Portfolio choice in a two-country DSGE model: Capital flows in emerging economies

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Job Market Paper

October 2017

Abstract

This paper builds an open-economy DSGE model that incorporates the portfolio choice of FDI-equity and bonds to analyze the role of asymmetries in explaining capital flows composition and size in emerging countries. The resulting framework mimics a financially integrated world of two asymmetric countries in which portfolios are time-variant and valuation effects channel matters. Quantitative results suggest that the higher business cycle volatility along with higher nominal rigidities in emerging countries in relation with advanced countries, may explain their positive net bond position and their negative equity position. Home equity bias is shown to be robust to small parameter variations in the model. Finally, the results are compared with a financial autarky version to show how the portfolio size and composition may affect macroeconomic outcomes, especially consumption, net exports and output.

KEY WORDS: Two-country DSGE models, portfolio choice, capital flows, financial globalization, two-way capital flows

JEL: F21, F36, F37, F41, G11, G15.

*I am grateful to my Ph.D advisor Miguel Casares and Pr. Stephanie Schmitt-Grohe for guidance on the theoretical framework of this paper. For comments, I thank Michael Devereux, Kiminori Matsuyama, Hafedh Bouakez, Andres Drenik, Yang Jiao, Justas Dainauskas and Noemie Lisack, as well as participants at the 21st T2M, 3rd RES Junior, 21st ICAMF and Columbia Economic Fluctuations Colloquium. Large parts of this research were completed while I was visiting the Columbia Department of Economics in Fall 2016, for which I received financial support from Caja Navarra Foundation and the Public University of Navarra. I thank Alan Sutherland for providing the code and solving technical issues. All errors are my own. alba.delvillar@unavarra.es PhD student, Department of Economics, Universidad Publica de Navarra. Research financially supported by Sabadell Foundation.
1 Introduction

Since 1990, many countries of the world have experienced a rapid increase in gross capital flows, characterized by large financial accounts in the balance of payments for most countries. As displayed in Figure 1 of the Appendix, average gross external positions are about five times the GDP for major industrialized countries (G7 countries) and grew from 1/3 to more than 2/3 of the GDP for emerging countries (BRICs). Moreover, empirical evidence shows not only large, but also heterogenous external positions across countries, often referred in the literature as two-way capital flows, (Gourichas and Rey, 2013). Figure 2 shows that after 1990, the heterogenous pattern between advanced and emerging countries for net FDI outflows and the rest of financial capital outflows is quite remarkable. In fact, many emerging and developing countries are net importers of foreign direct investment while being net exporters of financial capital. Advanced countries such as the United States do exactly the opposite by importing financial capital and exporting FDI.\footnote{For further reading see Ju and Wei (2010), Ghironi et al., (2005), Gourinchas and Rey (2007), and Tille (2008).}

Recent research is focusing on country portfolio effects on macroeconomic outcomes, especially examining the US exorbitant privilege. Gourichas and Rey (2013) state that “Existent large and heterogenous portfolios might lead to potential wealth transfers across countries when asset prices and exchange rate fluctuate”. Capital gains and losses on gross external asset and liabilities, account for an increasing part of the dynamics of external positions of countries.\footnote{See Benigno (2009), Devereux and Sutherland (2010), Gourichas and Rey (2013) and Rey (2015).} In Figure 3, I show the net foreign asset (NFA) positions and cumulated current accounts for the US, the UK, India and China.\footnote{Data taken from Lane Milessi and Ferretti (2007) Wealth of Nations Dataset.} In the US, cumulative current account deficit is about 60% of GDP, but US foreign position might be underestimated if we take into account the difference relative to NFA. This wide gap represents a capital gain of about 20% of GDP coming from the US external position. Hence, valuation effects matter and they can affect significantly macroeconomic outcomes. This paper examines endogenous portfolio choice and valuation effects in a extended New Keynesian open economy model.

In relation with these empirical facts, several important questions for international economics literature, cannot be answered using the standard open economy theory, which abstracts from a crucial transmission mechanism: portfolio choice. Specifically, what are the effects of large and heterogenous gross external positions for aggregate fluctuations? and, do the size and composition of gross portfolio positions in emerging countries matter?. This paper tries to give some answers to these questions by introducing a two-country DSGE model with endogenous portfolio choice of FDI-equities and bonds calibrated for the relationships between advanced and emerging market economies.

The model builds on the New Keynesian literature related to Woodford (2003), Gali and Monacelli (2005, 2008), Christiano et al., (2010), and its extension to the Open Economy context of endogenous portfolio choice initiated by Devereux and Sutherland (2009, 2010, 2011) and Tille et al., (2008, 2010). Each country can be described by a medium-scale fully-fledged model of the New Keynesian approach in which agents are allowed to con-
sume domestic and foreign goods and optimally purchase financial assets, such as sovereign bonds and FDI-equity. Each economy features home good bias, Calvo-style pricing mechanisms, incomplete financial markets and real and nominal exogenous shocks. Particularly, the environment in each economy is very close to that of Smets and Wouters (2007), except for some frictions not relevant to this study, like physical capital accumulation, wage rigidities and consumption habits.

I report three main findings. First, in the asymmetric case in which the domestic economy faces a higher volatility than the foreign country, two-way capital flows arise and the most volatile economy is less financially integrated than the other one. Thus, the domestic (emerging) economy net bond position becomes positive and its net equity position becomes negative. This result goes in line with the empirical evidence about business cycles in rich countries being approximately half volatile than those in emerging countries or poor countries (Garcia-Cicco, 2010). Moreover, adding a higher degree of nominal rigidities in the home economy, increases the two-way capital flows pattern, which goes in line with Gagnon (2009) who suggests that emerging countries present less flexible nominal prices than advanced countries, using Mexico-US data. Second, the model shows a robust home equity bias, which is close to the empirical evidence for advanced and emerging countries (Courdacier and Rey, 2013). Specifically, results suggest that those countries facing higher degree of nominal rigidities, stronger home good bias and higher business cycle volatilities tend to have a higher degree of home equity bias. Third, the capital gain coming from households portfolio positions is distributed not only by adjusting their position in financial markets but also by adjusting their aggregate consumption which in turn affects net exports and aggregate output.

The contribution of this study is at least threefold; First, I develop a novel two-country dynamic stochastic general equilibrium model with portfolio choice of financial assets to characterize the structural determinants of gross portfolio positions and capital flows behavior in emerging countries. Second, I provide a framework which mimics a financially integrated world of asymmetric countries to study the international business cycle in a setting in which portfolios are time-variant and valuation effects channel matters. Third, I analyse in detail the overall performance of the financially integrated model and I compare it with a financial autarky version to show how portfolio choice affects macroeconomic outcomes.

The rest of the paper is organized in seven sections: Section II describes related literature. Section 3 lays out a two-country DSGE model with international trade in equities and bonds (i.e., the financial integration model). Section 4 explains the portfolio choice solution method. Section 5 uncovers which asymmetries matter and to what extent they matter to determine portfolio positions (i.e., zero-order approximation analysis). Section 6 provides quantitative results and second moment statistics and compares the portfolio model with a financial autarky version. Section 7 concludes with some remarks on further research.
2 Connections to the related literature

Important progress in structural macroeconomic modelling has been achieved since the late 1990s, as reflected in the vast amount of papers on New Keynesian dynamic stochastic general equilibrium (NK DSGE) models. There has also been improvement in generalizing the initially closed-economy NK DSGE models to study the international transmission of shocks and policy design in open economies, giving rise to New Open-Economy Macroeconomics (NOEM, Obstfeld and Rogoff, 1996). NK DSGE models have become standard elements of the macroeconomists’ toolbox, in fact, nowadays they are used in many Central Banks. Nonetheless, the powerful spillover channel created by international financial markets has not been routinely incorporated into these models. Therefore, these models are not useful tools to fully analyze the overall macroeconomic effects of gross capital flows across countries. This work addresses some of the limitations of previous literature by using a fully structural open economy DSGE model with endogenous portfolio choice to analyze various interesting questions in international macroeconomics.

There is a vast theoretical and empirical literature on net foreign assets and current account balance analysis (Obstfeld and Rogoff (1995), Corsetti and Peseti (2001, 2012), Kollmann (2002, 2006) Gali and Monacelli (2005, 2008), among others). The majority of these models restrict the number of financial assets available in the economy. They mostly rely on financial market structures based on Arrow-Debreu securities, which implies assuming complete asset markets and that households are able to fully hedge against country specific income shocks. More recent literature has begun to analyze open economy models in which financial markets are incomplete, mainly by limiting the number or type of assets available in the economy or by limiting the functions of the financial market. For instance, Corsetti et al., (2010, 2011) analyze monetary policy in a context where international financial trade is absent or is restricted to a single non-contingent bond. They show that, in contrast to the previous literature, when international financial markets are incomplete there are significant internal and external trade-offs that prevent optimal policy from simultaneously closing all welfare relevant gaps. In this model, agents are allowed to trade internationally in a wider range of financial assets\(^4\), so that there is more scope for hedging than in one-single asset frameworks, like Corsetti et al., (2010, 2011).

Ju and Wei (2010) remark that while there is a well-settled literature on horizontal FDIs and the gains of multinationals (Helpman et al., (2003)) capital flows across the categories of financial capital and FDI have not received much attention in the literature. Another standard assumption both in closed and open economy models, is to take the representative household as the owner of the firm. By contrast, I will allow firm ownership to be traded through FDI-equities so that agents in each country may hold different portfolios depending on country-specific risk and the returns they expect.

There are just a few two-country general equilibrium models which incorporate endogenous portfolio choice in an open economy framework\(^5\) (Devereux and Sutherland (2008, 2013)).

\(^4\)By including more stochastic shocks we ensure that, despite the presence of more assets, financial markets are still not complete.

\(^5\)See Courdacier and Rey (2013) for an extended literature revision on Open Economy Financial Macroeconomics.
2009, 2010, 2011), Tille, C. et al., (2008, 2010), Engel and Matsumoto, 2009, and Courdacier et al., (2010, 2013)). Until recently, there was no suitable computable method to solve portfolio choice in the context of dynamic stochastic general equilibrium models. However, there has been some developments in macroeconomic modelling to deal with portfolio choice and gross capital flows. Michael Devereux and Alan Sutherland developed a perturbation-based novel method, which is described in Section 4. In Devereux and Sutherland (2008), authors solve a two-country endowment model with international trade in real bonds and equity but constant portfolio shares. Also, in 2010, they published an extended version of their method to allow for time-varying portfolios and another paper with a focus on the role of changes in valuation for the international distribution of wealth. At the same time, a second solution method was proposed Cedric Tille and Wincoop (2010) to examine how current account and net foreign assets react to changes in savings. They use a two country general equilibrium model with physical capital accumulation and international trade in equities using two symmetric economies. Both solution procedures are novel but their mathematical foundations are already established in the literature, in particular the work of Samuelson (1970)\textsuperscript{6}. Samuelson (1970), was the first to establish that in order to derive the \( N \) order component of the portfolio, it is necessary to approximate the portfolio problem up to order \( N+2 \). The important innovation in Devereux and Sutherland work is that they find that to derive the \( N \) order accurate solution for portfolio, only the portfolio optimality conditions need to be approximated up to \( N+2 \) order. The rest of the non-portfolio optimality and equilibrium conditions need only to be approximated up to \( N+1 \), which simplifies the solution considerably.

