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Portfolio Flows in a two-country RBC model with financial intermediaries

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Abstract

The paper presents a two-country real business cycle model with a financial sector that intermediates portfolio flows. It is changes in demand for financial assets from foreign investors *relative to* domestic investors that gives rise to portfolio flows. The simulations show that portfolio flows to emerging markets respond negatively to global risk in line with findings from the empirical literature. The transmission channel that links portfolio flows to credit in emerging markets is the financial intermediary's demand for deposit liabilities (demand for savings).

One can avoid the transmission by absorbing the shock before it affects the intermediary's demand for savings. The results show that financial shocks (eg: risk) can be absorbed by optimal changes in the supply of risk free assets. Real shocks (eg: income) can be absorbed by keeping the supply of financial assets fixed and instead allowing the prices to adjust to demand. Macroprudential regulation that limits the total risk exposure of the financial sector increases the volatility of portfolio flows, but reduces the volatility of consumption and labour and therefore increases welfare. Volatility in the composition of the balance sheet (portfolio flows), does not necessarily increase volatility in the aggregate size of the balance sheet (savings).

The model uses a risk-constraint on bank balance sheets as a tool to ensure *less-than-perfect* elasticity of demand for financial assets. The elasticity of demand is important because it determines the size and direction of portfolio flows.

1 Introduction

Capital flows are thought to affect credit in the recipient economy. Policy makers may attempt to use capital controls, monetary policy, fiscal policy or macroprudential regulation to dampen the associated credit volatility. Finding the appropriate policy response requires proper understanding of the transmission channel that links capital flows to credit. Here we present a model that provides new insights into the transmission channel for one sub-set of capital flows: non-resident net purchases of domestic shares and bonds (henceforth *portfolio flows*). We show that gross portfolio flows can behave different from net portfolio flows. We use model simulations to guide our discussion of how global and domestic policy may affect the transmission of gross and net portfolio flows to the real economy. [1]

Portfolio flows may affect the demand for credit, the supply of credit, or both. Demand for credit may increase as the portfolio flow causes asset prices to rise, creating a positive wealth effect. Supply of credit may increase as the portfolio flow causes an injection of cash on bank balance sheets, reducing the cost of funding for the banking sector. Kavli and Viegi (2015: Empirical chapter) show that the supply channel is dominant. Portfolio inflows come in the form of non-resident net purchases of domestic financial assets. The financial assets are most likely purchased from a domestic fund manager who recives cash in return for the assets. The fund manager must find use of this cash. He may return the cash to clients, purchase foreign assets, or deposit the funds in a bank account. The fraction that is deposited in bank accounts will fund the bank's expansion of credit supply. The model presented here gives rise to this type of transmission channel and allows us to study the transmission of global shocks to domestic macroeconomic activity and welfare.

The empirical literature has shown that global financial risk and risk aversion are important determinants of portfolio flows (Rey, 2013; Bekaert, Hoerova, and Duca, 2010; Bruno and Shin, 2013). When financial assets are more risky, or the financial sector is more risk averse, the financial sector may reduce leverage to avoid letting the risk of its balance sheet exceed the target level (Adrian and Shin, 2010; Bekaert et al., 2010). A risk shock

[1] Gross flows are a trade in assets for other assets, for example the foreigner may sell domestic shares and purchase domestic bonds. The trade does not reflect in the current account. A net flow changes the total international investment position of the economy and will be reflected on the current account. For example the foreigner may purchase domestic shares and bonds. In return the recipient economy gets goods for consumption.

will therefore affect portfolio flows directly as the leverage adjustment implies changes in demand for financial assets, including foreign assets. Here we present a model based partly on the insights from Adrian and Shin (2010); Bruno and Shin (2013); Rey (2013) in which we model the financial sector as operating at a binding risk constraint. The risk constraint may be viewed as macroprudential regulation.

The model presented will show how portfolio flows arise in response to shocks in financial variables, such as risk, and to shocks in real economic variables, such as productivity and income. The portfolio flow is always the product of changes in the foreign and domestic relative demand for domestic assets. A shift in relative demand from the domestic to the foreign intermediary will cause a portfolio inflow, that is net purchases of domestic assets by the foreigner. The relative shift in demand may for example be caused by increased saving in the foreign economy, causing a general increase in demand for financial assets by the foreign intermediary. Another less obvious example can be an increase in the risk of domestic assets; a negative shock that may affect the home intermediary more than the foreign. Since the home intermediary reduces her demand more than the foreign intermediary reduces his demand, the home intermediary will sell domestic assets to the foreign intermediary. Similar to the foreign savings shock, the domestic risk shock leads to a portfolio inflow, but with different macroeconomic implications.

We show how fiscal and monetary policy in the originating economy can use different instruments to absorb volatility caused by different shocks. A financial shock to the global economy, for example an increase in the expected risk of global shares, can be absorbed almost completely by appropriate adjustments in the supply of global risk free assets. That is, the government adjusts its deficit with infinite elasticity, thus keeping the price of government bonds constant. A real shock to the global economy, for example an increased endowment to the households, will not be absorbed by adjustments in fiscal policy, but can be absorbed almost completely by allowing interest rates to respond freely while keeping the supply of global government bonds fixed. The distinction between the optimal response to real and financial shocks was highlighted in the classic paper by Poole (1970). The results of our model illustrates that Poole's findings remain important in a modern economy where the global financial markets link the shocks of one economy to the macroeconomic variables of another.

Policy makers at the receiving end of portfolio flows may use macroprudential regulation as a tool to reduce the aggregate risk of its banking sector. This could potentially be expected to reduce the impact of portfolio flows on the domestic economy. One may for example link the maximum allowed leverage of bank balance sheets to the expected risk of the assets held by the bank. Our model simulations suggest such macroprudential regulation will increase the volatility of portfolio flows, but reduce the volatility of consumption and labour and therefore increase household utility. The macroprudential regulation will also increase the steady state consumption and reduce steady state labour, another positive impact on household utility. It is conceivable that even better welfare effects could be achieved by adjusting the risk allowance in a counter-cyclical response to portfolio flows. This approach is recommended by for example Rey (2013). Such a counter-cyclical adjustment of policy variables is not modeled explicitly in this paper.

It is relevant to note that model simulations with tighter macroprudential policy increased welfare despite increasing the volatility of gross portfolio flows. This illustrates that gross flows are important because they allow an optimal reallocation of the balance sheet, and this reallocation may alleviate the need to adjust the aggregate size of the balance sheet. In this case, as the volatility of gross flows increases, the volatility of net flows and the current account decreases. This is reflected in lower fluctuations in the demand for savings and less volatility in consumption, labour and output. The empirical literature has found a similar lack of correlation between net and gross capital flows, as we will see in section 1.2.

Figure 1 illustrates that the past decade has seen large fluctuations in gross portfolio flows to most emerging economies (IMF, 2014a). China had USD 13.3 billion of equity liabilities to foreigners and USD 7.1 billion of debt liabilities to foreigners in 2001. During the following 12 years, these numbers increased to USD 427.8 billion and USD 192.4 billion. Brazil saw portfolio flows pushing its foreign equity and debt liabilities from USD 33.9 billions and USD 47.5 billion in 2001 to USD 231.4 billion and USD 261.5 billion in 2013. Interestingly, for most emerging economies the bulk of the equity flows happened prior to the global financial crisis of 2008, while the majority of bond flows happened after 2009. *Figure 2* compares the portfolio flows to the GDP of the respective economies, and we see for example that South Africa has experienced capital inflows pushing its bonds and equity liabilities from 5.9% and 11% of GDP in 2001 to 12.9% and 27.3% of GDP in 2013.

These large and volatile portfolio flows have motivated a recent wave of academic studies into their causes and consequences. For example, the International Monetary Fund (IMF) published in November 2012 their revised institutional view on capital flows, taking a more lenient stance towards capital controls (IMF, 2012). In September 2012, the Brookings Institution held a gathering of its Committee on International Economic Policy and Reform with the title *Banks and cross-border capital flows: Policy challenges and regulatory responses* (Brookings Institution, 2012). And the Centre for Economic Policy Research (CEPR) recently published a comprehensive report on the issue of cross border banking in Europe (Allen, Beck, Carletti, Lane, Schoenmaker, and Wagner, 2011). In the following sections we briefly review this literature and thereby demonstrate the need for a model that combines some of the literature's key findings: financial intermediaries target risk and leverage; risk and risk aversion affects asset demand; gross portfolio flows arise as relative demand for assets change; the net portfolio flow affects demand for savings / supply of credit; policy may target the source of shocks or the transmission mechanism.

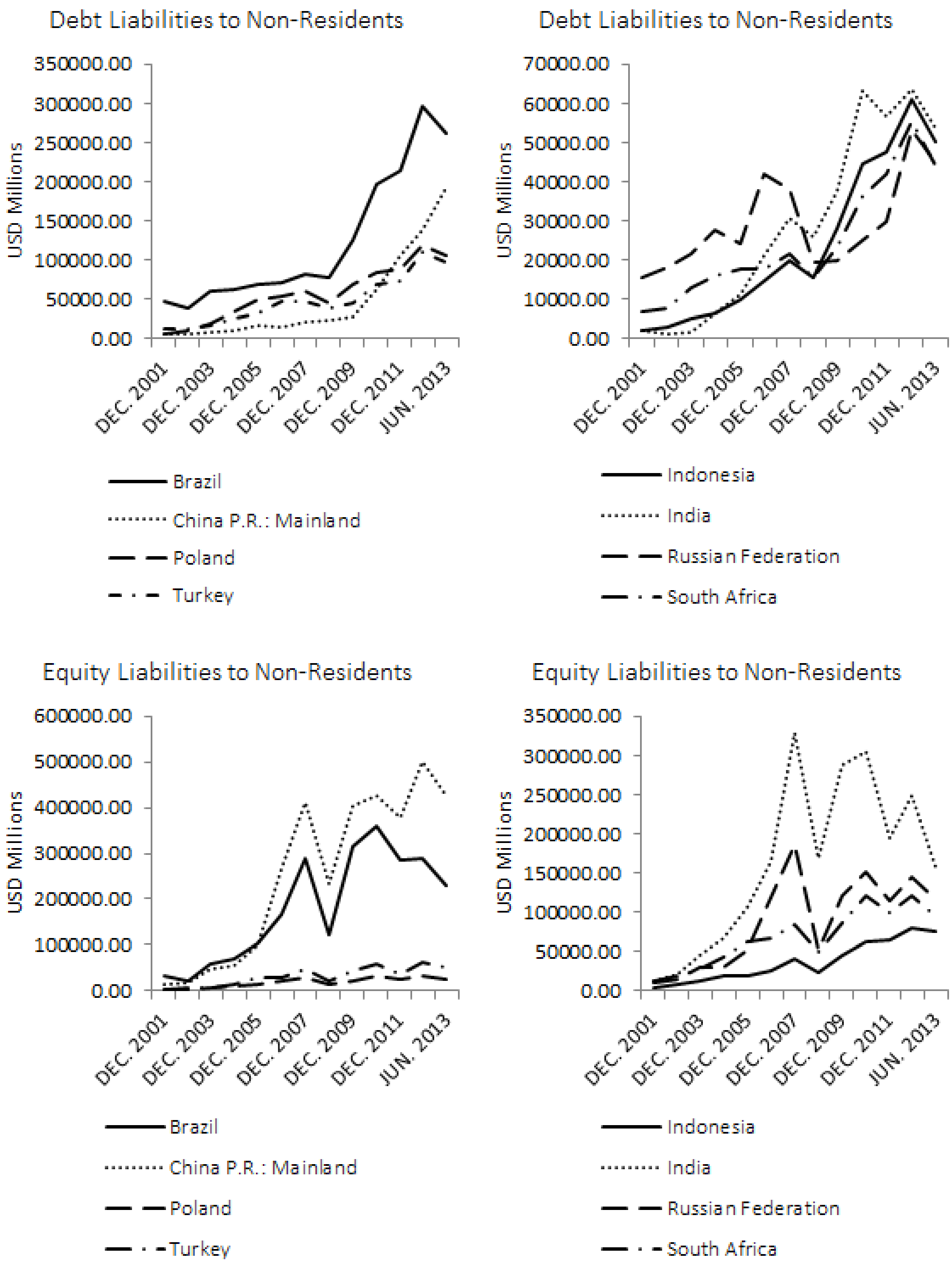

Figure 1: Foreigners bought domestic equities between 2001 and 2008. They bought domestic debt after 2008. Source: IMF (2014a,b)

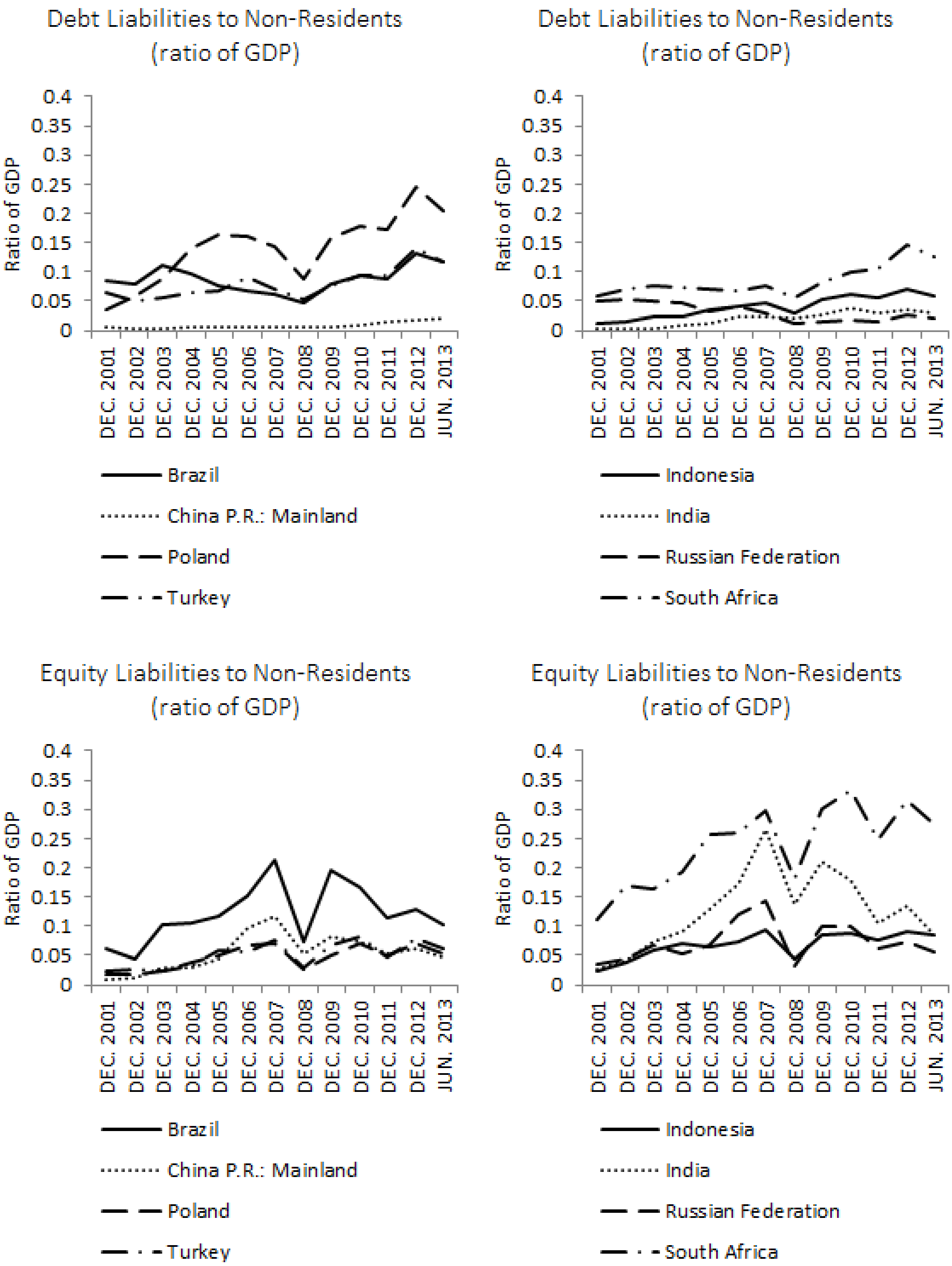

Figure 2: Foreign ownership of domestic assets as a share of GDP roughly doubled since 2001 in most emerging economies. Source: IMF (2014a,b)

1.1 Portfolio flows are mainly driven by external factors

Taylor and Sarno (1997) find empirical evidence that bond flows to Latin America and Asia between 1988 and 1992 were predominantly caused by global factors, whilst both global and local factors were equally important in determining long-term equity flows. Similar findings were made by Calvo, Leiderman, and Reinhart (1996) who showed that external factors (which they gave the term "push factors" as opposed to domestic "pull factors") were important determinants of capital flows to Latin America in the 1990s. Both papers find US interest rates to be one of the most dominant determinants. [2] Chuhan, Claessens, and Mamingi (1998) conduct a panel study of both bond and equity flows to Latin America and Asia for the same period as Taylor and Sarno (1997), 1988-1992. Their findings indicate that local factors are "at least as important" determinants of capital inflows. In addition they find equity flows to be more sensitive to global factors than bond flows, a finding that goes directly against the evidence found by both Taylor and Sarno (1997) and Calvo et al. (1996). Furthermore Chai-Anant and Ho (2008) make the interesting finding that equity inflows in Asia tend to be driven by common regional (Asian) factors, whilst equity outflows tend to be driven by idiosyncratic local factors. Their results also support the argument of Hau and Rey (2006) that positive asset returns cause a capital outflow from the respective economy as foreign investors rebalance their portfolio.

More recent research has confirmed the earlier findings that push factors are dominant in explaining capital flows. Of particular importance is monetary policy (interest rates) and risk. For example, Taylor (2013) argue that monetary policy in the US tends to force other economies to follow suit with similar policy to avoid the large capital flows caused by the initial change in the US. The link between monetary policy and risk can be very tight, and it is not always straight forward to distinguish the effects of one from the other. For example, Rey (2013) demonstrates forcefully that monetary policy drives capital flows by affecting leverage of global banks and risk / risk aversion. This story is supported by Bekaert et al. (2010) who decomposes the VIX [3] into a risk aversion and uncertainty component. They find that both risk and risk aversion are reduced with monetary stimulus. It may not be immediately obvious how asset risk should affect capital flows. Risk aversion, on the other hand, should make investors more willing to purchase more risky emerging market assets and thereby affect portfolio flows directly.

