The shortage of safe assets in the US investment portfolio: Some international evidence

Florian Huber[1] and Maria Teresa Punzi*[1]

[1]Vienna University of Economics and Business

Abstract

This paper develops a Bayesian Global VAR (GVAR) model that is subsequently used to shed further light on the issue whether the shortage of US safe assets is due to demand or supply-sided factors. Within this modeling framework, we track the international transmission dynamics of two stylized shocks under the assumption that nominal short-term interest rates are constrained by the zero lower bound (ZLB). Our main findings can be summarized as follows. First, we find that the effect of a supply-sided shock appears to have a moderate effect on the US economy, while the evidence on international spillovers is rather limited. Second, by constructing a demand-sided shock that assumes that US investors increasingly shift their portfolios towards foreign fixed income securities yields sizable positive effects on US output, equity prices and a general decrease in financial market volatility. Internationally, this surge in foreign funding exerts powerful effects on output and equity prices. In addition, we find that interest rates decrease in order to fight the upward pressure on the home currency.

Keywords: Safe Assets, Zero Lower Bound, Treasury Bonds, Shortgage, Global VAR.

JEL Codes: C32 E23, E32.

June 20, 2016

Preliminary draft: Please do not cite.

*Corresponding author: Maria Teresa Punzi, Vienna University of Economics and Business. E-mail: mpunzi@wu.ac.at. The work on this paper is part of FinMaP (Financial Distortions and Macroeconomic Performance, contract no. SSH.2013.1.3-2), funded by the EU Commission under its 7th Framework Programme for Research and Technological Development.

1 Introduction

The presence of safe assets during the aftermath of the global financial crisis has gained increasing attention from policy makers, both in advanced and emerging economies. Safe assets are typically perceived to be a reliable store of value which contains almost no uncertainty about future payments. Moreover, save assets can be used as a collateral and are often utilized as a benchmark to value risky assets. Generally, safe assets are defined as all assets that fall within the highest rating category used by the three major ratings agencies, namely Standard and Poors, Fitch and Moodys. However, the recent crisis highlighted that even assets that fall in the "triple-A" category are not always entirely risk free. During such times, financial market participants typically invest in US treasuries, which are still considered as risk free. The implementation of unconventional monetary policy by the US federal reserve that heavily intervened on the US treasury market, however, implies that the availability of safe assets has declined significantly, translating into increased financial instability and important consequences in economic policy effectiveness.

Portes (2011) argues that insufficient supply of safe assets has depressed real interest rates to historical low values, increasing the incentive of investors to search for excessively risky assets with higher returns, such as real estate. Such insufficient supply of safe assets is considered to be a cause of global imbalances and asset bubbles that ultimately engulfed in the burst of the US subprime bubble in early 2007. Caballero (2006) states that the global economy suffered from a critical shortage of safe assets, in particular during the recent financial crisis, when investors exclusively demanded safe and liquid assets. According to Caballero (2006), excess demand of safe assets led to tight spreads, low yields and asset price volatility across advanced economies.[1] Deflating housing bubbles contributed to a deep reduction in the value of safe assets, which further increased the excess assets demand coupled with excess supply of goods. With the crash of the housing market and the prolonged recession since 2007, the U.S. portfolio investment flow has inverted with a significant reallocation toward emerging market assets. DeLong (2012) finds that precautionary motives increased the excess demand for safe assets during the crisis, while supply fell as counterparty risk increased due to information -sensitive debt.

The prevalent shortage of safe assets is not a new phenomenon. Prior to the 2007 crisis, portfolio managers in policy institutions and some sovereign wealth funds displayed a large appetite for safe assets, in particular US safe assets. This contributed to the build-up of dollar denominated reserves by emerging market countries and oil/commodity exporters. Ben Bernanke coined this phenomena as global saving glut hypothesis which led to a long-lasting decrease in the real interest rate. Similarly, Caballero, Farhi, and Gourinchas (2008) show that the inability of emerging markets to supply safe assets led to global imbalances and low interest rates. However, since the global crisis and the recovery thereafter, the gap between demand and supply of

[1] Caballero (2006) defines this as a bubbly equilibrium.

safe assets continues to increase, possibly translating in further financial instability. Moreover, several advanced economies hit the zero lower bound (ZLB), worsening the shortage of safe assets. Caballero, Farhi, and Gourinchas (2016) show that outside the ZLB, when shocks hit the economy, safe asset prices adjust and interest rates decrease even to negative values to restore equilibrium.[2] At the ZLB, interest rates are not able to dip below zero. This increases the shortage of safe assets, in the form of US treasury securities and prevents the price of treasury assets to increase in order to satisfy the excess demand. Therefore, investors will not purchase enough treasury securities to sufficiently raise treasury prices (i.e. lower interest rates) and clear the market.

