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Abstract

The paper shows that monetary policy shocks exert a substantial effect on the size and composition of capital flows and the trade balance for the United States, with a 100 basis point easing raising net capital inflows and lowering the trade balance by 1% of GDP, and explaining about 20-25% of their time variation. Monetary policy easing causes positive returns to both equities and bonds. Yet such a monetary policy easing shock also induces a shift in portfolio composition out of equities and into bonds, implying a negative conditional correlation between flows in equities and bonds. Moreover, such shocks induce a negative conditional correlation between equity flows and equity returns, but a positive conditional correlation between bond flows and bond returns. The findings thus provide evidence for the presence of a portfolio rebalancing motive behind investment decisions in equities, but the dominance of what is akin to a return chasing motive for bonds, conditional on monetary policy shocks. The results also shed light on the puzzle of the strongly time-varying equity-bond return correlations found in the literature.

Keywords: monetary policy, trade balance, capital flows, portfolio choice, asset prices, United States, vector auto regressions, sign restrictions.

JEL Classification: F4, E52, G1, F32.

Non-technical summary

The current financial crisis has been preceded for several years by substantial global imbalances in trade and capital flows. In particular, the United States has not only been the origin of the financial crisis, but it had been among the economies globally relying most heavily on capital inflows to finance a large and growing trade deficit. At the same time, a number of observers have argued that accommodative monetary policy over the past decade has been a key culprit behind these imbalances by inducing the build-up of excess liquidity, a rise in financial leverage and a boom in asset prices. This, in turn, may have contributed to a surge in private consumption, in part due to wealth effects, and ultimately to a rising US current account deficit (e.g. Taylor 2009).

The role of monetary policy thus warrants closer scrutiny in order to understand how it may have contributed to the dynamics of capital flows, both in terms of their size and their composition. Moreover, the focus on the effect of monetary policy shocks on the direction and composition of capital flows allows us to contribute to the debate on the determinants of portfolio choice, and how asset price movements are related to portfolio decisions of investors across countries as well as across financial asset classes.

This paper tests empirically the effect of US monetary policy shocks on the composition of US capital flows and the US trade balance, and its channels. It employs a standard structural VAR specification to identify monetary policy shocks, relying on sign restrictions imposed on the impulse response functions of a few macroeconomic variables. The empirical analysis yields two key findings. First, US monetary policy shocks exert a statistically and economically meaningful effect on US capital flows. An exogenous easing of US monetary policy by 100 basis points (b.p.) induces net capital inflows and a worsening of the US trade balance of around 1% of GDP after 8 quarters. The variance decomposition indicates that US monetary policy shocks over the period 1974 to 2007 explain about 20-25% of the variation in both the US trade balance and capital flows at that horizon. As to the channels, it appears that wealth effects play a central role. Equity returns rise on impact by about 6% in response to a 100 b.p. policy easing, while interest rates fall. Both of these responses in turn induce an increase in private consumption for about 8 quarters, and thus a deterioration in the trade balance.

The second main finding focuses on the effect of monetary policy shocks on the composition of US capital flows. The intriguing finding is that an exogenous US monetary policy easing causes net inflows in debt securities, foreign direct investment (FDI) and other investment, while inducing net outflows in portfolio equities from the United States. Monetary policy shocks thus entail a conditional negative correlation between flows in portfolio equity and debt. By contrast, monetary policy shocks induce a positive conditional correlation in equity returns and bond returns, as is well known in the literature. Moreover, they cause a negative conditional correlation between equity flows and equity returns, but a positive conditional correlation between bond flows and bond returns. The findings are robust to a battery of extensions and sensitivity checks.

Relating our results to the literature on portfolio choice, the evidence presented in this paper is consistent with a portfolio rebalancing motive for equity portfolio flows - as implied in the negative conditional correlation between equity returns and equity flows - and a motive akin to return chasing behind investment decisions in bonds - as indicated by the positive conditional correlation between bond returns and bond flows.

The present paper stresses that a positive correlation between stock returns and bond returns are present precisely when discount effects (monetary policy shocks) dominate. Of course, it also implies that this correlation may be different when other shocks dominate. As such, the present paper focuses on understanding the effect of one specific shock for portfolio choice and asset prices, while we leave it for future research to condition the analysis on other types of economic shocks. Moreover, the paper's findings emphasise the importance of jointly analysing quantities and prices, i.e. portfolio flows in conjunction with asset price movements, and also across asset classes for understanding the portfolio choices of investors.

1 Introduction

The current financial crisis has been preceded for several years by substantial global imbalances in trade and capital flows. In particular, the United States has not only been the origin of the financial crisis, but it had been among the economies globally relying most heavily on capital inflows to finance a large and growing trade deficit. At the same time, a number of observers have argued that accommodative monetary policy over the past decade has been a key culprit behind these imbalances by inducing the build-up of excess liquidity, a rise in financial leverage and a boom in asset prices. This, in turn, may have contributed to a surge in private consumption, in part due to wealth effects, and ultimately a rising US current account deficit (e.g. Taylor 2009).

At the same time, capital flows to the United States have exhibited peculiar dynamics regarding their composition in recent years, with net inflows having become characterised by an ever heavier US dependence on inflows into US bonds, as opposed to equities. Figure 1 illustrates this point, underlining that in particular since 2001, in an environment of accommodative monetary policy, net inflows into US debt securities have surged to close to 6% of US GDP or about USD 800 billion per year, while net inflows into equities, FDI and other investment have been modest and even negative at times.

The role of monetary policy thus warrants closer scrutiny in order to understand how it may have contributed to the dynamics of capital flows, both in terms of their size and their composition. This is a first objective of the paper. More specifically, the paper focuses on the effect of monetary policy shocks in the United States on the US trade balance and different types of capital flows. Our analysis is in part motivated by the build-up of large trade and financial imbalances in recent years, which are now unwinding to some extent.

Moreover, the focus on the effect of monetary policy shocks on the direction and composition of capital flows allows us to contribute to the debate on the determinants of portfolio choice, and how asset price movements are related to portfolio decisions of investors across countries as well as across financial asset classes. This is the second objective of the paper. An important strand of this literature analyses portfolio rebalancing versus return chasing as motives for investment decisions, in an environment of incomplete financial markets and imperfect substitutability of financial assets (e.g. Bohn and Tesar 1996, Hau and Rey 2006 and 2008, Albuquerque 2007, Devereux and Sutherland 2006, Tille and van Wincoop 2007). A related literature focuses on understanding asset price comovements, in particular the peculiar stock-bond return correlation, which are hard to explain with empirical models to date (e.g. Shiller and Beltratti 1992, Baele, Bekaert and Inghelbrecht 2008).

The paper tests empirically the effect of US monetary policy shocks on the composition of US capital flows and the US trade balance, and its channels. It employs a standard structural VAR specification to identify monetary policy shocks, relying on sign restrictions imposed on the impulse response functions of a few macroeconomic variables, following closely Canova and De Nicolo (2002), Uhlig (2005) and Fratzscher and Straub (2008). These identifying restrictions are by now not only standard and relatively uncontroversial concerning their economic interpretation, but they also allow us to distinguish monetary policy shocks from other types of shocks, such as to technology, demand and fiscal policy. We specify our Bayesian VAR using US variables relative to those of other G7 members in the baseline specification, and relative to an extended sample of rest of the world countries in the robustness specification.

The empirical analysis yields two key findings. First, US monetary policy shocks exert a statistically and economically meaningful effect on US capital flows and the trade balance. An exogenous easing of US monetary policy by 100 basis points (b.p.) induces net capital inflows and a worsening of the US trade balance of around 1% of GDP after 8 quarters. The variance decomposition indicates that US monetary policy shocks over the period 1974 to 2007 explain about 20-25% of the variation in both the US trade balance and capital flows at that horizon. As to the channels, it appears that wealth effects play a central role. Equity returns rise on impact by about 6% in response to a 100 b.p. policy easing,[1] while interest rates fall. Both of these responses in turn induce an increase in private consumption for about 8 quarters, and thus a deterioration in the trade balance.

The second main finding focuses on the effect of monetary policy shocks on the composition of US capital flows. The intriguing finding is that an exogenous US monetary policy easing causes *net inflows* in debt securities, foreign direct investment (FDI) and other investment, while inducing *net outflows* in portfolio equities from the United States. Monetary policy shocks thus entail a conditional negative correlation between flows in portfolio equity and debt. By contrast, monetary policy shocks induce a positive conditional correlation in equity returns and bond returns, as is well known in the literature. Moreover, they cause a negative conditional correlation between equity flows and equity returns, but a positive conditional correlation between bond flows and bond returns.

The findings are robust to a battery of extensions and sensitivity checks, such as using the approach suggested by Fry and Pagan (2007) to extract the median impulse responses from a single model, as well as relaxing some of the sign restrictions, extending the model to the rest of the world and using alternative variable definitions.

How should one understand and rationalise these empirical findings? From an observational perspective, the findings seem to fit well with the stylised facts of Figure 1 stressing the shift in the composition from equities to bonds in the United States amid an environment of low interest rates in recent years. Moreover, our empirical analysis allows us to contribute to the literatures on the determinants of portfolio choice as well as on asset price comovements.

As to the literature on portfolio choice, one strand of the debate has emphasised the role of a return chasing motive behind international capital flows, in which investment decisions are primarily driven by expected returns. Bohn

[1] This estimate is essentially the same as that found in the literature (Rigobon and Sack 2002, Ehrmann and Fratzscher 2004, Bernanke and Kuttner 2005) which mostly use an event-study methodology focusing on the daily response to FOMC policy surprises.

and Tesar (1996) analyse return chasing and portfolio rebalancing in a simple ICAPM framework, yielding a decomposition of net purchases into transactions necessary to maintain a balanced portfolio and net purchases that are triggered by time varying investment opportunities. Their results suggest that US transactions in foreign equities are primarily driven by the latter return chasing effect. In another classic paper, Brennan and Cao (1997) study the effect of information asymmetries between domestic and foreign investors on international portfolio flows, finding evidence in favour of a positive correlation between equity flows and returns, though only for US investments abroad.[2] Finally, an important recent strand of this literature rationalises the return chasing motive of capital flows (Albuquerque 2007), while there is indeed evidence that such return chasing is taking place at a global scale due to asymmetries in information and differences in investor performance (Albuquerque et al. 2008).

Another strand of the literature has provided evidence for a prominent role of the *portfolio balancing motive* as a driver of capital flows as demonstrated in Branson and Henderson (1985). The more recent literature stresses the incompleteness of financial markets and the role of various forms of risk that make domestic and foreign assets imperfect substitutes, and in which thus *portfolio rebalancing* is a key driver of international capital flows. Hau and Rey (2006) argue that the (unconditional) negative correlation between equity returns and exchange rate returns may be rationalised through a portfolio rebalancing motive in which exchange rate risk induces investors to reallocate capital out of countries with rising exchange rates.

In Hau and Rey (2008), they find this indeed to be the case for a set of 6500 international equity funds for the US, UK, Canada and the EU. Calvet et al. (2009) find similar micro evidence for portfolio rebalancing in the behaviour of a subset of Swedish households. Froot and Ramadorai (2002) use proprietary data on daily institutional investor currency flows and find that these flows are highly correlated with contemporaneous and lagged exchange rate changes. At a macro level, there is a growing literature emphasising the role of country risk and market frictions for why capital is not flowing to countries which have high asset returns (e.g. Kraay et al. 2005, Gourinchas and Rey 2006, Gourinchas and Jeanne 2006, Lane and Milesi-Ferretti 2006, Daude and Fratzscher 2007, Alfaro et al. 2008).[3]

The evidence of the present paper is consistent with a portfolio rebalancing motive for equity portfolio flows - as implied in the negative conditional correlation between equity returns and equity flows - and a motive akin to return chasing behind investment decisions in bonds - as indicated by the positive conditional correlation between bond returns and bond flows.

[2] However, they do not find such a positive correlation for foreign investment into US assets. They explain this finding by the notion that foreigners are less informed and thus revise their predictions more strongly when they receive a given signal.

[3] An important related literature is emerging using DSGE models with endogenous portfolio choice (Coeurdacier 2005, Devereux and Sutherland 2006, Tille and van Wincoop 2007, Pavlova and Rigobon 2008), which stresses the imperfect tradability of risk, which contributes to the home bias in the international investment patterns.