This paper is also related with number of studies analyzing business cycles in emerging countries. Mainstream research takes into account market failures and monetary policy roles when characterizing economic fluctuations in emerging and developing countries. Nevertheless, there has been a new strand in the literature which argues that emerging market business cycles can be replicated using the neoclassical model with no distortions. Kydland and Zarazaga (2002) argue that the real business cycle model (RBC) can characterize well the lost decade in Argentina in the 1980s. Moreover, Aguiar and Gopinath (2007) suggest that an RBC model driven primarily by permanent shocks to productivity can very well explain the business cycles in developing countries. These authors are aware about the fact that shocks infringing upon emerging countries are quite numerous and of different types but they argue that the combined effect of all different shocks can be modeled as an aggregate shock to total factor productivity with a large non-stationary component. In addition, they show that the neoclassical model is an adequate framework for analyzing the transmission of such shocks.

This model is similar to the one of Engel and Matsumoto (2009), which may be considered a starting point for sticky-price portfolio models in a fully integrated dynamic stochastic general equilibrium (DSGE) framework. They develop a model characterized by complete financial markets to analyze the factors determining portfolio choice in equilibrium. A key difference is that while they solve only equilibrium portfolio shares, in the model presented here, portfolio shares are allowed to vary over time in response to shocks. Moreover, their model features complete financial markets and they assume two

\textsuperscript{6}Judd(1998), and Judd and Guu (2001).
symmetric countries, while I focus on the role of country asymmetries in shaping portfolio choice in the context of incomplete financial markets. Another minor differences are that they use one period in advance price setting mechanism, while I use Calvo(1983)-type pricing mechanism and that they use money-in-the utility function while this paper takes endogenous monetary policy rules which may play an important role in shaping portfolio choice as shown in Devereux et al., (2014).

Finally, this model is also close to Devereux and Sutherland (2009), in the sense that they incorporate portfolio choice dynamics in a structural general equilibrium model of two asymmetric countries. However, their focus is on risk sharing properties of three different financial market structures, (i.e., autarky, complete markets and asymmetric financial markets). Their framework uses one-single good consumption which price level is determined by a simple money rule characterized by a ”velocity shock” to money demand. The model presented in this study, assumes differentiated consumption goods which are international traded and it provides a richer framework in which price and exchange rate fluctuations have sizable effects on country external positions.

3 Financial Integration Model

3.1 The framework

There are two economies in the model that are referred as home (domestic) economy and foreign economy. There is free international trade in goods and financial capital assets (equity and bonds), where equity assets are claims on firms profitability and bonds are claims on each country currencies. Labour is not mobile across economies. I abstract from physical capital accumulation. Regarding the exogenous variables, for each economy there are two AR(1) process for technology, government spending and monetary policy shocks.

In the baseline set up, I consider that economies have equal size for two reasons. On the one hand, I want to focus on the role played by economic structure asymmetries, neutralizing any effect driven by the size of countries. On the other hand, the focus of this paper is not the financial integration of small open economies, but asset flows between advanced and emerging economies, which account for a large part of the total volume of transaction since 1990 (Courdacier and Rey, 2010).

3.2 Households

There is a continuum of households in each economy indexed by j. Representative households maximizes the following lifetime utility function, which is separable in consumption, $C_{jt}$ and hours worked, $N_{jt}$:

$$E \sum_{t=0}^{\infty} \beta_t U_t(C_{jt}, N_{jt})$$

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7Foreign economy is not explicitly displayed here, since it is identical to the one presented in this section, with the specific notation of an asterisk (*).
where $\beta^t$ is the discount factor and the instantaneous utility function takes the following form,

$$U_t(C_{jt}, N_{jt}) = \left[ \frac{C_{jt}^{1-\sigma}}{1-\sigma} - \frac{N_{jt}^{1+\phi}}{1+\phi} \right]$$

(3.1)

Following Schmitt-Grohe and Uribe (2003), I assume an endogenous discount factor to ensure a stationary wealth distribution in the linearized approximated dynamic model.\(^8\) In particular, the discount factor is a function of aggregate consumption determined as follows,

$$\beta_{t+1} = \beta_t (1 + C_t)^{-\nu}$$

(3.2)

The rest of structural parameters from household preferences are the risk aversion parameter ($\sigma > 0$) and the inverse of Frisch labor supply elasticity ($\phi > 0$). Let $C_t$ be a CES composite consumption index defined by,

$$C_t \equiv \left[ (1 - \alpha) (C_{h,t})^{\frac{1}{\theta}} + \alpha (C_{f,t})^{\frac{1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

(3.3)

where $C_{h,t}$ and $C_{f,t}$ are bundles of consumption of home and foreign goods respectively (i.e., the term $C_{f,t}$ refers to imports),

$$C_{h,t} \equiv \left( \int_0^1 C_{h,t}(j)^{\frac{1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, C_{f,t} \equiv \left( \int_0^1 C_{f,t}(j)^{\frac{1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}$$

Hence, the parameter $\alpha \in [0, 1]$ is inversely related to the degree of home bias in preferences\(^9\). Moreover, parameter $\theta > 1$ denotes the elasticity of substitution between domestic and foreign goods from the viewpoint of domestic consumer, and $\epsilon > 1$, denotes the elasticity of substitution between goods produced within the same economy. Standard open macroeconomics models normally sets $\epsilon > \theta$. The optimal choices of domestic and imported goods are

$$C_{h,t} = (1 - \alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} C_t, \ \ C_{f,t} = \alpha \left( \frac{P_{F,t}}{P_t} \right)^{-\theta} C_t$$

(3.4)

The consumption-based price indices that correspond to the above specifications of preferences are given by the following domestic Consumer Price Index (CPI)

$$P_t = \left[ (1 - \alpha) P_{H,t}^{1-\theta} + \alpha P_{F,t}^{1-\theta} \right]^{\frac{1}{1-\sigma}}$$

(3.5)

where $P_{H,t}$ is the price index for domestically produced goods also expressed in domestic currency and $P_{F,t}$ is the price index for foreign produced goods expressed in domestic currency.

**The Household Budget Constraint**

\(^8\)They propose five different ways to induce stationarity in an open economy model. I choose the endogenous discount factor for simplicity.

\(^9\)If price indexes for domestic and foreign goods are equal (as assumed in the steady state equilibrium), the model parameter $\alpha$ corresponds to the share of domestic consumption allocated to imported goods.
Households consume bundles of goods ($C_t$) which can be domestically produced ($C_{h,t}$) or produced abroad ($C_{f,t}$). They acquire equity shares to increase their participation in international financial markets and they increase the amount of national and foreign government bonds held during next period.

As owners of labor services, they obtain real wage ($w_t$) from hours worked ($N_t$). As financial capital owners, they obtain total returns from last period equity and bond holdings ($r_{EH,t}, r_{EF,t}, r_{BH,t}$ and $r_{BF,t}$). The budget constraint of the domestic household, expressed in bundles of consumption goods, is

$$w_t N_t + \frac{P_{H,t}}{P_t} (D_t + V_t) S_{H,t-1} + \frac{P_{F,t}^*}{P_t^*} Q_t (D_t^* + V_t^*) S_{F,t-1}$$

$$+ \frac{B_{H,t-1}}{P_t} + S_t \frac{B_{F,t-1}}{P_t} = C_t + \frac{P_{H,t}}{P_t} V_t S_{H,t} + Q_t \frac{P_{F,t}^*}{P_t^*} V_t^* S_{F,t} + (r_t)^{-1} \frac{B_{H,t}}{P_t} + S_t (r_t^*)^{-1} \frac{B_{F,t}}{P_t}$$

$$+(\bar{g}) e^{G_t}$$

for $t = 1, 2, 3, ...$.

where $V_t$ refers to domestic equity value, $V_t^*$ to foreign equity value, $S_{H,t}$ refers to the share of domestic equity held by domestic households and $S_{F,t}$ refers to that of foreign equity. $B_{H,t}$ and $B_{F,t}$ are the amount of domestic and foreign government bonds purchased by the domestic household in period $t$ to be reimbursed in $t+1$. $D_t$ ($D_t^*$) refers to Dividends. $Q_t$ refers to real exchange rate defined in terms of domestic bundles that can be purchased with one foreign bundle.

$$Q_t = \frac{E_t P_t^*}{P_t}$$

where $E_t$ is the nominal exchange rate also in foreign currency terms. Note that $P_t$ and $P_t^*$ refer to CPI level of each country.

Finally, I assume that total government expenditure is exogenous and it is subject to an stochastic shock process. Following standard literature (Smets and Wouters, 2007), I assume that $G_t$ is 25% of the output in steady state, $\bar{g} = 0.2 \bar{Y}$, and that it is determined by the AR(1) process.

$$G_t = \rho^G G_{t-1} + \epsilon^G_t$$

where $0 < \rho^G < 1$ and $\epsilon^G_t$ is a zero-mean distributed i.i.d shock with $Var[\epsilon^G_t] = \sigma^2_G$.

The key equations coming from the first order conditions from the domestic household optimizing problem are the Euler equation of domestic consumption,

$$C_t^{-\sigma} = \beta E_t [C_{t+1}^{-\sigma} r_{EH,t+1}]$$

The optimality condition for equity and bonds

$$E_t [C_{t+1}^{-\sigma} r_{EH,t+1}] = E_t [C_{t+1}^{-\sigma} r_{EH,t+1}]$$

(3.10)
\[ E_t[ C_{t+1}^{-\sigma} r_{BF,t+1} ] = E_t[ C_{t+1}^{-\sigma} r_{BH,t+1} ] \] (3.11)

and the labour supply function\(^{10}\)
\[ w_t = \chi C_t^\sigma N_t^\phi \] (3.12)

First order conditions (FOC) for domestic holdings of home and foreign equity (returns in domestic consumption units) are,
\[ r_{EH,t+1} = \frac{\pi_{H,t+1} E_t(D_{t+1} + V_{t+1})}{V_t} \] (3.13)
\[ r_{EF,t+1} = \frac{\pi_{F,t+1} Q_{t+1} E_t(D_{t+1}^* + V_{t+1}^*)}{Q_t} \] (3.14)

Same for domestic holdings of home and foreign bonds,
\[ r_{BH,t+1} = \frac{i_{t}}{\pi_{t+1}} \] (3.15)
\[ r_{BF,t+1} = \frac{i_{t}^*}{\pi_{t+1}^*} \] (3.16)

where \( \pi_{t+1} \) refers to domestic CPI inflation level, \( \pi_{H,t+1} \) to domestic producer price inflation level, and the same applies for \( \pi_{t+1}^* \) and \( \pi_{F,t+1}^* \). Also, \( i_t \) refers to nominal interest rate set by the central bank in the domestic economy, and \( i_t^* \) that of the foreign economy. In order to implement Devereux and Sutherland solution procedure, the household budget constraint needs to be rewritten in terms of net foreign asset position. Domestic agent portfolio holdings of domestic assets (\( \alpha_{H,t} \)) and foreign assets (\( \alpha_{F,t} \)) are written as the product of the asset value in domestic currency units (\( q_{a,t} \)) and the volume of assets they hold (\( S_{H,t}, S_{F,t} \) for equities and \( B_{H,t}, B_{F,t} \) for bonds). Formally, we have
\[ \alpha_{EH,t} \equiv q_{EH,t} S_{H,t} \] (3.17)
\[ \alpha_{EF,t} \equiv q_{EF,t} S_{F,t} \] (3.18)
\[ \alpha_{BH,t} \equiv q_{BH,t} \frac{B_{H,t}}{P_t} \] (3.19)
\[ \alpha_{BF,t} \equiv q_{BF,t} \frac{B_{F,t}}{P_t} \] (3.20)

Hence, net foreign asset position becomes
\[ NFA_t \equiv [ \alpha_{EF,t} + \alpha_{BF,t} - \alpha_{EH,t} - \alpha_{BH,t} ] \] (3.21)

\(^{10}\)Where \( \chi \) is a fixed parameter obtained from the steady-state resolution of the model.
where $\alpha_{EH,t}^*$ and $\alpha_{BH,t}^*$ denote foreign agent holdings of domestic equity and domestic bonds respectively. As in Devereux and Sutherland (2010), I set domestic equity to be the reference asset and I define a three-element vector with the excess return on financial assets relative to it.