In this paper, we focus attention on US portfolio investment. The US is a special case because during the run up to the crisis, huge amounts of capital from foreign countries, precisely Asian and oil/commodity producing countries, poured into the U.S. economy. By contrast, in the period after the crisis, capital mainly moved from the US to emerging countries. As shown in Gourinchas and Rey (2007), the US shifted from holding a large creditor position around the early 1950s to a large debtor position since the 2000s. However, the net foreign asset position of the U.S. has been large and persistent.[3]. The rest of the world displayed a particular appetite for US Treasury and Agency assets, i.e. safe assets, coupled with the inability of emerging market economies to issue safe assets because of limited institutional capability.[4] Caballero and Farhi (2014a) find that such increases in the shortage of safe assets for any given safe interest rate lead to a persistent downward trend in the equilibrium interest rate, which turned the economy in a secular stagnation. During the post-crisis period, the shortage of safe assets has continued as the availability of assets perceived safe was falling due to rating downgrades of sovereigns. Since the financial crisis in 2007, investors scrambled to find safety and liquidity. Such excess demand results in low yields, tight spreads and higher asset price volatility. As a consequence, advanced economies, in particular the US, have been reallocating assets towards emerging markets. Burger, Sengupta, Warnock, and Warnock (2015) show, for the post-crisis period, that US investors' increasingly increase their exposure with respect to emerging markets, more precisely towards local currency bonds. This finding mainly stems from global "push" factors such as low US long-term interest rates and unconventional monetary policy.

To investigate the possible sources of the shortage in safe assets, we adopt an empirical macroeconomic framework and ask whether the shortage is due to insufficient supply or excess demand. We explore the international transmission of the US shortage of safe assets during the periods of the ZLB with the aim to evaluate the impact on the US economy and the rest of the world when interest rates are constrained by zero.

[2]Since the crisis began in 2007, several shocks hit the global economy and stimulated the demand for safe asset, such as the US debt-ceiling crisis in 2011, the European sovereign debt crisis in 2010-2012, the U.S. fiscal cliff in 2013.

[3]The net position in the U.S. has increased enormously, generating a deep current account deficit. However, gross flows are also very important and their increasing trend has gained momentum since the early 2000s (Johnson, 2009; Obstfeld, 2012; Shin, 2012; Punzi and Kauko, 2015)

[4]See Caballero and Krishnamurthy (2008a) and Caballero and Krishnamurthy (2008b).

Fig. 1 analyzes the equilibrium in the safe assets market: Panel (a) shows a shift of the demand curve due to a rise in demand for safe assets that could be due to fear and uncertainty during crisis periods or in times central banks increasingly conduct unconventional monetary policy. Panel (b) depicts a shift to the left of the supply curve due to the disappearance of private-label safe assets.[5]

[Fig. 1 about here.]

Clearly, both shocks show that the ZLB prevents the price of safe assets to reach the equilibrium price level P^1 and the equilibrium interest rate R_1 that it would be achieved if markets were clearing. This implies that treasury prices have been too low during periods of the ZLB. The price level P^* leads to an endogenous excess of safe assets. Caballero and Farhi (2014b), Caballero, Farhi, and Gourinchas (2015) and Caballero, Farhi, and Gourinchas (2016) show that output decreases in order to equilibrate markets, leading to a *safety trap*. The shortage of US safe asset spreads influences the rest of the world via the capital account. As a consequence, risk premia increase and foreign currencies appreciate.