The literature on asset price comovements may help us rationalise this pattern across financial assets. This literature stresses that there tend to be strong time variations in the comovements of returns across different asset classes, such as between equity returns and bond returns. These strong time variations constitute a puzzle, as neither present value models (Shiller and Beltratti 1992), nor consumption-based asset pricing models (Bekaert, Engstrom and Grenadier 2005), nor dynamic factor models with a broad set of economic state variables (Baele, Bekaert and Inghelbrecht 2008) are able to explain them well. Andersen et al. (2007) show that the bond-stock return correlation is positive during periods of expansion but negative and large during economic contractions. They conjecture that this strong time variation and switch in sign in the correlation may be explained by the time-variation in the relative importance of cash flow effects and discount rate effects: during expansions, discount effects dominate thus inducing a positive correlation between stock and bond returns; while cash flow effects are dominant in contractions so that returns on bonds - with fixed nominal cash flows - have the opposite sign compared to returns on equities - which have stochastic dividends.

The present paper stresses that this positive correlation between stock returns and bond returns are present precisely when discount effects (monetary policy shocks) dominate. Of course, it also implies that this correlation may be different when other shocks dominate. As such, the present paper focuses on understanding the effect of one specific shock for portfolio choice and asset prices, while we leave it for future research to condition the analysis on other types of economic shocks. Moreover, the paper's findings emphasise the importance of jointly analysing quantities and prices, i.e. portfolio flows in conjunction with asset price movements, and also across asset classes for understanding the portfolio choices of investors.

The paper proceeds as follows. In Section 2, we examine the determinants of net capital flows in a simple intertemporal capital-asset pricing model as discussed in Bohn and Tesar (1995). Section 3 presents the empirical model and outlines methodology used to identify monetary policy shocks in detail. Section 4 presents the empirical findings for the benchmark specification and discusses the interpretation and the implications of the results. Robustness and sensitivity tests are presented in section 5. Section 6 concludes.

2 Decomposing Net Capital Flows

We begin by examining the determinants of net capital flows in an intertemporal capital-asset-pricing model as discussed in Bohn and Tesar (1995). We use the model to fix language and notation. Although originally constructed for equity investment, the intutition of the model can be applied to most other forms of investment in a similar fashion. The model yields a natural decomposition of net purchases of assets into (i) transactions that are necessary to maintain a balanced portfolio of securities (*portfolio-rebalancing* effect) and (ii) net purchases that are triggered by time-varying investment opportunities (*return-chasing* effect). As a result, depending on which of the two effects dominate in the investor's portfolio allocation, the correlation between investment returns and net capital flows may take either sign.

We begin by considering the problem an investor faces who can purchase both domestic and foreign equity. Let NP_{kt} be the period t net purchases of stocks in country k and let W be the value of the investor's portfolio. By definition, the following relationship determines how net purchases of asset k are related to portfolio shares (α_{kt}) and total wealth (W_t):

$$NP_{kt} = \alpha_{kt}W_t - (1 + g_{kt})(\alpha_{kt-1}W_{t-1}) \qquad (1)$$

where g_{kt} is the capital gain on security k. Since wealth at time t is a function of the return on the *total* portfolio between periods $t-1$ and t, net purchases can be approximated as:

$$NP_{kt} = (\alpha_{kt} - \alpha_{kt-1})\, W_{t-1} + (d_t^p + g_t^p - g_{kt})(\alpha_{kt-1}W_{t-1}) \qquad (2)$$

where d_t^p and g_t^p are the dividends and capital gains on the investor's total portfolio. The right hand side of equation (2) comprises two terms, each representing possible motives for the investor to purchase or sell security k. The first component indicates that a change in the investor's desired portfolio weight on security k between period $t-1$ and t may trigger the purchase or sale. The second component suggests that the investor will purchase security k when her wealth increases due to dividend payments on her total portfolio of assets. However, she will sell security k when returns on asset k exceed returns on the rest of the portfolio such that the portfolio is not in balance anymore.

In particular, Cox et al. (1985) show that investors facing the standard trade-off between mean return and variability behave subject to the following optimality condition linking the portfolio weight on security k to the return process:

$$\alpha_{kt} = \sigma e_k \Sigma_t^{-1} E_t(\mu) + \eta_{kt} \qquad (3)$$

where σ is the coefficient of relative risk aversion, $E(\mu_t)$ is the vector of expected excess returns on all securities, e_k is a 0-1 vector that selects element k, Σ_t is the covariance matrix of returns and η_{kt} is the component of the portfolio used to hedge the investor against all other types of risks that are not related to her equity investment strategy. For tractability, it is assumed that time variation in the model occurs in the first moments of the driving processes for returns and the state variables only. The reason is that this ensures that the hedge terms are constant. Substituting into (2) yields a condition that determines the investor's portfolio adjustment strategy:

$$NP_{kt} = (d_t^p + g_t^p - g_{kt})(\alpha_{kt-1}W_{t-1}) + \sigma e_k \Sigma_t^{-1} \left[E_t(\mu) - E_{t-1}(\mu)\right] W_{t-1} \qquad (4)$$

The first component on the right hand side of equation 4 captures what we denote the *portfolio-rebalancing* effect, namely net purchases of asset k that are required to maintain constant portfolio weights. The second term captures the extent to which investors adjust portfolio weights as the portfolio is reoptimized over time. Given a fixed level of risk aversion and a constant variance-covariance matrix of returns, an investor adjusts portfolio weights only if his expectations of excess returns are revised over time. We therefore refer to this as the *return-chasing* effect.

The two effects imply different correlation structures between the (expected) return on capital and capital flows. If the *portfolio rebalancing* effect dominates, an increase in the relative return on assets in country k should lead to a net capital outflow as indicated by the negative coefficient on the local capital gain g_{kt}. On the other hand, if the *return chasing* effect dominates then changes in the investor's expectation of excess returns in country k should dominate portfolio flows. The latter implies a positive correlation between expected excess returns and net capital flows.

We emphasise that the purpose of this section is purely motivational in order to illustrate the implications of changes in returns for portfolio flows, and vice versa. Our empirical exercise in the next sections will investigate which effect dominates empirically when analysing net portfolio flows of debt and equity following a monetary policy shock in the United States.

3 The Empirical Model

In this section, we present our empirical model and explain the implementation of our pure-sign restrictions approach. In Appendix 1 we define further the variables that we use in the analysis and declare the respective data sources.

3.1 Model Specification

We estimate a structural VAR model of the form

$$y_t = c + \sum_{i=1}^{p} A_i y_{t-i} + B^{-1}\varepsilon_t \tag{5}$$

where B is an $(n \times n)$ matrix of contemporaneous coefficients, A_i is an $(n \times n)$ matrix of autoregressive coefficients, ε_t is an $(n \times 1)$ vector of structural disturbances and y_t an $(n \times 1)$ vector of endogenous variables, and p is the number of lags in the VAR. The model we use is of dimension $n = 8$, where y_t is defined as

$$y_t = [c_t - c_t^*, i_t - i_t^*, cpi_t - cpi_t^*, eq_t - eq_t^*, nb_t, reer_t, tb_t, cap_t] \tag{6}$$

The variable cap_t represents the different capital flow variables that are included in the model one at a time. These are the aggregate *Financial Account*, and its four individual components *Foreign Direct Investment*, *Portfolio Equity, Portfolio Debt* and *Other Investment*. All of these are net flows, i.e. changes in assets minus liabilities, and are by definition relative variables where a positive value denotes a net inflow of the respective type of capital from the rest of the world into the United States.[4] The remaining variables are the trade balance as a ratio of GDP, tb_t, which is the main counterpart of the financial account in the balance of payments identity.[5] We include this variable not only because at any point in time trade deficits must be balanced by financial account surpluses, but also because potentially net financing needs for trade deficits may be an important driving factor of capital flows.[6]

The variable nb_t is the ratio of non-borrowed to total reserves which we include solely for the purpose of identifying monetary policy shocks. We follow Strongin (1995), Faust and Rogers (2003) and Uhlig (2005), among others, who argue that the reserve ratio is the monetary aggregate that can be most closely associated with changes in the monetary policy stance of the United States. The variable $reer_t$ is the log of the real effective exchange rate. The remaining variables $c_t - c_t^*, i_t - i_t^*, cpi_t - cpi_t^*$ and $eq_t - eq_t^*$ respectively represent the percentage differences between US and rest of the world variables for consumption ($c_t - c_t^*$, in USD), short term interest rates ($i_t - i_t^*$), CPI inflation ($cpi_t - cpi_t^*$) and equity returns ($eq_t - eq_t^*$, in USD).

In the benchmark specification, "Rest of the World" is defined as a GDP weighted average of the non-US G7 countries. The exception is the equity return differential $eq_t - eq_t^*$ for which countries are given weights according to their share in the aggregate non-US G7 equity market capitalization. It is important to note that the given definition of the equity return differential $eq_t - eq_t^*$ in USD terms implies that it effectively represents the deviation from equity parity as defined in Hau and Rey (2006). According to their definition, equity parity holds whenever the equity return differential in local currency terms is exactly offset by the nominal exchange rate return.

We use quarterly data that spans the sample period between 1974 and 2007. The year 1974 is used as a starting point of the analysis as it marks the beginning of the floating exchange rate period after the collapse of the Bretton Woods system. The choice of the time period and the associated data availability considerations naturally limit the choice of candidate countries to be included in our definition of the "Rest of the World". We will, however, test the robustness of our results to the extension of the definition by including a range of additional countries. The economies included in the two "Rest of the World" samples are

[4] A problem associated with the capital flow variables is that they tend to be very volatile at times. We therfore use five-quarter moving averages of them for our estimation.

[5] More precisely, given the accounting identity of the balance of payments, the financial account tracks the trade balance quite closely (with the opposite sign) with differences arising due to the income and transfer accounts under the current account, the capital account, changes in reserves and statistical discrepancies.

[6] The qualitative results of this study are robust to the inclusion of the current account balance in place of the trade balance in the model.

listed in the Appendix.

3.2 Identification of Monetary Policy Shocks

We are interested in the effect of a monetary policy shock on the different types of net capital flows between the United States and the rest of the world. We identify monetary policy shocks using the pure-sign restrictions approach pioneered by Faust (1998), Canova and de Nicoló (2002) and Uhlig (2005). The technique allows us to identify structural error terms from a reduced form version of the VAR model presented in equation (5) by using a minimum of intuitively appealing sign restrictions on the impulse response functions of some of the endogenous variables included in the vector y_t. The identification restrictions we use are well grounded in economic theory and are by now widely used in the academic literature to identify monetary policy shocks.

We present the restrictions we use to identify an expansionary monetary policy shock in Table 1. An upward arrow indicates that the respective variable is required to increase for four quarters following the shock. In particular, we assume that an expansionary monetary policy shock reduces short term interest rates and has a positive effect on consumption, inflation and the ratio of non-borrowed to total reserves. In terms of the relative variables in our model, this implies that a monetary policy shock reduces $i_t - i_t^*$ and increases $c_t - c_t^*$, $cpi_t - cpi_t^*$ and nb_t. In Table 1, the upward arrow on $c_t - c_t^*$ is shown in parentheses as we will leave out this restriction at a later point in the analysis as a robustness check. Table 1 also presents the restrictions of two additional types of shocks: an aggregate demand shock and an aggregate supply shock. The reason is that it has been shown that increasing the number of identified shocks can help to uncover the correct sign of the impulse response functions (Paustian 2007). We therefore identify these two additional structural shocks as a robustness check but do not report results on the impulse responses to these shocks in what follows. Moreover, the table illustrates that the identifying restriction for monetary policy shocks make this type of shock distinct from supply and demand shocks.

Table 1: Sign restrictions

	$i_t - i_t^*$	$cpi_t - cpi_t^*$	nb_t	$c_t - c_t^*$
monetary policy	↓	↑	↑	(↑)
aggregate demand	↑	↑		↑
aggregate supply	↓	↓		

We now move to the implementation of the pure-sign restrictions approach. Thereby, we follow Canova and De Nicoló (2002), Uhlig (2005) and Peersman and Straub (2008) in recovering the structural error terms from the estimated reduced form model via the use of sign restrictions on the impulse response functions of some of the endogenous variables. Let us first define $v_t = B^{-1}\varepsilon_t$

as the reduced form residuals of the VAR. Standard OLS estimation of the reduced form VAR yields thereby an estimate of the variance-covariance matrix $\Sigma = E(v_t v_t')$. In order to identify the structural error terms underlying these disturbances such that impulse response functions can be constructed, we need to find a way to choose among the infinite number of possible decompositions of Σ. Two candidate decompositions are the Cholesky Factor and the eigenvalue-eigenvector decomposition. The latter is given by $\Sigma = CC' = PDP'$ where P is a matrix of eigenvectors and D is a diagonal matrix with the corresponding eigenvalues on the main diagonal. Although this decomposition of the variance-covariance matrix is intuitively not very appealing as it is economically not meaningful, the crucial advantage is its uniqueness and the fact that it generates orthonormal shocks. It therefore allows us to generate any possible decomposition of Σ by finding an orthonormal matrix Q such that $QQ' = I_n$ and writing the newly found candidate decomposition as $\Sigma = CQQ'C' = \widehat{C}\widehat{C}'$.