$$r_{x,t} \equiv \left[r_{BH,t} - r_{EH,t}, r_{BF,t} - r_{EH,t}, r_{EF,t} - r_{EH,t}\right]$$ (3.22)

I also introduce a vector with the real holdings of financial assets

$$\alpha_{t-1} \equiv [\alpha_{BH,t-1}, \alpha_{BF,t-1}, \alpha_{EF,t-1}]$$ (3.23)

Using (3.21), (3.22) and (3.23), the domestic budget constraint can be rewritten as follows,

$$C_t + (\bar{g})e^{G_t} + NFA_t = w_t N_t + D_t + r_{x,t} \alpha_{t-1} - r_{EH,t} NFA_{t-1};$$ (3.24)

**Valuation Effects: $\Delta$ in Net Foreign Asset position minus Current Account**

Standard international macroeconomics uses the following country’s Balance of Payments (BoP) definition, in which the LHS of the equation refers to the current account and the RHS to the capital account.

$$CA_t \equiv \Delta NFA_t$$ (3.25)

It states that changes in the net foreign asset position ($\Delta NFA_t$) are equivalent to current account ($CA_t$). Normally, these two terms differ in the capital gains and losses from asset and liability positions. Following Devereux et al., (2010), I can assume the following approximation,

$$CA_t \approx w_t N_t - C_t - (\bar{g})e^{G_t} + D_t + (r_{EH,t} - 1) NFA_{t-1}$$ (3.26)

Therefore, it is easy to derive from the budget constraint the following definitions of the BoP,

$$\Delta NFA_t \equiv CA_t + (r'_{xt} \alpha_{t-1})$$ (3.27)

$$(r'_{xt} \alpha_{t-1}) \equiv VAL_t = \Delta NFA_t - CA_t$$ (3.28)

where $(r'_{xt} \alpha_{t-1})$ is an adequate measure of the valuation effects.

Meanwhile, net exports are defined as,

$$NX_t \equiv \alpha \left(\frac{RP_t^*}{Q_t^*}\right)^{-\theta} C_t^* - \alpha \left(\frac{RP_t^*}{Q_t}\right)^{-\theta} C_t$$ (3.29)

where the first term refers to exports and the second one to imports. Note that $RP_t$ ($RP_t^*$) refers to relative domestic (foreign) price defined as,

$$RP_t \equiv \frac{P_{H,t}}{P_t}; \quad RP_t^* \equiv \frac{P_{F,t}}{P_t^*};$$ (3.30)
Financial Autarky case

In financial autarky, no financial assets are traded internationally, and the budget constraint for the representative household is given by,

\[ w_t N_t + D_t + \frac{B_{H,t-1}}{P_t} = C_t + (r_t)^{-1}\frac{B_{H,t}}{P_t} + (\bar{g})\epsilon^{G_t} \]  

for \( t = 1, 2, 3, \ldots \).

Note that \( C_t \) is the composite index of domestic and foreign bundles of goods, so that international goods trade is still open.

3.3 Firms

There is a continuum of intermediate goods producers that operate under monopolistic competition and seek to maximise their profits. In this setup, there is no physical capital. Each firm produces a unique differentiate good and earns some monopoly profit. The amount of output produced of the representative \( j^{th} \) firm, \( Y_t(j) \), is subject to Dixit-Stiglitz demand constraints (3.4) and to a technology function with the following form,

\[ Y_t(j) = \exp(A_t)N_t(j)^{1-\tau} \]  

where \( N_t \) is the amount of labor employed by the representative firm, and \( A_t \) follows the following AR(1) exogenous process,

\[ A_t = \rho^A A_{t-1} + \epsilon^A_t \]  

with a coefficient of autocorrelation \( 0 < \rho^A < 1 \) and white-noise innovation, \( \epsilon^A_t \).

It is worth to notice that \( A_t \) factor involves any idiosyncratic source that increases marginal product of inputs.

Price stickiness is modelled a la Calvo (1983) with a fixed probability of either re-setting price or to maintaining it from last period. Hence, a fraction of \( (1 - \eta) \) randomly selected firms set optimal prices each period, with an individual firm’s probability of re-setting in any given period being completely independent of the time elapsed since it last re-optimised its price. In comparison with the flexible price setting, now adjusting price firms will recognise that the optimal price chosen will remain effective for a random number of periods so that they will account for expected future marginal costs, instead of looking at the current level only. However, by setting \( \eta \to 0 \) the model effectively represents the special case of flexible prices. Many portfolio choice models assume flexible price setting. This model features nominal rigidities in order to have a role for monetary policy and shocks in determining gross external positions and dynamics\(^{11} \).

\(^{11}\)However, it may be the case that financial globalisation influences inflation, which is studied in Devereux, Senay and Sutherland, 2014.
Intermediate domestic producers take the competitive real wage, and solve the following maximization problem. For the representative firm, it becomes,

$$Max \sum_{j=0}^{\infty} \eta_j \Theta_t D_t(j) = Max \sum_{j=0}^{\infty} \eta_j \Theta_t \left[ \left( \frac{\bar{P}_H(j)}{P_{H,t}} \right)^{1-\epsilon} Y_t - \frac{P_t}{P_{H,t}} W_t \right] N_t(j)$$  (3.34)

s.t

$$exp(A_t)N_t(j)^{1-\tau} - \left( \frac{\bar{P}_H(j)}{P_{H,t}} \right)^{-\epsilon} Y_t = 0$$  (3.35)

where upper case letters denote nominal variables. \( \Theta \) is the stochastic discount factor to evaluate its dividend stream. This will be no longer related to the household’s intertemporal marginal rate of substitution since the firm is now owned by domestic and foreign agents, so I use a weighted combination of the home and foreign discount factors as in Devereux and Sutherland (2010).

The key equations coming from first order conditions describe the labour demand,

$$\left( \frac{P_t}{P_{H,t}} \right) w_t = mc_t(j)exp(A_t)(1-\tau)N_t(j)^{-\tau}$$  (3.36)

where \( mc_t(j) \) is the firm-specific real marginal cost, which can be defined in terms of aggregate marginal cost as follows,

$$\mathbb{E}_t mc_{t+k}(j) = \mathbb{E}_t mc_{t+k}\left( \frac{\bar{P}_{H,t}(j)^{1-\epsilon} Y_{t+k}^{1-\epsilon} \left( 1 - \eta \right) \bar{P}_H(j)^{1-\epsilon} Y_{t+k} \right) = 0$$  (3.37)

Then, optimal price equation is obtained,$^{12}$

$$\bar{P}_H(j) = \left( \frac{\epsilon}{\epsilon - 1} \right) \mathbb{E}_t \sum_{k=0}^{\infty} \Theta^{\epsilon} \eta^{k+1} \left[ \left( \frac{\bar{P}_{H,t+k}(j)}{P_{H,t+k}} \right)^{1-\epsilon} Y_{t+k} \right] = 0$$  (3.38)

where \( 0 < \eta < 1 \) is the Calvo probability. \( \bar{P}_H(j) \) would be the optimal price obtained from the non-linear maximization problem.$^{13}$

Under the assumed price-setting structure, dynamics of domestic producer price index are described by the equation,

$$P_{H,t} = \left( \eta \right) P_{H,t-1}^{1-\epsilon} + \left( 1 - \eta \right) \bar{P}_{H,t}^{1-\epsilon}$$  (3.39)


$^{13}$Real magnitudes from the firm-optimization problem are expressed in domestically produced units, (i.e., nominal terms divided by \( P_{H,t} \)). Since real wage (\( w_t \)) and dividends (\( d_t \)) are expressed in CPI units in the household problem (i.e., divided by \( P_t \)), to be consistent with notation they are now multiplied by \( \frac{P_t}{P_{H,t}} \).
Finally, aggregating across firms, average dividend is obtained,

\[ D_t = \int_0^1 d_t(j) dj = \int_0^1 \left( \frac{P_{h,t}(j)}{P_{h,t}} \right)^{-\epsilon} Y_t(j) dj - \left( \frac{W_t}{P_{h,t}} \right) \int_0^1 N_t(j) dj \]

\[ D_t = \int_0^1 \left( \frac{P_{h,t}(j)}{P_{h,t}} \right)^{1-\epsilon} Y_t - \left( \frac{W_t}{P_{h,t}} \right) N_t \]  

(3.40)

where price dispersion \((PD_t)\) is also modelled following Schmitt-Grohe-Uribe (2006)

\[ PD_t = \int_0^1 \left( \frac{P_{h,t}(j)}{P_{h,t}} \right)^{-\epsilon} dj \]  

(3.41)

\[ 3.4 \text{ Equilibrium Conditions} \]

Goods market clearing conditions take the form,

\[ Y_t = \left( \frac{P_{h,t}}{P_t} \right)^{-\theta} \left[ (1 - \alpha) C_t + \alpha Q^H C^* \right] + (\bar{g} e^G_t) / PD_t \]  

(3.42)

which has been derived from the following market condition for each firm \((j)\),

\[ Y_t(j) = C^H_t(j) + C^*_H(j) + \bar{g} e^G_t \]  

(3.43)

where \(C^H_t(j)\) corresponds to domestic demand for domestic goods and \(C^*_H(j)\) foreign demand for domestic goods, which comes from the optimal allocation of home-produced goods for foreign agents. In aggregate terms take these take the following forms,

\[ C^*_H_t = \alpha \left( \frac{P^*_H}{P^*_t} \right)^{-\theta} C_t^* \]

Asset markets clear at all times according to the following equilibrium conditions;

\[ S_{H,t} + S^*_H = S_{F,t} + S^*_F = 1; \]  

(3.44)

\[ b_{H,t} + b^*_H = b_{F,t} + b^*_F = 0 \]  

(3.45)

Noticing that \(S^*_H\) refers to the foreign share of domestic equity, and \(S^*_F\) would refer to the foreign share of foreign equity. The same applies to \(b^*_F\) and \(b^*_H\).
3.5 Monetary policy rules

In this section I describe how the nominal interest rate \((i_t)\) is determined through a reaction function describing monetary policy decisions made by the central banks. I use a simplified version to that of Fernandez-Villaverde (2009). In contrast with some macroeconomics literature, where monetary policy is introduced by assuming that some monetary aggregate follows an exogenous stochastic process, DSGE literature models monetary policy as endogenous, with a short-term interest rate being the instrument of that policy. The size and composition of country portfolios will depend on the structure and stochastic environment of the model, including the properties of the monetary rule. There is therefore an interaction between policy choice and portfolio choice, which has been studied by Senay and Sutherland (2016). Formally, the country specific inflation-based Taylor rules are specified as follows,

\[
\begin{align*}
\frac{i_t}{\bar{\pi}^{CPI}_t} &= \left( \frac{\pi^{CPI}_t}{\bar{\pi}^{CPI}_t} \right)^{\mu_{\pi}} \varepsilon^i_t \\
\frac{i^*_t}{\bar{\pi}^{CPI}_t} &= \left( \frac{\pi^{CPI*}_t}{\bar{\pi}^{CPI*}_t} \right)^{\mu_{\pi}} \varepsilon^{i*}_t
\end{align*}
\]

in which I assume symmetric inflation targeting coefficients, \(\mu_{\pi}\), for both the domestic and the foreign economies. I select CPI-inflation targeting rule instead of producer price inflation rule, since the Central Bank is aimed to stabilise the real interest rate. Each economy is subject to monetary policy shocks modelled as AR(1) processes, with a coefficient of autocorrelation \(0 < \rho^M < 1\) and white-noise innovation, \(\varepsilon^i_t\).