The aim of this paper is to identify if the shortage of safe assets indicated in Fig. 1 comes from shrinking supply or excess demand, or both. To do this, we estimate a Global VAR (GVAR) model over the period 1984-2014 at quarterly frequencies and consider 34 countries. The GVAR model allows us to analyze the economic implications of safe assets shortage in the US economy and investigate the consequences for the rest of the world. Our modeling approach is based on Feldkircher and Huber (2016), who propose a Bayesian variant of the GVAR model to alleviate the curse of dimensionality. Using a set of spike and slab priors allows us to account for model uncertainty for each country separately, providing a large degree of flexibility and parsimony. To identify structural demand and supply shocks we follow Caballero, Farhi, and Gourinchas (2016) and use sign restrictions imposed on the US responses and the average international responses of certain key macroeconomic quantities. On the supply side, as a proxy for the availability of US safe assets, we update data from Gorton, Lewellen, and Metrick (2012) until 2013. Their measure is constructed as the sum of US government debt and the safe component of private financial debt. On the demand side, we use data from Bertaut and Tryon (2007) and Bertaut and Judson (2014) to evaluate US investors' increasing demand for foreign safe assets.

We find that shrinking supply of US safe assets affects only GDP in the US economy. At the international level, this effect spills over to other countries and foreign GDP also significantly drops, as predicted in Caballero, Farhi, and Gourinchas (2015) and Caballero, Farhi, and Gourinchas (2016). However, this finding arises only for a limited set of countries under consideration, most notably countries that appear to among the largest (in dollar terms) international investors in the US treasury market. On the other hand, the global economy tends to be much more reactive with respect to a demand-side shock. The increasing preference of US investors for foreign bonds during the ZLB

[5]We simply assume that the supply of safe assets is independent from the interest rate. A more general assumption, i.e. an upward-sloping supply curve would lead the same intuition.

leads to a persistent increase in US output and a temporary decrease in the volatility index VIX. Taking an international stance reveals that foreign countries that received sharp increases in capital inflows from the US also react positively. More specifically, foreign output and equity prices increase while interest rates in foreign economies tend to decrease in order to avoid a strong appreciation of the foreign currency. Demand shocks have definitely a stronger impact on the US economy and on the global economy.

The rest of the paper is organized as follows: Section 2 provides a comprehensive literature review on the importance of safe assets and international spillover effects. Section 3 discuss the Global VAR model adopted in the empirical application. Section 4 describes the data and the identification of demand and supply shocks. Section 5 presents the results. Finally, the last section concludes the paper.

2 Related Literature

This paper is related to different strands of the literature on international finance. First, the paper adds to the literature on international portfolio allocation and cross-country interdependencies. In a recent contribution,Burger, Sengupta, Warnock, and Warnock (2015) analyze the impact portfolio re-allocations on US bond portfolios and find that global "push" factors such as low US long-term interest rates and quantitative easing have contributed to the increasing appetite of US investors towards emerging market (EMEs) securities. Burger, Sengupta, Warnock, and Warnock (2015) finds that among EMEs, capital flows were directed to countries with sound macroeconomic fundamentals like low inflation volatility and positive current account balances. Fratzscher (2012) shows that global liquidity and risk largely affect capital flows during periods of crisis and recovery, but the impact is highly heterogeneous depending on the quality of institutions and the fundamentals of the home country. Mendoza and Terrones (2008), Gourinchas and Obstfeld (2012), Schularick and Taylor (2012) and Forbes and Warnock (2012) show that large debt inflows, in the form of surges and stops, are dangerous because they sharply increase credit and therefore the probability of crises. When capital flows from advanced to emerging economies, real exchange rates tend to appreciate, corporate debt increases and asset prices tick up, leading to adverse effects on financial stability. Bernanke et al. (2005) and Bernanke et al. (2007) introduced the global savings glut hypothesis stating that the excess supply of savings relative to investments in surplus countries was channeled into deficit countries, affecting credit conditions. Caballero and Krishnamurthy (2009) presented a model to explain how foreign demand for safe USD-denominated assets led to a shift towards advanced financial instruments that led to innovations in mortgage processing, creating the low-risk assets strongly demanded by international investors. Thus, such recent developments made it possible to pool loans of low quality and transform them into highly rated securities that have been largely recognized as being safe investments. This in turn had substantial macroeconomic effects: capital flows from emerging markets made credit cheap and fueled the boom in asset prices (see, for instance, Bertaut, DeMarco, Kamin, and Tryon, 2012). Another strand of the literature focuses on gross-border banking flows. The findings