Theoretical models developed by Adrian and Shin (2009) and Bruno and Shin (2013) show that cross-border capital flows can be explained by market-based banks targeting a certain level of risk in their portfolio. They show that not only risk aversion affects portfolio flows, but also risk itself. A drop in the expected risk of assets leads the banks to increase leverage until the aggregate risk (measured by the so-called *Value at Risk* metric) is back to its target level. The increase in leverage is partly achieved by purchasing foreign assets for borrowed money. McCauley (2012) finds additional evidence that variations in global asset price volatility are driving factors of portfolio flows into emerging market bonds and shares.

Global interest rates and the expected risk of asset returns are found to be the main drivers of portfolio flows and will together constitue the key financial variables in the model presented in this paper.

1.2 Gross flows matter

The text book argument in favor of free capital flows suggests that international financial markets are used to hedge risk to future consumption. Through *intertemporal* trade a country trades current consumption for future consumption by purchasing foreign financial assets, reflected as a current account surplus (see for example Obstfeld and Rogoff (2005)). And through *intratemporal* trade a country trades its own risky assets for foreign risky assets. These trades create gross flows that cancel each other out and are not reflected on the current account. Intertemporal trade is used to smooth consumption across time by *trading goods for assets*, and intratemporal trade is used to smooth consumption across stochastic states of nature by *trading assets for other assets* with different risk profiles. This should raise welfare of risk averse agents and indeed be a Pareto improvement if markets are complete (Obstfeld and Rogoff, 2005). Trading goods for assets would result in an entry on the country's current account, whereas a trade in assets for assets will not. This distinction has recently been drawn into the spotlight, most notably by Borio and Disyatat (2011) who argue heavily against the narrow focus on current account imbalances.

Borio and Disyatat suggest that the global financial crisis of 2008 is too often explained as the consequence of current account imbalances and the net capital flows this entails. Examples of such reasoning include Eichengreen (2009) and Bernanke (2009), who argue that consistent savings above investments in emerging markets caused a flow of capital from these economies into advanced economies. This flow of excess savings pushed down interest rates which incentivized increased credit and risk taking. However, Borio and Disyatat (2011) argue that this focus on excess savings "diverts attention away from the global financing patterns that

[2] See Calvo (2013) for a more recent discussion of this and other related papers.

[3] Implied volatility in put and call options on the S&P 500 (Carr and Wu, 2004)

are at the core of financial fragility" (Borio and Disyatat, 2011). In other words, they suggest that focus should be shifted towards gross flows, that is *intratemporal* trades of assets for assets. His point is illustrated by the debt and equity liabilities of emerging markets plotted in *Figures 1* and *2*. During the same time period that China and other emerging markets had consistent current account surpluses accumulating foreign assets, we see that they simultanously experienced gross capital inflows building up their foreign liabilities.

Global gross capital flows have increased from approximately 10% of world GDP in 1998 to over 30% in 2007 (Borio and Disyatat, 2011). The volume and composition of these gross flows have not been closely related to the current account deficit (the net flow) of the respective countries. Lane and McQuade (2013) find that "the current account balance is a misleading indicator in understanding the inter-relation between international capital flows and domestic credit growth"'. Forbes (2012) emphasizes the volatility of gross flows and find that both inflows and outflows have been "extremely volatile" in most countries around the world, and that this volatility has sharply increased since the mid-2000s. Again, this volatility is often not visible in net flows, as "gross capital inflows and outflows tend to move simultaneously in opposite directions and be roughly the same magnitude" (Forbes, 2012). Forbes and Warnock (2012) find evidence that while net flows show no significant reaction to global risk, there is a highly significant response in gross capital flows.

In the words of Obstfeld (2011) :"While the general scale and persistence of current account imbalances certainly has increased over the past two decades, even more strikingly - and potentially more threatening to financial and economic stability - is the rapid expansion of *gross* international asset and liability positions [...] [I]t is the gross positions that better reflect the impact on national balance sheets of various economic shocks, including counterparty failure" (emphasis in original).

The model presented below explicitly models gross international asset and liability positions as well as the gross portfolio flows arising from reallocating these portfolios. We explicitly model the foreign liabilities of emerging economies and then study how changes in these liabilities provide a transmission channel from external 'push factors' to domestic macroeconomic variables.

1.3 Desired model ingredients: risk, leverage and relative asset demand

It is possible to simulate portfolio flows in a model with only one economy. A shock that increases asset demand will lead agents to purchase assets from the rest of the world. Asset demand by agents in the rest of the world is assumed to be constant. But that assumption eliminates several dynamics in the relationship between the two countries. It is possible that agents in the rest of the world will also change their asset demand in response to the shock. The size and direction of the resulting portfolio flow is then unknown, unless we have a two-country model that explicitly specifies the asset demand function from both economies. The size and direction of the flow is determined by relative changes in asset demand between the two countries.

We can illustrate the importance of relative demand with an example. Say we observe a portfolio inflow in which foreigners purchase domestic assets from domestic residents. This could be caused by a fall in both domestic and foreign demand as long as domestic demand falls more than foreign demand. For example, the fall in demand could be caused by a shock to the risk of domestic assets. The opposite scenario is also possible. A portfolio outflow may be caused by an increase in demand for domestic assets by both residents and non-residents, as long as the domestic demand increases more than foreign demand. This could for example be caused by an increase in domestic productivity. [4]

1.3.1 Risk adjusted leverage gives downward sloping asset demand

In the literature, asset demand is typically derived from utility maximizing behavior of households who save for future consumption by purchasing financial assets today. The household's demand for financial assets is represented by the first order conditions of the optimization problem, and will generally depend on the expected discounted cash flow of the asset. We can for example assume the household faces a simple two-period utility maximization problem represented as:

$$\begin{aligned}
&\max\ u(c_t) + E_t[\beta u(c_{t+1})] \\
&\text{s.t} \\
&c_t + p_t\gamma_t = e_t + x_t\gamma_{t-1}
\end{aligned}$$

[4] One last, probably redundant, example: A typical hypothesis of the casual market observer might be that portfolio inflows should, *ceteris paribus*, lead to an increase in the share price. This seems natural. But an increase in non-resident share purchases is just another name for an increase in resident sales of shares. An increase in selling pressure should, *ceteris paribus*, reduce the share price. Which statement is correct? A structural model allows us to disentangle the selling pressure from buying pressure and further analyse the links to other macroeconomic variables.

where γ_t = holdings of the financial asset, p_t = price of the financial asset, x_t = payoff from financial asset, c_t = consumption, and e_t = endowment. The first order conditions of this problem gives a demand function:

$$p = E_t\left[\beta\frac{u'(c_{t+1})}{u'(c_t)}\right]$$

In steady state when consumption is constant the demand becomes perfectly elastic equal to β; it does not depend on the quantity of assets held. Once an external shock pushes the consumption away from steady state there will be an adjustment during which the consumption path is non-constant and the demand is a downward sloping function assets held. This is not obvious from the equation, but note that the level of future consumption depends on the number of assets held today. If we hold more assets we get more future consumption and thus lower marginal utility of future consumption. The lower marginal utility of future consumption gives lower asset demand according to equation 1.

During the adjustment to a shock, the price the agent is willing to pay is a downward sloping function of the quantity held, but in steady state it is perfectly elastic at a price equal to the agents time preference discount factor.

Now, imagine there is a second agent, say from a foreign country, with a discount rate of β^f. In steady state, when demand equals the discount rate, the two demand functions cannot hold at the same time: $p = \beta \neq \beta^f$. By plotting the demand functions together (*Figure 3, Panel a*) we see that there is a boundary steady state solution where the household with the lower discount rate (higher β) holds all assets. An interior steady state solution is only possible if at least one agent has a downward sloping demand function. An example is plotted in *Figure 3*, where Panel *b* illustrates a hypothetical interior solution that arises when the two demand functions have $less-than-perfect$ elasticity.

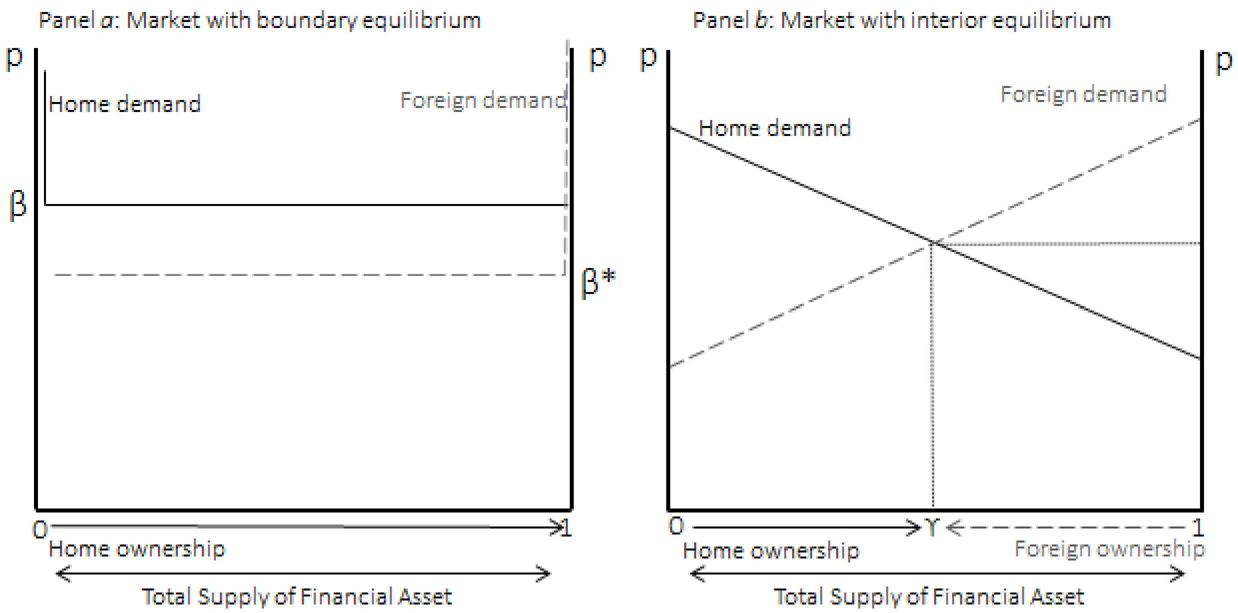

Figure 3: *Home demand is plotted from left to right and foreign demand plotted from right to left.* There is a fixed supply of financial assets equal to 1 (the full width of the x-axis). Markets clear if total demand for assets from home and foreign add up to the full supply. *Panel a:* Demand from home and foreign are both perfectly elastic. There is a boundary solution where *home* holds all assets ($\gamma = 1$) and foreign holds zero ($\gamma^f = 0$). *Panel b:* Home and foreign demand are both slightly inelastic (downward sloping). There is an interior solution where home holds γ and foreign holds $\gamma^f = 1 - \gamma$.

There is no empirical support for the steady state boundary solution associated with the perfect elasticity of demand. In a two-country model, the boundary solution implies that all domestic assets are held either by residents or by non-residents. In reality we see that domestic financial assets are held partly by residents and partly by non-residents. There needs to be some other characteristic of the maximization problem that ensures an interior solution. This can only occur if asset demand is slightly inelastic in steady state (as in Panel b of *Figure 3*). The source of this inelasticity will determine the model's steady state distribution of financial asset ownership between residents and non-residents.

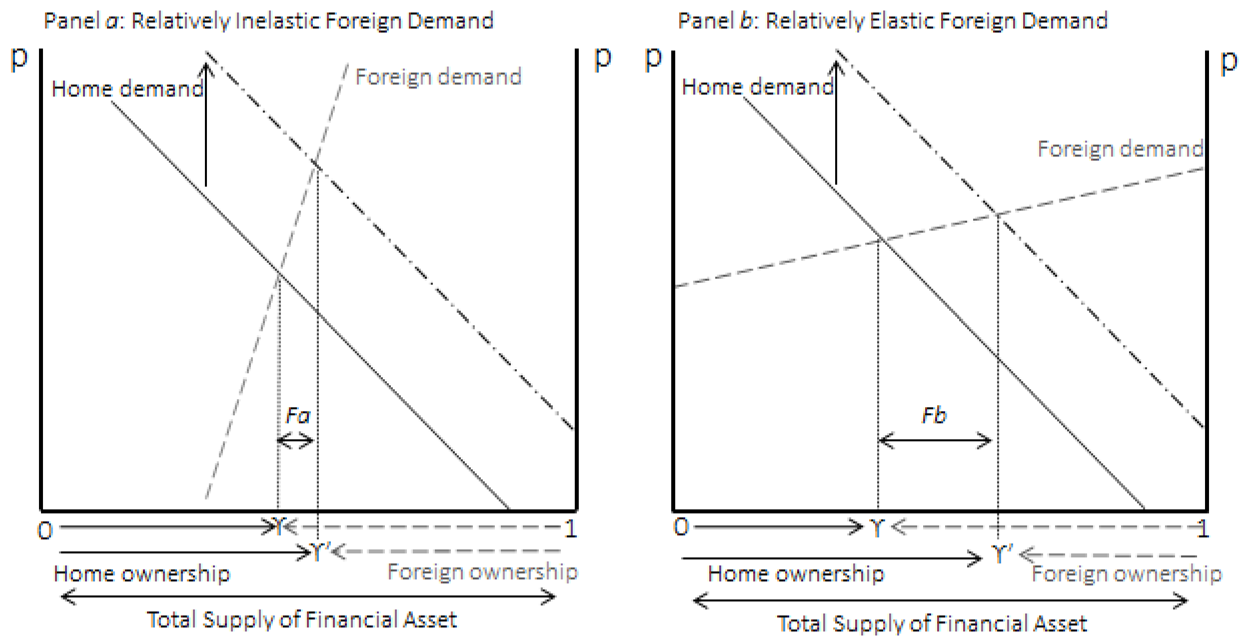

Figure 4: ***Home demand is plotted from left to right and foreign demand plotted from right to left***. *Panel a:* Relatively inelastic demand by the foreign agent. A shock to home demand causes a small capital outflow (the foreign agent sells Fa assets to the home agent). *Panel b:* Relatively elastic demand by the foreign household. A shock to home demand causes a large capital outflow (the foreign agent sells Fb assets to the home agent).

Furthermore, the elasticity of demand for financial assets will determine the size (and in some cases the sign) of portfolio flows in response to external shocks. This is illustrated in *Figure 4* where we shock the home agent's demand for the financial asset. In *Panel a* the foreign demand is relatively inelastic, leading to a small capital flow of size Fa. In *Panel b*, the foreign demand is relatively elastic, leading to a larger capital flow (Fb) in response to the same shock. In most cases, both demand functions will shift in response to the same shock, either in the same direction or opposite directions, making the elasticity even more significant in determining the size and sign of capital flows.

1.3.2 The literature lacks a model that binds empirical findings together

There has been significant progress in the modelling of aggregate demand for risky assets. A notable contribution is a series of papers including Adrian and Shin (2009, 2010) and Bruno and Shin (2012, 2013) that have carefully modelled the behavior of US market based banks and their demand for risky domestic and foreign securities. Most significantly, they argue that financial intermediaries optimise their objective function by targeting leverage and risk.

Adrian and Shin (2009) demonstrate how higher asset prices, *ceteris paribus* will reduce leverage and *Value at Risk (VaR)* on bank's balance sheets. This leads to increased risk appetite as the market based banks aim to increase *VaR* back to its binding limit. Based on these insights, Bruno and Shin (2012) and construct a model of cross border financial flows. Bruno and Shin (2013) utilize this model and show that market based banks actively keep *VaR* its binding limit to maximize profits and therefore must increase leverage as soon as markets are less volatile (risky). One way of adding risk to their balance sheet is by investing in *EM* assets.

While the risk targeting behaviour of market based banks create downward sloping demand for financial assets in the models mentioned above, they cannot explain portfolio flows that arise from changes in *relative* demand. This issue was addressed by Devereux and Saito (2006),Devereux and Sutherland (2009) and Devereux and Sutherland (2011), and and almost identical solution was independently developed by **?**. Their models are solved by second order approximations in order to preserve the effect of variances and covariances of assets in the portfolio optimisation problem. The demand functions are downward sloping due to endogenous discount rates that depend on the expected variance of the portfolio. Devereux and Sutherland (2009) applies this approach to a two-country real business cycle model that explains portfolio flows to emerging markets as consequences of shifts in relative demand from households. **?** also applies the solution approach to a two-country

DSGE model of portfolio flows. As such, both models captures our interest in portfolio flows that arise from relative demand changes, but they both lack the ability to study the role played by a risk targeting financial sector in transmitting global shocks to the recipient economy.

An alternative approach to solve portfolio choice problems while preserving that variance and covariance features of the risky variables in steady state was suggested by Coeurdacier, Rey, and Winant (2011). They show that it is possible to approximate the solution by simultaneously computing the dynamics and the 'risky steady state'[5]. This ensures that the households Euler equation depends on both the variance of future consumption and the covariance between returns and consumption. This approach could create less - than - infinitely elastic demand functions, and thereby yield an interior solution for portfolio allocation in the 'risky steady state'. However, we will see below that this approach to preserving the variance / covariance characteristics is not strictly necessary once we include a risk adjusted leverage constraint on financial intermediaries.

The remaining gap in the literature is a general equilibrium model that incorporates the findings from Shin and co-authors in a two-country real business cycle model similar to Devereux and Sutherland. In this paper we construct a model with households and firms roughly similar to Devereux and Sutherland (2009), but we include a financial sector in each economy with characteristics similar to Bruno and Shin (2012) and Adrian and Shin (2010). The risk and leverage targeting characteristics of the financial intermediaries is introduced to the model by imposing a risk adjusted leverage constraint on the financial sector. This generates downward sloping asset demand functions and yields interior steady state solutions without the need for second order approximations.

1.4 Emerging markets are distinguished by capital controls on outward investments

We aim to model portfolio flows between advanced markets and emerging markets. To distinguish between the two markets we impose an admittedly exaggerated version of the capital controls observed in practice. Using data on financial transactions for 91 countries between 1995 and 2005, Schindler (2009) finds that emerging markets tend to impose more controls on outflows than on inflows, and they do so to a much larger extent than developed economies. These controls are most prominent in South Asia and Sub-Saharan Africa, while least prominent in North America and Western Europe (Schindler, 2009). To best capture this contrast between capital controls in emerging and advanced markets, we impose a complete restriction on agents in the emerging economy from investing in the advanced economy.