4 Portfolio choice solution method

The model is a set of 50 equations providing solution paths for the domestic and foreign variables. There are 21 domestic endogenous variables \(r_{EH,t}, r_{EB,t}, i_t, C_t, \beta_t, \Theta_t, w_t, N_t, C_h, C_f, D_t, V_t, mct, mcj, \tilde{\rho}, RP_t, \pi^{CPI}_t, \pi^{H}_t, SS_t, PD_t, Y_t\) and foreign endogenous variables are completely analogous. Plus, there are 8 common variables in both economies, \(dER_t, Q_t, NX_t, CA_t, NFA_t, VAL_t, cg, cd_t\). Regarding the exogenous variables; for each economy there are two AR(1) processes for technology and government spending shocks and a white noise innovation for monetary policy shocks.

DSGE models are typically solved by taking log-linear approximation around a non-stochastic steady state. However, optimal portfolios cannot be uniquely pinned down in a non-stochastic steady state. As Devereux and Sutherland (2008) state "The reason is that there is no natural point around which to approximate the model. It is because the steady state is free-risk, there is no uncertainty, so any portfolio allocation would be valid." Actually, in a non-stochastic world all portfolio allocations are equivalent and can

---

14In fact, this will allow to model alternative monetary regime, which may affect international capital flows. However, the interactions between monetary policy rules and portfolio choice is left out for future research.

15See Appendix for a full description of model equations.
be regarded as valid equilibria.

Up to a first order approximation, the expected returns on financial assets have no difference, they are perfect substitutes, so portfolio dynamics are not pinned down either. Risk is the only fact that would made assets distinguishable, but neither the non-stochastic steady state nor a first order approximation capture the differences in risk characteristics of assets.

Recently methods developed by Devereux and Sutherland are limited because they rely on local approximations around the non-stochastic steady state, and they are valid around the point of approximation, which is problematic when there are large deviations away from this point. To avoid this, global solution methods are being increasingly chosen to solve medium-scale models. Rabitsch et al., (2015) compare the performance of Devereux and Sutherland (DS) method with a global solution method. They find that the DS method works very well when focusing in short horizons, especially true where assets returns are similar, whether countries are symmetric or asymmetric. I also follow DS solution method for other reasons; It is close to standard approximation methods used in DSGE models and it can be applied to a broad range of environments with complete and incomplete financial markets models an a potentially large number of shocks and/or financial assets.

In a 2-economy model with portfolio choice, there is a set of portfolio optimality conditions and a set of equations defining the rest of the model. The solution of both set of equations will give a vector of the real portfolio holdings solution for each asset traded. For the steady state portfolio to be well defined, also called zero-order portfolio, we need the 2\textsuperscript{nd} order approximation of the portfolio equations and the 1\textsuperscript{st} order approximation of the rest of the model equations. I use the non-stochastic steady state of the model as the approximation point for the non-portfolio variables (see Appendix B for the steady state equations). Then, I use a combination of the 2\textsuperscript{nd} order approximation of the portfolio optimal conditions for home and foreign country to tie down the zero order component of portfolio, as follows,

\begin{equation}
\mathbb{E}_t \left[ (C_{t+1} - C_t^*) r_{x,t+1} \right] = 0 + O(\epsilon^3) \tag{4.1}
\end{equation}

\begin{equation}
\mathbb{E}_t r_{x,t+1} = -\frac{1}{2} \mathbb{E}_t \left[ \hat{r}_{H,t+1} - \hat{r}_{F,t+1} \right] + \frac{1}{2} \rho \mathbb{E}_t \left[ (C_{t+1} + C_t^*) + \frac{Q_t}{\sigma} \right] + O(\epsilon^3) \tag{4.2}
\end{equation}

Equations (4.1) and (4.2) together with the 1\textsuperscript{st} order approximation of the rest of the model equations will yield the zero-order portfolio holdings solution. DS also show that to obtain the 1\textsuperscript{st} order portfolio solution, in which true portfolios are allowed to move over time, the portfolio equations need to be approximated to the 3\textsuperscript{rd} order and the non-portfolio equations up to 2\textsuperscript{nd} order.

5 Quantitative Results

In this section, I will calibrate the model and search for structural asymmetries that can be potential explanations for the empirical evidence on international capital flows. It might
be the case that several asymmetries between the two economies coexist at the same time, therefore I follow a two-step procedure to investigate their impact in equilibrium portfolio holdings and their effects in time-varying portfolio in the following Section. First, I consider individual effects of each asymmetry on gross and net portfolio positions to know which asymmetry is able to generate the pattern of two-way capital flows. I use the foreign economy as a control group and fix its parameter values at the benchmark levels. To see how asset positions respond to changes in each asymmetry, I change the value of the corresponding parameter over a range around the benchmark value. Next, I put all the asymmetries together into the model to simulate a fully asymmetric model which would represent an economy with both emerging and advanced countries. Thus, the overall effect of all asymmetries on portfolio choices can also be measured.

In what follows, the home economy is considered to represent an emerging country while the foreign economy is viewed as an advanced country. The emerging country is characterised by considering asymmetries in the following single structural parameters: home goods bias ($\alpha$), nominal price rigidity ($\eta$) and Dixit-Stiglitz demand elasticity for home and imported consumption goods ($\theta$). In addition, various empirical studies provide values for output volatility that are on average twice as large in emerging markets compared to developed countries (Aguiar and Gopinath, 2007). In that sense, I will explore the case in which home country faces greater shocks volatility than foreign economy, so that standard deviation of shocks on the domestic (emerging) economy is set to higher values than the standard deviation of shocks on the foreign (advanced) economy.

Then, I report the "Zero-order Taylor Approximation analysis" which describes non-varying gross and net asset positions as we vary model parameters in the domestic (emerging) economy. Within this subsection I analyze how two-way capital flows arise upon the inclusion of higher volatility in the shocks of the domestic economy relative to those in the foreign economy and once a higher degree of price stickiness is introduced. In the following section I report a second set of results, the "First-order Taylor Approximation analysis"; in which true portfolios are time-variant and respond to real and nominal shocks.

5.1 Parameter calibration

The numerical values of all parameters for the baseline calibration are reported in Table 1, where bold font marks those parameters subject to asymmetries and their corresponding values for the benchmark case. I choose parameter values at their standard levels of calibration in the literature which are mostly descriptions of advanced economies (Devereux and Sutherland, 2009, Smets and Wouters, 2007, Aguiar and Gopinath, 2007, and Gali and Monacelli, 2005). A period in the model corresponds to one quarter, which is consistent with the literature on business cycles. The discount factor parameter is chosen so that the annualized steady-state real interest rate is 4%. The elasticity of consumption marginal utility is set to have the logarithmic case and labour supply elasticity is set to

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16All parameters within the model have been analysed. For the shake of simplicity I present here only those parameters with relevant effects on portfolio choice, the rest are available from author upon request.

17See Schmitt-Grohe and Uribe, Open Economy Macroeconomics, Chapter 1, for a detailed description of business cycle facts around the world with special interest in emerging and poor countries.
Table 1: Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concept / Home (Foreign)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>4% steady state real interest rate</td>
<td>0.99 (0.99)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Consumption elasticity</td>
<td>1 (1)</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Labour supply elasticity</td>
<td>2(2)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Share of domestic consumption to imported goods</td>
<td>0.35-0.4-0.45 (0.4)</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>Elasticity b/varieties within the same country</td>
<td>6 (6)</td>
</tr>
<tr>
<td>$\theta$</td>
<td>E b/varieties produced at H and F</td>
<td>1.3-1.5-1.9 (1.5)</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Calvo probability of price stickiness</td>
<td>0.56-2/3-0.74 (2/3)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Inflation weight</td>
<td>1.5 (1.5)</td>
</tr>
<tr>
<td>$\rho^A$</td>
<td>Productivity shock persistence</td>
<td>0.941 (0.941)</td>
</tr>
<tr>
<td>$\rho^G$</td>
<td>Government shock persistence</td>
<td>0.85 (0.85)</td>
</tr>
<tr>
<td>$\rho^M$</td>
<td>Monetary shock persistence</td>
<td>0.8 (0.8)</td>
</tr>
<tr>
<td>$\epsilon^r$</td>
<td>Monetary shock volatility</td>
<td>0.2%-1%-2% (1%)</td>
</tr>
<tr>
<td>$\epsilon^A$</td>
<td>Productivity shock volatility</td>
<td>0.2%-1.1%-2% (1.1%)</td>
</tr>
<tr>
<td>$\epsilon^G$</td>
<td>Government shock volatility</td>
<td>5%-10%-15% (10%)</td>
</tr>
</tbody>
</table>

2, for a Frisch labour supply elasticity of 0.5. For the symmetric simulation, home bias parameter is set to 0.4 which is standard in open economy models (Gali and Monacelli, 2005). Also, following Smets and Wouters (2007), Calvo probability parameter equals 2/3. The elasticity of substitution between home and foreign produced goods is set at 1.5 as suggested by Backus et al., (1992). For the asymmetric case, I follow Gagnon (2009) and set the Calvo-probability for the home(emerging) economy to a higher value (0.72), since it is shown that emerging markets, like Mexico, tend to have less flexible prices than more advances countries, like the US. Finally, the parameters for the persistence of the exogenous shocks are set to values found in the literature, in which the productivity shocks are clearly more persistent (0.94) than the demand shocks (0.85), and monetary shocks (0.8). The standard deviations of the shocks are matched to obtain a reasonable variance decomposition in which the total variation of domestic output, is explained by the supply shock (42%), the demand shock (21%) and monetary shock (32%).

5.2 Equilibrium Portfolio: Zero-Order Solution

In this section, I solve for country portfolio equilibrium position using the solution procedure of Section IV. Equilibrium portfolio is used as a starting point to analyze the level of noise on portfolios and the time varying portfolios, which are analyzed in subsection 5.3.

Figure 4 reports ‘near-non-stochastic steady state’ positions relative to domestic output for different scenarios (i.e., $\bar{\alpha}/\bar{\beta}Y$). In the symmetric case under benchmark calibration, domestic agents go long (buy) in home bonds and foreign equity, while they go short (sell) in foreign bonds and domestic equity. Actually, they own about 24% of the foreign corporate value and 76% of the domestic one. The sign of home bonds holdings is positive,

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18Devereux and Sutherland argue that to better understand the term near-non-stochastic steady state, take a limit to a sequence stochastic worlds with diminishing noise, then equilibrium portfolio would tend towards a limit which corresponds to one of many valid equilibria in the non-stochastic world.

19See Parameter calibration Section 5.1.
reflecting the fact that domestic economy supplies home bonds. Subsequently, the position of foreign bond holdings is negative and the domestic economy demands foreign bonds. The sign of asset holdings, reflects the correlation between relative disposable income and excess returns of the asset conditional on the excess returns of other assets. Thus, for a positive correlation, the optimal choice is going "short", while for a negative correlation, the optimal choice would be going "long". In order to diversify risks, domestic agents optimally choose to hold those assets with the highest relative return in order to smooth down the negative effects in the case of a decrease in their relative disposable income. Thus, domestic agent goes long (short) in domestic (foreign) bonds since their respective excess returns co-move negatively (positively) with relative disposable income. On the equity side, the domestic agents optimally choose to hold a positive positions in foreign equity, since its returns co-move negatively with disposable income, conditional on the rest of the assets returns. Also, they choose to go "short" in domestic equity. The sign of external financial positions remain unchanged when asymmetries are introduced in the parameter values for the domestic economy, mainly because the correlation between relative disposable income and excess returns of the asset conditional on the excess returns of other assets remains fairly similar. Nevertheless, the size of portfolio positions is changed, as it will be discussed in the following subsection.