in Shin (2012) suggest that the loose credit conditions in the US can be attributed to gross cross-border positions rather than net capital flows. Punzi and Kauko (2015) also distinguish between gross and net flows in explaining the US housing and credit boom. Second, the paper is also closely related to the literature on the shortage of safe assets and its impact on global interest rates, capital flows and economic crises (Caballero, 2006; Caballero and Krishnamurthy, 2008b; Caballero, Farhi, and Gourinchas, 2008; 2016). This literature explicitly deals with the ZLB. During normal times, countries that are running a current account surplus are tempted to buy foreign safe assets because of insufficient domestic supply. This requires the interest rate to decrease in order to restore equilibrium across economies. When the ZLB is binding, interest rates are not able to restore equilibrium, therefore output and exchange rates adjust endogenously, generating a global recession. On the supply side, Krishnamurthy and Vissing-Jorgensen (2012) and Krishnamurthy and Vissing-Jorgensen (2015) show that shrinking supply of Treasury bonds lower the yield on Treasury bonds. The premium associated to those risk-free government securities declines with the total supply of Treasury bonds.[6] If financial sector short-term debt is due to demand for safety/liquidity, then Treasury supply should crowd out financial sector short-term debt via effects on the equilibrium prices of safety and liquidity.

Third, the papers relates to the growing literature on trade and financial integration. Dedola and Lombardo (2012) and Perri and Quadrini (2011) show that domestic shocks propagate across countries as asset prices and the cost of credit clear in the international markets, while Devereux and Yetman (2010) and Devereux and Sutherland (2011) show how leverage-constrained investors rebalance their diversified international portfolios.

Last, the paper contributes to the empirical literature on the international transmission of shocks using Global VAR (GVAR) models. Canova (2005), using a sign restriction approach to analyses the response of eight Latin American countries to three different US shocks, finds that U.S. monetary policy shocks have larger and significant effects on Latin American domestic macroeconomic variables, relative to US aggregate demand and supply shocks. Similarly, Feldkircher and Huber (2016) estimate a GVAR model and find that US monetary policy shocks have a strong impact on international output. Galesi and Sgherri (2009) estimate a GVAR and find that in the short run, asset prices are the main channel through which financial shocks are transmitted internationally. Chudik and Fratzscher (2011) employ a GVAR approach to highlight the diversity of the transmission channels. Tightening financial conditions and monetary policy shocks in advance economies are identified to be important sources for international business cycles, and liquidity shocks have been relatively more important for advanced economies than for emerging market economies (EMEs). By contrast, they find that EMEs were mostly affected by shocks to risk appetite relative to advanced economies.

[6] Krishnamurthy and Vissing-Jorgensen (2012) call such premium as a "moneyness" premium.

3 The econometric framework

This section describes the econometric framework adopted. In subsection that follows, the global vector autoregressive (GVAR) model is outlined and several features of the model are discussed. The second subsection describes the prior setup adopted and the third subsection briefly describes the Markov chain Monte Carlo (MCMC) algorithm.

3.1 A global macroeconomic model

The GVAR model, originally proposed by Pesaran, Schuermann, and Weiner (2004), builds on a set of N country-specific VAR models augmented with weakly exogenous regressors. For a typical country i, such a model is given by

$$x_{it} = a_{i0} + \sum_{p=1}^{P} \Psi_{ip} x_{it-p} + \sum_{q=0}^{Q} \Lambda_{iq} x^*_{it-q} + \varepsilon_{it} \tag{3.1}$$

with

- x_{it} being a k_i-dimensional vector of endogenous variables specific to country i at time t,
- a_{i0} being a k_i-dimensional vector of intercept terms
- Ψ_{ip} for $p \in \{1, \ldots, P\}$ is a $k_i \times k_i$ matrix of autoregressive coefficients associated with the pth lag of the endogenous variable,
- Λ_{iq} for $q \in \{0, \ldots, Q\}$ is the matrix associated with the qth lag of the *weakly exogenous* variables x^*_{it}
- The k^*_i weakly exogenous variables in x^*_{it} are constructed by taking weighted averages of other countries' endogenous variables, i.e.

$$x^*_{ij,t} = \sum_{j=0}^{N} w_{ij} x_{jt}, \tag{3.2}$$

  with w_{ij} being a set of bilateral weights between countries i and j.