In Chapter 3 we discussed whether such capital controls could explain the stronger response of South African bond flows to risk shocks. If South African investors and foreign investors have the same perception of the risk of South African bonds, and they face the same pool of investable assets with no frictions, it is hard to explain why bond flows respond more consistently to risk than share flows do. However, if South African investors are restricted from purchasing risk free global assets, the South African bond becomes the closest thing they have to a risk free asset. Thus, higher risk aversion will lead South African investors to purchase more South African bonds, while the higher risk aversion causes global investors to demand less South African bonds as they shift their portfolio home to the global risk free assets. Thus, higher risk aversion causes strong responses in emerging market bond flows. By imposing the strict capital controls on foreign investments by emerging market agents in the model, we are able to simulate and better understand these potential dynamics.

The structure of the resulting model is illustrated in Figure 5. The flow chart indicates the four agents of each economy and the markets in which they interact. The *home* economy is thought of as the emerging economy, and the $foreign$ economy is thought of as an advanced economy. That is, the remaining text is written from the perspective of the emerging economy.

Households provide work to the firm in return for wages. They interact with the financial sector by depositing savings in return for interest. They interact with the government by paying a tax that funds the governments interest expenses. The government borrows by issuing bonds to the financial sector. The financial sector takes deposits from households and invest these in government bonds in return for a discount rate and in firm shares in return for dividends. Lastly the *home* financial sector trades with the $foreign$ financial sector and thereby links the two economies. The link is asymmetric,: the $foreign$ financial sector is allowed to purchase *home* assets, while the *home* financial sector is restricted from purchasing $foreign$ assets.

The capital flow in the financial market will always be balanced by a current account deficit in the goods market. When $foreigners$ increase their holdings of *home* assets the *home* economy will run a current account deficit. In steady state, they will run a current account surplus caused by the interest payments on debt held by foreigners and dividend payments on shares held by foreigners.

[5] The risky steady state is the equilibrium at which there are zero innovations and all variables therefore remain unchanged at their optimal level given the expected value of state variables

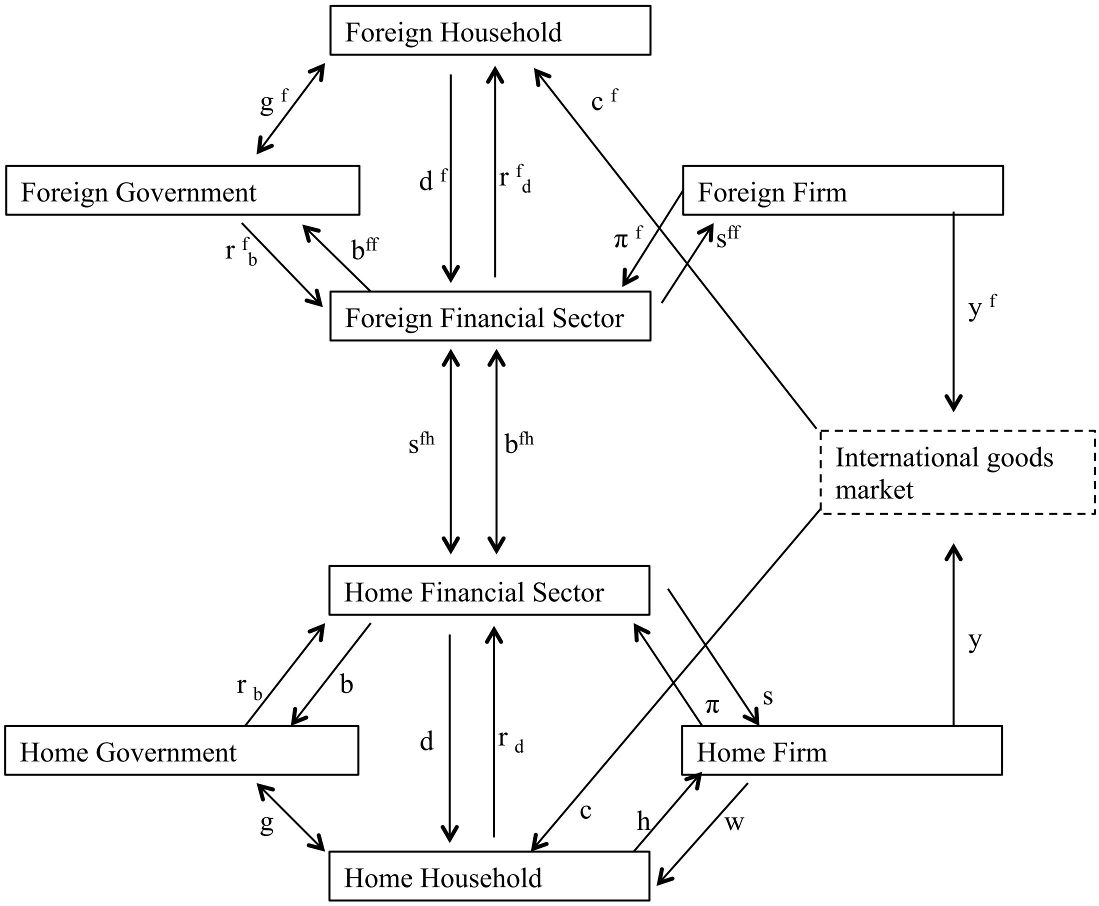

Figure 5: The two economies are linked by their financial sectors. Each economy has four agents. The current account balance in the international goods market will always balance against the capital flows in the financial market.

2 The model

The model presented is a two-country dynamic stochastic general equilibrium (DSGE) model. Most recent DSGE models in international finance and macroeconomics include money and frictions that give rise to a Keynesian multiplier and effective monetary policy. Such complications are not necessary for our purposes. Our goal is to understand the link between financial shocks and portfolio flows, and the role of financial intermediaries in transmitting portfolio flows to credit extension. Therefore, to keep the analysis as tractable as possible, we work in a parsimonious real business cycle (RBC) framework where we include only the most essential components required to capture the relevant dynamics. [6]

The model includes two countries, *home* and *foreign*. *Home* is thought of as an emerging economy while *foreign* is thought of as advanced. There is a single good traded in a friction free international market. Labour is not traded across borders. Each country have their own domestic financial sector which intermediates savings from households to firms and the governments. Households save by keeping deposits in banks. A reduction in deposits will reflect dissaving and can be viewed as an increase in household credit.

We structure the aggregate financial sector to capture the relationship between fund managers and banks as observed in Chapter 4. That is, in practice we saw that fund managers are linked to banks by depositing the proceeds from asset sales on bank balance sheets. In the model we combine the fund managers and banks in one aggregate financial intermediary, thus we assume that the entire proceeds from asset sales are deposited in banks, and the entire funding of asset purchases is raised from household deposits. The household deposits are liabilities of the financial intermediary and must be matched by assets. The assets of the financial intermediary are shares and government bonds. We said in section 1.4 that empirical data suggests emerging markets tend to impose more capital controls than advanced economies. Furthermore, the capital controls in emerging markets tend to be most restrictive on capital outflows, that is restricting residents from investing abroad. This empirical fact, we argued, can be utilized to distinguish between emerging and advanced economies in the model. Thus, the *home* intermediary is completely restricted from purchasing *foreign* assets, while the *foreign* intermediary is free to purchase both *home* and *foreign* assets.

The assets available are shares in firms and bonds issued by the governments. The firms own physical capital and hire labour from domestic households. There is perfect competition and the firms therefore earn profits equal to the required return on the physical capital they own. The profits are paid as dividends to the shareholders. The firms' objective is to maximize shareholder value; that is the present value of total current and future expected dividends.

The governments raise taxes to fund the cost of servicing its debt. The debt consists of one period government bonds. In the 'base case' model, the supply of bonds is fixed at 1. That is, in each period the government issues one government bond which can be divided between different bondholders. In an alternative 'fixed rate'-scenario, we model the price of *foreign* government bonds as fixed and instead the government issues bonds with perfect elasticity in response to demand.

In any given period, the current account and capital account must balance. That is, the current account deficit is funded by portfolio inflows and *vice versa*.

2.1 Households

2.1.1 Home household:

The representative *home* household receives income from labour and interest on deposits. Their only expenditure is consumption. Consumption increases utility, while labour reduces utility. The household problem is then to maximise expected utility by choosing consumption, labour and deposits subject to their budget constraint:

$$\max \Sigma_{t=0}^{\infty}\beta^t E_0\left[\frac{c_t^{1-\rho}}{1-\rho} - \chi\frac{h_t^{1+\gamma}}{1+\gamma}\right] \qquad \text{s.t}$$

$$c_t + d_t = g_t + w_t h_t + (1+r_t^d)d_{t-1} - \frac{\psi_d}{2}d_t^2 \tag{1}$$

[6] While RBC models have lost favor in the academic field, there are several instances of recent research demonstrating that the more parsimonious RBC models can provide valuable insights. McGrattan and Prescott (2014) and Kydland and Zarazaga (2002) show that these models can replicate many empirical observations previously thought to be out of the range of RBC models.

which gives the following first order conditions:

$$c_t^{-\rho} = \chi \frac{h_t^{\gamma}}{w_t} \tag{2}$$

$$1 + r_{t+1}^d = E_t\left[\frac{1}{\beta}(\frac{c_{t+1}}{c_t})^{\rho}\right](1 + \psi_d d_t) \tag{3}$$

Note that we have imposed a small cost (baseline calibration has $\psi_d = 0.002$) on squared deposits.[7] This is done to avoid perfect elasticity of household demand for deposits (i.e: supply of liabilities to the intermediary). It is important to note that the household saves by supplying deposits to the financial intermediary. This deposit is assumed to be risk free. The household is thus inhibited from investing directly in shares and bonds, but they do get indirect exposure through the intermediary. An increase in expected financial asset returns will increase the deposit rate, by increasing the intermediary's demand for deposit liabilities.

2.1.2 Foreign household:

The $foreign$ household is identical to the *home* household except that they recive an exogenous endowment instead of working. This simplication is done in order to keep the model as parsimonious as possible. The $foreign$ household maximises expected utility by choosing consumption and deposits in the $foreign$ financial intermediary subject to a budget constraint:

$$\max \Sigma_{t=0}^{\infty}\beta^t E_0\left[\frac{c_t^{*1-\rho}}{1-\rho}\right] \qquad \text{s.t}$$

$$c_t^f + d_t^f = n_t + (1 + r_t^{df})d_{t-1}^f - \frac{\psi_d^f}{2}(d_t^f)^2 \tag{4}$$

which gives the following first order condition:

$$1 + r_{t+1}^{df} = E_t\left[\frac{1}{\beta}(\frac{c_{t+1}^f}{c_t^f})^{\rho}\right](1 + \psi_d^f d_t^f) \tag{5}$$

As for the *home* household, there is a cost of holding deposits reflected in the parameter ψ_d^f. In the 'base case' calibration, this cost is slightly lower in the advanced economy compared to the emerging economy, with $\psi_d^f = 0.001$ as opposed $\psi_d = 0.002$.

2.2 Financial Intermediaries

The financial intermediaries take deposits from households and invest in shares and bonds. They construct a portfolio at time t to maximize the payoff (θ) in the following period ($t+1$) subject to a risk adjusted leverage constraint. We will interchangeably use returns and prices in equations, where the relation between the two are as usual:

$$E_t(1 + r_{t+1}^s) \equiv E_t\frac{p_{t+1} + \pi_{t+1}}{p_t} \tag{6}$$

$$E_t(1 + r_{t+1}^{sf}) \equiv E_t\frac{p_{t+1}^f + \pi_{t+1}^f}{p_t^f} \tag{7}$$

$$1 + r_{t+1}^b \equiv \frac{1}{q_t} \tag{8}$$

$$1 + r_{t+1}^{bf} \equiv \frac{1}{q_t^f} \tag{9}$$

2.2.1 Macroprudential policy attaches exogenous risk factors to assets

The return on shares clearly depend on future expected profits (dividends). These expected dividends are the main drivers of the intermediary's asset demand. With zero frictions, the demand will simply be the present value of the expected future dividends. But it was argued in Chapter 2 that financial intermediaries tend to operate with a binding risk and leverage constraint. Here we view this constraint as a macro prudential policy

[7] One can for example think of this as a cost of ensuring that deposits are risk free. That is, an exogneous deposit insurance.

that directly imposes a risk adjusted limit on total leverage. The more risky portfolio, the less leverage is permitted. The macro prudential policy calculates portfolio risk by atributing three different risk factors to the different assets. The risk factors are exogenous and together they determine how the risk of the portfolio is calculated.[8]

We hypothesised in Chapter 3 that the stronger risk sensitivity of bond flows compared to share flows can be explained by the different risk exposure carried by different agents. This is directly incorporated in the model presented here. Each asset and each intermediary have different exposure to the various risk factors. The factors are *home* share risk, *foreign* share risk and general emerging market risk. The third factor, general emerging market risk, can be viewed as the exchange rate risk of investing in emerging markets. As such, this risk only affects the advanced economy intermediary when they invest in emerging market assets.

The risk exposures of different assets are as follows: *Foreign* shares are only exposed to the *foreign* share risk, σ_{sf}^2. *Foreign* bonds are risk free. *Home* shares held by the *home* intermediary are only exposed to *home* share risk, σ_s^2. *Home* shares held by the *foreign* interemediary are exposed to *home* share risk, σ_s^2, and emerging market risk, σ_x^2. *Home* bonds held by the *home* intermediary are risk free. *Home* bonds held by the *foreign* intermediary are exposed to emerging market risk, σ_x^2. Thus, for the *foreign* intermediary, the *home* assets are correlated via their common exposure to emerging market risk, σ_x^2.

The required return on *home* shares by the foreigner can be decomposed into required compensation for the share risk and orthogonal emerging market risk. Similarly, the required return by the foreigner on the *home* bond can be decomposed to the risk free bond return and the emerging market risk:

$$E_t\Big[1 + r_{t+1}^{s,f}\Big] = E_t\Big[(1 + r_{t+1}^{s})(1 + r_{t+1}^{x})\Big]$$
$$E_t\Big[1 + r_{t+1}^{b,f}\Big] = E_t\Big[(1 + r_{t+1}^{b})(1 + r_{t+1}^{x})\Big]$$

All return series are independent except the return on *foreigner*'s two *home* assets, $r_{t+1}^{s,f}$ and $r_{t+1}^{b,f}$. The common exposure to emerging market risk causes a positive covariance between *home* shares and *home* bonds held by the *foreign* intermediary:

$$Cov(r_{t+1}^{s,f}, r_{t+1}^{b,f}) = \sigma_x^2 E_t\left[\left(\frac{\pi_{t+1}}{p_t}\right)\left(\frac{1-q_t}{q_t}\right)\right] \quad (10)$$

From this we can calculate the distribution of returns on all assets held by the *foreign* intermediary:

$$r_{t+1}^{sf,f} \sim N\left(\frac{\pi_{t+1}^f}{p_t^f}, \sigma_{sf}^2\right)$$
$$r_{t+1}^{bf,f} \sim N\left(\frac{1-q_t^f}{q_t^f}, 0\right)$$
$$r_{t+1}^{s,f} \sim N\left(\frac{\pi_{t+1}}{p_t}, \sigma_s^2 + \sigma_x^2(1 + \sigma_s^2 + E_t[\frac{\pi_{t+1}}{p_t}]^2])\right)$$
$$r_{t+1}^{b,f} \sim N\left(\frac{1-q_t}{q_t}, \sigma_x^2(1 + E_t[\frac{1-q_t}{q_t}]^2)\right)$$

The distribution of each asset held by the *home* intermediary is as follows:

$$r_{t+1}^{s,h} \sim N\left(\frac{\pi_{t+1}}{p_t}, \sigma_s^2\right)$$
$$r_{t+1}^{b,h} \sim N\left(\frac{1-q_t}{q_t}, 0\right)$$

[8]The fact that the risk factors are exogenous reflects the tendency of macro prudential policy to avoid using actual expected risk. Using expected risk will cause pro-cyclical policy because the increase in volatility observed during credit crises will force intermediaries to cut lending, thereby exaggerating the credit crunch.

In the following sections, we define two new variables, $\sigma^2_{s,f}$ and $\sigma^2_{b,f}$ as the variance of the home assets held by the foreigner:

$$\sigma^2_{s,f} \equiv \sigma^2_s + \sigma^2_x(1 + \sigma^2_s + E_t[\frac{\pi_{t+1}}{p_t}]^2]) \tag{11}$$

$$\sigma^2_{b,f} \equiv \sigma^2_x(1 + E_t[\frac{1-q_t}{q_t}]^2) \tag{12}$$

It is important to emphasise that the probability distributions listed above are those used by the intermediaries in calculating the risk of their portfolio. It is this risk that determines the maximum permitted leverage. As such, they do not use the observed variance / covariance of the asset returns, but rather the variance / covariance that is exogenously determined as appropriate by the macro prudential regulator.

There is therefore a difference between the actual observed variance / covariance between the different return processes and the variance / covariance used in the leverage constraint. The actual covariance depends on the responses of the different agents to different shocks. Certain shocks will give highly correlated return variations across assets, while other shocks will give different responses in different assets. In the deterministic steady state, the actual variance / covariance is zero. However, the variance / covariance used by intermediaries in the leverage constraint is dependent on the exogenous risk factors, σ^2_x, σ^2_s and σ^2_{sf} as determined by the regulator. These are greater than zero also in the deterministic steady state and always constant unless shocked directly.[9]

2.2.2 Home intermediary:

The *home* intermediary borrows from *home* households by raising deposits. These deposits are then invested in bonds and equity in order to maximize the profit in the investment period. The profit is simply the difference between the total payoff on assets and the total deposit and interest liabilities. There is a budget constraint and a constraint that limits leverage depending on the risk of the portfolio. If there is zero risk, the intermediary can have leverage approaching infinity. If the risk approaches infinity, the leverage must approach zero. We solve this using Kuhn-Tucker conditions and see that under certain conditions the optimal behavior is to always operate at the binding constraint where leverage is maximized.