Let us define net bond position for the domestic agent as,

\[ NBA \equiv \alpha_{B,H} + \alpha_{B,F} \]  

and net equity position as,

\[ NEA \equiv \alpha_{E,H} + \alpha_{E,F} \]  

Particularly, the symmetric calibration leads to \( \alpha_{B,H} = 1.01 \) and \( \alpha_{B,F} = -1.01 \), so that \( NBA \) is zero. The solution for \( \alpha_{E,F} \) is 11.17, and that of \( \alpha_{E,H} \) is -11.17. Hence, \( NEA \) is also zero. NFA is assumed to be zero in the symmetric equilibrium, thus global imbalances cannot occur. It has been shown that the symmetric setting does not capture the empirical facts related with international capital flows. Particularly, the fact that advanced countries are net demanders of equity \( (NEA > 0) \) and net suppliers of bonds \( (NBA < 0) \) and emerging countries being the opposite, net demanders of bonds and net suppliers of equity. Therefore, there must be some asymmetries between the two economies that make two-way capital flows arise. To separate the effects of asymmetries from each other, I examine those asymmetries with the larger effects on portfolio holdings for different parameter values in Figure 4 and different standard deviation of the shocks in Figure 5. Then, I compute the NBA and NEA for the domestic economy under different parameter values in Figure 6 and for different volatilities of the shocks in the domestic economy in Figure 7.

First, I describe equilibrium asset holdings for different degrees of price stickiness (i.e., \( \eta \neq \eta^* \)). Domestic agent financial positions in bonds increases with the degree of price rigidities, and those on equity decrease, as shown in Plots (1)-(3), Figure 4. Domestic and foreign bond position do not present the same behaviour, therefore two-way capital flows arise, when the domestic economy faces higher nominal rigidities than the foreign one, as shown in Plot (3), Figure 6. This result goes in line with the empirical evidence on emerging economies being positive in their net bond positions and negative on their
equity positions, if we assume that emerging countries face a higher degree of nominal rigidities. Price rigidities issues in the context of macroeconomic modelling are key part of the vast DSGE literature (Fernandez-Villaverde, 2009, Smets and Wouters, 2007, Woodford, 2003). Nevertheless, studies assessing the empirical validity of such hypothesis using micro-data are scarce. The majority of these few papers have been focused in developed economies. Hence, analysis on emerging and/or developing countries are rare and country-based. As one representative example, Gagnon (2009) focuses on the relationship between inflation and consumer price setting by examining a large data set of Mexican consumer prices. He finds that overall, the Mexican prices appear less flexible than the U.S. ones for comparable inflation rates. I also conduct the exercise when monetary policy shocks are cancelled out in both economies in order to isolate nominal rigidities effects from those coming from the iteration of nominal rigidities and monetary policy functions. Domestic bond holdings and Foreign bond holdings present the exact same pattern with opposite sign, so that NBA and NEA positions do not vary when nominal price rigidities change. Equity holdings are not sensitive to variations in $\eta$-parameter under this very specific case.

I also describe zero-order asset holdings depending on different calibrated values of the $\theta$-parameter describing the elasticity of substitution between domestic and imported consumption goods. Results show that portfolio positions are also sensitive to this parameter modifications. In fact, a more elastic consumption of domestic goods relative to foreign goods, increases the size of the domestic economy portfolio position of bonds. Hence, portfolio holdings of domestic and foreign bonds increase for $\theta$-values greater than those of foreign economy, as shown in Plot (4)-(5), Figure 4. However, once we departure from the symmetric case, domestic agents increase their position in foreign equity holdings, Plot (6), Figure 4. In fact, the higher the home good bias, the higher the equity bias. The pattern for domestic and foreign asset holdings is not exactly the same, so that non-zero NBA and NEA arise, as shown in Plot(1), Figure 6. Two-way capital flows appear only in the case when the domestic economy agent demand is more elastic than the foreign agent one.

Then, I describe the domestic agent portfolio holdings depending on different calibrated values for the $\alpha$- parameter, which describes the domestic equilibrium share of foreign goods in total consumption basket. The higher the home consumption bias ($\alpha \approx 0$), the smaller the portfolio position. This result goes in line with the previous results on the elasticity of substitution between domestic and imported goods. When agents preferences are biased to domestically produced goods, their external portfolio positions are smaller than their foreign counterparts. Two-way capital flows appear in the case when consumption good bias at home is smaller than in the foreign economy, particularly if $\theta > 0.4$ in the domestic economy, and $\theta^* = 0.4$ in the foreign economy. These results point out that when consumption preferences related with international trade are more restricted, agents bear uncertainty through portfolio choice.

Figure 5 analyzes asymmetries in the standard deviations for the domestic economy real

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20See Devereux et al., 2014 for a study on nominal stability and financial globalization.
21It should be noticed than for values of $\alpha = 0.5$, real exchange rate = 1 and bond positions are close to zero.
exogenous shocks, $\sigma_A^2$, $\sigma_G^2$ and $\sigma_M^2$. Results show that bond holdings increase with the standard deviation of productivity and monetary policy shocks, while decrease with demand shocks volatility. Domestic agents increase their positive position in domestic bonds and increase their negative position in foreign bonds, with the volatility of supply and monetary shocks. Moreover, domestic agents choose a larger position in foreign equity holdings for higher volatility of supply shocks, while a smaller position for higher volatility in demand and monetary shocks. The portfolio pattern is not exactly equal for home and foreign assets, so that NBA and NEA are non-zero, as shown in Figure 7. In fact, it shows that when the home economy faces more volatility than the foreign economy, two-way capital flows arise and replicate the empirical fact of emerging and developing economies being positive in their domestic NBA position and negative in their NEA. Particularly, for the case in which productivity and monetary policy shocks present higher volatility than those in the foreign economy. This result goes in line with empirical literature on the business cycle facts for emerging markets, which are found to be at least double as those in advanced countries.

Once the effect of each relevant asymmetry on the pattern of portfolio position has been analyzed, I now focus on the overall effect of all asymmetries together and compare it with the fully symmetric case.\textsuperscript{22} The choices of asymmetric parameter values are; Calvo probability ($\eta = 0.72$ and $\eta^* = 2/3$), home good bias ($\alpha = 0.41$ and $\alpha^* = 0.4$) and agent preferences ($\theta = 1.55$ and $\theta^* = 1.5$). Under this scenario two-way capital flows are also obtained as shown in Figure 7, plot 4, in which I vary the standard deviation of the domestic productivity shocks. When the domestic economy volatility is set at $\sigma_A^2=1.13\%$, and the foreign economy one is set at $\sigma_A^2=1.1\%$, then the domestic economy buys home bonds to the amount of $1.99(\times \beta \bar{Y})$ and sells foreign bonds to the amount of $1.81$, which results in a positive but small net position in bonds ($NBA = \alpha_B + \alpha_B^* > 0$). On the equity side, home country sells domestic equity to the amount of $11.95$ which results in a negative but small net position in equity ($NEA = \alpha_E + \alpha_E^* < 0$).

The empirical literature that discusses the Equity Bias Puzzle shows large home equity bias in international capital markets, Heathcote and Perri (2002). Courdacier and Rey (2013) review various explanations of this international macroeconomic puzzle and relate it with hedging motives in frictionless financial markets, the role of transaction costs and informational asymmetries. Also, they present empirical evidence on cross-border asset holdings across time and across countries. They find that on average, the degree of home bias across the world is $0.63$. With an average of $0.9$, emerging markets have less diversified portfolios than advanced countries ($0.67$), and they present more stable home equity bias. This paper does not obtain asset positions that match exactly the empirical findings in this regard, but it provides insights to analyse the role of asymmetries in the degree of home equity bias and in the pattern of two-way portfolio flows. In fact, the home equity bias produced by this model is around $75\%$ in all cases and it is fairly stable across different parameter settings. Figure 8 provides the home equity bias across different values for the domestic parameters and standard deviations of the domestic economy shocks. Some

\textsuperscript{22}I have also analyzed asymmetries in the degree of market competitiveness (i.e., Dixit-Stiglitz elasticity of substitution between varieties, $\epsilon$) and the weight on inflation from Taylor rule monetary policy, $\mu_{\pi}$. They turn out not to have any significant effect on the pattern of equilibrium portfolio. Results are not provided in the paper due to the lack of space, but they are available upon request.
interesting remarks are; First, home equity bias seems to increase with the degree of domestic nominal rigidities, which goes in line with empirical evidence on emerging countries having higher home equity bias and higher degree of nominal price rigidities. Second, the more restricted the international goods preferences are, the higher the home equity bias. In fact, results suggest that home good bias may lead to home equity bias, as Plot 3 shows. Third, results show a fairly stable home equity bias, which varies around 0.75% and 0.79% for different values for the standard deviations of the domestic economy shock. Moreover, the degree of home equity bias is shown to increase with the volatility of productivity shock, which goes in line with the empirical evidence related with the emerging countries business cycle facts. Therefore, results suggest that those countries facing higher degree of nominal rigidities, stronger home good bias and higher business cycle volatilities tend to have a higher degree of home equity bias.

6 Business cycle analysis with gross capital flows

In this section, I analyze gross capital flow dynamics ("First-order Taylor Approximation analysis") in an asymmetric calibration that may replicate the interactions between emerging and advanced countries. The behaviour of gross portfolio flows is related with the equilibrium position on each financial asset. Domestic households select whether to invest more or less in each one of the financial assets, and they also choose whether to hold long (buy) or short (sell) positions, thus both the size and the sign of portfolio choices play an important role in shaping gross portfolio flows. Then, I compare the financial integrated model with a financial autarky model and I provide second-moment statistics.

6.1 Portfolio dynamics: First-Order solution

For the model dynamics, the portfolio positions are first solved as shown in Section 5, because they may impact the responses of the endogenous variables and may also bring valuation effects. I follow Devereux and Sutherland (2010) to describe 1st order movements in the home country holdings with the gamma vector, which is obtained through the following linear function,

\[
\hat{\alpha}_{a,t} = \alpha_{a,t} - \bar{\alpha}_{a}
\]

\[
\alpha_{a,t} - \bar{\alpha}_{a} \approx \gamma_{1}\hat{A}_{h,t} + \gamma_{2}\hat{A}_{f,t} + \gamma_{3}\hat{G}_{h,t} + \gamma_{4}\hat{G}_{f,t} + \gamma_{5}\hat{F}_{A,t} + \gamma_{6}\hat{V}_{h,t} + \gamma_{7}\hat{V}_{f,t} + \gamma_{8}\hat{R}_{h,t} + \gamma_{9}\hat{R}_{f,t}
\]

where \( a \) refers to any assets of the following four: domestic equity, domestic bonds, foreign equity and foreign bonds. The number of rows in the gamma vector is equal to the number of assets minus one, the reference asset, whose value can be calculated using its foreign counterpart. The number of columns depends on the number of purely predetermined variables and all the underlying shocks in the model\(^{23}\).

The standard open macroeconomic model can only analyze overall net foreign asset dynamics (NFA). The introduction of endogenous portfolio choice not only allows to analyze

\(^{23}\)Due to space limitations I report only variables with sizable effects. The true gamma vector is available upon request.
in detail gross movements of each financial asset available \((α_{FE,t}, α_{HE,t}, α_{HB,t} \text{ and } α_{FB,t})\), but also to separate gross assets and liabilities movements between price and volume movements. Up to a 1st-order approximation, the following relationships hold,

\[
\begin{align*}
\hat{α}_{FE,t} &= q^*_{FE,t} S_f \times q^*_{FE,t} + \hat{S}_{F,t} \\
\hat{α}_{DB,t} &= q_{DB,t} b_h \times q^*_{DB,t} + b^*_H,t \\
\hat{α}_{FB,t} &= q^*_{FB,t} b_f \times q^*_{FB,t} + b^*_F,t
\end{align*}
\]

where \(q^*_{FE,t} = \frac{P^*_{F_t}}{P^*_{t}} Q_t V^*_t\) is the value of foreign equity in domestic consumption units, \(q_{DB,t} = (r_t)^{-1}\) is the value of the domestic bonds and \(q^*_{FB,t} = Q_t (r^*_t)^{-1}\) is the value of the foreign bonds, also in domestic consumption units.