- Finally, we let ε_{it} be a vector white noise error term with

$$\varepsilon_{it} \sim \mathcal{N}(0, \Sigma_i) \tag{3.3}$$

  where Σ_i is a $k_i \times k_i$ dimensional positive definite variance-covariance matrix.

At the individual country level, the presence of the weakly exogenous variables accounts for the presence of global factors that impacts all countries simultaneously. The inclusion of these international proxies accounts for cross-country correlation in the errors

and allows the country-specific models to be treated as being independent from each other, effectively simplifying the estimation problem at hand considerably.

In order to derive the global VAR model it proves to be convenient to set $P = Q = 1$ and work with the VARX*(1,1) model. Rewriting Eq. (3.1) yields

$$x_{it} - \Lambda_{i0} x^*_{it} = a_{i0} + \Psi_{i1} x_{it-1} + \Lambda_{i1} x^*_{it-1} + \varepsilon_{it}, \tag{3.4}$$

which can be further simplified as

$$A_i z_{it} = a_{i0} + B_i z_{it-1} + \varepsilon_{it}. \tag{3.5}$$

Here, we let $A_i = (I_{k_i}, \Lambda), B_i = (\Psi_{i1}, \Lambda_{i1})$ and $z_{it} = (x_{it}, x^*_{it})$. Introducing a so-called global vector $x_t = (x'_{0t}, \ldots, x'_{Nt})'$ of dimension $k = \sum_{j=0}^{N} k_j$ and a suitable $(k_i + k_i^+) \times k$ linking matrix W_i allows us to replace z_{it} with

$$z_{it} = W_i x_t. \tag{3.6}$$

Stacking the equations for each country finally yields

$$G x_t = b_0 + F x_{t-1} + \varepsilon_t \tag{3.7}$$

where $G = ((A_0 W_0)', \ldots, (A_N W_N)'), b_0 = (a_{00}, \ldots, a_{N0})', F = ((B_0 W_0)', \ldots, (B_N W_N)')$ and $\varepsilon_t = (\varepsilon'_{0t}, \ldots, \varepsilon'_{Nt})'$. The errors in ε_t feature a variance-covariance matrix that is block-diagonal with Σ_i being in the ith diagonal block of this matrix.

After multiplying with G^{-1} from the left the model can be used to perform structural analysis or forecasting. In addition, the matrix G serves to establish contemporaneous relationships between countries in our system of equations.

3.2 Bayesian inference

Because the model outlined in the previous subsection is heavily parameterized, we adopt a Bayesian approach to estimation and inference. This implies that we have to specify a suitable set of prior distributions on the parameters. More specifically, we follow Feldkircher and Huber (2015) and impose a stochastic search variable selection (SSVS) prior in the spirit of George, Sun, and Ni (2008) on the parameters of Eq. (3.1). It proves to be convenient to collect all slope coefficients and the intercept in a generic matrix Ξ_i with typical element $\xi_{ij}, j \in \{1, \ldots, K_i\}$ where $K_i = k_i(k_i \times P + k_i^* \times Q + 1)$ denotes the number of autoregressive coefficients in country is model.

The SSVS prior implies that

$$\xi_{ij} | \delta_{ij} \sim \delta_{ij} \mathcal{N}(0, \tau^2_{ij,0}) + (1 - \delta_{ij}) \mathcal{N}(0, \tau^2_{ij,1}), \tag{3.8}$$

where δ_{ij} denotes the indicator function that equals unity if a variable is included in the model. In that case, the first component of the mixture normal is imposed as a prior distribution with $\tau^2_{ij,0}$ being the prior variance that is set to a rather large value, rendering the additional information stemming from the prior to be quite loose. By

contrast, if δ_{ij} equals zero, the second component is used where $\tau^2_{ij,1}$ is set to a small value, thus imposing heavy shrinkage towards zero on the jth element of Ξ_i. To specify the prior scalings $\tau^2_{ij,0}$ and $\tau^2_{ij,1}$ we follow George, Sun, and Ni (2008) and adopt a semi-automatic approach that relies on scaling the prior with the OLS standard deviations for each parameter under scrutiny, denoted by $\hat{\sigma}_{ij}$. This implies setting $\tau_{ij,0} = 3 \times \hat{\sigma}_{ij}$ and $\tau_{ij,1} = 0.1 \times \hat{\sigma}_{ij}$

For the variance-covariance matrix we adopt a inverted Wishart prior,

$$\Sigma_i \sim \mathcal{IW}(v_i, S_i). \tag{3.9}$$

Hereby, we let v_i denote the prior degrees of freedom and S_i the prior scale matrix. In our application we specify $v_i = k_i$ and $S_i = 10 \times I_{k_i}$ to render this prior effectively uninformative.