The decision problem of the financial intermediary can be formally expressed as:

$$\begin{aligned}
&\max E_t(\theta_{t+1}) \\
&\text{subject to:} \\
&E_t(\theta_{t+1}) = E_t\Big[(p_{t+1} + \pi_{t+1})s_t + b_t - (1 + r^d_{t+1})d_t\Big] \\
&p_t s_t + q_t b_t = d_t + (p_t + \pi_t)s_{t-1} + b_{t-1} - (1 + r^d_t)d_{t-1} \\
&\frac{q_t b_t}{d_t} \geq 1 - e^{-\psi\sigma^2_\theta}
\end{aligned}$$

where the only risky asset is the shares. The expected risk on shares is an exogenous process, σ^2_s. Thus the variance of the portfolio and its derivative with respect to s_t is:

$$\sigma^2_\theta = \sigma^2_s(p_t s_t)^2 \tag{13}$$

$$\frac{\delta\sigma^2_\theta}{\delta s_t} = 2p^2_t\sigma^2_s s_t \tag{14}$$

As long as the expected return on shares is greater than the rate on deposits, and the rate on deposits is greater than the rate on bonds, it will be optimal for the financial intermediaries to always operate at the maximum allowed risk (the leverage constraint is binding). This is intuitive: the fact that shares return more than the cost of deposit liabilities means the intermediary wishes to raise as much deposits as possible to invest in shares. The fact that bonds return less than returns on deposits means that the intermediary will invest as little as possible in bonds. Thus, the intermediary will always maximize the ratio of shares to bonds. Solving the optimisation problem at the binding leverage constraint gives the following first order conditions:

[9] Alternatively, we can view the risk adjusted leverage target as internally imposed by the intermediary without the presence of a regulator. In this case, the three risk factors can be viewed as the intermediary's expected risk. Note that this view implies that the intermediary's risk expectations are nor affected by the actual observed variation in asset returns.

$$p_t = E_t\left[\frac{p_{t+1} + \pi_{t+1} - d_t\psi\frac{\delta\sigma_\theta^2}{\delta s_t}(r_{t+1}^d - r_{t+1}^b)}{1 + r_{t+1}^b + e^{\psi\sigma_\theta^2}(r_{t+1}^d - r_{t+1}^b)}\right] \tag{15}$$

$$b_t = \frac{p_t s_t}{q_t}(e^{\psi\sigma_\theta^2} - 1) \tag{16}$$

$$d_t = p_t s_t e^{\psi\sigma_\theta^2} \tag{17}$$

This holds as long as $r_t^s > r_t^d > r_t^b$, as is the case in the solved steady state. Since the derivative of total risk with respect to s_t and the total risk itself both increase with s_t, it appears from equation 16 that the demand for shares is downward sloping with respect to s_t. This is intuitive: the intermediary will add risk by increasing the position in high yield assets (shares) and reducing the position in low yielding bonds. This is done until the risk constraint is binding. At this point, adding more shares is only possible if the price is reduced (thereby keeping the exposure unchanged) or if it is combined with an increased position in risk free assets funded by increased deposits. The increased demand for deposit liabilities will pull up the rates on deposits. The increased demand for bonds will push down the rates on bonds. Thus, the loss on the spread between bond rates and deposit rates will increase as the share position is increased. To compensate for this increasing loss the higher share position is only optimal if the expected return on shares is higher, that is, the price is lower. Thus we have a downward sloping demand for shares: The intermediaries require higher returns (lower price) the more shares they hold.

This is a vital characteristic of the financial intermediary's behavior. We saw in section 1.3.1 that a downward sloping, *less-than-perfect* elasticity of demand, is required to yield an interior solution in the asset allocation problem. Thus, the risk constraint serves a dual purpose in the model: It enables an interior solution and it allows us to study the effects of macroprudential policy on capital flows and the macro economy.

2.2.3 Foreign intermediary:

The $foreign$ intermediary maximises expected profit by investing in *home* and $foreign$ assets. All *home* assets carry an additional risk orthogonal on the other risk factors. This risk factor may for example be thought of as an exchange rate risk or intermediation risk that only affects $foreign$ investors when investing in *home* (emerging market)assets. The $foreign$ bonds are perfectly risk free.

We can express the maximization problem as:

$$\max E_t(\theta_{t+1}^f)$$

subject to:

$$E_t(\theta_{t+1}^f) = E_t\left[(p_{t+1} + \pi_{t+1})p_t s_t^{fh} + (p_{t+1}^f + \pi_{t+1}^f)s_t^{ff} + b_t^{fh} + b_t^{ff} - (1 + r_{t+1}^{df})d_t^f\right]$$

$$p_t s_t^{fh} + p_t^f s_t^{ff} + q_t b_t^{fh} + q_t^f b_t^{ff} = d_t^f + (p_t + \pi_t)s_{t-1}^{fh} + (p_t^f + \pi_t^f)s_{t-1}^{ff} + b_{t-1}^{fh} + b_{t-1}^{ff} - (1 + r_t^{d,f})d_{t-1}^f$$

$$\frac{q_t^f b_t^{ff}}{d_t^f} \geq 1 - e^{-\psi^f\sigma_{\theta f}^2}$$

The variance of the $foreign$ intermediary's payoff is therefore more complex than for *home*, as it depends on the emerging market risk (σ_x^2), orthogonal *home* share risk (σ_s^2) and orthogonal $foreign$ share risk (σ_{sf}^2). Importantly, the foreigner's expected *total* return on *home* shares and bonds is correlated via the emerging market risk compensation.

The variance of the total payoff and its derivatives are then:

$$\begin{aligned}
\sigma^2_{\theta f} &= (p_t s_t^{fh})^2 \sigma^2_{s,f} \\
&+ (q_t b_t^{fh})^2 \sigma^2_{b,f} \\
&+ 2 p_t s_t^{fh} q_t b_t^{fh} Cov(r^{s,f}_{t+1}, r^{b,f}_{t+1}) \\
&+ (s_t^{ff} p_t^f)^2 \sigma^2_{sf} && (18) \\
\frac{\delta \sigma^2_{\theta f}}{\delta s_t^{fh}} &= 2 p_t^2 s_t^{fh} \sigma^2_{s,f} \\
&+ 2 p_t q_t b_t Cov(r^{s,f}_{t+1}, r^{b,f}_{t+1}) && (19) \\
\frac{\delta \sigma^2_{\theta f}}{\delta b_t^{fh}} &= 2 q_t^2 b_t^{fh} \sigma^2_{b,f} \\
&+ 2 p_t s_t q_t Cov(r^{s,f}_{t+1}, r^{b,f}_{t+1}) && (20) \\
\frac{\delta \sigma^2_{\theta f}}{\delta s_t^{ff}} &= 2 s_t^{ff} (p_t^f)^2 \sigma^2_{sf} && (21)
\end{aligned}$$

Where the covariance terms are defined earlier in equations 10, 11 and 12.

As long as the risk free rate of return is less than the funding rate (deposit rate) the first order conditions are:

$$\begin{aligned}
p_t &= E_t\left[\frac{p_{t+1} + \pi_{t+1} - d_t^f \psi^f \frac{\delta \sigma^2_{\theta f}}{\delta s_t^{fh}} (r^{df}_{t+1} - r^{bf}_{t+1})}{1 + r^{bf}_{t+1} + e^{\psi^f \sigma^2_{\theta f}} (r^{df}_{t+1} - r^{bf}_{t+1})}\right] && (22) \\
p_t^f &= E_t\left[\frac{p^f_{t+1} + \pi^f_{t+1} - d_t^f \psi^f \frac{\delta \sigma^2_{\theta f}}{\delta s_t^{ff}} (r^{df}_{t+1} - r^{bf}_{t+1})}{1 + r^{bf}_{t+1} + e^{\psi^f \sigma^2_{\theta f}} (r^{df}_{t+1} - r^{bf}_{t+1})}\right] && (23) \\
q &= E_t\left[\frac{1 + r^f_{t+1} - d^f_{t+1} \psi^f \frac{\delta \sigma^2_{\theta f}}{\delta b_t^{fh}} (r^{df}_{t+1} - r^{bf}_{t+1})}{1 + r^{bf}_{t+1} + e^{\psi^f \sigma^2_{\theta f}} (r^{df}_{t+1} - r^{bf}_{t+1})}\right] && (24) \\
b_t^{fh} &= (p_t s_t^{fh} + p_t^f s_t^{ff})(e^{\psi \sigma^2_\theta} - 1) && (25) \\
d_t^f &= (p_t s_t^{fh} + p_t^f s_t^{ff}) e^{\psi \sigma^2_\theta} && (26)
\end{aligned}$$

2.3 The firm

The $foreign$ firm is not modelled explicitly and simply provides an exogenous dividend stream to the share holders. The *home* firm produces a global good using *home* labour and it's own invested capital. The firm is a price taker and earns profits sufficient to compensate for the required return on capital owned by the firm itself.

The *home* firm maximizes share holder value by maximizing the present value of current and future expected dividends. The firm's decision involves investing in physical capital as well as hiring employees. Note that the firm owns the capital used in production and funds investment in capital by reinvesting profits. The investment decision for the firm depends on whether the present value of the capital investment is greater than the foregone dividend payment. There is an adjustment cost (ϕ) associated with investing in physical capital.

$$\begin{aligned}
&\max\ E_0 \Sigma_{t=0}^{\infty} \beta^t \left[a_t k_t^\mu h_t^{1-\mu} - w_t h_t - i_t - \frac{\phi}{2} i_t^2\right] \qquad \text{s.t:} \\
&k_{t+1} = i_t + (1-\delta) k_t && (27)
\end{aligned}$$

which yields the FOCs:

$$\begin{aligned}
w_t &= (1-\mu) a_t \left(\frac{k_t}{h_t}\right)^\mu && (28) \\
i_t &= E_t \frac{\beta}{\phi}\left[\mu a_{t+1} \left(\frac{h_{t+1}}{k_{t+1}}\right)^{1-\mu} + (1-\delta)(1 + \phi i_{t+1})\right] - \frac{1}{\phi} && (29)
\end{aligned}$$

Dividends paid to the share owners are equal to total revenue less labour cost, investment and investment cost:

$$\pi_t = a_t k_t^{\mu} h_t^{1-\mu} - w_t h_t - i_t - \frac{\phi}{2} i_t^2 \tag{30}$$

2.4 Government

The respective governments borrow by issuing bonds and raise taxes (g) on the domestic household to fund the debt service cost:

$$g_t = q_t b_t^S - b_{t-1}^S \tag{31}$$

$$g*_t = q_t^f b_t^{s^{fh}} - b_{t-1}^{s^{fh}} \tag{32}$$

2.5 Market Clearing

The *home* bond and equity markets clear when domestic and foreign agents demand all issued bonds and shares. The $foreign$ bond and share markets clear when all issued assets are demanded by the $foreign$ intermediary.

$$b_t + b_t^f = b_t^S \tag{33}$$

$$b_t^{ff} = b_t^{s^{fh}} \tag{34}$$

$$s_t + s_t^{fh} = 1 \tag{35}$$

$$s_t^{ff} = 1 \tag{36}$$

3 Calibration, Steady State and Volatility

3.1 Calibration

We calibrate the model with four different scenarios: 'closed economy', 'base case', 'tight home leverage constraint' and 'fixed global risk free rates'. Under the first scenario the *home* economy is completely closed, that is, the $foreign$ intermediary cannot invest in *home* assets and the $foreign$ economy is therefore completely removed from the model. We keep all remaining parameters in the closed economy as they are in the base case open economy calibration. In the 'tight leverage constraint' scenario, all the parameters are identical to the base case, with the exception of the penalty on risk (ψ) which is higher in the 'tight leverage constraint' scenario. At last we have the fixed rate scenario, in which the global risk free rate is fixed at zero, while allowing the supply of bonds to adjust to demand. In the base case scenario, the supply of bonds is fixed at unity, while the price of bonds adjusts to demand. Other than the fixed rate on risk free bonds, the calibration of the 'fixed global risk free rates' scenario is identical to the 'base case'. The 'base case' calibration is listed in *Table 1*.

We base most of the standard parameters on the calibration of Devereux and Sutherland (2009) with the exception that we use quarterly rates rather than annualised rates. Since Devereux and Sutherland (2009) use a rather non-traditional calibration for emerging market share of capital in production of 0.5, we rather use a more common emerging market calibration of 0.33 as found in for example Mendoza (2010). The calibration of the investment cost is based on the recommendation of Bernanke, Gertler, and Gilchrist (1999) who refers to the lack of consensus in the literature and therefore suggests a value between 0 and 0.5.

The standard deviation of asset returns is calibrated to reflect US stock market data for the $foreign$ economy, and South African stock market data for the *home* economy. The quarterly standard deviation of total returns on the iShares SPDR S&P 500 ETF over the last 10 years was approximately 8%. The quarterly standard deviation of the South African Johannesburg Stock Exchange index (JSE-All Share) over the same time period was approximately 9.5%. The last risk factor in the model is the emerging market risk carried by foreigners holding home assets. This risk factor must be orthogonal on the *home* share risk and have expected return of zero. We estimate this by regressing the US dollar returns from investing in the (unhedged) iShares MSCI South Africa ETF on the rand returns on the JSE All-Share index. The residual indicates the risk not associated with the shares themselves, and therefore captures the remaining orthogonal currency risk with zero expected returns. The standard deviation of the residual is 12%. We use these estimates in the model calibration. [10]

It is more complicated to find reasonable calibrations for the parameters related to the financial intermediary. In the literature, the cost of deposits is typically zero (that is, there is usually no cost of deposits). We therefore use the lowest calibration possible that generates reasonable steady state results for leverage and interest rates.

[10] All data used in calculations are accessed from Yahoo Finance.

The penalty on risk in the leverage constraint is set at 1, implying steady state leverage of 9 in the emerging economy and 6.5 in the advanced economy. In the 'tight home leverage constraint' scenario, the risk penalty on the *home* intermediary is set at 2. This scenario yields steady state leverage of 5.6 in the *home* economy and 6.5 in the $foreign$ economy.

Table 1: Base Case Calibration

Parameter	Symbol	Calibration	Source
Autocorrelation of shocks	α	0.8	
Discount factor of home household	β	0.99	(Devereux and Sutherland, 2009)
Discount factor of firms	β^{firm}	0.99	(Devereux and Sutherland, 2009)
Discount factor of foreign household	β^f	0.99	(Devereux and Sutherland, 2009)
Labour disutility	χ	8	Steady state labour = approx 35%
Capital depreciation rate	δ	0.025	(Devereux and Sutherland, 2009)
Labour supply elasticity	γ	1	(Devereux and Sutherland, 2009)
Capital share of production	μ	0.33	(Mendoza, 2010)
Investment cost	ϕ	0.1	(Bernanke et al., 1999)
Deposit cost - home	ψ^d	0.002	See discussion
Deposit cost - foreign	ψ^{df}	0.001	See discussion
Risk penalty - foreign	ψ^f	1	See discussion
Risk penalty - home (base case)	ψ	1	See discussion
Risk penalty - home (tight constraint)	ψ	2	See discussion
Intertemporal elasticity of substitution	ρ	1	(Devereux and Sutherland, 2009)
St. Dev. Home shares	σ	0.095	See discussion
St. Dev. foreign shares	σ^f	0.08	See discussion
St. Dev. Emerging Market risk	σ^x	0.12	See discussion

3.2 Steady state results

The steady state results generally look reasonable. In the following we compare some key financial ratios for the *home* economy to those of South Africa in 2014. The model is calibrated with a total supply of *home* shares equal to 1, and total supply of *home* bonds equal to 1. The steady state price of shares is 5.39 and the price of bonds is 0.982. This implies that the market capitalisation of the stock market is roughly 5.5 times the size of the local debt market. In comparison, the market capitalisation of the Johannesburg Stock Exchange in South Africa is roughly 7 times the size of the domestic marketable government debt issue (South African Reserve Bank, 2015).

In the base case scenario, we find that the *home* intermediary has slightly higher leverage than the $foreign$ intermediary, meaning they hold more risky asset relative to risk free assets. The leverage (total holdings of shares and bonds over bond holdings) is 9.2 in the base case calibration. In South Africa, the total domestic holdings of shares and bonds are approximately 4 times the value of total bond holdings (South African Reserve Bank, 2015). If we calibrate the penalty on risk in the leverage constraint to be higher in the *home* (emerging market) economy, we see that the leverage drops to 5.6, closer to the observed ratio in South Africa.

The *home* (emerging market) intermediary holds roughly 45% of the *home* bond issue and 65% of the *home* share issue, with the remaining held by the foreign intermediary. In comparison, based on data for South Africa at the end of 2014 we estimate that residents owned approximately 60% of the local bond issue and close to 90% of the local equity issue IMF (2014a,b); South African Reserve Bank (2015).

The *home* intermediary is forced to hold only home assets. The $foreign$ intermediary is free to hold both home and foreign assets. In steady state, the market value of the foreign intermediary is 6.24, of which 37.7% is invested in emerging market assets and the remaining 62.26% is invested in the foreigner's domestic assets. The model most similar to ours in the current literature is found in Devereux and Sutherland (2009). As explained earlier, they develop a two country real business cycle model with no frictions, but an endogenous discount factor that yields a unique portfolio solution in the stochastic steady state. They find the steady state portfolio of the 'developed' country to hold 234% of the 'developing country' shares, while the 'developing' country holds 350% of the home shares. This is balanced by large short positions in their domestic shares. This result shows that in a frictionless economy, risk sharing is possible and optimal. Households minimise consumption risk by having short position in their employers stock. A short position in domestic equity is found to be optimal in several other models for this same reason, see for example **?**. In our model, however, the financial intermediaries display a strong 'home bias' compared to the portfolio that would be optimal if households invested on their own behalf in friction free markets.

One of the major puzzles in the macro-finance literature is the documented presence of home bias in international equity portfolio allocation **?**. The macro finance literature has now come a long way to explain this puzzle, with important contributions from **?**,**?** and **?**. Much of the explanation tend to lie in the cost of trading physical goods, thus restricting the consumption smoothing achieved even with financial risk sharing (**?**).

In our model, the resulting portfolio of the foreign intermediary displays strong home bias compared to the friction-free results simulated in Devereux and Sutherland (2009). Unfortunately, the home bias of the foreign intermediary in our model does not mean our model has solved the 'home bias puzzle'. Firstly, the *home* intermediary is forced by capital controls to allocate 100% of their portfolio in domestic assets. If the capital control was relaxed, the *home* intermediary would likely reduce exposure to domestic assets by selling the assets to the $foreign$ intermediary in return for $foreign$ assets. This would reduce the home bias of the foreign investor. Thus, capital controls restricting agents in emerging markets from investing in foreign assets will likely have the side effet that foreigners invest less in emerging markets and therefore they display more home bias.