### 6.2 Impulse-response functions

Figure 9 shows the impulse-response functions of portfolio-related variables to a positive 1 standard deviation productivity shock in the emerging economy, using the parameters described in previous section. Transmission mechanism works as follows: Marginal cost decreases, optimizing firms reset their prices to a lower level, and there is a real depreciation in the home economy that boost net exports. Consumption also increases and so does aggregate output. Since the central bank reacts to changes in CPI inflation, it cuts nominal interest rate, making domestic real bond returns fall relative to the foreign bonds return. The shock is persistent and the expected rate of return on all assets rises so that realized returns will be equalized after one period. Hence, return on domestic equity rises relative to that of foreign equity. Domestic households experience an overall capital loss due to their pre-existing net bond portfolio position. The small financial gain through domestic bonds, is out-weighted by the loss coming for their short position in foreign bonds. This explains, the increase in domestic bond holdings and the decrease in foreign bond holdings, Plot (1), Figure 9. At the same time, they also face a capital loss due to their pre-existing net equity portfolio position. Agents hold foreign equity, and increase their position position, since its returns also increase. However, their ”short” positions in domestic equity make them loose since the returns on domestic equity also increase. Because, the increase in domestic equity return is higher than that of foreign equity, agents have a capital loss on their equity side too. Thus, valuation effects are negative in the first period. After the adjustment on each portfolio position, domestic agents gain on their new position, since they have increased their positions in those assets providing capital gains. After the first period, domestic agents gain on their net portfolio position. In period one, the negative difference between \(dNFA_t\) and \(NX_t\) is reflected by the negative valuation effects. However, when this difference is approximately zero, the negative valuation effects reflect an increase on their net income received from the equity side. Since I have assumed that \(dNFA_t - CA_t = VAL_t\) and \(CA_t = NX_t + NetIncomeReceived\), when \(dNFA_t - NX_t\) is close to zero and \(VAL_t < 0\), then it must be true that Net Income Received is positive. In fact, this result can be deduced by the increase in equity prices and dividends. This overall positive effect does not only affect domestic agents position in financial assets.
but also their consumption decisions. Hence, home consumption becomes larger relative to the autarky case. The analysis can go further by decomposing the increase in equity holdings between volume and price effects. Figure 9, shows that the increase in foreign equity holdings is due to a relatively small increase in its price and, more substantially, due to the adjustment in its volume.

Figure 10 shows the impulse-response functions to a positive 1 standard deviation government expending shock in the emerging economy. Transmission mechanism works as follows: Government expending increases, optimizing firms reset their prices to a higher level, and there is a real appreciation in the home economy that decreases domestic consumption and net exports. Because CPI inflation increases, the central bank sets nominal interest rate to a higher level, making domestic real bond returns fall less relative to the foreign bonds return. Therefore, the return on both domestic and foreign equity also falls. Thus, domestic households experience a capital gain due to their net bond portfolio position. Agents have long positions in domestic bonds, and they decrease their position due the the fall of domestic bond returns. Thus, they have a financial loss on their pre-existing position in domestic bonds. Their short position in foreign bonds and the fall in foreign bond returns creates a financial gain, and agents increase their position in foreign bonds. On the equity side, the capital gain coming from the positive position in foreign equity is almost out-weighted by the capital loss coming from their negative position in domestic equity. Overall, domestic households experience a capital gain due to their pre-existing portfolio choice which leads to an initial improvement in the home country NFA. However, all financial asset returns are expected to increase in the following period, which will produce a small capital loss followed by an overall capital gain, due to the adjustment of capital flows. The movement in $\Delta NFA$ and the current account differ due to this valuation effect on the pre-existing portfolio, which it is shown to be positive. The positive valuation effects after first periods, reflect a decrease on their net income received from the equity side. Recall, that $dNFA_t - NX$ is approximately zero and equity prices and returns are negative. Since ex-post returns of pre-existing portfolio increase domestic economy NFA, domestic agents reallocate net gains by increasing their consumption relative to the autarky case. Optimal portfolio choice helps to smooth domestic agents consumption, since the negative effects produced after a positive demand shock are balanced out with the positive valuation effects coming from their optimal position in external financial assets.

The model incorporates also monetary policy shocks. Figure 11 shows the impulse-response functions to a positive 1 standard deviation monetary policy shock in the emerging economy. Transmission mechanism works as follows: Nominal interest rates push domestic households to postpone their consumption, which causes a drop in aggregate home consumption, and thus a decrease output. The increase in the nominal interest rates also appreciates the nominal domestic currency making home produced goods less competitive for the foreign economy, leading to a decrease in domestic exports. There are two opposing forces which affect the foreign economy. The foreign economy experiences an increase in its competitiveness relative to the domestic economy due to the appreciation of their currency, their overall consumption should increase and so their demand for domestic goods. The decrease in aggregate consumption in the domestic economy affects the demand of foreign goods, which leads to a decrease in foreign output. Return on
domestic bond increases, and domestic agents increase their respective positive positions, as reflected in Plot (1)-(2). Foreign bond return decreases in response to a decrease in the foreign CPI-level and domestic agents holding a negative pre-existing position in foreign bonds, will experience a capital gain. Domestic agents decrease their position in foreign equity, since its return decreases relatively to that of domestic equity. Since, agents go short in domestic equity, they increase their positions due to the relative capital gain. Despite the small capital gain on the domestic equity side, the domestic agent experiences an overall capital loss on their pre-existing portfolio followed by a capital gain due to the adjustment on their portfolio, so that valuation effects turn positive after the first period as shown in Plot (8). The positive valuation effects also reflect a decrease on their net income received from the equity side, which can be seen in the decrease equity prices and returns. In this case, portfolio helps to smooth down the negative effects of a positive shock to the monetary policy nominal interest rate in the domestic economy.

Finally, I follow the same structure than previous subsection to characterize the asymmetries role in shaping portfolio first order dynamics. Starting from benchmark symmetric calibration, I add parameter asymmetries to capture its effects on portfolio dynamics after each shock on the domestic economy. Figure 12 introduces only different degrees of nominal rigidities in the domestic economy. The red line represents the symmetric case in which both countries face the same of price stickiness (2/3) and it is shown to vary between the other two extreme cases. One the one hand, the blue line represents the case in which home economy is less rigid than the foreign economy, for a Calvo probability value of 0.62, and on the other hand, the yellow line representing the case in which the domestic economy faces higher nominal rigidities, with a value of 0.72. Take the portfolio variables IRF to a positive 1 standard deviation productivity shock in the emerging economy; in this case, domestic agents increase their domestic bond position and decrease their foreign bond position. It has been shown, that the the size on bond position increases with the degree of nominal rigidities, thus, domestic agents receive a higher capital gain on their domestic bond positions, in those countries facing more nominal rigidities, just because they optimally chose a larger positive position. Moreover, returns on domestic bonds are expected to be smaller when there are higher nominal rigidities in the economy, which reduces the potential gain. Overall, it is shown that a higher degree of nominal rigidities increases portfolio positions, and thus, capital flows are more dynamic. Figure 13 shows the role of asymmetries in the standard deviation of the productivity shocks on the domestic economy in shaping portfolio choice. The red line represents the symmetric case in which both countries face the same level of volatility and it is shown to vary between the other two extreme cases. One the one hand, the blue line represents the case in which home economy is less volatile than the foreign economy, for a standard deviation of (0.5%) and on the other hand, the yellow line representing the case in which the domestic economy volatility is three times the one in the foreign economy. It has been shown that equilibrium portfolio positions vary across different values for the standard deviation of the shocks, but this variation is fairly small (Figure 5). Thus, it is expected that capital flow dynamics do not show either large variation across the different values.

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24All the model’s parameters are also included in the 1st order approximation analysis. Results are available upon request.
Results show that when the home economy faces higher volatility on the productivity shocks, capital flows dynamics are smoother than in the opposite case, in which the home economy faces a lower volatility. This is mainly due to the fact that, when the volatility of the productivity shock moves, returns on each financial assets vary way more than portfolio size, so that the effect on returns outweighs the effects on portfolio positions size. This results suggest that the higher volatility in emerging countries business cycles may explain why they are less financially integrated.

6.3 A comparison to financial autarky

I compare the portfolio choice model with a case of financial autarky where households are allowed to trade internationally in domestic and foreign goods at no cost, but financial markets are closed at the international level. Same conditions apply to foreign households. In previous subsection, both bond and equity gross capital flows are analysed and the valuation effects channel matters: households who experience a capital gain (loss) on their portfolio position increase (decrease) their respective financial assets positions. Moreover, agents distribute their capital gain over both financial goods and consumption goods. However, in the autarky case and in most standard open economy models, only overall net foreign asset position can be calculated, thus valuation effects can not be analyzed.

Figure 13 presents the impulse-response functions of key macroeconomic variables to a positive 1 standard deviation productivity shock, government expending shock and monetary policy shock in the emerging economy. in each column. It is clear to see the differences between the two models; First column analyses the case of a positive supply shock in the emerging economy. It shows how consumption differences between home and foreign economies respond differently in the portfolio model and in the autarky case. Domestic households gain on their net portfolio position which is reflected in positive valuation effects, thus they increase their aggregate consumption more than in the autarky case. On the contrary, foreign households loose on their portfolio and decrease their aggregate consumption relative to the autarky case, so that consumption difference between home and foreign economies is larger in the portfolio case than in the autarky case, in which valuation effect channel is closed. Moreover, net exports behave differently in both models too. On the one hand, in the portfolio model domestic households increase more their aggregate consumption composed by domestic and imported goods than in the autarky case. Thus, imports increase more in the portfolio model than in the autarky case. On the other hand, foreign households increase less their aggregate consumption than in the autarky case, so that their consumption on domestic goods ( i.e exports) are also smaller relative to the autarky case. The opposing effects of a higher (smaller ) consumption and smaller ( higher) net exports under the financially integrated model (autarky model) are reflected in the cross-country output differential, which presents a similar response in both cases.

Second column analyses the case of a positive demand shock in the emerging economy. Domestic households gain on their net portfolio position which is reflected in positive valuation effects, thus they decrease their aggregate consumption less than in the autarky case. On the contrary, foreign households loose on their portfolio and decrease their aggregate consumption more than in the autarky case, so that consumption difference between home...
and foreign economies is larger in the portfolio case than in the autarky case, in which valuation effect channel is closed. Actually, under the autarky case the difference is negative, reflecting the fact that domestic economy consumption decreases more than foreign consumption. In the portfolio model, however, this consumption difference is positive, because now it is the foreign consumption the one that declines more relative to domestic consumption. The same applies to net exports. Domestic households increase imports in the portfolio model relative to the autarky case. Foreign households do the opposite. Thus, net exports are smaller relative to the autarky case, so that their consumption on domestic goods (i.e., exports) are also smaller relative to the autarky case. The opposing effects of a higher (smaller) consumption and smaller (higher) net exports under the financially integrated model (autarky model) are reflected in the cross-country output differential, which presents a similar response in both cases.

Finally, I analyze the case of a positive monetary shock in the domestic economy. Again, the difference between the two model lies in the valuation effects of pre-existing portfolio holdings and its time varying adjustment. Domestic agents decrease their consumption but less than in the autarky case due to their positive capital gain. On the contrary, foreign agents are double damaged, so that their consumption falls relative to the autarky case. Thus, cross-country consumption gap is wider under the portfolio model. It should be noticed that the role of asymmetries does not change the overall results on main differences between the portfolio model and the autarky model, however, introducing asymmetries increases the pattern, as shown in Figure 14, in which I have introduced main asymmetries explained in the previous section.