The only task left is thus to find an algorithm that allows to efficiently search through the infinite space of orthonormal matrices Q and to construct candidate decompositions accordingly. Such an algorithm can be achieved by constructing a desired number of orthonormal matrices Q as $Q = \prod_{m,n} Q_{m,n}(\theta)$ where $Q_{m,n}(\theta)$ are rotation matrices of the form:

$$Q_{m,n}(\theta) = \begin{bmatrix} 1 & \cdots & 0 & \cdots & 0 & \cdots & 0 \\ \ldots & \ddots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & \cdots & \cos(\theta) & ... & -\sin(\theta) & \cdots & 0 \\ \vdots & \vdots & \vdots & 1 & \vdots & \vdots & \vdots \\ 0 & \cdots & \sin(\theta) & \cdots & \cos(\theta) & \cdots & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ddots & \ldots \\ 0 & \cdots & 0 & \cdots & 0 & \cdots & 1 \end{bmatrix} \tag{7}$$

and where m and n are the rows that are being rotated by the angle θ. The number of rotation matrices is naturally large in a model of dimension $n = 8$. In fact, there are $n(n-1)/2 = 28$ bivariate rotations for a given angle θ. The algorithm we use entails to randomly draw a rotation angle $\theta(j)$ and to construct the matrix Q as the product of the resulting rotation matrices $Q_{m,n}(\theta)$. In principle, any rotation can be constructed by varying the parameter $\theta(j)$ in the range $[0, \pi]$. This algorithm allows for an efficient exploration of the infinite space of possible realizations of the matrix Q. A given draw Q_j allows us to construct a candidate contemporaneous impact multiplier matrix $\widehat{C_j}$ and the corresponding set of impulse response functions

$$R_{j,t+k} = A(L)^{-1}\widehat{C}_j v_t \tag{8}$$

For estimation and inference, we use a Bayesian approach. Our prior and posterior for the coefficient matrix $A(L)$ and the variance covariance matrix Σ come from the Normal-Wishart family. We use the same weak parameterization for the prior as in Uhlig (2005). In order to draw "candidate truths" $\widehat{C_j}$, we jointly draw from the Normal-Wishart posterior for the variance covariance matrix Σ_j and the coefficient matrix $A_j(L)$ as well as from the uniform distribution of the rotation angles $\theta(j)$. Impulse response functions are then constructed using the above procedure. A sign restriction on the impulse response of variable p to shock q after k periods following the shock is of the form:

$$R_k^{pq}(j) \gtrless 0 \tag{9}$$

We impose our set of sign restrictions for four periods after the shock occurs. If the impulse response functions obey the postulated sign restrictions, we keep the draw. If they do not, we discard it. We continue this procedure until we have found 1000 admissible draws. When identifying multiple shocks, we identify them simultaneously. This means that, in order for a given draw to be accepted, it must obey the restrictions applicable to each of the identified shocks simultaneously.

At any point in the response horizon the distribution of impulse responses across accepted draws is subject to two different sources of variation. One is the uncertainty around the estimates of $A(L)$ and Σ which we take into account by means of using a Bayesian approach. The other source of variation is the uncertainty introduced by drawing a value for the candidate rotation angle $\theta(j)$. This effectively generates variation "across models" and brings about the question of how to summarize the distribution of impulse response functions across accepted draws at each point along the response horizon. Following most of the sign restrictions literature, we simply report the median of each distribution along with upper and and lower quantiles in order to give an idea of the range of permissible impulse responses. Fry and Pagan (2007) criticize this practice on the grounds of the fact that the resulting benchmark impulse response function does not necessarily emerge from a single model. In fact, it would only be the case if $R_k^{pq}(j)$ was monotonous in the rotation angle $\theta(j)$ at each k. But since there is no guarantee for monotonicity, the different points in the benchmark impulse response function will generally come from different models, i.e. different values of $\theta(j)$. The issue is the same across all variables and all shocks. As a consequence, the identified shocks are no longer orthogonal to each other and we present a set of impulse responses which are not simultaneously generated by the same model.

In order to remedy these shortcomings, Fry and Pagan (2007) suggest to choose the rotation angle $\theta(j)^*$ as a benchmark for which the impulse responses are as close as possible to the median response across all shocks and variables. In their approach, the impulse responses are thus produced by a single model and a set of orthogonal shocks, while at the same time somewhat preserving the consensus view that the median is a good way of summarizing the results. As a criterion for choosing the rotation angle $\theta(j)^*$, for which the impulse response functions $R_k^{pq}(j)$ are closest to $med(R_k^{pq})$, the authors suggest to use the sum of the squared deviations, normalized by the standard deviation across the response horizon and across all variables and shocks.

$$\min_{\theta(j)} \sum_{p=1}^{n} \sum_{q=1}^{n} \sum_{k=1}^{h} \left(\frac{R_k^{pq}(j) - med\left(R_k^{pq}\right)}{std\left(R_k^{pq}\right)} \right)^2 \tag{10}$$

where h is the horizon considered in the impulse response function and $std\left(R_k^{pq}\right)$ is the standard deviation of R_k^{pq} across all accepted draws. While employing the standard approach of reporting the median response in our benchmark case, we use the approach of Fry and Pagan (2007) as a robustness check for our results. Similarly, we compute the variance decomposition as the median of the variance decompositions produced by all accepted draws, but report the variance decomposition resulting from $\theta(j)^*$ as a robustness check.

4 Estimation Results

We now turn to the empirical findings. We estimate the Bayesian VAR described in Section 2. Throughout the analysis, we identify monetary shocks using the sign restrictions presented in Table 1. It is important to emphasize that we do not place any restrictions on the capital flow variables (cap_t) in the definition of the vector of endogenous variables y_t. We therefore allow the data to speak for itself in terms of the responses of our variables of interest. In addition, the real exchange rate ($reer_t$), the trade balance (tb_t) and the relative equity returns ($eq_t - eq_t^*$) are left unrestricted in each of the specifications we employ. This is important because we draw inference upon the correlations between the impulse responses of these and the capital flow variables. We first present impulse response functions of the endogenous variables in the model and later their variance decomposition.

4.1 The Response and Composition of Capital Flows

In this subsection, we present the results from estimating the Bayesian VAR presented in equation (5). The vector of endogenous variables is defined as in (6). The model thus includes seven control variables plus one of the capital flow variables at a time. We estimate the model for each of the four different types of capital flows as well as the financial account as an aggregate. In our benchmark specification, the capital flows are nominal flows denominated in billions of US dollars. Moreover, the capital flow variables are defined such that a positive value signals a net capital inflow into the United States. The fact that these variables can thus take both positive and negative values is the reason why we use the variables in levels instead of log terms. It is clear that the use of nominal flow variables is subject to the critique that eventual impulse responses to the monetary shock can be distorted by the response of relative price levels and/or the exchange rate to the same shock. We will address this caveat in the robustness section.

Figure 2 shows the impulse response of all eight variables in the VAR to a one-standard deviation expansionary monetary shock when the financial account, i.e. the net aggregate of all types of capital flows is included in the model. In this benchmark specification, the monetary easing implies a 16 basis points (b.p.) reduction in nominal short term interest rates relative to the rest of the world. The solid line in each of the subplots illustrates the median response of the respective variable to the shock. It is presented for a horizon of 20 quarters. Following most of the sign restrictions literature, we also report 16th and 84th quantiles of the response functions (Uhlig, 2005).[7]

The impulse responses depicted in Figure 1 suggest that the reserve ratio nb_t, relative consumption $c_t - c_t^*$ and the percentage difference in CPI inflation $cpi_t - cpi_t^*$ react positively to the monetary shock as imposed via the identification restrictions. However, in particular in the case of $c_t - c_t^*$ the response is short-lived. The interest rate differential $i_t - i_t^*$ falls for few additional periods before its response reverts to zero. The ex ante unrestricted equity return differential $eq_t - eq_t^*$ increases for about ten quarters following the shock. In terms of magnitude, on impact a monetary policy easing shock by 100 b.p. raises relative equity returns by about 6%. The distribution of the impulse responses is strongly positive for about five quarters. Moreover, on impact the one standard deviation expansionary monetary shock leads to a deviation from equity parity of more than 1.5 percent.

After an initial appreciation, the real exchange rate $reer_t$ begins to depreciate in response to the expansionary monetary shock, and then stabilises and appreciates again after about 8 quarters.[8] This pattern is somewhat different, though not inconsistent with the evidence on "delayed overshooting" in the literature, as e.g. shown in Scholl and Uhlig (2008). While its dynamics are in line with the standard UIP reasoning underlying the overshooting model, the magnitudes of the initial appreciation and the rather weak depreciation thereafter are unexpected. An explanation for these findings might be the fact that we use real effective exchange rates (given the purpose of our analysis) rather than bilateral nominal exchange rates as is standard in the work on testing Dornbusch's overshooting hypothesis. Moreover, another reason may have to do with the fact that we restrict the consumption differential to rise on impact of the monetary shock. This is a restriction not employed in Scholl and Uhlig (2008). Intuitively speaking, a rise in consumption will put appreciating pressure on the real exchange rate. A robustness exercise presented in Figure 6 shows that the real exchange rate indeed depreciates for most of the response horizon if we relax this restriction, while the main results for capital flows remain unchanged. Note however that the initial appreciation of the exchange rate following a monetary

[7] In the VAR literature using Cholesky or Blanchard-Quah type decompositions, two standard deviation error bands are typically reported. This is equivalent to using 2.3% and 97.7% quantiles. However, in the sign restrictions literature inference is typically based on a limited number of draws which increases the uncertainty around the quantiles.

[8] The link between monetary poliocy shocks and exchange rates is covered extensively by the literature on testing Dornbusch's overshooting hypothsis - see Eichenbaum and Evans (1995), Kim and Roubini (2001), Faust and Rogers (2002) and Scholl and Uhlig (2008).

easing, which goes against the standard UIP reasoning, is found also in Scholl and Uhlig (2008) and Grilli and Roubini (1995).

The next subplot of Figure 1 shows that the trade balance tb_t worsens significantly and persistently throughout the entire response horizon. In terms of magnitude, a monetary policy easing shock by 100 b.p. worsens the US trade balance by about 1% of US GDP after 8 quarters. This finding is in line with Kim (2001), Bems, Dedola and Smets (2007) and Barnett and Straub (2008) who also find evidence in favour of a significant current account worsening following an expansionary monetary shock. The reason is likely to be an "income absorption effect", i.e. an increase in domestic import demand following the fall in the interest rate differential. We therefore provide evidence against the presence of a significant expenditure switching effect, the importance of which is highly disputed in the open economy macroeconomics literature.[9] Given the balance of payments identity, we would expect the net aggregate of all capital flows to react in the opposite way of the trade balance. And indeed we find that the response of the financial account is almost the exact mirror image of the trade balance response. This strong and persistent inflow of capital into the United States in response to the expansionary monetary shock may be an additional explanation for the above discussed response of the real exchange rate.

As a next step, we decompose the financial account into its different components in order to better understand the transmission mechanism and the heterogeneity across different types of capital. As discussed above, different types of capital flows have their own characteristics and determinants. While trade credits, loans and currency flows are likely to be at least partly driven by financing motives for trade flows, FDI, equity and debt flows may be driven more by return considerations. We hope to uncover some of these motives by examining the correlation between the impulse responses of our control variables and the responses of each of the different types of capital flows. As outlined in the previous section, the literature on cross-border capital flows has attempted to answer the question of whether return-chasing or portfolio rebalancing motives are dominant in driving cross-border equity flows by establishing correlations between net equity flows and equity returns at particular points in time. The present study has the advantage of allowing for an additional time dimension through the impulse response functions we generate. This allows us to deduce investors' decisions by tracing the response of both capital flows and the relevant macro variables to structural economic shocks along the response horizon.