However, the main reason for the home bias displayed in our model is that the financial intermediaries allocate their portfolio according to expected payoffs and the risk factors imposed on them by the macroprudential regulator. They do not consider the correlation between returns and consumption. The home bias puzzle arises if instead households were the equity holders. In models like Devereux and Sutherland (2009), the households then allocate the portfolio based on the expected correlation to their own consumption. This leads to low (even negative) portfolio weights in their home country where the payoffs are highly correlated to the wages paid on their labour.

Table 2: Steady State Means

Variable	Symbol	Closed	Base Case	Tight Constraint	Fixed Rate
Leverage home	L	5.6565	9.1827	5.5760	7.3474
Leverage foreign	L^f	-	6.5518	6.4902	13.1167
Share of bonds held by home	b	1.0000	0.4467	0.7428	0.6548
Share of bonds held by foreign	b^f	-	0.5533	0.2572	0.3452
Share of shares held by home	s	1.0000	0.6637	0.6213	0.8256
Share of shares held by foreign	s^f	-	0.3363	0.3787	0.1744
Price of shares - home	p	4.6428	5.3854	5.3262	4.8767
Price of shares - foreign	p^f	-	2.8997	2.8952	2.8394
Price of bonds - home	q	0.9783	0.9824	0.9823	0.9815
Price of bonds - foreign	q^{rf}	-	0.9856	0.9860	1.0000
Return on bonds - home	r^b	0.0221	0.0179	0.0180	0.0189
Return on bonds - foreign	r^{rf}	-	0.0146	0.0142	0.0000
Return on shares - home	r^s	0.0207	0.0184	0.0186	0.0200
Return on shares - foreign	r^{sf}	-	0.0172	0.0173	0.0176
Return on deposits - home	r^d	0.0213	0.0182	0.0183	0.0196
Return on deposits - foreign	r^{df}	-	0.0166	0.0166	0.0150
Consumption home	c	0.7561	0.7347	0.7352	0.7444
Consumption foreign	c^f	-	1.0930	1.0920	1.0734
Deposits home	d	5.5340	4.0299	4.0685	4.7220
Deposits foreign	d^f	-	6.4578	6.3992	4.8839
Government transfers home	g	-0.0217	-0.0176	-0.0177	-0.0185
Government transfers foreign	g^f	-	-0.0144	-0.0140	0.0000
Employment	h	0.3303	0.3398	0.3396	0.3355
Investment	i	0.2264	0.2327	0.2326	0.2298
Capital stock	k	9.0563	9.3086	9.3025	9.1929
Wages	w	1.9981	1.9975	1.9975	1.9978
Output	y	0.9851	1.0132	1.0125	1.0003

3.2.1 Tighter leverage constraint increases steady state welfare

The penalty on risk (ψ) in the leverage constraint has a direct effect on total steady state leverage. The 'tight constraint' calibration yields a simulated leverage of 5.6 in steady state, compared to 9.2 in the 'base case'. This is reflected in a greater *home* ownership of *home* bonds, with 74.3% of the issue owned by the *home* intermediary versus 44.7% in the 'base case'. In the share market, the tighter leverage constraint means that the *home* intermediary holds 62.1% versus 66.4% in the 'base case'. The remaining financial variables are largely unaffected by the tightness of the leverage constraint. Of the real variables, we see that the tighter leverage constraint is associated with more consumption, less employment and higher taxes (negative transfers from the government (g)). This is all funded by higher returns ($r_d = 2.86\%$ vs $r_d = 1.84\%$) on higher savings ($d = 4/07$ vs $d = 4.03$). The higher return is explained by the financial intermediary's greater demand for deposits to invest in safe assets in order to keep leverage below the tighter constraint. The reduced supply of labour leads to reduced investment in physical capital, and therefore lower capital stock and lower output.

Table 3 reports the standard deviation of variables in response to a one percentage point increase in the standard deviation of the three risk factors: home shares, foreign shares and emerging market risk. A tighter leverage constraint on the *home* intermediary reduces the volatility of *home* leverage in response to risk shocks, but increases the volatility of portfolio flows in both bonds and shares. All asset returns become less volatile. Savings, consumption and employment at home are all slightly less volatile, causing higher welfare. However, the impulse responses plotted in section 4.3 show that the impact of macroprudential regulation is minimal.

3.2.2 Elastic supply of risk free bonds can absorb risk shocks

A shock that increases the risk of assets will force the financial intermediaries to reduce leverage. Delevering by the intermediary implies purchasing more risk free bonds, either funded by selling shares or by raising deposits. Demanding more deposits will increase the rate of return offered on deposits. And the higher demand for bonds will pull up their price, reducing their return. Thus, the spread between deposit returns and bond returns will widen, increasing the loss associated with reducing risk.

However, it is feasible, at least in the model world simulated here, to drastically reduce the variability in the cost of reducing risk. This is done by providing an infinitely elastic supply of risk free global bonds and thereby keeping the risk free rate fixed. Such a policy will enable the $foreign$ intermediary to adjust its leverage to risk shocks at a much lower cost than before. That is, the cost of reducing risk does not increase with demand for risk free assets.

We simulate such a model in the 'Fixed Rate' calibration. This calibration yields higher steady state consumption and lower labour, both implying greater welfare. The remaining factors affecting welfare are the volatility of consumption and labour. We see that the fixed rate policy causes a significant increase in the volatility of leverage in the $foreign$ financial sector in response to the three risk shocks. The large fluctuations in the balance sheet of the financial sector is explained by the now lower cost of adjusting leverage. The balance sheet fluctuations imply greater fluctuations in portfolio flows. However, the remaining financial and real variables are now remarkably stable. The volatility of consumption and labour in response to risk shocks are significantly lower, also suggesting higher welfare. As with the macroprudential policy, we see that welfare increases despite more volatility in portfolio flows. It appears as if the balance sheet variables absorb the risk shock by reallocating assets between the two intermediaries, reducing the need for adjustments in the real economy. In the following sections we will carefully analyse the transmission mechanism from risk shocks via the financial sector to the household and the real variables that affect welfare. This will enable us to better understand the role of policies such as leverage constraints and fixed versus floating risk free rates.

Table 3: Standard Deviations in response to risk shocks

Variable	Symbol	Base Case	Tight Constraint	Fixed Rate
Leverage home	L	2.5750	1.325373	1.835217
Leverage foreign	L^f	0.5686	0.548702	3.525134
Share of bonds held by home	b	0.1350	0.195602	0.163325
Share of bonds held by foreign	b^f	0.1350	0.195602	0.163325
Share of shares held by home	s	0.0272	0.028508	0.032318
Share of shares held by foreign	s^f	0.0272	0.028508	0.032318
Price of shares - home	p	0.3178	0.325497	0.011842
Price of shares - foreign	p^f	0.0535	0.045179	0.010898
Price of bonds - home	q	0.0170	0.01564	0.000482
Price of bonds - foreign	q^{rf}	0.1075	0.098308	0
Return on bonds - home	r^b	0.0176	0.016208	0.0005
Return on bonds - foreign	r^{rf}	0.1106	0.101123	0
Return on shares - home	r^s	0.0610	0.061145	0.001702
Return on shares - foreign	r^{sf}	0.0163	0.012831	0.002445
Return on deposits - home	r^d	0.0501	0.043921	0.001174
Return on deposits - foreign	r^{df}	0.0416	0.035966	0.000993
Consumption home	c	0.0375	0.035047	0.001179
Consumption foreign	c^f	0.0666	0.062686	0.001914
Deposits home	d	0.2079	0.205537	0.013242
Deposits foreign	d^f	0.2975	0.279368	0.101606
Government transfers home	g	0.0170	0.01564	0.000482
Government transfers foreign	g^f	0.1075	0.098308	0.06897
Employment	h	0.0132	0.012403	0.000414
Investment	i	0.0104	0.01085	0.000402
Capital stock	k	0.0627	0.067275	0.003728
Wages	w	0.0244	0.022593	0.000726
Output	y	0.0273	0.025836	0.0009

4 Portfolio Flows and Credit

4.1 Comparing the open economy to a closed economy

If we close the home economy completely, this becomes a rather standard simple RBC model with the exception of the risk constrained financial intermediary. We can better understand the effects of the model innovations by studying the comparing the impulse responses of this closed model to those we would expect from the standard closed economy RBC model. The most typical shock would be to the productivity of the firm. We plot the responses to such a shock in *Figure 6*. The (red) lines marked with 'x'-es indicate the responses in the closed economy, while the (blue) lines marked with 'o'-es indicate the responses in the open economy.

The higher productivity leads to higher wages (marginal product of labour) and greater investment in physical capital due to the higher marginal product of capital. The higher wages attract more labour supply. The combination of more labour and higher wages causes a great increase in household income.The household gets a further boost to income from the government transfers due to the now higher bond prices. The increase in income and government transfers must be allocated to consumption and savings by the household. We therefore see that both consumption and deposits (savings) increase. All these responses are similar to what one would expect from a basic RBC with no financial frictions. Whether the economy is open or closed does not have a great impact on any of these real responses. The only real variable with a significantly different response in the open economy is household consumption. When the economy is open, the households are better able to smooth consumption over time in response to increased productivity. The inter temporal smoothing is possible because they can run a current account surplus by purchasing domestic financial assets from the foreigner, who in return purchases goods from the home firm. This buildup of home savings will gradually be unwound in the following periods as the home agents sell the assets back to the foreigner until the economy has returned to the steady state.

The same result is found in other two-country DSGE models of portfolio flows. Devereux and Sutherland (2009) found that a positive shock to home productivity led the home agent purchase home shares partly funded by selling foreign shares and partly funded by running a current account surplus. Similarly, **?** found a positive productivity shock at home to cause agents to sell foreign assets to the foreigner and purhcase home assets from the foreigner. Exactly as in Devereux and Sutherland (2009), they purchase more assets than they sell, reflecting a current account surplus to distribute the higher income over several future periods of consumption. Our model presented here, like the models by Tille *et.al* and Devereux *et.al* are deliberately parsimonious in order to highlight only the most relevant relationships. However, the equivalent responses to a productivity shock are encouraging. It suggests a certain robustness of the framework. The responses are the same under a neoclassical model with zero frictions and symmetric equity markets in which households consider the correlation of asset returns to future income (Devereux and Sutherland, 2009), in a model with finite-lifespan agents who need not consider the correlation between returns and productivity (**?**), and lastly in our model where investments are allocated by financial intermediaries with externally imposed leverage constraints.

In our simulations, the financial variables are more affected than real variables by opening the financial markets than real variables like consumption and labour. Naturally there is no foreign holding of home shares and bonds in the closed model, and therefore no response in portfolio flows. In both the closed and open economy, there is a sharp increase in supply of deposit liabilities due to higher household savings. In the open economy, the home intermediary uses the increased supply of deposit liabilities to fund purchases of both shares and bonds. The intermediary purchases more bonds than shares, causing a drop in leverage (defined as total assets over risk free bonds). The ability to purchase bonds from the foreign intermediary is essential. In the open economy, the foreigner stands ready to sell his holding of home bonds, and thus the increased demand for these bonds by the home intermediary does not have a great impact on the price. This means that the cost of reducing leverage is lower than in the closed economy. This further means that the cost of purchasing shares is lower than in the closed economy. At last, this explains why leverage increases and share prices drop in the closed economy, while leverage drops and share prices increase in the open economy.

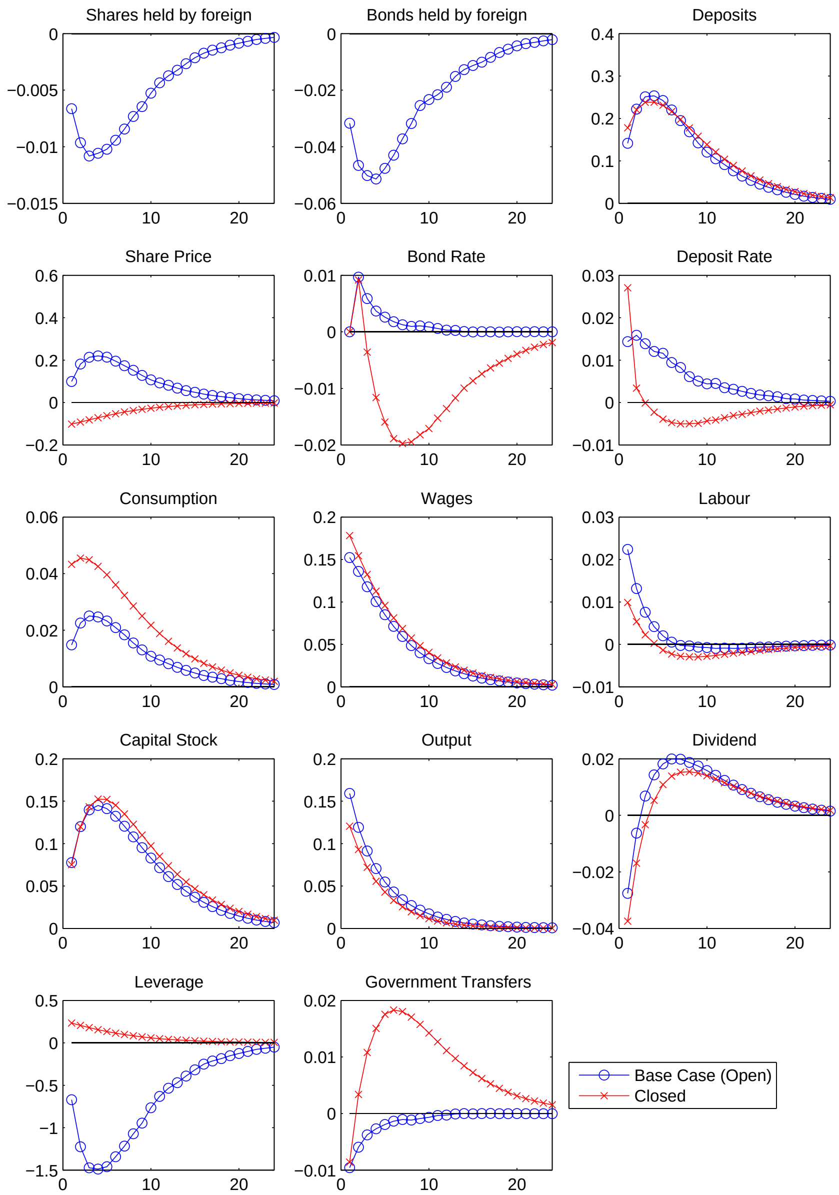

Figure 6: **Productivity shocks** cause higher consumption and investment. Portfolio flows reduce the impact on consumption in the open economy.

4.2 Increasing risk causes current account surpluses in emerging economies

The academic literature has increasingly focused on the relationship between risk, leverage and capital flows. Risk is generally thought to cause lower leverage and portfolio outflows from emerging markets (Rey, 2013; Bruno and Shin, 2013; Adrian and Shin, 2009; McCauley, 2012). Portfolio outflows are further thought to reduce credit / increase savings (Rey, 2013; Magud, Reinhart, and Vesperoni, 2014; Lane and McQuade, 2013; Calvo, 1998). The results of our model support this story. The impulse responses to the three different risk shocks are plotted in *Figure 7*. The (green) dotted lines plot the responses to a shock in *home* share risk. The (blue) lines marked with 'x'-es plot the responses to a shock in $foreign$ share risk. The (red) lines marked with 'o'-es plot the responses to a shock in emerging market risk carried by the $foreign$ intermediary.

Risks that affect the foreigner (that is foreign share risk and emerging market risk) cause portfolio flows out of emerging markets. *Figure 7* shows that this is the case in both shares and bonds, but mainly in shares. Since the shock does not affect the *home* agent directly, the different response of bonds compared to shares is likely reflecting a greater elasticity of share demand with respect to risk than the elasticity of bond demand with respect to risk. The reason is likely to be the greater total risk of shares, thus reducing share exposure is more effective in reducing total risk on the global intermediary's balance sheet. The outcome is a relative shift in demand for *home* assets away from the foreign intermediary towards the home intermediary.

The portfolio flows respond differently to a shock in *home* (emerging market) share risk. This shock directly affects both the global and emerging market financial intermediaries. This forces both intermediaries to reduce leverage which means the *home* intermediary will reduce demand for shares and increase demand for *home* bonds. The higher risk on shares will also reduce the $foreign$ intermediary's demand for *home* shares, but the net effect is that the $foreigner$ buys shares from the *home* intermediary. In other words, the direction of the portfolio flow is determined by the relative change in demand, and in this case the *home* demand fell more than the $foreign$ demand. This gives rise to a negative correlation between share prices and portfolio flows: share prices dropped as foreigners bought shares. The bond price, however, rises while there is a bond outflow. It is unclear whether the $foreign$ intermediary demands more or less *home* bonds in response to the risk shock. The *home* intermediary is certain to demand more *home* bonds to reduce leverage. The outcome is that the *home* intermediary purchases *home* bonds from the foreigner, reflected in a portfolio outflow from the bond market. The higher price associated with this outflow is explained by higher demand for *home* bonds by the home intermediary. These simulated impulse responses can potentially explain the results observed in Chapter 3. We observed that risk shocks consistently cause portfolio outflows from South African bonds, but not significant flows in shares. This is consistent with a risk shock that affects both the global and local emerging market investors.

Figure 7 also illustrates that the source of risk and direction of flows do not matter much for the response of real variables. Home consumption, labour and output respond in almost exactly the same way to an increase in *home* share risk as to a shock in $foreign$ share risk or general emerging market risk. This similarity in effects of the different risk shocks is not trivial. The real effects are independent on the source of risk only because each risk shock happens to have the same effect on the *home* intermediary's demand for deposit liabilities. This is the only link between the financial sector and real sector of the economy. It is the rate of return offered on deposits that cause all adjustments by households. The adjustments by the households further cause adjustments by the firm. The corollary is that our understanding of the real effects of a risk shock depends on our understanding of the effect the shock has on the financial intermediary's demand for savings (deposit liabilities).