Estimation is carried out on a country-by-country basis as described in Crespo Cuaresma, Feldkircher, and Huber (2016) and Feldkircher and Huber (2015). For all results presented below we simulate a Markov chain with 30,000 iterations where we discard the first 15,000 as burn-in.

4 Demand and Supply of safe assets

Our dataset includes a broad set of developed and developing countries that cover over 90% of global output. More specifically, the countries included are Austria, Belgium, Germany, Spain, Finland, France, Greece, Italy, Netherlands, Portugal, Australia, Canada, Switzerland, Japan, Norway, Sweden, UK, US, Argentina, Brazil, Chile, China, Indonesia, India, South Korea, Mexico, Malaysia, Peru, Philippines, Singapore, Thailand, South Africa, Turkey, Denmark.

For a typical country i, we consider the following variables in our GVAR estimation,

$$x_{it} = \{Y_{it},\, R_{it},\, RP_{it},\, Claims_{it},\, Eq_{it},\, \epsilon_{it}\}.$$

Here, we let Y_{it} denote real GDP, R_{it} is the short-term interest rate, RP_{it} is the risk premium constructed as the difference between 10-year government bond yields and the US 10-year treasury bond yield. $Claims_{it}$ is the U.S. capital outflow, i.e. U.S. resident acquisition of foreign assets, Eq_{it} is the real asset price (measured through the largest equity index in each country) and ϵ_{it} is the real exchange rate vis-a-vis the US dollar. For the US, we moreover include the volatility index and the ratio of US safe assets to GDP ($SA_{US,t}/Y_{US,t}$).

$SA_{US,t}$ is used to represent the supply of US safe assets. We follow Gorton, Lewellen, and Metrick (2012)'s list of safe assets in constructing this series with the corresponding data stemming from the US Flow of Funds.[7] This measure pools data on the liabilities of financial intermediaries and the government that are information-insensitive, i.e. securities whose value is immune to adverse selection in exchange, and thus reduces

[7]See the Data Appendix in Gorton, Lewellen, and Metrick (2012) for details of the corresponding composition of this measure.

the incentive of traders to verify the asset creditworthiness. The safe asset measure is constructed as a sum of US government debt and the safe component of private financial debt.[8] According to Gorton, Lewellen, and Metrick (2012), deposits are the most obvious example of safe assets, despite the fact that Treasury and Agency assets are also information-insensitive and share other typical characteristics of safe assets[9] Gorton, Lewellen, and Metrick (2012) also compute an "high" and "low" estimate of the amount of safe debt in the US. The *high* category includes all government and financial-sector liabilities, which largely comprise Treasuries, municipal bonds, short-term and long-term corporate debt, securitized debt, and other miscellaneous liabilities, while the *low* category excludes miscellaneous financial liabilities, loans, a number of accounts involving payables, and other liabilities that are not routinely traded. In our estimation, we consider only the *high*-type of safe assets because we assume that the insufficient availability of safe assets is mainly due to decreasing amount of treasuries and securitized debt. Fig. 2 reports our updated measure of high estimates of Gorton, Lewellen, and Metrick (2012)'s safe asset share to GDP. The figure reveals a positive trend until the end of 2008, since then the share shows a continuous shrinking of the availability of safe assets. This is partial due to the implementation of quantitative easing by the Federal Reserve, which has absorbed more than half of the increase in government securities outstanding through the purchase of large-scale assets.

[Fig. 2 about here.]

On the demand side, we utilize data from Bertaut and Tryon (2007) and Bertaut and Judson (2014) to evaluate the international impact of increasing demand of US investors for foreign safe assets.[10] Recently, Bertaut, Tabova, and Wong (2014) show that in the post-crisis period, US investors displayed increasing demand for foreign safe assets, which is in contrast to their past behavior. Contemporaneously, the Federal Reserve has absorbed more than half of the increase in outstanding safe government debt through its different large scale asset purchasing programs, implying that less safe assets have been available to private investors. Fig. 3 and Fig. 4 display the evolution of the US investment portfolio since 1994 relative to 34 countries, using data from Bertaut and Tryon (2007) and Bertaut and Judson (2014).

