta(g^* - \overline{g}^*) \tag{6.1}$$

When γ is allowed to change symmetrically with respect to deviations from the expected growth rate, δ is estimated as -12.74, using the same technique as in the previous chapter. With these new preference parameters, this chapter analyzes the three cases again, and also introduces further cases.

6.1 Yield on Domestic Asset Falls by Half

The results of this case does not change since the fall in the yield of the domestic asset does not affect foreigners' risk aversion. So, when the yield on the domestic asset falls by half, i.e., $r_d = 0.04105 < r_f$, again the demand for the domestic asset by both the domestic and the foreign agent falls while the demand for the foreign asset increases: $\omega_d = 0.0368$, $\omega_f = 0.963$, $\omega_f^* = 0.985$

and $\omega_d^* = 0.015$. The external position of the domestic country again worsens as $\triangle\ KA_d = -0.892$ and $\triangle\ KA_f = 0.892$.

6.2 Growth Rate Reduces by Half

Since δ is changed when the coefficient of relative risk aversion responds to the deviations from the expected growth rate symmetrically, the result of this case is different from the one in the previous chapter. If the growth rate is observed at 0.2 % instead of 0.4%, γ becomes 2.55 (it used to be 3.118 in the previous chapter). Then the coefficient of risk aversion increases to $\phi_f = 12.32$. With this new value of ϕ_f, portfolio allocations are updated as: $\omega_f* = 0.492$, $\omega_d^* = 0.508$. Then the change in the capital accounts are given as: $\triangle\ KA_d = -0.1183$ and $\triangle\ KA_f = 0.1183$, which are lower than the values in the previous chapter.

6.3 Foreigners Asking for Higher Premium

Following from the previous section, suppose that the growth rate is observed at 0.2 % and consequently the coefficient of risk aversion of foreigners increases to $\phi_f = 12.32$. In order for foreigners to continue holding the same portion of their wealth on the domestic asset, i.e., $\omega_d^* = 0.6268$, the return on the domestic asset should increase to $r_d = 0.0921$, with a risk premium of $\theta = 0.01$. With this increase, domestic agents adjust their portfolio choices accordingly and hence allocate $w_d = 0.3863$ of their wealth to their own assets. The resulting change in the capital accounts are: $\triangle\ KA_d = 0.0683$ and $\triangle\ KA_f = -0.0683$, which are again lower than the values in the previous chapter.

6.4 Growth Rate Rises by Half

When the coefficient of relative risk aversion can change symmetrically depending on the growth rate deviations, when the growth rate is realized at 0.8% instead of .4%, γ becomes -5.1. Then the coefficient of risk aversion decreases to $\phi_f = 4.67$. Keeping the mean and variance of returns constant, this causes

foreigners to increase the weight of domestic asset in their portfolio by short-selling their own assets : $\omega_f* = -0.25$, $\omega_d^* = 1.25$. The the total demand for domestic assets thus increases and the change in the capital accounts are given as: $\triangle\ KA_d = 0.6232$ and $\triangle\ KA_f = -0.6232$, which improves the capital account of the domestic country to a great extent.

6.5 Domestics Providing Lower Premium

Following from the previous case, suppose the domestic agents decides to lower their premium so that the foreigners continue holding the same portion of their wealth on the domestic asset, i.e., $\omega_d^* = 0.6268$. Keeping everything else constant, the return on the domestic asset should decrease to $r_d = 0.062$, so the risk premium should fall by 0.02. With this change in the domestic returns, domestic agents adjust their portfolio choices accordingly and hence allocate $w_d = 0.18$ of their wealth to their own assets. The resulting change in the capital accounts are: $\triangle\ KA_d = -0.138$ and $\triangle\ KA_f = 0.138$, which worsens the external balance of the domestic country. The results of this chapter is summarized at Table- 6.