4.2.1 All risk shocks increase demand for deposit liabilities...

A shock to *home* risk causes a drop in leverage. The drop in leverage is a direct consequence of the risk adjusted leverage constraint. Leverage equals the ratio of household savings (deposits) to risk free assets. In order to reduce leverage, the intermediary must either sell risky assets, or raise more deposit liabilities from households to invest in risk free assets. The intermediary does both simultaneously in response to a risk shock. This implies a higher demand for deposit liabilities, causing the interest rate offered on deposits to increase.

It is perhaps less obvious how a shock to $foreign$ share risk will affect the *home* intermediary. In this case, the foreign intermediary is directly forced to reduce risk, and will do so evenly across their portfolio. Since both *home* shares and *home* bonds are risky in the eyes of the foreigner, they will reduce demand for both. This leads to a portfolio outflow. The outflow implies that the home intermediary purchases *home* shares and bonds causing a temporarily higher leverage. The purchase of shares is optimal because the price has dropped due to the lower foreign demand. The purchase of bonds is required to keep the leverage at its constraint when more risky shares are added to the balance sheet. The combined purchase of shares and bonds requires the financial intermediary to raise funds by taking more household deposits. Again, this implies a higher demand for deposit liabilities, causing the interest rate offered on deposits to increase.

The last risk shock was to general emerging market risk. This is the risk that is associated with investing in *home* shares and bonds by the $foreign$ intermediary. The *home* intermediary has no exposure to this type of risk. But again we see that despite their lack of exposure, the home intermediary is affected. The effects are similar to that of a shock in $foreign$ share risk. The foreigner's cost of holding *home* shares and bonds are now higher, causing them to reduce demand for both. The home intermediary's demand for these assets has not changed, and therefore the home intermediary will purchase these assets as the price drops due to the lower foreign demand. Again we see that the *home* intermediary must fund this by raising deposits. As with the other two risk shocks, this implies a higher demand for deposit liabilities, causing the interest rate offered on deposits to increase.

4.2.2 ...Therefore all risk shocks have similar real effects.

Nobody would care about the financial sector if it did not have real effects that determine our welfare. But so it does. When any kind of risk increases we saw that the *home* intermediary purchases more *home* assets. We saw that the three different risk shocks had for different reasons the exact same effect on demand for household deposits. The financial intermediary demands more household deposits, causing the interest rate offered on these savings to increase. And this is the financial variable that transmits into the real sector where welfare is derived.

All three risk shocks caused higher rates offered for household deposits. The higher rates offered induce more saving. The increased saving is funded by less consumption and more labour. The increased supply of labour causes a drop in the marginal productivity of labour, reflected in lower wages. The reduced cost of labour will also lead to temporary disinvestment in physical capital. This causes an increase in dividends, as the return on capital is greater and profits are paid as dividends rather than reinvested. Further, the proceeds from disinvestments are also paid as dividends. This is a counter-cyclical feature of the firm, reducing the negative impact of risk on share prices.

The outcome is that portfolio flows, credit, leverage, consumption and investment all respond in a manner consistent with findings of the empirical literature. Output increases temporarily as more labour is supplied, but this added output is exported rather than consumed, reflecting a current account surplus that balances the portfolio outflows. Furthermore, we observe that the welfare effects of the risk shocks are negative. Households derive utility from consumption and leisure, both of which decline in response to risk shocks. The challenge is now to find a policy response that reduces the fluctuations of consumption and labour in response to exogenous shocks.

The transmission channel from the inital shock to the *home* household goes through the *home* financial intermediary's demand for deposit liabilities. If the shock does not cause a change in the interest rate offered on deposits, the household's savings decision will not be affected. And if savings are not affected, then neither are consumption and labour. There are consequently no welfare implications. Targeting the transmission channel means targeting the financial intermediary's demand for savings / supply of credit. The optimal policy in response to portfolio flows is that which keeps the financial intermediary's demand for deposit liabilities unchanged.

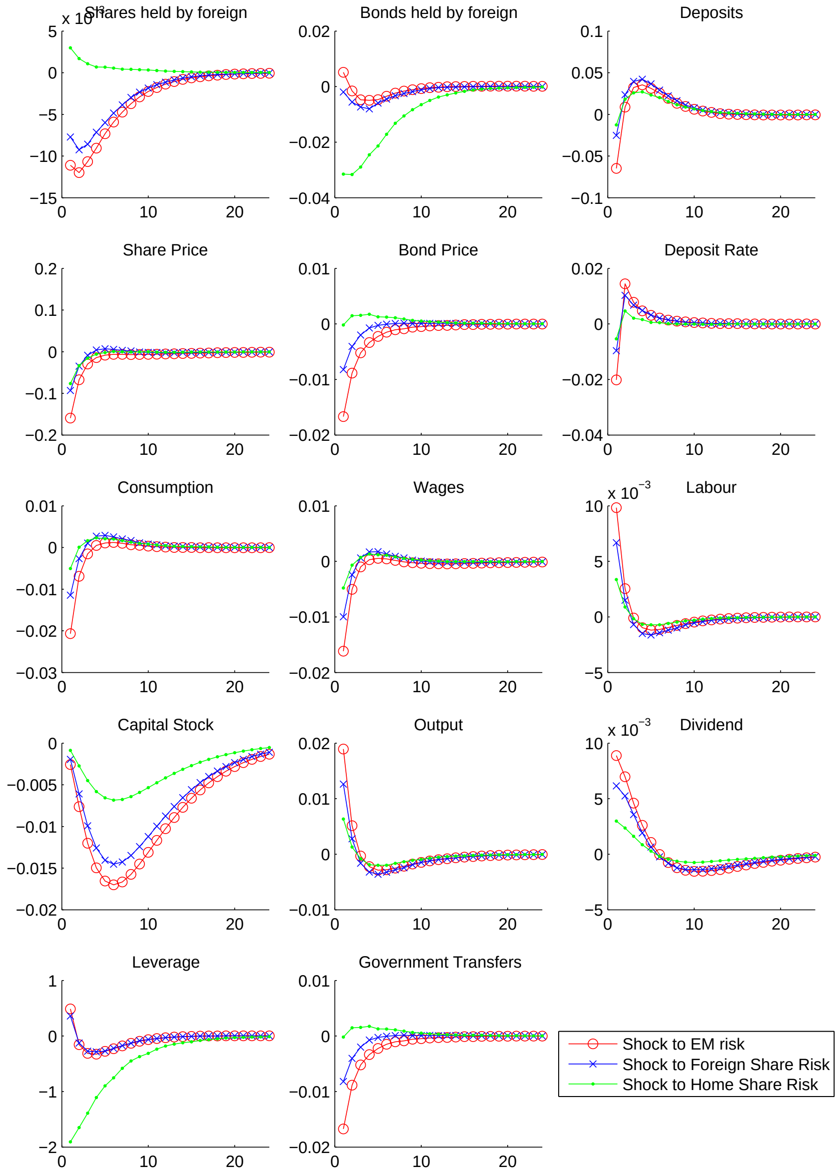

Figure 7: **Risk shocks** cause portfolio outflows, less credit (more saving) and lower consumption. The (green) unmarked lines plot the responses to a shock in *home* share risk. The (blue) lines marked with 'x'-es plot the responses to a shock in *foreign* share risk. The (red) lines marked with 'o'-es plot the responses to a shock in emerging market risk carried by the *foreign* intermediary.

4.3 Macroprudential policy does not break the transmission channel

We argued above that the optimal policy in the recipient economy is one which reduces the volatility of intermediary's demand for savings. In this section we explore the power of macroprudential policy in achieving this goal. We see that tightening the leverage constraint on *home* financial intermediaries will improve welfare, but the effect on macroeconomic volatility is minimal. In *Figures 8 - 10*, the (green) lines marked with 'x'-es and the (blue) lines marked with dots indicate the impulse responses from a calibration with $\psi = 1$ (risk penalized less) and $\psi = 2$ (risk penalized more). That is, for any given level of total portfolio risk, a higher ψ reduces the maximum allowed leverage (total assets over risk free assets). We view this as tigher macroprudential regulation.

The transmission mechanism from the risk shock to the financial sector and real sector are all as described above. The only variables that significantly change their response to risk shocks are portfolio flows and financial sector leverage. Firstly, steady state leverage is significantly lower when the risk is penalized more ($\psi = 2$). Therefore it is not surprising that the cut in leverage in response to risk shocks is smaller when $\psi = 2$.

In steady state, the *home* intermediary will hold 76.4% of the *home* bonds when risk is penalized more, as opposed to 47.9% when risk is penalized less. Consequently, they will sell more bonds to foreigners in response to risk shocks when risk is penalized more. In the share market, the *home* intermediary holds 53.3% of the *home* shares in the base case steady state, while they hold 42.8% of the shares in the steady state where risk is penalized more. The smaller steady state position is reflected in a smaller adjustment in the share market to *home* risk shocks.

The tightness of macroprudential regulation does not have great effects on the adjustment of real variables to financial shocks. However, we did see that the tighter risk constraint improved steady state welfare by increasing steady state consumption and reducing steady state labour. These effects are presumably happily embraced, but they do not reflect the goal of the policy which was to reduce real economic volatility. While it is difficult to read from the plotted impulse responses, we see in *Table 2* that the fluctutations of consumption and labour are slightly lower in response to risk shocks when macroprudential policy is tighter. This is largely reflected in the contemporanous response to a shock. Other than the slightly lower immediate volatility of the real economy, we see that the sign and duration of all real economy impulse responses look identical independent of the tightness of macroprudential policy. The similarity in responses of real variables indicate that the transmission channel is not affected by the macroprudential policy. Above we discovered that the transmission channel goes through the intermediary's demand for household savings. We see in *Figures 8 - 10* that the demand for savings (that is the rate offered on household deposits) responds in the same manner independent of changes to macroprudential policy. Essentially, the entire effect of the tighter leverage constraint is absorbed in the greater fluctuations of gross portfolio flows.

The volatility of gross portfolio flows has no negative welfare effects by itself. On the contrary, portfolio flows enable the *home* intermediary to better manage its leverage without having large impacts on the price of assets. The lower volatility in asset returns further ensures lower volatility of deposit rates. Lower volatility of deposit rates ensures lower volatility of savings, and therefore lower volatility of consumption and labour.

Portfolio flows enable the *home* economy to transfer some of the adjustments to risk shocks to the $foreign$ intermediary rather than on its own households. The downside is that risk shocks in the $foreign$ economy can similarly be transfered to the *home* intermediary and further to the *home* household. This transmission was not significantly dampened by imposing a tighter leverage constraint on the *home* intermediary. It is possible that counter-cyclical adjustments to the risk penalty as recommended by Rey (2013) would be more effective in breaking the transmission channel.

4.4 Global policy makers have a great impact on emerging economies

Rey (2013) suggests there are four alternatives of policies that can deal with the fluctuations in credit caused by gross portfolio flows: (1) capital controls, (2) changing behaviour of the Federal Reserve and other global policy makers, (3) cyclical policies "limiting credit growth and leverage durint the upturn of the cycle" and (4) structural policies "imposing stricter limits on leverage for all financial intermediaries" (Rey, 2013; p314). Rey recommends the latter two in addition to some capital controls. We saw above that our model does not find strong effects of a structural policy imposing limits on leverage. Our model does not have the capacity to study the effect of a cyclical leverage constraint. However, we do have the capacity to study the effect of changing behavior by global policy makers. In the following we show that the behavior of global policy makers can have a significant impact on portfolio flows and welfare effects in the recipient economy.

In a classic paper, Poole (1970) made the argument that the optimal choice of monetary policy instruments depends on the type of shocks the policy responds to. If the goal is stable output, Poole demonstrates that financial shocks (demand for money) are best absorbed by adjusting the quantity of money while keeping interest rates fixed. On the other hand, a shock to the real economy (demand for goods) is best absorbed by adjusting the interest rates while keeping the quantity of money fixed.

Poole's results were based on a stochastic Hicksian IS-LM model of aggregate demand. But we see the echo of his findings in our more contemporary DSGE model of two economies where demand for goods and money is the outcome of utility optimising agents. To be specific, the impulse responses of *home* real economic variables such as consumption, labour and output are highly dependent on the policy framework in the $foreign$ economy. Real shocks are best absorbed by adjusting prices, while financial shocks are best absorbed by adjusting quantities.

As an example of a financial shock, *Figure 11* plots the impulse responses to an unexpected increase in the risk of $foreign$ shares. [11] Together, the impulse responses bring a clear message: One may use the supply of risk free bonds to almost completely absorb the risk shock. The alternative policy of fixing the supply of bonds and letting the rates adjust will see the risk shock causing larger adjustments to portfolios, asset returns, deposit rates, saving, consumption, labour and output. *Quantities absorb financial shocks.*

This policy works because the $foreign$ financial intermediary can now reduce portfolio risk by raising deposits and purchasing risk free bonds rather than selling risky assets. There is no significant change in demand for *home* assets, and therefore no significant portfolio flow, and no response is required by the *home* intermediary. The *home* intermediary's demand for deposit liabilities is unchanged and the *home* real economy is unaffected. The same holds for shocks to other financial variables, as illustrated in the impulse responses reported in section 6.1 in the Appendix. The credit response to a shock in risk was avoided, not by addressing the transmission channel in the home economy, but because the global policy maker absorbed the shock before it was transmitted to the *home* intermediary.

Poole's story persists when we shock a 'real' variable in the $foreign$ economy. In *figure 12* we simulate the impulse responses to a shock in the income of the $foreign$ household. In the model where global bond rates are fixed and the global bond supply is perfectly elastic, the shock causes large adjustments to the *home* households savings, consumption, labour, wages, and output. If instead the global bond supply is fixed and the rates adjust to demand, we see smaller portfolio flows, less adjustment in asset prices and less adjustment in the real economy. *Prices absorb real shocks.*

First the higher foreign household income raises the supply of deposits, and this will cause the foreign intermediary to demand more assets. To purchase risky high yielding assets then financial intermediary is required to also purchase a certain amount of global risk free bonds. The demand for bonds leads to higher bond prices and lower bond rates. The lower bond rates makes the position more costly as it is funded by deposits with relatively higher rates. The intermediary's demand for deposits therefore falls, providing a further downward pressure on deposit rates.

Consequently, deposit rates will see a greater fall when bond rates are flexible than when they are fixed. The larger fall in deposit rates ensures a smaller increase in savings, reducing the transmission from the income shock to the financial sector. The price adjustment dampens the adjustment in balance sheet quantities. The net flow of deposits into the $foreign$ financial sector is smaller, and the intermediary therfore has a smaller increase in demand for other assets, including shares and bonds issued in the *home* economy. The impact on the *home* asset prices, and therefore on the home intermediary, is reduced.[12] Since the *home* intermediary is less affected there is no need make large adjustments to their demand for deposit liabilities from the *home* households. This keeps household savings, consumption and labour more or less stable. Overall, we see that the behavior of the foreign policy maker effectively stopped the transmission to the *home* economy by allowing $foreign$ asset prices to absorb the shock to household income.

[11] The (blue) lines marked with dots plot the responses from a model where the global policy maker keeps the supply of risk free bonds fixed while allowing the rate to adjust freely to demand. The (green) lines marked with 'x'-es plot the impulse responses from a model where the global policy maker keeps the rate of return on their risk free bonds fixed, while allowing the supply of bonds to freely adjust to demand.

[12] In fact, the effect on *home* prices is negative. This is a bit of a fluke. Notice that when global risk free rates are fixed, the portfolio flow into shares pull their price up while dividends fall. Dividends fall due to the reduced supply of labour. The combination of higher prices and lower dividends imply significantly lower expected returns on shares. This is acceptable to the foreigner when risk free rates remain high which reduces the loss making spread between deposit rates and risk free rates. The small loss on reducing risk means less return is required on risky assets. However, in the policy regime where risk free rates fall due to fixed supply of risk free assets we see that this falling return on home shares does not outweigh the rising cost of reducing risk. In sum, the foreign intermediary actually demands less *home* shares. The increased supply of foreign savings is rather invested in foreign shares.

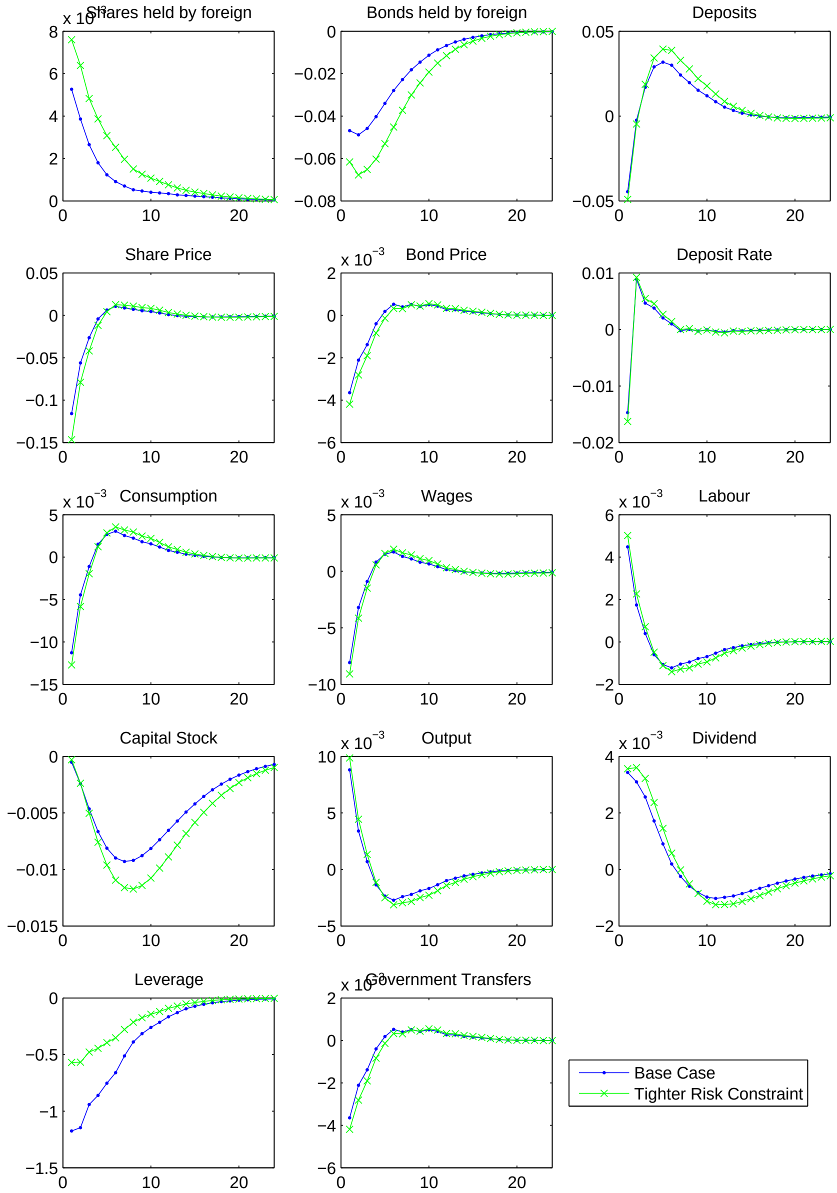

Figure 8: **A shock to** *home* **share risk** causes inflows in the share market and outflows in the bond market. The responses are stronger when the macroprudential policy is tighter. The inflows in shares is due to the stronger reduction in domestic demand compared to foreign demand for *home* shares. The bond outflow is due to the increased demand for bonds by the *home* intermediary.