Figure 3 shows the impulse response functions of foreign direct investment (fdi), equity investment flows ($equity$), debt investment flows ($debt$) and other investment flows (oi) to an expansionary monetary policy shock. The responses of the control variables are omitted since they do not differ in any noteworthy way from what is shown in Figure 2. The solid lines in Figure 3 again represent the median impulse response of the respective variable to the monetary shock. As discussed above, Fry and Pagan (2007) challenge the usefulness of the median

[9] For early references see Obstfeld and Rogoff (1995) and Betts and Devereux (1996).

as a summary measure of the impulse response distributions at each point along the response horizon. In order to show that our results are robust to this criticism, we report the median impulse responses together with the impulse responses generated by minimizing the Fry and Pagan (2007) criterion. In Figure 4, the dashed lines represent the set of response functions produced by the rotation angle θ^*, while the solid lines show the median response. It is obvious that the two sets of response functions look very much alike. In fact, the qualitative results presented below hold irrespectively of the summary measure considered. In order to save space, we therefore concentrate in what follows on the more commonly used median response as a benchmark case.

A first glance at the results of Figure 3 reveals that the different types of capital flows react very heterogeneously to monetary policy shocks. The main striking finding is the opposite response of equity flows to that of debt flows, as well as FDI and other investment flows. In order to interpret this finding, it is instructive to recall the response of key control variables in the model. In particular, we witnessed a positive deviation from equity parity for about one to one and a half years following a monetary policy shock. Thus, taking into account the entire response horizon, we confirm the predictions of Hau and Rey (2006) and others (conditional on the monetary shock) , namely that a positive deviation from equity parity is associated with portfolio equity outflows. However, the opposite is the case for bonds: the decline in US short-term interest rates - and thus the rise in bond returns - induces net inflows into US bonds, thus implying a positive correlation between bond returns and bond flows that is consistent with a return-chasing motive of investors.

A crucial advantage of our approach is that we can trace the dynamic response pattern of the various variables over time, and in particular we can trace both equity returns and the evolution of net equity flows over time in response. In fact, our results suggest that equity outflows materialise later than the rise in relative equity returns in response to a monetary policy shock. Thus these outflows occur some time after returns have already begun deviating from parity. This suggests a more differentiated answer to the question of whether return chasing or portfolio rebalancing motives dominate investors' decisions. In particular, as regards the return chasing motive, it is important to examine the risk-adjusted performance of an investment strategy of betting on violations of the equity parity condition. In fact, our results suggest that an investor who is overexposed to the US stock market will refrain from rebalancing his portfolio if the expected returns from buying additional US equity are large enough relative to the risk associated with the investment.

In order to illustrate this point, we take the perspective of a Bayesian investor who considers to bet on violations from (conditional) equity parity at each point during the response horizon. Note that the impulse response of the equity return differential k periods after the shock is the period k excess return due to the monetary policy shock of the following investment strategy: in period $k-1$ after the shock, the investor sells one (foreign currency) unit of foreign equity, exchanges the payoff into US dollars and reinvests it into US equity. Following Scholl and Uhlig (2008), we calculate the implied return-to-risk

(Sharpe) ratio of this (conditional) investment as $\frac{eq_t - eq_t^*}{sd(eq_t - eq_t^*)}$ for every point in the response horizon. In particular, we define it as the ratio of the posterior mean excess return and the posterior standard deviation of the distribution of impulse response functions in period k. This measure gives us an idea of the reward and the risk a potential investor faces when betting on a deviation from equity parity at different points along the response horizon.[10] It is important to note that the investor bets on violations from equity parity conditional on the monetary shock. In other words, as Scholl and Uhlig (2008) argue, the implied Sharpe Ratio we construct for the hedging strategy presented takes the perspective of a Bayesian investor, who remains uncertain about the precise impact of the monetary shock, but can insure against any other types of shocks that might occur during the investment horizon.

As Figure 5 illustrates, the Sharpe Ratio increases strongly on impact of the shock and then falls persistently. It reaches a value of about 0.75 at the point at which substantial amount of net equity investment flows out of the US. The reward-to-variability ratio of betting on positive deviations from equity parity thus needs to fall by a substantial amount before investors start rebalancing their portfolio and selling US equity. In sum, the portfolio rebalancing motive does trigger an outflow of equity from the country in which relative equity returns rise. However, the outflow only occurs when the profitability of chasing higher expected returns diminishes to a sufficient extent.

Figure 3 also shows the response of foreign direct investment to the monetary easing. Although most of the relevant literature has focused on equity flows when discussing the implications of the portfolio balance model for cross-border capital flows, similar arguments can be made for FDI. The figure shows that there is a net inflow of FDI immediately following the shock. The inflow is quite persistent and remains substantially positive for about two years. This result is quite intriguing given the fact that equity flows respond in the opposite way. As discussed previously, the inflow of FDI coincides with simultaneous increases in the equity return differential $eq_t - eq_t^*$ and the consumption differential $c_t - c_t^*$. This implies that, contrary to equity flows but similar to bond flows, foreign direct investment appears to be driven by expected returns rather than portfolio rebalancing considerations. A reason for this finding might be the fact that short term risk and portfolio balance considerations play less of a role for FDI flows than for equity flows as the former are typically more long term oriented. In any case, the result emphasizes the particular nature of FDI flows compared to less concentrated forms of equity investment.

The third subplot in Figure 3 presents the impulse response of debt flows to the monetary shock. The responses of the interest rate differential, the inflation differential and the real effective exchange rate at least allow for a suggestive

[10] Scholl and Uhlig (2008) compute Sharpe ratios for a Bayesian investor betting on deviations from uncovered interest rate parity in response to a monetary policy shock. In contrast to the present paper, the authors focus on the return-to-risk ratio of bets of differing length that all begin in the impact period of the shock. For the purpose of this study, however, it is more interesting to examine simple one-period bets that begin at different points in the response horizon.

interpretation of the response of debt instruments to a deviation from interest rate parity. In particular, it appears that investment in debt increases quite persistently in the US relative to the rest of the world when US interest rates fall, thus inducing a deviation from interest rate parity. Hence, contrary to portfolio equities, the monetary policy shock induces a positive conditional correlation for bonds between returns and flows - as returns rise when interest rates fall - suggesting that return chasing motives play a dominant role for debt flows. A stronger argument in this respect could be made if bilateral nominal exchange rates were included in the model such that deviations from interest rate parity could be observed and a similar analysis as in the case of equity investment could be conducted. However, due to the rest of the world definition behind the construction on the real exchange rate, this is not possible such that the evidence must remain suggestive.

The last plot in Figure 3 shows the response of other investment to the monetary easing, showing that other investment flows into the United States increase strongly and significantly during the first part of the response horizon and become insignificant thereafter. In order to understand the reasons behind this finding, it is perhaps useful to remember that major categories of these flows are trade credits, loans and currency flows. These types of capital are typically used to directly finance import expenditure. Hence, one might categorize these flows as borrower rather than investor driven. It is then reasonable to expect that inflows of this type of capital should occur prior to the import expenditure actually being made. And this is precisely what we observe.

In summary, the evidence of this section has shown that monetary policy easing shocks cause *net inflows* in debt securities, foreign direct investment (FDI) and other investment, while inducing *net outflows* in portfolio equities from the United States. Monetary policy shocks thus entail a conditional negative correlation between flows in portfolio equity and debt. A key for understanding this conditional correlation is the effect of monetary policy shocks on asset price returns, which induces a positive correlation between equity returns and bond returns. Overall, our evidence suggests that, conditional on monetary policy shocks, a portfolio rebalancing motive dominates for investment decisions in equity securities but a return chasing motive is the main driver for investments in bonds.

4.2 Variance Decomposition

As a complement to the analysis in the previous subsection, we decomposed the variance of the endogenous variables in our model in order to determine the variance share explained by the monetary shock. Notice that the findings presented here are based on the benchmark specification but are not sensitive to identifying additional (aggregate supply and demand) shocks.[11] Table 2 contains the median results for the capital flow variables of interest and the trade balance. A first glance at the numbers suggests that monetary policy

[11] The resulting variance shares for these additional shocks are available upon request.

shocks are important drivers of all these variables. The share of the variation explained by the monetary shock ranges from 4 to 23 percent across horizons of one to four years. Another compelling finding is that the monetary policy shock explains around 20 percent of the variance of both the trade balance and the financial account at various horizons while the explanatory power for the disaggregated capital flows is much more limited in size. This finding may seem contradictory at first but is in line with the fact that the variance of the financial account variable is the sum of both the variances and the covariances of the individual capital flow variables. It appears that the monetary shock explains the covariances very well, while this is less the case for the individual variances of the flows. Intuitively, it is reasonable that the monetary shock must have strong explanatory power for the financial account as an aggregate if it does so for its counterpart in the balance of payments identity.

Table 2: Variance Decomposition

Horizon	Financial Account	FDI	Equity	Debt	Other	TB
1 Year	12.6	7.3	4.1	3.5	14.0	16.7
2 Years	20.7	8.5	7.4	5.7	22.9	22.9
3 Years	22.2	8.7	8.6	7.5	20.5	22.4
4 Years	22.3	9.0	8.3	8.8	19.2	21.5

Most of the individual types of capital flows, on the other hand, are purely incentive driven. Their variances can thus be rather decoupled from the financing needs for trade expenditure as long as their covariances are such that the balance of payments accounting identity is achieved. In other words, the investor does not consider the financing needs of the country he or she invests in. It is only in the aggregate that investors' decisions need to be such that capital flows balance the net flow of goods and services. This argument is perhaps emphasized by the fact that other flows are the only individual type of capital that is driven by monetary shocks to a similar extent as the trade balance. As we outlined above, these types of capital are typically less incentive driven and likely to be very closely aligned with changes in the trade balance.

Table 3: Variance Decomposition (Fry and Pagan, 2007)

Horizon	Financial Account	FDI	Equity	Debt	Other	TB
1 Year	10.2	17.2	2.6	6.6	9.4	14.6
2 Years	19.4	12.8	2.8	6.2	21.7	17.0
3 Years	20.7	10.6	4.0	8.9	19.8	20.2
4 Years	24.7	9.0	4.1	12.1	18.0	22.4

In Table 3, we present the results from an equivalent variance decomposition based on the set of impulse responses that minimize the Fry and Pagan (2007) criterion. The numbers show that the qualitative arguments we made above are not sensitive to a different summary measure of the distribution of impulse response functions. At the same time, however, it is interesting to note that the precise numbers for each individual variable differ quite strongly in some cases. This suggests that caution is in order when interpreting variance decompositions solely based on one summary measure of the distribution of impulse response functions.

4.3 Robustness Analysis

We conduct a battery of robustness checks to ensure that the main findings in the previous sections are not sensitive to the specification of the empirical model. In this subsection, we present the results obtained from these tests.

In the previous section, we employed a restriction in the identification scheme of a monetary policy shock, which differs from the analysis of Uhlig(2005). In particular, we assume that an expansionary monetary shock must have a positive effect on consumption. The reasoning behind this assumption is rather obvious and it is well-established in the literature. We believe that it helps to identify monetary shocks with greater precision. However, one might argue that the restriction implies an unnecessary reduction of the degrees of freedom in the empirical model. As a first robustness check, we therefore identify the monetary policy shock solely on the basis of the remaining three restrictions, i.e. the restrictions on the response of the interest rate differential, the inflation differential and the reserve ratio. The resulting responses of the endogenous variables in the model can be found in Figure 6 for the case in which the financial account is added to the basic specification. The impulse response functions presented show that the consumption differential still reacts positively to the expansionary shock in the impact period. Following a brief initial appreciation, the real exchange rate depreciates strongly in response to the monetary shock and shows evidence of delayed overshooting. The impulse responses of the remaining control variables and the financial account do not change in any important way compared to the benchmark case. Figure 7 shows that the same is true for the responses of the other capital flow variables.

It has frequently been argued that the number of shocks identified in a VAR is positively related to the probability of identifying each individual shock correctly (Paustian, 2007). As a second robustness check, we therefore identify two additional structural shocks simultaneously with the monetary shock. We have chosen simple aggregate supply and demand shocks because the underlying identifying restriction are rather uncontroversial. In particular, Table 1 shows that we require the aggregate supply shock to reduce inflation and to have a positive effect on consumption whereas an aggregate demand shock must increase the interest rates, inflation and consumption. Formally, we extend the method outlined in Section 2 by requiring that a candidate draw of the decomposition of the variance covariance matrix must, in order to be accepted, uncover one shock that obeys the restrictions of the monetary shock, one that obeys the restrictions of the aggregate supply shock and one that obeys the restrictions of the aggregate demand shock. The resulting impulse response functions for the capital flow variables are shown in Figure 8. It is immediately obvious that the response functions do not differ in any important way from their equivalents in the benchmark specification.[12] If anything, the responses are more precise than before.