It has been shown that introducing endogenous portfolio choice in an otherwise standard open economy model is important. Macroeconomic outcomes differ from standard predictions once we open up international financial markets and valuation channel starts operating, which reinforces our motivation to study gross flows instead of net flows in a general equilibrium model.

### 6.4 Second-moment statistics

It is well known that the standard international business cycle model developed by Backus et al. (1992) fails to match the empirical evidence on cross-country correlations of output and consumption. In fact, cross-country correlation of consumption is much higher in their model than in the data and cross-country correlation of output is positive in the data and negative in their model. Part of the open macroeconomic literature has focused at reconciling the empirical findings with the results of the standard model, mostly by relaxing the assumptions on complete financial markets. The reason is quite clear: the existence of a full set of state-contingent assets implies that risk is perfectly distributed among home and foreign agents and determines the efficient allocation of resources. Thus, country-specific shocks are also distributed internationally, creating an almost perfect correlation of consumption across countries. Heathcote and Perri (2002) show that the incompleteness of financial markets has important effects on the international business cycle, actually, the correlation of output across countries becomes positive as in the data.

Table 2 compares model statistical moments with business cycle data for a group of
advanced and emerging countries. The autarky model represents the standard open economy New Keynesian model in which I have just included home good bias, Calvo-type sticky prices and a simple Taylor-monetary rule to provide a comparable version with the financial integrated model.

The symmetric case uses benchmark parameter values for both countries. The correlation of consumption across countries is 0.76 for the portfolio model and 0.97 for the autarky case and that of output is close to zero in all cases. The predicted standard deviation for output is 1.88% and 1.97% respectively. The predicted standard deviation for consumption over GDP in the portfolio model (0.84) is closer to the empirical standard deviation for advanced countries (0.85%) than the one predicted by the autarky case (0.77). The models predicted standard deviations for net exports over GDP (0.64 and 0.57, respectively) are close to their empirical value for advanced countries. However, the predicted net exports correlation with domestic GDP is positive, while it is well known that this value is negative for most advanced and emerging countries.

<table>
<thead>
<tr>
<th>Case</th>
<th>Model</th>
<th>St. Deviation</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Y</td>
<td>C/Y</td>
</tr>
<tr>
<td>HP Data</td>
<td>Emerging</td>
<td>2.6%</td>
<td>1.32%</td>
</tr>
<tr>
<td>HP Data</td>
<td>Advanced</td>
<td>1.38%</td>
<td>0.85%</td>
</tr>
<tr>
<td>Symmetric</td>
<td>Autarky</td>
<td>1.88%</td>
<td>0.77</td>
</tr>
<tr>
<td>Asymmetric</td>
<td>Autarky (H)</td>
<td>2.35%</td>
<td>0.70</td>
</tr>
<tr>
<td>Asymmetric</td>
<td>Autarky (F)</td>
<td>1.88%</td>
<td>0.82</td>
</tr>
<tr>
<td>Symmetric</td>
<td>Portfolio</td>
<td>1.97%</td>
<td>0.84</td>
</tr>
<tr>
<td>Asymmetric</td>
<td>Portfolio (H)</td>
<td>2.49%</td>
<td>0.74</td>
</tr>
<tr>
<td>Asymmetric</td>
<td>Portfolio (F)</td>
<td>1.98%</td>
<td>0.87</td>
</tr>
</tbody>
</table>

For the asymmetric case, I introduce differences in the Calvo probability (i.e., $\eta = 0.72, \eta^* = 2/3$), in the home good bias parameter (i.e., $\alpha = 0.41, \alpha^* = 0.4$), in the consumption elasticity between home and imported goods (i.e., $\theta = 1.55, \theta^* = 1.5$) and in the volatility of shocks (i.e., $\epsilon^2_A = 1.13\%, \epsilon^2_G = 10\%, \epsilon^2_M = 1.1\%, \epsilon^2_A^* = 1.1\%, \epsilon^2_G^* = 10\%, \epsilon^2_M^* = 1\%$). The predicted correlation of consumption across countries (0.77) is closer to its empirical value than the symmetric version of the portfolio model which predicts a lower value (0.76). Again, the autarky asymmetric versions yield high cross-country correlation of consumption close to one. Introducing asymmetries in the portfolio model does not improve the predicted cross-country correlation of output which is still negative. The predicted standard deviation for consumption over GDP in the portfolio model is not close to their empirical counterparts, since the relative consumption volatility is higher in emerging countries than in advanced countries. The model variants also fail to reproduce

I take HP-Filtered Business cycle quarterly data from S.Schmitt-Grohe and Uribe, Open Economy PhD textbook, Chapter 1. Sample period from 1980:Q1 to 2012:Q4, and country coverage are 11 emerging market economies (Argentina, Israel, Korea, Rep., Mexico, New Zealand, Peru, Portugal, South Africa, Spain, Turkey, Uruguay) and 15 advanced countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Italy, Japan, Netherlands, Norway, Sweden and Switzerland). Correlation across home and foreign output and consumption is taken from Coeurdacier et al., (2010).
the counter-cyclicality of the trade balance and the current accounts. The calibration for the baseline model is oriented to replicate portfolio behaviour rather than matching the business cycle second moments. In a future work, I will consider to replicate the moments for two specific countries, namely the United States and Mexico. In that setting, a more robust model evaluation can be done in terms of the general fit.

7 Conclusion

This work addresses some of the limitations of the standard open-economy theory by using a fully structural open economy DSGE model with endogenous portfolio choice of FDI-equity and bonds, Calvo-prices, home goods bias and incomplete financial markets. Blanchard et al., (2015) have recently mentioned that there is a "stricking schizophrenia" derived from the contradictions between standard open economy models predictions, empirical evidence on the macroeconomic effects of international capital flows and policy makers’ beliefs. This paper tries to give some lights to this questions by analysing gross capital flows and valuation effects between advanced and emerging countries in a fully structural model. This paper shows that introducing endogenous portfolio choice in an otherwise standard open economy model is important. Macroeconomic outcomes differ from standard predictions once we open up international financial markets and valuation channel starts operating, which reinforces our motivation to study gross flows instead of net flows in a general equilibrium model. Quantitative results suggests that the higher business cycle volatility in emerging countries in relation with advanced countries along with a higher degree of nominal rigidities, may not only explain their smaller external position in international financial markets but also their positive net bond position and their negative equity position.

In this paper, I have focused on the role of country asymmetries in shaping portfolio size and composition in emerging countries. I have abstracted from issues related to the trade-off between monetary policy rules, nominal rigidities and portfolio choice (Devereux, Senay and Sutherland, 2014). Moreover, I have ignored the heterogeneity across households in their access to financial assets. These important aspects, as well as the analysis of global imbalances in an environment of endogenous portfolio choice, are left for future research.
A The steady state

The system of steady state functions that solves the following steady state variables $mc, i, R, \beta, \Theta, Y, C, C_h, C_f, w, N, V, D, NX$ is the following. Note that the foreign country system of equations and variables is analogous. Assuming steady-state rate of inflation at 0;

Marginal cost
\[ mc = \frac{\epsilon - 1}{\epsilon} \]  
(SSB1)

Nominal interest rate
\[ i = 1 - \beta \]  
(SSB2)

Real interest rate
\[ R = i \]  
(SSB3)

Parameter from endogenous discount factor
\[ \mu = -\frac{\log(\beta)}{\log(1 + C)} \]  
(SSB4)

Firm endogenous discount factor
\[ \Theta = (1 - \alpha^{equity})\beta + \alpha^{equity}\beta^* \]  
(SSB5)

Production function
\[ Y = N^{1-\tau}; \]  
(SSB6)

Goods market clearing
\[ C = Y - NX - \bar{g}Y \]  
(SSB7)

Net exports
\[ NX \equiv 0 \]  
(SSB8)

Domestic consumption of domestically produced goods
\[ C_h = (1 - \alpha)C \]  
(SSB9)

Domestic consumption of foreign produced goods
\[ C_f = (\alpha)C \]  
(SSB10)

Real Wage
\[ w = mc(1 - \tau)N^{-\tau} \]  
(SSB11)
Labour supply

\[ wC^\sigma = \chi N^\phi \]  

(SSB12)

Domestic equity

\[ V = \frac{\beta}{1 - \beta} D \]  

(SSB13)

Aggregated dividends domestic firms

\[ D = Y - wN \]  

(SSB14)
B The model equations

The model is a set of 50 equations providing solution paths for the domestic and foreign variables. There are 21 domestic endogenous variables \( r_{EH,t}, r_{EB,t}, i_t, \beta_t, \Theta_t, w_t, N_t, C_h, C_f, D_t, V_t, mc_t, mc_t(j), \tilde{\rho}, RP_t, \pi_{CPI,t}, \pi_{H,t}, SS_t, PD_t, Y_t \) and foreign endogenous variables are completely analogous. There are 8 common variables in both economies, \( dER_t, Q_t, NX_t, CA_t, NFA_t, VAL_t, cg_t, cd_t \). Regarding the exogenous variables; for each economy there are two AR(1) process for technology and government spending shocks and a white noise innovation for monetary policy shocks.

The following [10] functions are unique in the model,

Euler equations

\[
C_t^{-\sigma} = \beta_t E_t[C_{t+1}^{-\sigma} r_{EH,t+1}] \quad \text{(EQ1)}
\]

\[
C_t^{-\sigma} = \beta_t E_t[C_{t+1}^{-\sigma} r_{EF,t+1}] \quad \text{(EQ2)}
\]

\[
C_t^{-\sigma} = \beta_t E_t[C_{t+1}^{-\sigma} r_{BH,t+1}] \quad \text{(EQ3)}
\]

\[
C_t^{-\sigma} = \beta_t E_t[C_{t+1}^{-\sigma} r_{BF,t+1}] \quad \text{(EQ4)}
\]

\[
\frac{1}{Q_t} C_t^{-\sigma} = \beta_t E_t[C_{t+1}^{-\sigma} r_{EH,t+1}] \frac{1}{Q_{t+1}} \quad \text{(EQ5)}
\]

Domestic economy equity asset demand (returns in domestic consumption units)

\[
r_{EH,t+1} = \frac{\pi_{H,t+1}}{\pi_{CPI,t+1}} \frac{E_t(D_{t+1} + V_{t+1})}{V_t} \quad \text{(EQ6)}
\]

Foreign economy equity asset demand (returns in domestic consumption units)

\[
r_{EF,t+1} = \frac{\pi^*_t}{\pi^*_{CPI,t+1}} \frac{Q_{t+1}}{Q_t} \frac{E_t(D^*_{t+1} + V^*_{t+1})}{V^*_t} \quad \text{(EQ7)}
\]

Domestic economy bond asset demand (returns in domestic consumption units)

\[
r_{EB,t+1} = \frac{i_t}{\pi_{CPI,t+1}} \quad \text{(EQ8)}
\]

Foreign economy bond asset demand (returns in domestic consumption units)

\[
r_{EF,t+1} = \frac{i^*_t}{\pi^*_{CPI,t+1}} \frac{Q_{t+1}}{Q_t} \quad \text{(EQ9)}
\]
Real Exchange Rate
\[
\frac{Q_t}{Q_{t-1}} = \frac{E_t}{E_{t-1}} \frac{\pi^*_t}{\pi_{CPI,t}}
\] (EQ10)

The following [17] equations describe domestic economy, and the foreign economy is described with the corresponding analogous functions [17x2]

Endogenous discount factor
\[
\beta_t = (1 + C_t)^{-\nu}
\] (EQ11)

Firm’s discount factor
\[
\Theta_t = (1 - \alpha^{equity})\beta_t + \alpha^{equity}\beta^*_t
\] (EQ12)
where \(\alpha^{equity}\) is the domestic agent ownership of foreign firm.