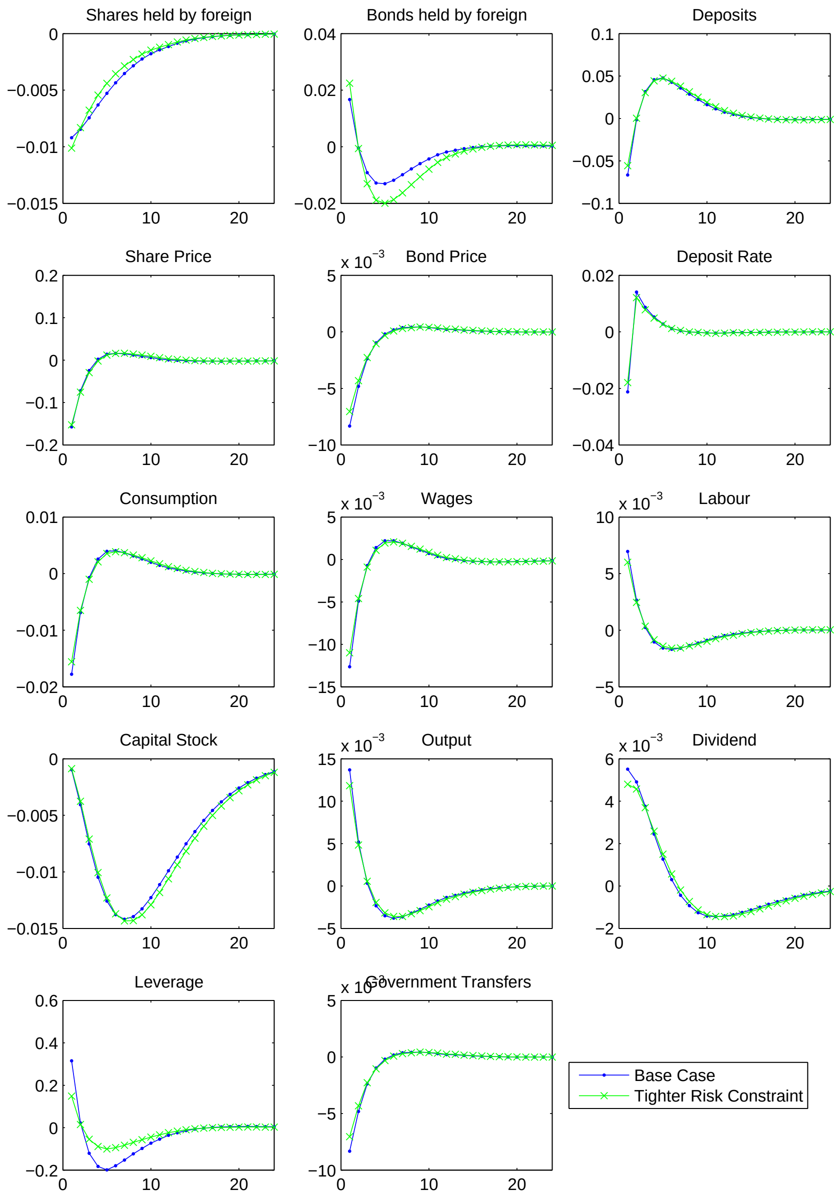

Figure 9: **A shock to** *foreign* **share risk** causes portfolio outflows. The effect of tighter macroprudential policy is minimal.

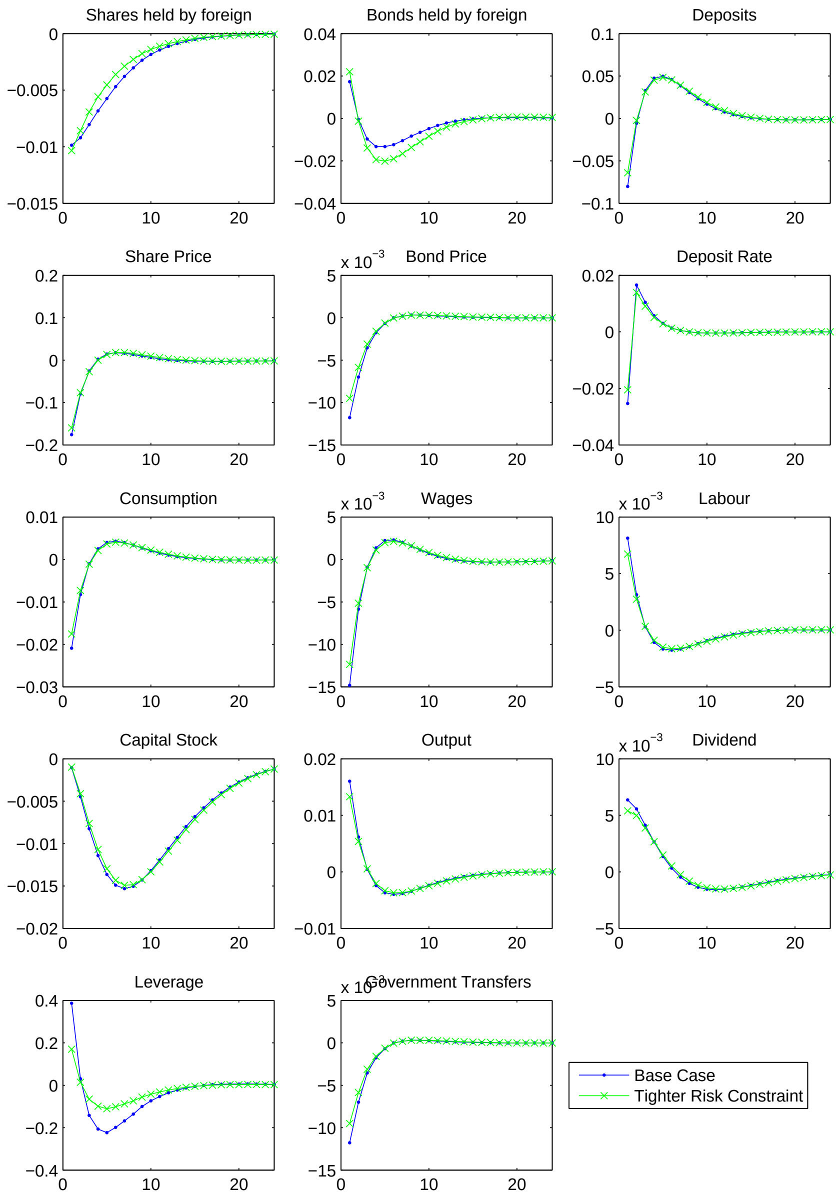

Figure 10: **A shock to emerging market risk** causes portfolio outflows. The effect of tighter macroprudential regulation is minimal.

4.5 Global policy makers have a great impact on emerging economies

Rey (2013) argues in favour of targeting the transmission channel that connects foreign events to capital flows and domestic savings. She suggests there are four alternatives of policies that can deal with the fluctuations in credit caused by gross portfolio flows: (1) capital controls, (2) changing behaviour of the Federal Reserve and other global policy makers, (3) cyclical policies “limiting credit growth and leverage durint the upturn of the cycle” and (4) structural policies “imposing stricter limits on leverage for all financial intermediaries” (Rey, 2013; p314). Rey recommends the latter two in addition to some capital controls. We saw above that our model supports Rey’s argument in favour of a structural policy imposing limits on leverage. Our model does not have the capacity to study the effect of a cyclical leverage constraint. However, we do have the capacity to study the effect of changing behavior by global policy makers. In the following we show that the behavior of global policy makers can have a significant impact on portfolio flows and welfare effects in the recipient economy.

In a classic paper, Poole (1970) made the argument that the optimal choice of monetary policy instruments depends on the type of shocks the policy responds to. If the goal is stable output, Poole demonstrates that financial shocks (demand for money) are best absorbed by adjusting the quantity of money while keeping interest rates fixed. On the other hand, a shock to the real economy (demand for goods) is best absorbed by adjusting the interest rates while keeping the quantity of money fixed.

Poole’s results were based on a stochastic Hicksian IS-LM model of aggregate demand. But we see the echo of his findings in our more contemporary DSGE model of two economies where demand for goods and money is the outcome of utility optimising agents. To be specific, the impulse responses of *home* real economic variables such as consumption, labour and output are highly dependent on the policy framework in the $foreign$ economy. Real shocks are best absorbed by adjusting prices, while financial shocks are best absorbed by adjusting quantities.

As an example of a financial shock, *Figure 11* plots the impulse responses to an unexpected increase in the risk of $foreign$ shares. [13] Together, the impulse responses bring a clear message: One may use the supply of risk free bonds to completely absorb the risk shock. The alternative policy of fixing the supply of bonds and letting the rates adjust will see the risk shock causing larger adjustments to portfolios, asset returns, deposit rates, saving, consumption, labour and output. Quantities (supply of risk free bonds) absorb financial shocks.

This policy works because the $foreign$ financial intermediary can now reduce portfolio risk by raising deposits and purchasing risk free bonds rather than selling risky assets. There is no significant change in demand for *home* assets, and therefore no significant portfolio flow, and no response is required by the *home* intermediary. The *home* intermediary’s demand for deposit liabilities is unchanged and the *home* real economy is unaffected. The same holds for shocks to other financial variables, as illustrated in the impulse responses reported in section 6.1 in the appendix. The credit response to a shock in risk was avoided, not by addressing the transmission channel in the home economy, but because the global policy maker behaved differently in response to the shock itself.

Poole’s story persists when we shock a ’real’ variable in the $foreign$ economy. In *figure 12* we simulate the impulse responses to a shock in the income of the $foreign$ household. In the model where global bond rates are fixed and the global bond supply is perfectly elastic, the shock causes large adjustments to the *home* households savings, consumption, labour, wages, and output. If instead the global bond supply is fixed and the rates adjust to demand, we see smaller portfolio flows, less adjustment in asset prices and less adjustment in the real economy. Prices (return on risk free bonds) absorb real shocks.

First the higher foreign household income raises the supply of deposits, and this will cause the intermediary to demand more assets. To purchase risky high yielding assets then financial intermediary is required to also purchase a certain amount of global risk free bonds. The demand for bonds leads to higher bond prices and lower bond rates. The lower bond rates makes the position more costly as it is funded by deposits with relatively higher rates. The intermediary’s demand for deposits therefore falls, providing a further downward pressure on deposit rates.

Consequently, deposit rates will see a greater fall when bond rates are flexible than when they are fixed. The larger fall in deposit rates ensures a smaller increase in savings, reducing the transmission from the income shock to the financial sector. The price adjustment dampens the adjustment in balance sheet quantities. The net flow of deposits into the $foreign$ financial sector is smaller, and the intermediary therfore has a smaller increase in demand for other assets, including shares and bonds issued in the *home* economy. The impact on the *home* asset prices, and therefore on the home intermediary, is reduced.[14] Since the *home* intermediary

[13]The (blue) lines marked with dots plot the responses from a model where the global policy maker keeps the supply of risk free bonds fixed while allowing the rate to adjust freely to demand. The (green) lines marked with ’x’-es plot the impulse responses from a model where the global policy maker keeps the rate of return on their risk free bonds fixed, while allowing the supply of bonds to freely adjust to demand.

[14]In fact, the effect on *home* prices is negative. This is a bit of a fluke. Notice that when global risk free rates are fixed, the portfolio flow into shares pull their price up while dividends fall. Dividends fall due to the reduced supply of labour. The

is less affected there is no need make large adjustments to their demand for deposit liabilities from the *home* households. This keeps household savings, consumption and labour more or less stable. Overall, we see that the behavior of the foreign policy maker effectively stopped the transmission to the *home* economy by allowing *foreign* asset prices to absorb the shock to household income.

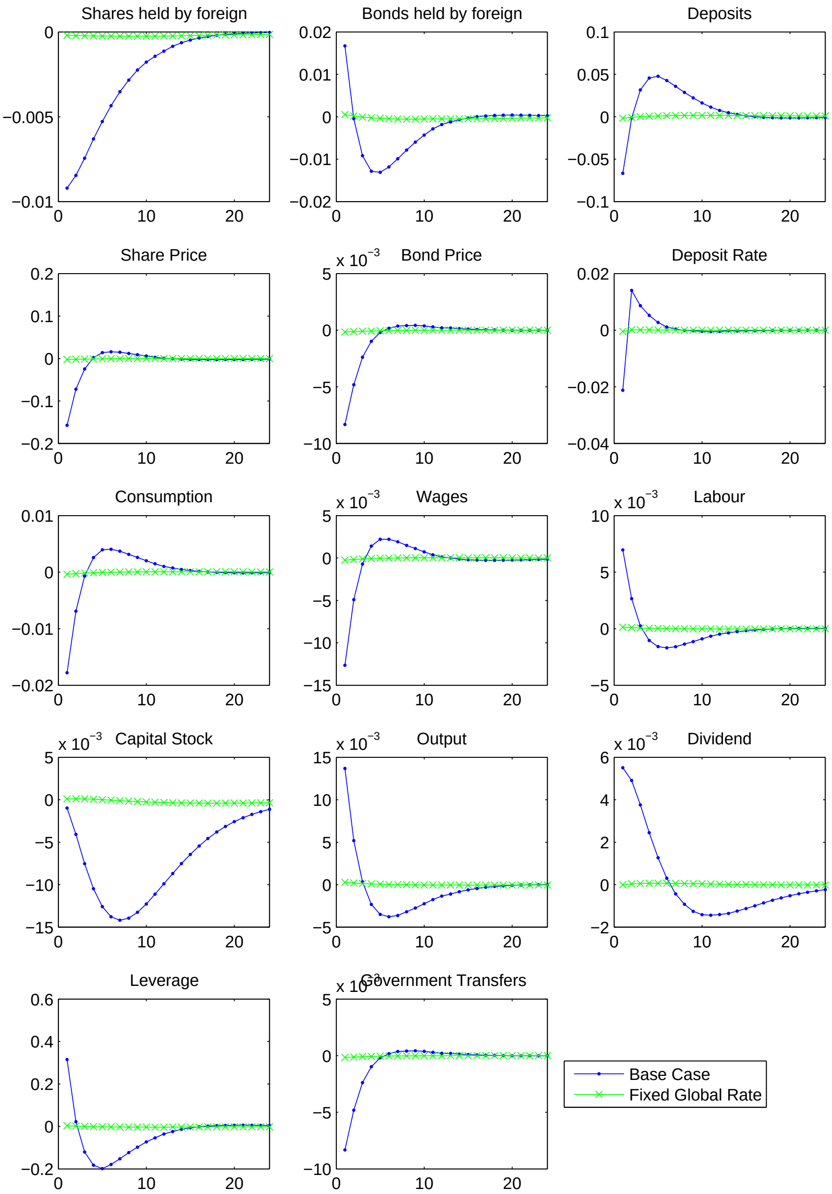

Figure 11: **Shock to *foreign* share risk** causes portfolio outflows. When global risk free rates are fixed the portfolio flows are greater but the real effects are significantly dampened. The (blue) lines marked with dots plot the responses from the 'base case' model with fixed global risk free bond supply and floating rates. The (green) lines marked with 'x'-es plot the responses from the model with fixed rates and infinitely elastic supply of global risk free bonds.

combination of higher prices and lower dividends imply significantly lower expected returns on shares. This is acceptable to the foreigner when risk free rates remain high which reduces the loss making spread between deposit rates and risk free rates. The small loss on reducing risk means less return is required on risky assets. However, in the policy regime where risk free rates fall due to fixed supply of risk free assets we see that this falling return on home shares does not outweigh the rising cost of reducing risk. In sum, the foreign intermediary actually demands less *home* shares. The increased supply of foreign savings is rather invested in foreign shares.

Figure 12: **Shock to** ***foreign*** **endowment** has mixed effects on portfolio outflows. The (blue) lines marked with dots plot the responses from the 'base case' model with fixed global risk free bond supply and floating rates. The (green) lines marked with 'x'-es plot the responses from the model with fixed rates and infinitely elastic supply of global risk free bonds.

4.5.1 Has recent global policy benefited emerging markets?

The behavior of foreign policy makers was shown to greatly affect the portfolio flows and welfare of recipient economies. This begs the question of whether recent global policy has benefited emerging economies. Our model is not even remotely equipped to fully answer the question, but we can analyse certain aspects of recent policy.

The dominant story in global financial markets since the financial crisis of 2008-2009 has been the large scale asset purchases (*Quantitative Easing*) by the US Federal Reserve. In 2008 there was a sudden large increase in risk of financial assets, causing a rush to reduce leverage. This, as the model suggests, caused a jump in demand for risk free assets. If the supply of risk free assets was fixed we would have seen a sharp drop in their rate of return. The drop in risk-free returns, as illustrated by the model, would cause greater volatility in the real economy as the delevering by banks would be more costly. The higher cost of reducing risk would be reflected in a sharper fall in demand for, and thus price of, risky assets.

In practice, however, the Federal Reserve provides an infinitely elastic supply of risk free assets to US banks in the form of reserve deposits. The rate of return on such deposits is fixed. Thus, despite the quantitative easing policies which in effect removed low-risk government bonds from circulation (the exact opposite of the model's recommendation), there was an infinitely elastic supply of other risk free assets. As the model predicts, these reserves have increased drastically throughout each round of quantitative easing. Removing the low-risk government bonds from circulation simply shifted banks demand towards their substitute, excess reserve deposits.