In this study we are interested in the channels through which the adjustment of the financial account takes place following the occurrence of a structural shock. The comovement of capital flows with the equity return differential $eq_t - eq_t^*$ naturally plays an important role in this context. We have so far used the equity return differential in US dollars in our model. The reason is that changes in relative equity returns should only play a role for the re-allocation of capital across borders is they are not offset by exchange rate movements. However, in order to ensure that the reaction of $eq_t - eq_t^*$ to the expansionary monetary shock is not entirely due to exchange rate fluctuations and indeed reflects asymmetric equity price changes, it is instructive to include the equity differential in local currencies as a robustness check. As Figures 9 and 10 show, the impulse response functions for the different types of capital flows and the equity return differential look qualitatively very similar to the benchmark results and deliver the same set of qualitative conclusions. The only striking difference is that the equity return differential increases for about eight instead of five quarters after the shock impacts the economy. In line with the above reasoning, this result perhaps strengthens the view that portfolio rebalancing motives are an important driving factor in the cross-border allocation of equity investment.

In the above analysis, we have used unadjusted capital flow variables. The results are therefore subject to the criticism that the response of the variables to the monetary shock might be driven by movements in relative price levels or the exchange rate. We tackle this criticism by including our capital flow variables as ratios to GDP as a robustness check. The resulting impulse response functions for each of the capital flow variables are contained in Figure 11. We can see that, compared to the benchmark specification, the adjustment by GDP lowers the impulse responses of all variables during the first quarters after the shock. The reason is simply that consumption and GDP increase in response to the shock for a few periods. Hence, positive responses become weaker whereas negative responses become more pronounced. However, the fact that all of the response functions retain their qualitative shape suggests that the impulse responses of the unadjusted capital flow variables in our benchmark specification are not simply the result of changes in relative price levels or the exchange rate.

Up until now, we have included one capital flow variable in the model at a time. However, it is clear that there might be important interdependency between the different types of capital flows that we miss if the remaining variables are omitted. As a robustness check, we therefore augment the VAR by dimension three such that the four different types of capital flows can be included at

[12] In order to save space, we have not reported the responses of the control variables themselves. But their impulse responses do not change either. The results are available upon request.

the same time. In spite of the fact that we are now working with a VAR of dimension eleven, the resulting impulse response plots shown in Figure 12 look almost exactly the same as in our benchmark specification.[13] There appears to be no loss in the precision of the estimates, which might be due to the fact that the interlinkages between the capital flow variables are indeed important and improve the fit of the model.

We also checked for the robustness of our results to an alternative definition of the "Rest of the World". We now define the "Rest of the World" as the G7 countries plus a range of additional economies, the selection of which was made solely subject to data availability.[14] Figure 13 shows that the results are robust to this redefinition.

Finally, we considered one potential criticism to our results with regard to the dynamics of net debt flows. In particular, the interest rate we have considered so far has been the short-term money market rate, while the return on international debt flows is rather better represented by the evolution of long-term interest rates. Therefore, in this exercise we replace the differential of short-term money market interest rate by the 10-year bond yield differential between the United States and other G7 economies. As shown in Figure 14, our main results that (i) debt flows and debt returns are positively correlated and (ii) debt and equity flows are negatively correlated still hold, confirming the dominance of the *return chasing* motive behind international debt flows following a monetary policy shock.

5 Conclusions

The evidence of the paper has shown that monetary policy shocks exert a substantial effect on the dynamics and composition of US capital flows. In aggregate, a monetary policy easing shock of 100 basis points leads to net capital inflows and a deterioration in the trade balance of about 1% of US GDP after 8 quarters. The key finding of the paper is that monetary policy shocks induce a negative conditional correlation between flows into equities and bonds, while causing a positive conditional correlation between equity returns and bond returns.

Moreover, for equities there is a negative conditional correlation between flows and returns, i.e. a rise in equity returns in response to monetary policy shocks is eventually associated with an outflow in equity portfolio investment from the country. The opposite is the case for bonds, for which there is a positive conditional correlation between returns and flows.

Yet it is not only the direction of capital flows and returns that exhibit an intriguing pattern, but also the dynamics of flows and returns. While returns - interest rate differentials and relative equity returns - react instantaneously to monetary policy shocks, capital flows react much more gradually over time,

[13] The response of the reserve ratio is omitted for presentation purposes.

[14] The "Rest of the World" now includes the G7 (minus the US) as well as Australia, Belgium, Denmark, Finland, Netherlands, Norway, Spain Sweden, and Switzerland.

with their peak response occurring only after about eight quarters or more. The strength of the methodology of the paper is hence that it allows tracing not only the overall reaction of capital flows and returns, but also to understand how the dynamics of these responses differ.

A central objective of the paper has been to contribute to the literature on the determinants of portfolio choice, and how asset price movements are related to such portfolio decisions. The evidence of the paper is consistent with a portfolio rebalancing motive for equity securities, and a motive akin to return chasing for bonds.

An intriguing issue is that flows and returns in equities and in bonds respond in the opposite way to such monetary policy shocks. The literature on asset price comovements has found it hard to explain the asset price comovements empirically, in particular the strong time variations in stock-bond return correlations. The findings of the paper suggest that such a positive correlation between stock returns and bond returns is present precisely when discount rate effects dominate. Of course, it also implies that the correlation may be very different when other shocks dominate. The present paper thus focuses on one specific shock for portfolio choice and asset prices, while we leave it for future research to condition the analysis on other types of economic shocks.

References

[1] Albuquerque, R. (2003), “The Composition of International Capital Flows: Risk Sharing Through Foreign Direct Investment,” Journal of International Economics, 61, pp. 353-383.

[2] Albuquerque, R., G. Bauer and M. Schneider (2007), "International Equity Flows and Returns: A Quantitative Equilibrium Approach,“ Review of Economic Studies, 74, pp. 1-30.

[3] Albuquerque, R., G. Bauer and M. Schneider (2008), "Global Private Information in International Equity Markets,“ mimeo.

[4] Alfaro, L., S. Kalemli-Ozcan and V. Volosovych (2008), "Why Doesn't Capital Flow from Rich to Poor Countries? An Empirical Investigation," The Review of Economics and Statistics, 90(2), pp. 347-368.

[5] Baele, L., G. Bekaert and K. Inghelbrecht (2007), "The Determinants of Stock and Bond Return Comovements," Research series 200711-27, National Bank of Belgium.

[6] Barnett, A. and R. Straub (2008), “What Drives US Current Account Fluctuations?,”ECB Working Paper.

[7] Bekaert, G., E. Engstrom and S. Grenadier (2006), "Stock and Bond Returns with Moody Investors," NBER Working Papers 12247, National Bureau of Economic Research.

[8] Bems, R., L. Dedola and F. Smets (2007), “US Imbalances the Role of Technology and Policy,” ECB Working Paper, 719.

[9] Betts, C. and M. Devereux (1996), "The Exchange Rate in a Model of Pricing-to-Market," European Economic Review, 40(3-5), pp. 1007-1021.

[10] Bohn, H. and L. Tesar (1996), “US Equity Investment in Foreign Markets: Portfolio Rebalancing or Return Chasing?” American Economic Review, 86, pp. 77-81.

[11] Branson, W. and D. Henderson (1985), “The Specification and Influence of Asset Markets,” in Kenen, P. and R. Jones (eds.), Handbook of International Economics, North-Holland.

[12] Brennan, M. and H. Cao (1997), “International Portfolio Investment Flows,” Journal of Finance, 52, 1851-1880.

[13] Calvet, L., J. Campbell and P. Sodini (2009), “Fight of Flight? Portfolio Rebalancing by Individual Investors,” Quarterly Journal of Economics, forthcoming

[14] Canova, F. and G. de Nicoló (2002), “Monetary Disturbances Matter for Business Fluctuations in the G7,” Journal of Monetary Economics, 49, pp. 1131-1159.

[15] Coeurdacier, N. (2005), “Do Trade Costs in Goods Markets Lead to Home Bias in Equities?” mimeo, Paris Jourdan Sciences Economiques.

[16] Daude, C. and M. Fratzscher (2008), "The Pecking Order of Cross-Border Investment," Journal of International Economics, 74(1), pp. 94-119.

[17] Devereux, M. and A. Sutherland (2006), “Country Portfolio Dynamics,” University of British Columbia.

[18] Eichenbaum, M. and C. Evans (1995), "Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates," Quarterly Journal of Economics, 110(4), pp. 975-1009.

[19] Faust, J. (1998), “The Robustness of Identified VAR Conclusions About Money,” Carnegie-Rochester Conference Series in Public Policy, 49, pp. 207-244.

[20] Faust, J. and J. Rogers (2003), “Monetary Policy’s Role in Exchange Rate Behavior,” Journal of Monetary Economics, 50, pp. 1403-1424.

[21] Frankel, J. (1982a), “In Search of the Exchange Risk Premium: A Six-Currency Test Assuming Mean-Variance Optimization,” Journal of International Money and Finance, 1, pp. 255-274.

[22] Frankel, J. (1982b), “A Test of Perfect Substitutability in the Foreign Exchange Market,” Southern Economic Journal, 49 (2), pp. 406-416.

[23] Fratzscher, M., L. Juvenal and L. Sarno, (2007), "Asset prices, exchange rates and the current account," ECB Working Paper No. 790.

[24] Fratzscher, M. and R. Straub (2008), "Asset Prices and Current Account Fluctuations in Industrialized Economies," mimeo.

[25] Froot, K. and T. Ramadorai (2005), “Currency Returns, Intrinsic Value and Institutional Investor Flows,” Journal of Finance, pp. 1535-1566.

[26] Fry, R. and A. Pagan (2007), “Some Issues in Using Sign Restrictions for Identifying Structural VARs,” NCER Working Paper Series, 14, National Centre for Econometric Research.

[27] Gourinchas, P.-O. and O. Jeanne (2006), "The Elusive Gains from International Financial Integration," Review of Economic Studies, 73(3), pp. 715-741.

[28] Gourinchas, P.-O. and H. Rey (2007), “International Financial Adjustment,” Journal of Political Economy, 115 (4), pp. 665-703.

[29] Hau, H. and H. Rey (2004), "Can Portfolio Rebalancing Explain the Dynamics of Equity Returns, Equity Flows and Exchange Rates?" American Economic Review, Papers and Proceedings, 94 (2), pp. 126-133.

[30] Hau, H. and H. Rey (2006), "Exchange Rate, Equity Prices and Capital Flows," Review of Financial Studies, 19 (1), pp. 273-317.

[31] Hau, H. and H. Rey (2008), "Global Portfolio Rebalancing under the Microscope,"

[32] Kraay, A., N. Loayza, L. Servén and J. Ventura (2005), "Country Portfolios," Journal of the European Economic Association, 3 (4), pp. 914-945.

[33] Kim, S. (2001), "International Transmission of US Monetary Policy Shocks: Evidence From VARs," Journal of Monetary Economics, 48(2), pp. 339-372.

[34] Kim, S. and N. Roubini (2000), "Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach," Journal of Monetary Economics, 45(3), pp. 561-586.

[35] Lane, P. R. and G.M. Milesi Ferretti (2007), "A Global Perspective on External Positions," in Richard Clarida (ed.) G7 Current Account Imbalances: Sustainability and Adjustment.

[36] Obstfeld, M. and K. Rogoff (1995), "Exchange Rate Dynamics Redux," Journal of Political Economy, 103(3), pp. 624-60.

[37] Ohanian, L. and M. Wright (2008), "Where Did Capital Flow? Fifty Years of International Rate of Return Differentials and Capital Flows," Federal Reserve Bank of Minneapolis.

[38] Park, K. (1984), "Tests of the Hypothesis of the Existence of Risk Premium in the Foreign Exchange Market," Journal of International Money and Finance, 3, pp. 169-178.

[39] Paustian, M. (2007), "Assessing Sign Restrictions," The B.E. Journal of Macroeconomics, 7, pp. 1-31.

[40] Peersman, G. and R. Straub (2008), "Technology Shocks and Robust Sign Restrictions in a Euro Area SVAR," International Economic Review, forthcoming.

[41] Rogoff, K. (1984), "On the Effects of Sterilized Intervention: an Analysis of Weekly Data," Journal of Monetary Economics, 14, 133-150.

[42] Scholl, A. and H. Uhlig (2008), "New Evidence on the Puzzles: Results From Agnostic Identification on Monetary Policy and Exchange Rates," Journal of International Economics, 76, pp. 1-13.

[43] Shiller, R. and A. Beltratti (1992), "Stock prices and Bond Yields : Can Their Comovements Be Explained in Terms of Present Value Models?," Journal of Monetary Economics, 30(1), pp. 25-46.

[44] Souriounis, G. (2003), "Uncovering the Dynamic Links of Capital Flows and Exchange Rates," mimeo, London Business School.

[45] Strongin, S. (1995), "The Identification of Monetary Policy Disturbances, Explaining the Liquidity Puzzle," Journal of Monetary Economics, 35 (3), pp. 463-497.