[Fig. 3 about here.]

[8] Alternative measure of the availability of US safe asset can be found in Bertaut, Tabova, and Wong (2014). They consider only the availability of safe assets to private investors, therefore they exclude from Gorton, Lewellen, and Metrick (2012)'s share the holdings of safe assets by the Federal Reserve and by foreign official investors.

[9] Another important role of safe assets and highly-rated government is that they can act as collateral in financial transactions, mimicking the role of money.

[10] Bertaut and Judson (2014) estimate monthly U.S. cross-border securities, combining information from detailed annual Treasury International Capital (TIC) surveys with new information from the TIC form SLT, "Aggregate Holdings of Long-Term Securities by U.S. and Foreign Residents." Bertaut and Judson (2014) decompose monthly data into flows, estimated valuation changes, and a residual gap in order to incorporate additional adjustments to the transactions data and survey data.

[Fig. 4 about here.]

US residents increasingly shifted assets towards advanced and emerging economies over time. Note that, with the exception of the large drop during the crisis, US exposure abroad quickly increased during the periods where the Fed implemented unconventional monetary policy. Moreover, Fig. 5 shows that the largest driver of the steep increase in the US investment portfolio in the aftermath of the crisis can be attributed to foreign bonds, i.e. foreign safe assets. However, it is noteworthy that a sizeable share of the overall portfolio is still invested in foreign stocks (see Fig. 6). The sharp increases of US investment activity in local bond markets concerns both advanced and emerging countries.

[Fig. 5 about here.]

[Fig. 6 about here.]

Fig. 7 shows how capital inflows in the US evolved over the last decades. While the data reveals that foreign countries still hold sizeable amounts of US assets, most notably Treasury securites, the trend has somehow reversed recently, displaying negative growth rates in all types of foreign holdings of US assets (Favilukis, Ludvigson, and Van Nieuwerburgh, 2014).

[Fig. 7 about here.]

4.1 Identification

We carefully follow the IS-LM/Mundell-Fleming framework adopted by Caballero, Farhi, and Gourinchas (2016) to identify supply and demand shocks in the US safe assets market. As in Caballero, Farhi, and Gourinchas (2016), we identify the shocks when the ZLB is binding.[11] Our approach to identification is based on sign restrictions (Uhlig, 2005). More specifically, we identify supply and demand shocks by using the set of (impact) restrictions shown in Table 1. The restrictions we impose are as follows. A decreasing supply of safe assets in the US leads to a reduction in output and an increase in the risk premium. Caballero, Farhi, and Gourinchas (2016) show that a central bank could avoid the output reduction by lowering the interest rate, but during periods of the ZLB, this is not feasible and the country enters into a liquidity trap. As countries are strongly interconnected, and still considering the inability to use the interest rate to re-balance the shortage, the exchange rate plays a crucial role in the adjustment process. Exchange rates relative to the US depreciate and the valuation effect reduces the scarcity of safe assets (in dollar terms). However, even if the exchange rate works in order to restore equilibrium, the US still suffers a rather pronounced drop in real

[11] Within the GVAR framework this implies that we zero-out the structural coefficients of the monetary policy rule for the US country model over the impulse response horizon.

activity. For the remaining variables, we impose no further restrictions (see Table 1, column 1).

In identifying demand shocks, we assume that a positive shock to the claims of US residents on foreign countries generates an increase in output and the return on safe assets, that means income is allocated and reinvested into safe assets, leading to a decrease in the risk premium. Technically, this is implemented by simultaneously shocking the bond inflows for the six countries that display the highest share of claims of US safe assets.[12]

US interest rate responses equal zero because nominal short-term interest rates are bound by the ZLB. The drop in the risk premium means that investors are searching for yield and this increases the implicit volatility in equity markets, leading to a positive response of the VIX index. As shown in Mendicino and Punzi (2014), Punzi and Kauko (2015) and Sá and Wieladek (2015), the increase in the perceived safety of foreign bonds encourages US investors to reallocate part of their savings from domestic assets into foreign assets. This redistributes resources away from the US toward foreign economies, leading to a reduction in US output and an increase in foreign output. Foreign interest rates decrease, reflecting the increase in demand for foreign bonds and the reduction in demand for US safe assets. Currencies appreciate and risk premia decrease to allow US residents to invest in foreign countries. The greater availability of US funds in foreign economies generates a greater availability of credit, leading to credit and asset price booms. See Table 1, column (2). It has to be noticed that we use SA/GDP or $Claims$ to identify individually supply and demand shocks.