Labour Supply Function
\[
w_t = \chi C^\sigma_t N^\phi_t;
\] (EQ13)

Relationship between CPI-inflation and Producer Price-inflation
\[
\pi_{H,t} = \frac{RP_t}{RP_{t-1}} \pi_{CPI_t}
\] (EQ14)

CPI index
\[
1 = \left[ (1 - \alpha)RP_t^{1-\theta} + \alpha\left( RP^*_t Q_t \right)^{1-\theta} \right]^{\frac{1}{\theta}}
\] (EQ15)

Price Dispersion is modeled following Schmitt-Grohe-Uribe (2006)
\[
PD_t = (1 - \eta) \left( \frac{P_H^t(j)}{P^t_H} \right)^{-\epsilon} + \pi^*_t \eta PD_{t-1}
\] (EQ16)

Optimal Price Function
\[
\bar{P}_H(j) = \left( \frac{\epsilon}{\epsilon - 1} \right) E_t \sum_{k=0}^{\infty} \Theta_{t+k} \eta^k \left[ \frac{(P_{H,t+k})^\epsilon Y_{t+k}mc_{t+k}(j)}{(P^\epsilon_{H,t+k})} \right]^{\epsilon - 1} Y_{t+k}
\] (EQ17)

Domestic produced goods Price index \((\pi_{h,t})\) using Dixit-Stiglitz aggregator
\[
P_{H,t} = \left[ (\eta)P_{H,t-1}^{1-\epsilon} + (1 - \eta)P^*_H(j)_{H,t} \right]^{\frac{1}{\epsilon}}
\] (EQ18)
Firm-Specific Real Marginal Costs

\[ \mathbb{E}_t m_{c_{t+k}}(j) = \mathbb{E}_t m_{c_{t+k}} \left( \frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\frac{\epsilon_{t}}{1-\tau}} \]  
\hspace{1cm} (EQ19)

Price Dispersion (also modeled following Schmitt-Grohe-Uribe (2006))

\[ SS_t = \int_0^1 \left( \frac{P_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} dj \]  
\hspace{1cm} (B.1)

\[ SS_t = (1 - \eta) \left( \frac{P_{H,t}(j)}{P_{H,t}} \right)^{1-\epsilon} \pi_{H,t}^{t-1} + \eta SS_{t-1} \]  
\hspace{1cm} (EQ20)

Real Marginal Cost (Labour demand function)

\[ m_{c_t} = \left( \frac{P_t}{P_{H,t}} \right) \frac{w_t}{\exp(A_t)(1-\tau)N_t^{-\tau}} \]  
\hspace{1cm} (EQ21)

Aggregate Production Function

\[ Y_t(PD_t) = \exp(A_t)N_t^{1-\tau} \]  
\hspace{1cm} (EQ22)

where \( A_t \) follows the following AR(1) exogenous process.

Aggregate Dividends Function

\[ D_t = (SS_t)Y_t - \frac{w_tN_t}{RP_t} \]  
\hspace{1cm} (EQ23)

**Equilibrium Conditions:**

Resources constraint

\[ Y_t = \left( \frac{P_{h,t}}{P_t} \right)^{-\theta} \left[ (1 - \alpha)C_t + \alpha Q_t^{\theta} C_t^{\ast} \right] + \left( \frac{\bar{g}_t^{G_t}}{PD_t} \right) \]  
\hspace{1cm} (EQ24)

Domestic Imports

\[ IM_t = \alpha \left( RP_t^s Q_t \right)^{-\theta} C_t \]  
\hspace{1cm} (EQ25)

Domestic Exports

\[ EX_t = \alpha^s \left( \frac{RP_t}{Q_t} \right)^{-\theta^s} C_t^s \]  
\hspace{1cm} (EQ26)
Monetary Rule

\[ \frac{i_t}{\bar{i}} = \left( \frac{\pi^{\text{CPI}}}{\pi^{\bar{\text{CPI}}}} \right)^{\mu_\pi} \varepsilon_t^R \]  

(EQ27)

The following [6] unique equations describe the Balance of Payments (Foreign economy uses the same variables with opposite sign)

Budget constraint in terms of NFA

\[ C_t + (\bar{g})e^{Gt} + NFA_t = w_t N_t + D_t + r_{X,t} \alpha_{t-1} + r_{EH,t} NFA_{t-1}; \]  

(EQ28)

Net Exports

\[ NX_t = \alpha^* \left( \frac{R_{P_t}}{Q_t} \right)^{-\theta^*} C_t^* - \alpha \left( R_{P_t}^* Q_t \right)^{-\theta} C_t \]  

(EQ29)

Current Account Approximation

\[ CA_t \approx w_t N_T - C_t - (\bar{g})e^{Gt} + D_t + (r_{EH,t} - 1) NFA_{t-1} \]  

(EQ30)

Valuation effects

\[ VAL = \Delta NFA_t - CA_t \equiv (r'_{xt} \alpha_{t-1}) \]  

(EQ31)

where the vector of excess return is the following

\[ r_{X,t} \equiv [r_{BH,t} - r_{EH,t}, r_{BF,t} - r_{EH,t}, r_{EF,t} - r_{EH,t}] \]  

(B.2)

and the vector with the real holdings of financial assets is;

\[ \alpha_{t-1} \equiv [\alpha_{BH,t-1}, \alpha_{BF,t-1}, \alpha_{EF,t-1}] \]  

(B.3)

Portfolio equations

\[ cd_t = C_t - C_t^* - \frac{Q_t}{\sigma} \]  

(EQ32)

\[ cg_t = \frac{1}{2} (C_t + C_t^* + \frac{Q_t}{\sigma}) \]  

(EQ33)
C Graphs and Tables

Figure 1: Financial global integration over last decades

![Graphs and Tables](image_url)

Figure 1: G7 (Canada, France, Germany, Italy, Japan, UK and US) and BRIC (Brazil, Russia, India and China) Total sum of cross border assets and liabilities as percentage of GDP. Portfolio asset and liabilities refer to the sum of FDI and portfolio equity asset and liabilities. Data source: Lane and Milesi-Ferreti (2007a) updated to 2015.
Figure 2. Net asset position for FDI and the rest of financial capital assets. BRIC countries are Brazil, Russia, India and China, G7 countries are Canada, France, Germany, Italy, Japan, UK and US. Data source: Lane and Milesi-Ferreti (2007a) updated to 2015.
Figure 3. Increasing importance of valuation effects.

Figure 3: Cumulated Current Account (CCA) and Net Foreign Asset Position (NFA) as percentage of GDP. The gap between the two lines represents valuation effects. Data source: Lane and Milesi-Ferreti (2007a) updated to 2015.
Figure 4: Equilibrium asset positions (y-axis) under alternative parameter calibration for domestic economy (x-axis). Foreign country parameter as reference in vertical blue line. Columns represent each financial asset, and rows represent the parameter being analysed.
Figure 5: Equilibrium portfolio choice in the domestic economy for alternative St.Deviation of the shocks at the domestic economy.

Figure 5: Equilibrium asset positions (y-axis) under alternative St.Deviation for the domestic economy shocks (x-axis). Foreign country St.Dev. as reference in vertical blue line. Columns represent each financial asset, and rows represent the shock being analysed.
Figure 6. Domestic economy net bond and equity position

Figure 6: Domestic economy net asset position under alternative parameter calibrations. NBA refers to net bond assets and NEA to net equity assets. Vertical line represents foreign economy parameter benchmark value. y-axis describes the size of NBA or NEA, and x-axis the value of the parameter being analysed in each plot.
Figure 7: Domestic economy net asset position under alternative St.Deviation for the domestic economy shocks (x-axis). NBA refers to net bond assets and NEA to net equity assets. Vertical line represents foreign economy parameter benchmark value. y-axis describes the size of NBA or NEA, and x-axis the value of the St.Dev of the shock being analysed in each plot. The choices of asymmetric calibration are; Calvo probability ($\eta = 0.72$ and $\eta^* = 2/3$), home good bias ($\alpha = 0.41$ and $\alpha^* = 0.4$) and agent preferences ($\theta = 1.55$ and $\theta^* = 1.5$).
Figure 8: Home equity bias refers to the percentage of the foreign firm owned by the domestic agents. It is shown in the y-axis under alternative model parameter values and different values for the St.Deviation of the domestic economy shocks (x-axis). Foreign country benchmark values as reference in vertical blue line.
Figure 9: IRF for the domestic economy portfolio variables to a 1 standard deviation productivity shock to domestic economy. Two countries are asymmetrically calibrated; $\eta = 0.72$, $\eta^* = 2/3$, $\alpha = 0.41$, $\alpha^* = 0.4$, $\theta = 1.55$, $\theta^* = 1.5$, $\epsilon^2_A = 1.13\%$, $\epsilon^2_G = 10\%$, $\epsilon^2_M = 1.1\%$, $\epsilon^*_{A} = 1.1\%$, $\epsilon^*_{G} = 10\%$, $\epsilon^*_{M} = 1\%$. 

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Figure 10: IRF for the domestic economy portfolio variables to a 1 standard deviation domestic government spending shock. Two countries are asymmetrically calibrated; $\eta = 0.72$, $\eta^* = 2/3$, $\alpha = 0.41$, $\alpha^* = 0.4$, $\theta = 1.55$, $\theta^* = 1.5$, $\epsilon_A^2 = 1.13\%$, $\epsilon_G^2 = 10\%$, $\epsilon_M^2 = 1.1\%$, $\epsilon_A^* = 1.1\%$, $\epsilon_G^* = 10\%$, $\epsilon_M^* = 1\%$. 

Figure 10. Gross capital flows in emerging countries: Demand shock
Figure 11: IRF for the domestic economy portfolio variables to a 1 standard deviation monetary shock. Two countries are asymmetrically calibrated; $\eta = 0.72$, $\eta^* = 2/3$, $\alpha = 0.41$, $\alpha^* = 0.4$, $\theta = 1.55$, $\theta^* = 1.5$, $\epsilon_{A}^{2} = 1.13\%$, $\epsilon_{G}^{2} = 10\%$, $\epsilon_{M}^{2} = 1.1\%$, $\epsilon_{A}^{*2} = 1.1\%$, $\epsilon_{G}^{*2} = 10\%$, $\epsilon_{M}^{*2} = 1\%$. 

Figure 11. Gross capital flows in emerging countries: Monetary shock
Figure 12: Portfolio behaviour for different degrees of nominal rigidities

Figure 12: IRF for domestic agent holdings of home bonds, foreign bonds and foreign equity to a 1 standard deviation productivity shock (First row), fiscal shock (Middle row) and monetary shock (Last row). The symmetric case is represented by the red line, in which both countries parameters are set to 2/3, other cases introduce asymmetries in the Calvo parameter for the domestic economy which takes the values 0.62 and 0.72.
Figure 13. Portfolio behaviour for different volatilities in the productivity shocks

Figure 13: IRF for domestic agent holdings of home bonds, foreign bonds and foreign equity to a 1 standard deviation productivity shock (First row), fiscal shock (Middle row) and monetary shock (Last row). The symmetric case is represented by the red line, in which both countries st.dev are set to 1.1%, other cases introduce asymmetries for the domestic economy which takes the values 0.5% and 3%.
Figure 14: Comparison between the portfolio and the autarky model. IRF for domestic variables to a 1 standard deviation productivity shock (First column), fiscal shock (Middle column) and monetary shock (Last column). Two countries are symmetrically calibrated using benchmark values.
Figure 15: IRF-comparison between international portfolio choice and financial autarky

Figure 15: Comparison between the portfolio and the autarky model. IRF for domestic variables to a 1 standard deviation productivity shock (First column), fiscal shock (Middle column) and monetary shock (Last column). Two countries are asymmetrically calibrated and foreign economy parameters are set to benchmark values.
References


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