[46] Taylor, J. (2009), "The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong," NBER Working Papers 14631, National Bureau of Economic Research.

[47] Tille, C. and E. van Wincoop (2007), "International Capital Flows," University of Virginia.

[48] Uhlig, H. (2005), "What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure," Journal of Monetary Economics, 52, pp. 381-419.

Appendix Table 1: Data definitions and sources

Variable	Definition	Source
asset prices	difference between domestic equity returns and foreign equity returns, both measured in US dollars	Bloomberg, mkt indices
trade balance	trade balance as a ratio of domestic GDP	IFS
REER	log real effective exchange rate computed using trade weights for a broad set of partner countries	IFS, OECD
Consumption	difference in log private consumption in the domestic and the foreign economy, both measured in US dollars	IFS
Inflation	percentage difference between domestic and foreign CPI inflation	IFS, OECD
Interest rate	percentage difference of short term (money market) interest rates percentage difference of 10 year bond yields	IFS
Reserve ratio	ratio of non-borrowed to total reserves	St. Louis Fed
Financial account	net aggregate inflows of capital in US dollars	IFS
FDI	net inflows of FDI in US dollars	IFS
Other investment	net inflows of other investment in US dollars	IFS
Equity	net inflows of equity investment in US dollars	IFS
Debt	net inflows of debt investment in US dollars	IFS

Notes: The variables in the VAR are quarterly over the period Q1/1974 – Q4/2007.

Figure 1: Decomposition of Net Capital Flows to the United States (in billions of USD)

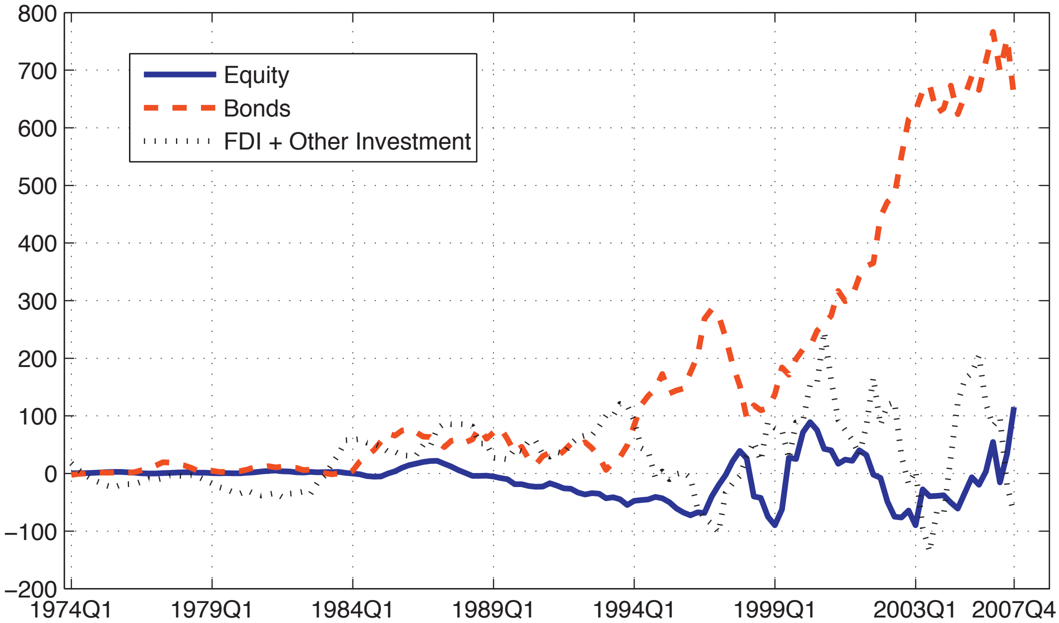


Figure 2: Benchmark Specification

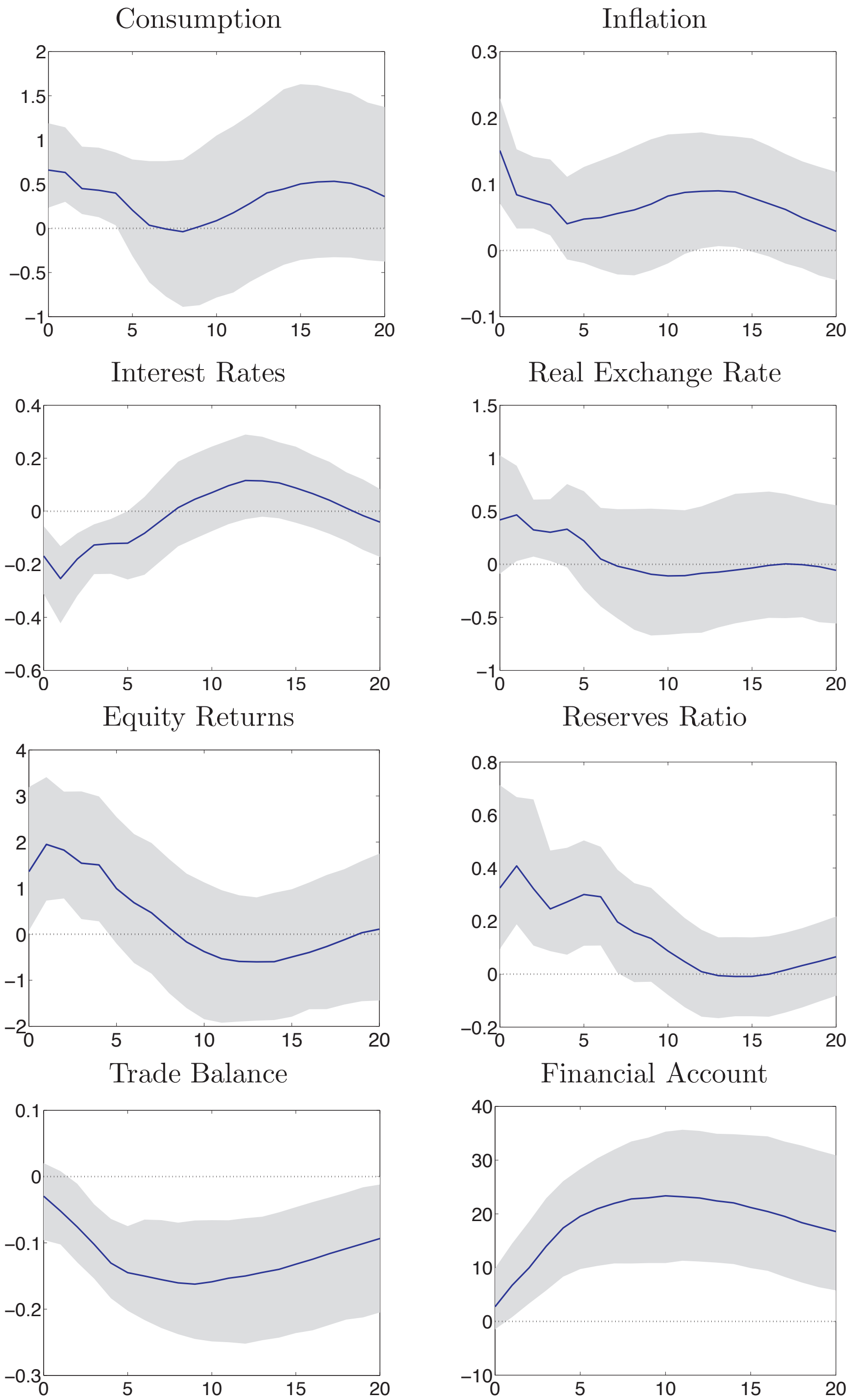


Figure 3: International Capital Flows - Benchmark Specification (in billions of USD)

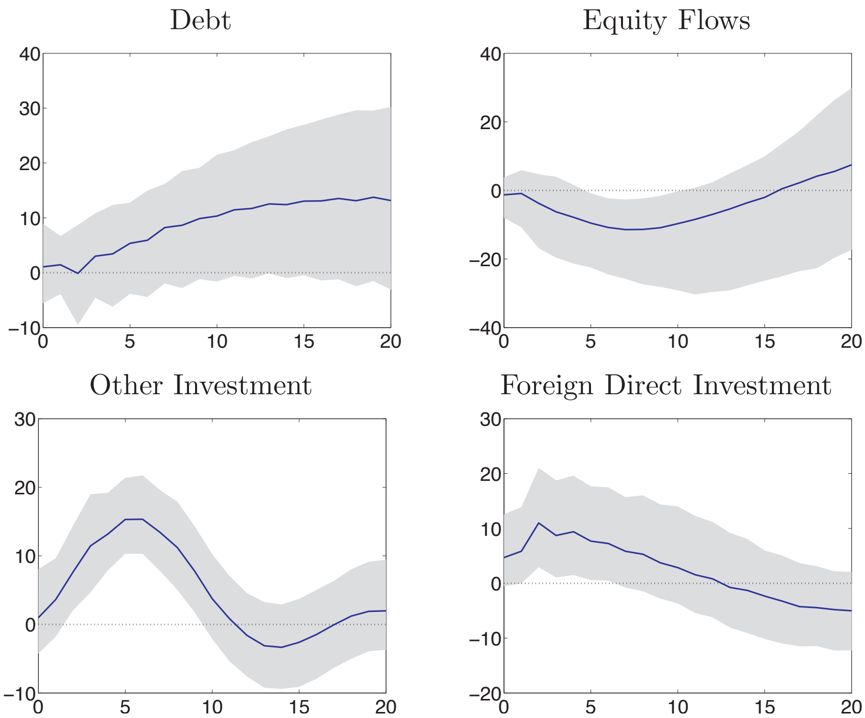


Figure 4: Robustness Exercise - Fry and Pagan (2007)(in billions of USD)