	Initial Case	**Case-I**	**Case-II**	**Case-III**	**Case-IV**	**Case-V**
	$r_d = 0.0821$	$r_d = 0.04105$	$r_d = 0.0821$	$r_d = 0.0921$	$r_d = 0.0821$	$r_d = 0.062$
	$r_f = 0.0437$	$r_f = 0.0437$	$r_f = 0.0437$	$r_f = 0.0437$	$r_f = 0.0437$	$r_f = 0.0437$
	$\sigma_d^2 = 0.0065$	$\sigma_d^2 = 0.0065$	$\sigma_d^2 = 0.0065$	$\sigma_d^2 = 0.0065$	$\sigma_d^2 = 0.0065$	$\sigma_d^2 = 0.0065$
	$\sigma_f^2 = 0.000377$	$\sigma_f^2 = 0.000377$	$\sigma_f^2 = 0.000377$	$\sigma_f^2 = 0.000377$	$\sigma_f^2 = 0.000377$	$\sigma_f^2 = 0.000377$
	$\gamma = 0$	$\gamma = 0$	$\gamma = 2.55$	$\gamma = 2.55$	$\gamma = -5.1$	$\gamma = -5.1$
ϕ_d	21.23	21.23	21.23	21.23	21.23	21.23
ϕ_f	9.77	9.77	12.32	12.32	4.67	4.67
ω_d	0.318	0.0368	0.318	0.3863	0.318	0.18
ω_d^*	0.6268	0.015	0.508	0.6268	1.25	0.6268
ω_f	0.682	0.963	0.682	0.6137	0.682	0.82
ω_f^*	0.3737	0.985	0.492	0.3737	-0.25	0.3737
Δ KA_d	0	-0.892	-0.1183	0.0683	0.6232	-0.138
Δ KA_f	0	0.892	0.1183	-0.0683	-0.6232	0.138

Table 6: Results Summary- The values in the initial case come directly from data. Case-I, II and III follow from the previous chapter with the only difference being δ. Case-IV is when the growth rate in the foreign country is realized twice as much of the expectation, and hence foreigners become less risk averse, short-selling their foreign assets and invest in the domestic asset, which improves the capital account of the domestic country as the total demand for the domestic assets rise. In Case-V, when the foreigners become more less averse, domestic agents offer a lower risk premium which allows the foreigners to keep the same portion of their wealth in the domestic asset, which decreases the total demand for the domestic asset since the return is lower and hence worsens the capital account of the domestic country.

CHAPTER 7

CONCLUSION

In this study, the role of endogenously changing risk aversion in the portfolio decisions of the countries in a heterogeneous agents setting is investigated. With the simplified model, using data for the US and the developing countries, it is shown that the US investors have a higher coefficient of risk aversion compared to a developing county resident on average. The relationship between changes in growth rate and the coefficient of risk aversion of the foreign country is estimated and it is found that as the growth rate is realized lower than the expected level, foreigners turn more risk averse and hence lower their demand for the risky domestic assets or require higher risk premium in order to keep their previous portfolio allocations. As a robustness check, the asymmetry in the deviations of the growth rate for the preference parameter is assumed away and hence foreign investors not only become more risk averse when the growth rate is realized at a lower rate than the expected, but they also become less risk averse when the growth rate is realized at a higher level compared to the expected growth rate. When the preference parameter γ is allowed to respond symmetrically to the growth deviations, an increase in the growth rate results in foreigners allocating more of their wealth in the risky domestic asset. Alternatively, they can also continue holding the same portion of their wealth in the risky domestic asset when the domestic returns fall, as less risk averse foreigners require a lower premium for the risky domestic assets. These exercises show that the risk aversion of the investors responds to changes in growth rate and hence agents revise their portfolio allocations accordingly. Thus, demand for assets of a country is affected

not only by the factors endogenous to that country which affect the riskiness or yields of the assets of that country directly, but also by factors exogenous to the country in consideration and yet affects the demand for their assets, such as a change in the risk aversion of the foreign investors caused by the changes in the fundamentals of the foreign country. The general model in Chapter-4 will provide a better insight to this topic; however it is left for future work due to time constraints.

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