However, it is possible that the reserve deposits are not perfect substitutes for government bonds. If this is the case, it is possible that quantitative easing goes against the advice of our model by reducing the supply of the very asset they should increase supply of. The Federal Reserve's asset purchases were intended to push demand from low-risk assets toward higher risk assets. The idea is that higher central bank demand for risk free bonds will push down their discount rate, and therefore the discount rate applied to other assets will also fall (for example by maintaining a constant risk premium). The idea is better explained by Woodford (2012) on page 244 of his paper presented at the 2012 Jackson Hole Economic Policy Symposium:

> "It is often supposed that open-market purchases of securities by the central bank must inevitably affect the market prices of those securities (and hence other prices and quantities as well), through what is called a "portfolio-balance effect": if the central bank holds less of certain assets and more of others, then the private sector is forced (as a requirement for equilibrium) to hold more of the former and less of the latter, and a change in the relative prices of the assets will almost always be required to induce the private parties to change the portfolios that they prefer. " (Woodford, 2012)

He further writes:

> "But it is important to note that such "portfolio-balance effects" do not exist in a modern, general-equilibrium theory of asset prices in which assets are assumed to be valued for their state-contingent payoffs in different states of the world, and investors are assumed to correctly anticipate the consequences of their portfolio choices for their wealth in different future states - at least to the extent that financial markets are modeled as frictionless. "

In our general equilibrium model presented here we do not make the latter assumption of frictionless markets. Financial markets are not frictionless and therefore asset prices may deviate from the present value of their expected state-contingent payoffs. We have imposed a risk adjusted leverage constraint on financial intermediaries, making demand for assets less than perfectly elastic, and we have introduced an exogenous cost of saving (deposits), making the supply of savings less than perfectly elastic. These frictions cause different price dynamcis in response to a policy that reduces the supply of risk free assets. The lower supply of risk free bonds increases the price of the bonds, similar to the portfolio-balance hypothesis referred to by Woodford (2012), but this higher price makes it more expensive to reduce risk by purchasing risk free assets. Instead the financial sector will reduce risk by demanding fewer risky assets. Asset purchases by the Federal Reserve were meant to increase all asset prices by pushing down the discount rate applied to future expected earnings. But in the model simulated here, the discount rate on other assets instead increases due to the higher risk premium. A somewhat related argument was presented in the same 2012 Jackson Hole presentation by Woodford (Woodford, 2012). On page 250 Woodford writes:

> "First of all, even though purchases of long-term Treasuries could raise the price of (and so lower the yield on) Treasuries, this would not necessarily imply any reduction in *other* long term insterst rates, since the increase in the price of Treasuries would reflect an increase in the **safety premium**, and not necessarily any increase in their price *apart from* the safety premium (and hence, not necessarily

any reduction in the discount rate that the market uses to value future payments)" (Woodford, 2012) (italics in original, bold emphasis added).

The term 'safety premium' mentioned here was introduced by Krishnamurthy and Vissing-Jorgensen (2012) and refers to the fact that certain assets trade at a price beyond the present value of their expected future cash flow. Krishnamurthy and Vissing-Jorgensen (2012) find evidence that US Treasury bonds trade at a 'safety premium' due to their accepted status as collateral in repurchase transactions. This is not unlike the role the bonds serve in our model. In fact, one may view the leverage constraint as a collateral constraint: The more risk on the balance sheet, the more collateral is required per deposit liability.

The above argument by Woodford suggested that the higher price of risk free bonds in response to central bank purchases (lower bond supply) only reflects a higher 'safety premium'. In our model, this effect is even greater. For the intermediary, the risk free bonds serve no other role than collateral. They earn lower returns than the cost of deposits, implying a loss on holding bonds. The spread between deposit rates and bond rates reflect the 'safety premium'. Without the collateral benefit, the intermediary would only hold bonds if they yield the same return as deposits (or more).

Now, quantitative easing, that is asset purchases funded by creating new reserves deposits, is impossible in our model since the model does not include an asset called 'reserve deposits'.[15] However, should we introduce a new risk free asset called reserve deposits, with return equal to that of the risk free bond, there would be no demand for this asset unless it was allowed to be used as collateral similarly to bonds. Without collateral qualities, the reserve deposits are not a perfect substitutes for government risk free bonds. Thus, a shock that removes risk free bonds and replaces them with reserve deposits will not have the desired effects of reducing discount rates. The bond rates will decrease, but that is due to the scarcity of collateral-worthy assets. The discount rate, excluding the 'safety premium' will most likely increase, as it is now more costly to purchase risky assets due to the high cost of collateral.

Woodford (2012); Krishnamurthy and Vissing-Jorgensen (2012) suggested that quantitative easing may indeed have removed low-risk bonds that have values beyond their expected future cash flows. That is, the bonds have value as accepted collateral in repurchase transactions and therefore provide market liquidity. If the reserve deposits that replace the bonds do not carry these benefits, then they are not perfect substitutes for government bonds. According to our model, if reserve deposits do not have the collateral benefits, the optimal policy response would be to increase the supply of risk free government bonds to fully absorb the higher demand. Instead the supply has decreased due to central bank purchases. The higher prices achieved on government bonds reflect the reduced supply of collateral, not reduced supply of risk free cash flows. Thus, *ceteris paribus*, the discount rate excluding the 'safety premium' is unchanged.

In practice, everything does not remain equal when the federal reserve trades reserve deposits for government bonds. Empirical work by Rey (2013),Adrian and Shin (2009) and Bekaert et al. (2010) show that quantitative easing reduced both risk and risk aversion. This effect is important as it directly addresses the shock itself and therefore reduces the demand for risk free assets. With less demand for risk free assets, the falling supply of these assets do less damage. However, the persistent record high holdings of excess reserves by US banks indicate a still strong demand for risk free assets. Woodford's concern may still be relevant.

To conclude, our model is not suited to study the full impact of quantiative easing. However, it does reflect the argument by Woodford (2012) and Krishnamurthy and Vissing-Jorgensen (2012) that the policy reduces supply of important risk-free assets. However, quantitative easing has benefits not captured by our model, most importantly in reducing asset price volatility. In our model, risk shocks, such as the global financial crisis, can be absorbed using fiscal policy. The government can issue as many risk free bonds as is demanded to keep the rates on the bonds fixed. The government then transfers the proceeds from the bond issuance to the households. This maintains the demand for risky assets and thereby preempts the portfolio outflows.

5 Conclusion

Portfolio flows to emerging markets reflect the portfolio reallocation that arises when foreign asset demand changes *relative* to domestic asset demand. We saw that portfolio flows carry little, if any, information about *total* demand for financial assets. However, the direction of the portfolio flow is important because it is likely to affect demand for savings in the recipient economy. A portfolio inflow implies that the financial intermediary

[15] We can of course simulate a negative shock to the supply of bonds in our model, but this will not reflect the effects of quantitative easing. If bond supply drops in our model, it is because the government issues fewer bonds and the burden of paying for this falls on the household. In response to their shrinking budget constraint, the household will save less, supplying less deposits to the intermediary, who in turn will have less funds to invest, thus demanding fewer assets, including fewer risk free bonds. In other words, reducing the supply of bonds will have the supply effect of higher prices, but through the household cause lower demand with a negative effect on prices.

in the recipient economy sells assets to foreign agents. The transaction injects cash on the balance sheet of the recipient intermediary, thus reducing their demand for household savings, or equivalently increases their supply of credit. We see that the lower demand for savings pushes down interest rates in the recipient economy, causing less saving, more consumption and less labour, less output and an associated current account deficit. The key link in the transmission channel is the financial intermediary's demand for savings or supply of credit.

While the direction of total portfolio flows has a predictable impact on demand for savings, the portfolio flow can be associated with different macroeconomic conditions. In the case of a domestic productivity shock, the domestic firm is expected to pay more dividends in the future, raising demand for shares from both domestic and foreign investors. The total demand for shares has increased, and the direction of the capital flow depends on whose demand increases more. In this case, domestic demand increases more than foreign demand because the higher productivity of labour increases the supply of savings, making it cheaper for the domestic intermediary to fund asset purchases. The portfolio outflow is associated with a domestic expansion with more output, more labour and more consumption.

On the contrary, a foreign risk shock will cause a portfolio outflow associated with lower total demand for assets. The domestic demand is unaffected as they have no exposure to foreign risks, but foreign demand for risky assets will fall. The foreign intermediary consequently sells assets to the domestic intermediary. The expansion of the domestic balance sheet must be funded by household deposits, therefore the demand for savings has increased. The risk shock, like the productivity shock, causes a portfolio outflow, but the risk shock is associated with falling consumption rather than rising consumption.

Despite the varying macroeconomic circumstances associated with portfolio flows, the transmission channel is always the same. Portfolio inflows will reduce demand for savings and therefore reduce the interest offered on deposits. The rate offered on deposits will further affect the household's decision to save, consume and work. A policy aimed at the transmission channel will in effect be one that reduces the volatility of demand for savings. In this paper we explored the power of macroprudential policy in this regard. The macroprudential policy imposes a risk adjusted leverage constraint on the intermediary. The more risk on the intermediary's balance sheet, the more risk free bonds must the intermediary hold in proportion to total liabilities. A permanently tighter macroprudential policy does not significantly affect the response of the intermediary's demand for savings. Tighter macroprudential policy is therefore not successful in targeting the transmission channel, though we do see marginally higher welfare due to higher steady state consumption and less labour when the macroprudential policy is tight. It is possible that the policy would be more successful in reducing volatility if the leverage constraint becomes tighter in response to portfolio inflows. Such a contercyclical policy was not simulated here.

Macroprudential policy was aimed at the transmission channel from the flow to credit and saving. It is also relevant to study how global policy may respond to global shocks in a manner that deters portfolio flows from happening in the first place. We first saw that an increase in global risk will reduce global demand for risky assets, causing a portfolio flow away from emerging markets as the global investors sell assets to local investors. Our simulations suggest that any type of risk shock can be absorbed by an appropriate adjustment in the supply of foreign risk-free bonds. A perfectly elastic supply of these assets will immediately adjust to demand while keeping prices fixed. This enables banks to reduce their leverage without drastically reducing their demand for risky assets.

However, if the same policy of adjusting supply of risk free assets to demand was used in response to a shock in foreign income, we saw that this would exaggerate the real adjustments of the emerging economy. Instead, the real shock was best absorbed by keeping the quantity of bonds fixed and rather let the price of bonds adjust to demand. We concluded that the model hints at a policy rule similar to Poole's (1970) finding that financial shocks can be absorbed by quantities while real shocks can be absorbed by prices.

In summary, we can distinguish between two kinds of policies to deal with volatile portfolio flows. The first kind of policy aims to deter the shock from creating portfolio flows in the first place. The global policy maker could achieve this by letting the supply of bonds or the price of bonds to almost completely absorb the shock, leaving little change in global demand for emerging market assets. The second kind of policy aims at the transmission channel linking portfolio flows to the recipient economy. The key link in this transmission channel was the financial sector's demand for savings. Macroprudential policy has previously been suggested as a tool that targets this transmission channel. Our simulations suggest that permanently tighter macroprudential policy will not have a meaningful effect on the transmission of portfolio flows to the real economy.

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6 Appendix

6.1 Impulse responses with fixed and floating rates on global bonds

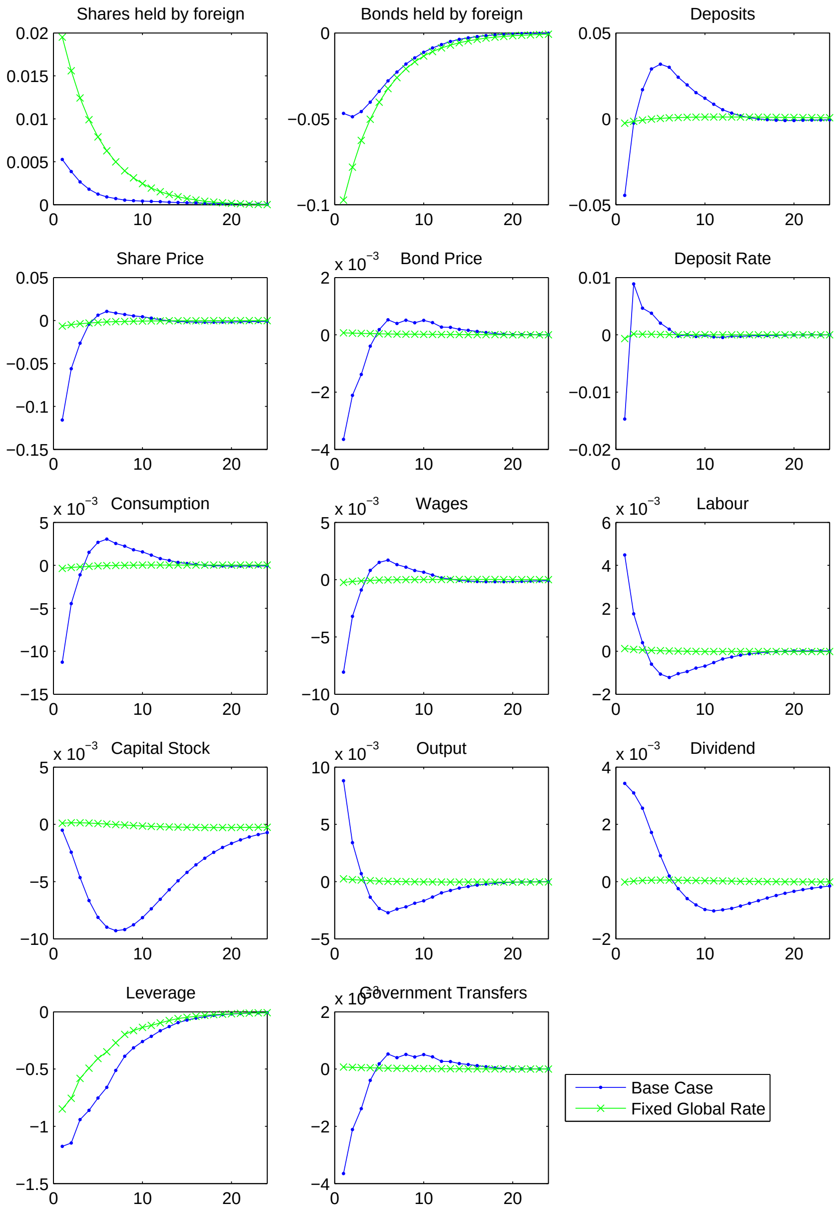

Figure 13: **Shock to *home* share risk** causes portfolio outflows, less credit (more saving) and lower consumption. The (green) unmarked lines plot the responses to a shock in *home* share risk. The (blue) lines marked with 'x'-es plot the responses to a shock in *foreign* share risk. The (red) lines marked with 'o'-es plot the responses to a shock in emerging market risk carried by the *foreign* intermediary.

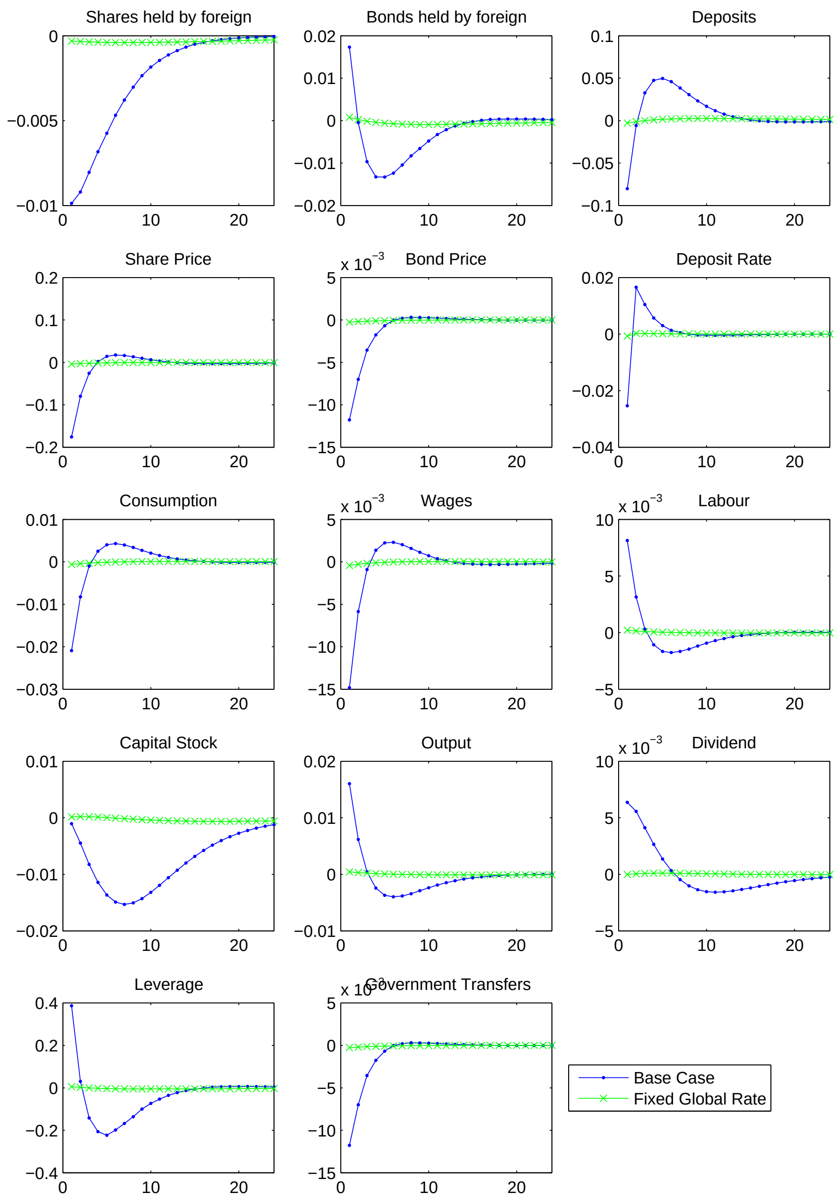

Figure 14: **Shock to Emerging Market risk** causes portfolio outflows, less credit (more saving) and lower consumption. The (green) unmarked lines plot the responses to a shock in *home* share risk. The (blue) lines marked with 'x'-es plot the responses to a shock in *foreign* share risk. The (red) lines marked with 'o'-es plot the responses to a shock in emerging market risk carried by the *foreign* intermediary.