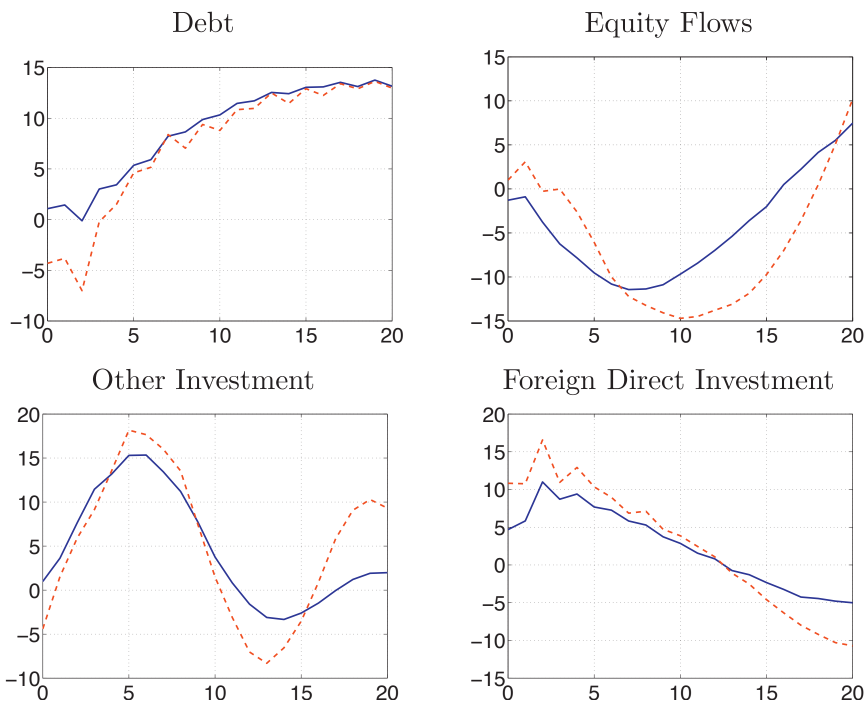


Figure 5: Equity Parity and Implied Sharpe Ratio

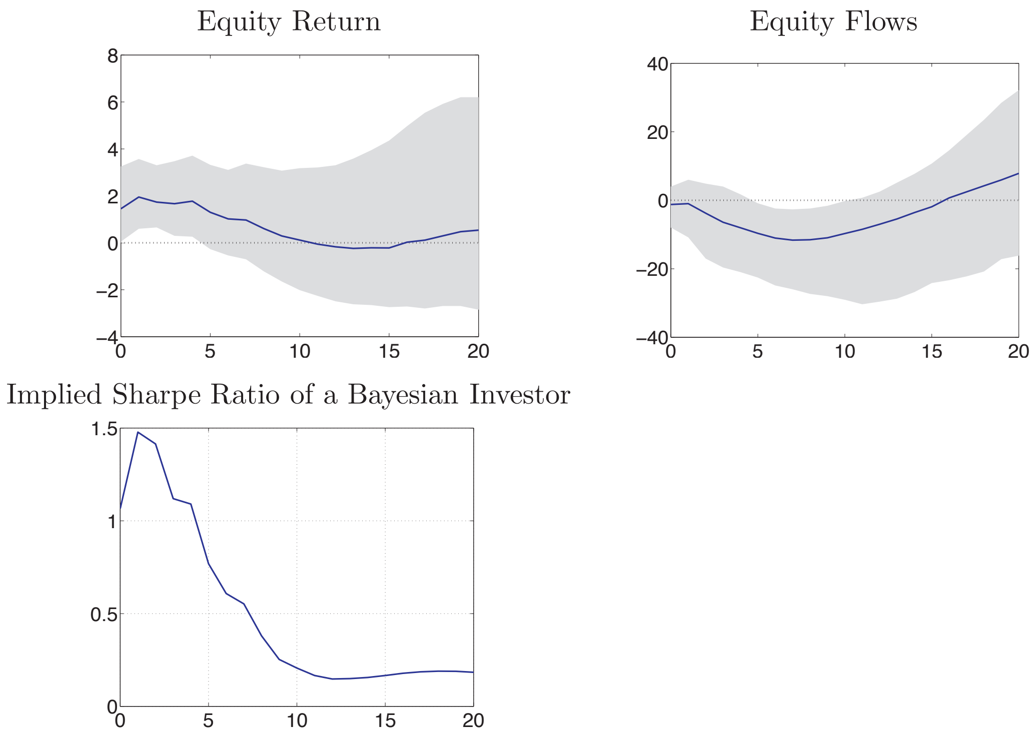


Figure 6: Robustness Exercise- no restriction on consumption

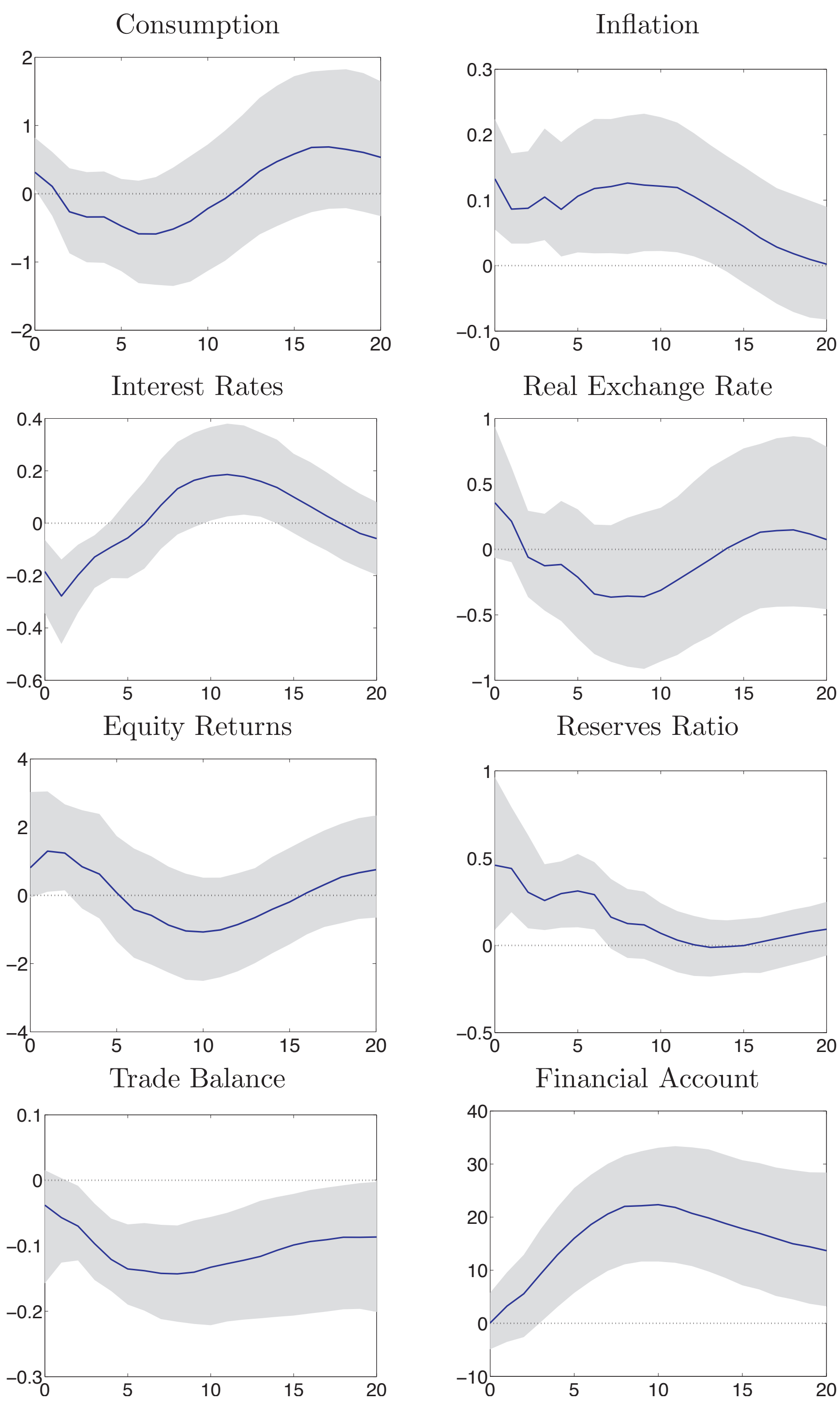


Figure 7: Robustness Exercise - no restriction on consumption (in billions of USD)

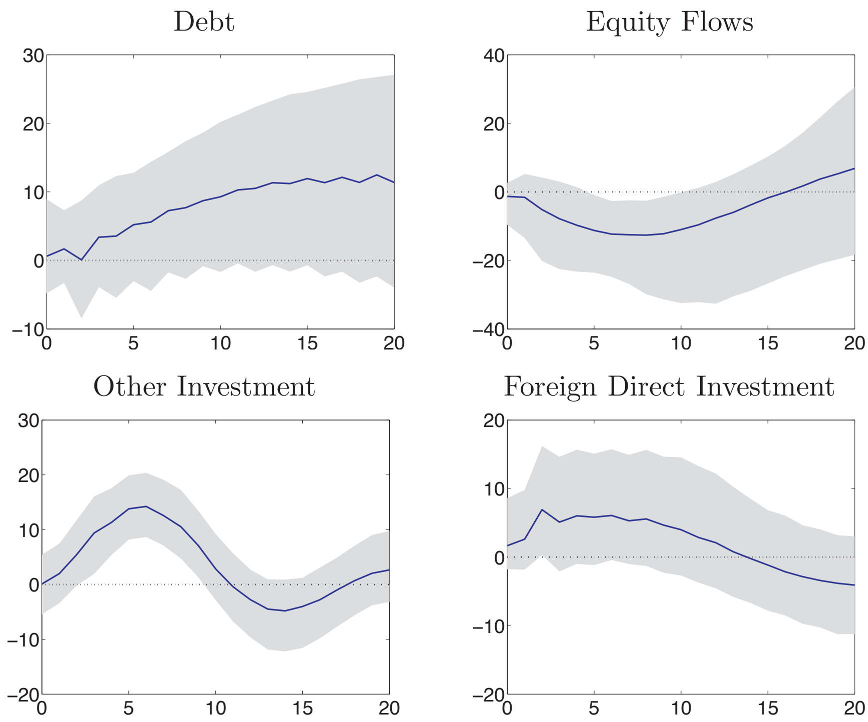


Figure 8: Robustness Exercise - identifying multiple shocks (in billions of USD)

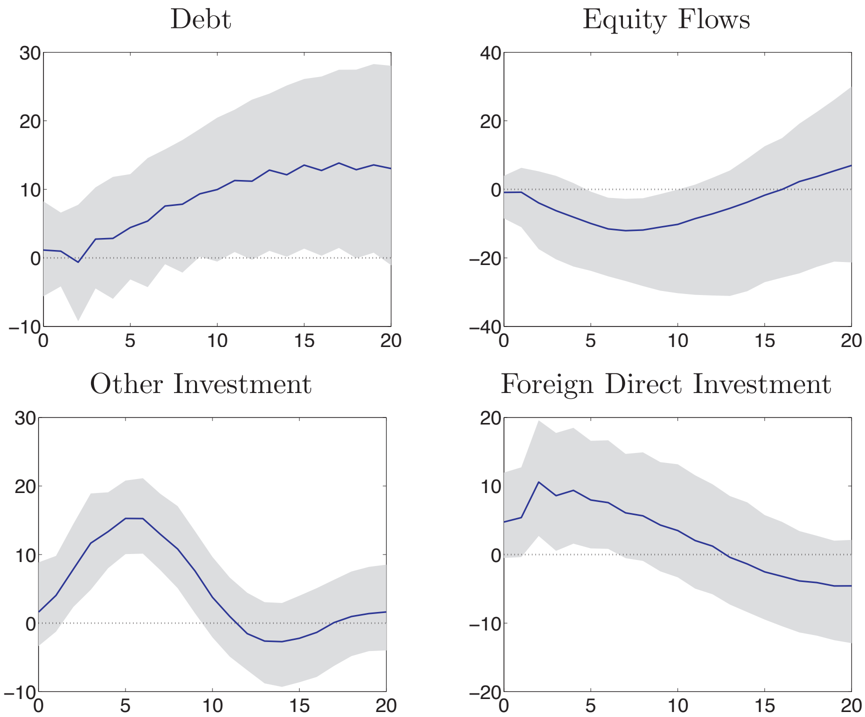


Figure 9: Robustness Exercise- equity prices in local currency

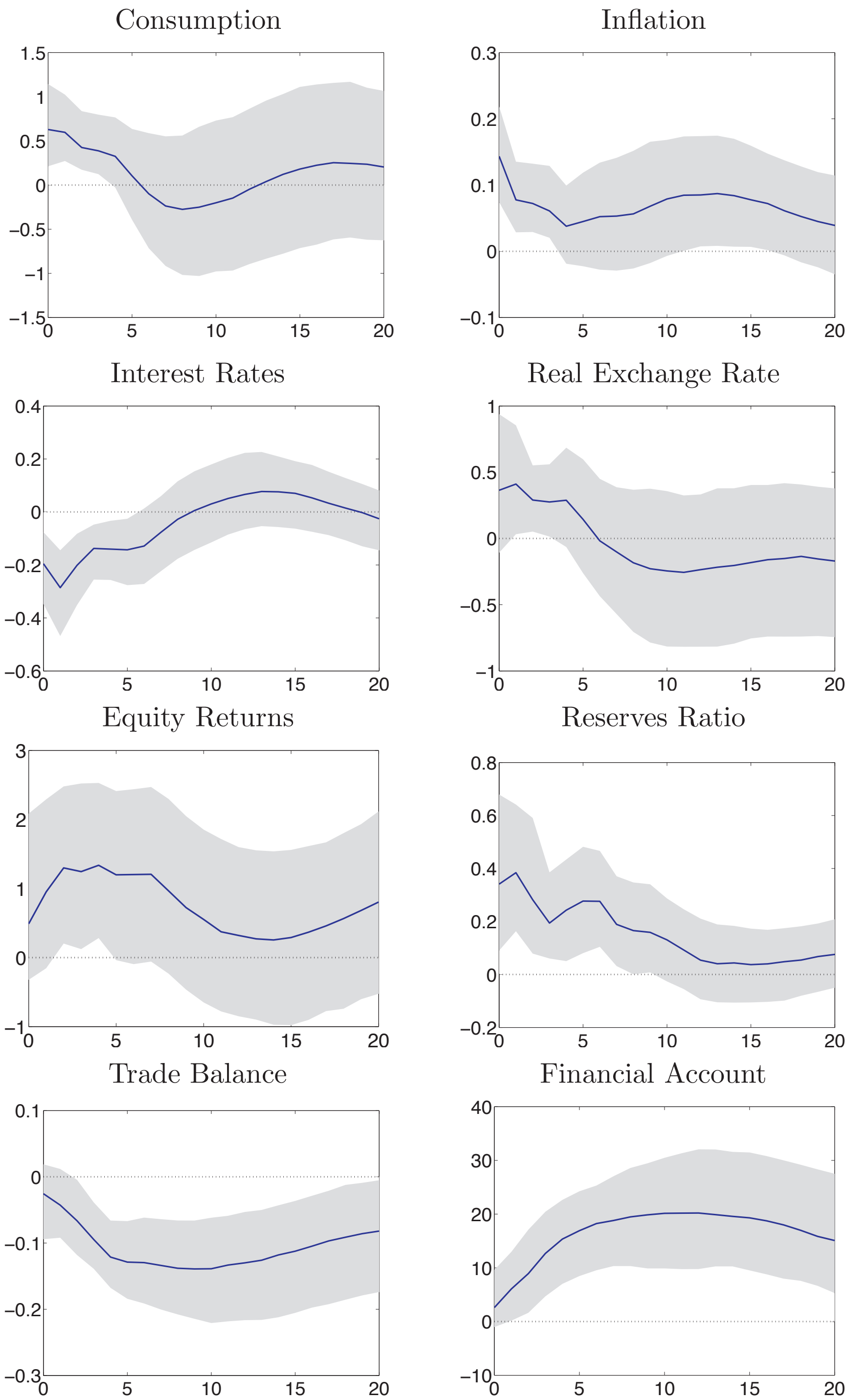


Figure 10: Robustness Exercise - equity prices in local currency (in billions of USD)

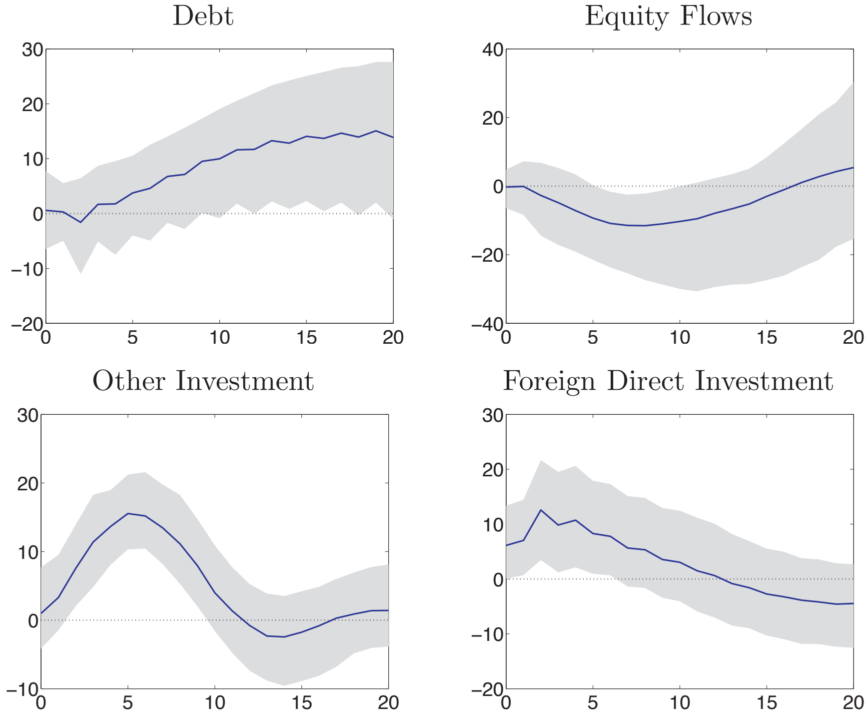


Figure 11: Robustness Exercise - capital flows as a share of GDP (in billions of USD)

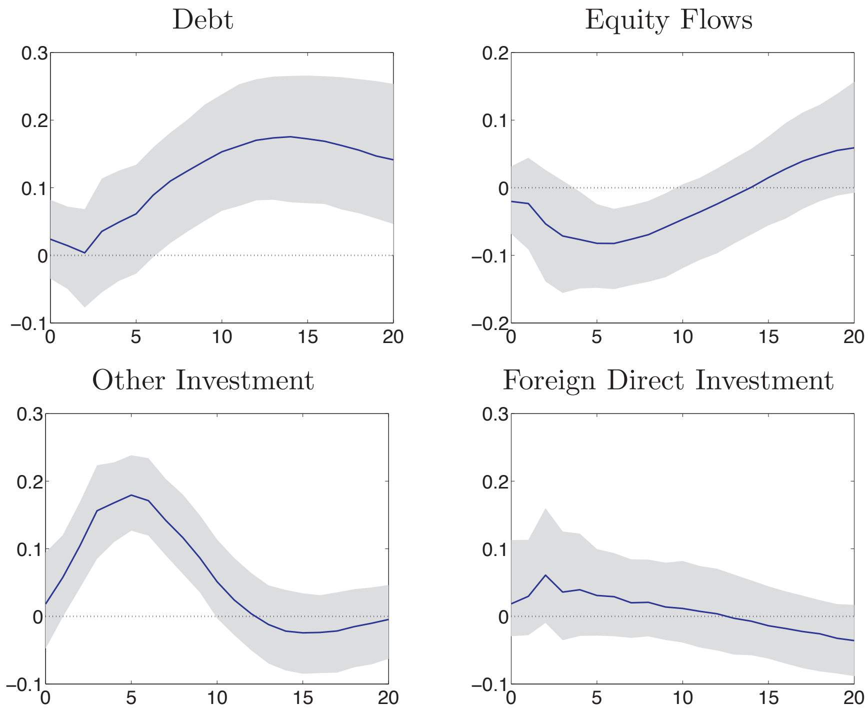


Figure 12: Including All Disaggregated Capital Flows

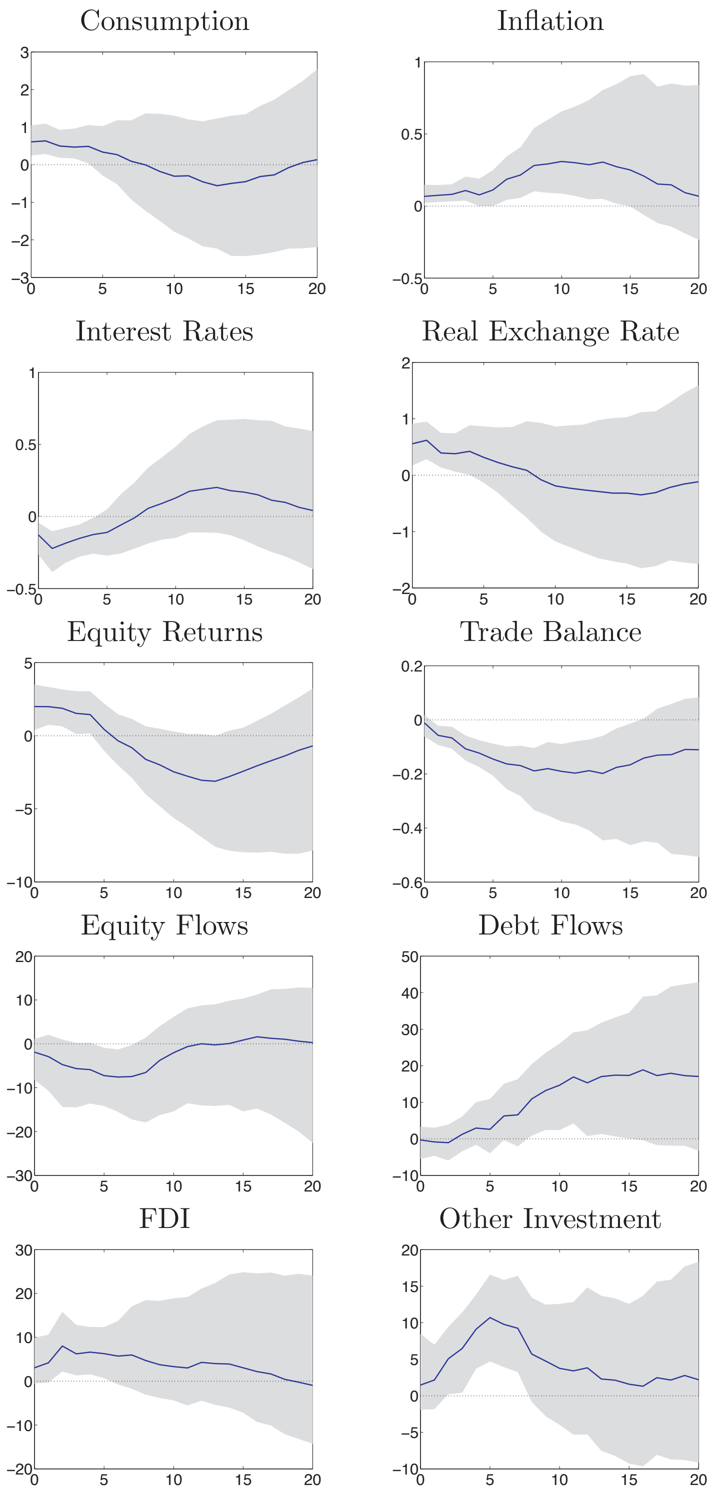


Figure 13: Robustness Exercise - extended rest of the world sample (in billions of USD)

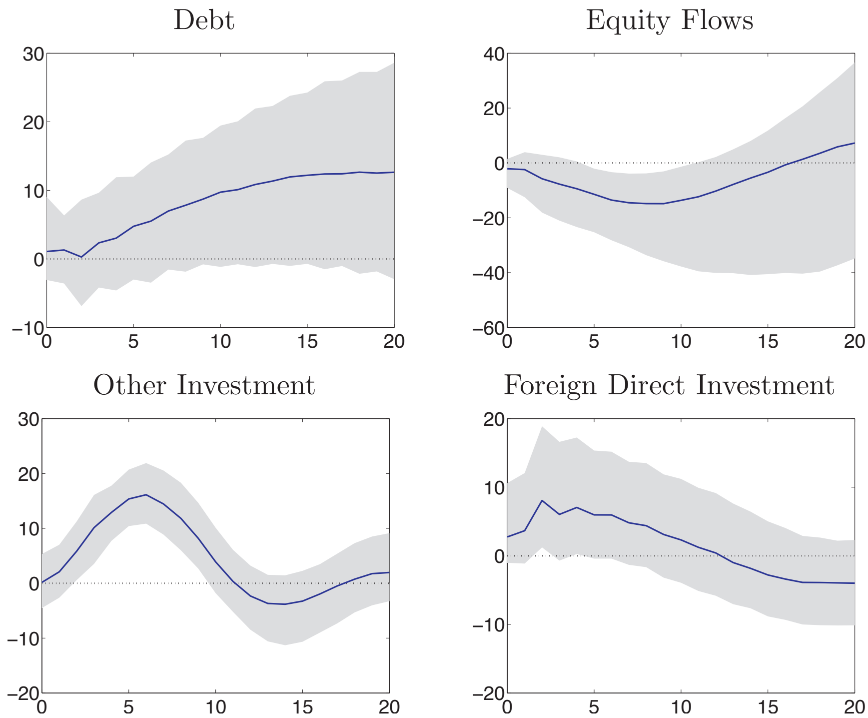
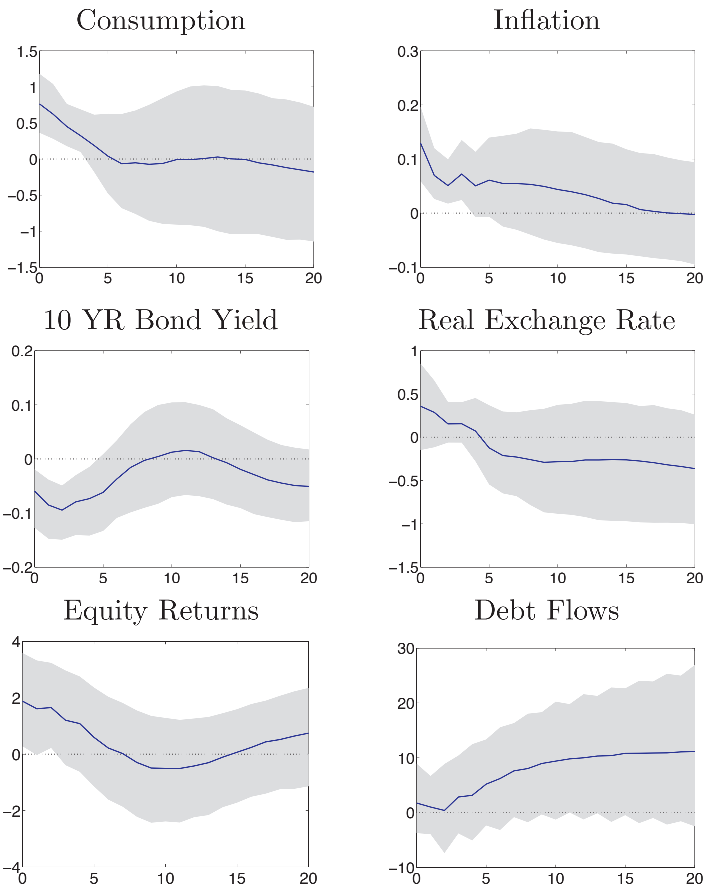


Figure 14: Including Long-Run Interest Rates



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