[Table 1 about here.]

4.2 IRFs

In this section we examine the impact of demand and supply shocks of safe assets. We also assess the effect on the global economy by analyzing the macroeconomic responses of each country in our dataset which covers a broad range of EMEs and AEs. However, due to space restrictions, we report IRFs for the US alone, Germany, Spain, France and the UK (Western Europe group), China, India, South Korea and Thailand (Asia group), Brazil, Chile, Mexico and Argentina (Latin America group) and US, Canada, Japan and Australia (Other developed economies group). In total we report IRFs for 16 countries. Furthermore, while we are interested in a negative supply shock to US safe assets we multiply the corresponding IRFs by -1 to obtain positive supply and demand shocks in the following empirical application.

4.3 Impulse responses for the United States

Fig. 8 shows responses to a one standard deviation positive demand shock (first two columns on the left side) and one standard deviation positive supply shock (last two

[12] In our case, the countries are Germany, France, Canada, Switzerland, Japan and the United Kingdom.

columns on the right). An increase in the US investors appetite for foreign assets, i.e an increase in foreign claims of US residents, leads to a positive and persistent reaction of US GDP, which increase about 0.2 per cent, median estimate. By construction, the response of the policy rate is zero over the forecast horizon, effectively capturing the notion that the policy rate is stuck at the ZLB. Equity prices increase on impact, but turn negative after six quarters. The initial increase might be due to favorable economic developments in the US. However, given the appetite for foreign bonds, the demand for US stock drops and the equity prices decrease after five quarters. Volatility in financial markets as measured by the VIX indicator decreases on impact by two per cent and turns positive after several quarters, with positive responses during the first four quarters. The decrease in the VIX reflects an improvement in market confidence and a flattening of the yield curve as investors re-balance their portfolios. Such lower perceived risk and uncertainty boosts capital inflows and compresses risk premiums. Similar results are found in Bruno and Shin (2015). However, the persistent demand for foreign safe assets will lead to a future increase in the VIX indicator, as economic agents are aware that the prolonged shortage of safe assets may lead to financial instability. Moreover, the future increase in the VIX indicator reflects the drop in asset prices: the decline in US equity prices suggest a general loss of financial confidence which may be followed by a decline in profit prospects of leverage-constrained banks.

Overall, Fig. 8 shows that the US exhibits a clear shift in terms of portfolio allocation which generates an excess demand. The supply shock leads to a rather short-lived reaction of US GDP, which increases only on impact but then it turns statistically insignificant afterwards. The response of output is in line with Caballero, Farhi, and Gourinchas (2016) who show that when the scarcity of assets increases, the equilibrium of safe assets occurs only via a reduction of output if the interest rate hits the ZLB. All the other variables are statistically insignificant. Those findings suggest that when the ZLB is reached, macroeconomic developments in the US are strongly driven by excess demand of foreign safe assets.

[Fig. 8 about here.]

4.4 International responses

Fig. 9 shows the output reaction to demand and supply shocks for four different groups of countries. Similar to the US case, insufficient supply of US safe assets has zero or marginal effect on foreign GDP. Only Spain, the UK and Canada respond with a rather muted positive reaction on their GDP, while Thailand and Argentina display a tiny negative response in the GDP to a positive increase in the supply of US safe assets. By contrast, demand shocks generate a positive reaction of output for most countries under scrutiny. Output reactions appear to be rather long lasting for the majority of countries. This result corroborates theoretical findings that establish a positive relationship between capital inflows and economic growth, i.e. foreign funding exerts downward pressure on interest rates and thus stimulate the economy (see Fig. 9). Across

countries and groups, output responses with respect to demand-sided shocks appear to be rather homogeneous while the responses to supply shocks are more heterogenous. As shown in Caballero, Farhi, and Gourinchas (2015) and Caballero, Farhi, and Gourinchas (2016), the reaction of output depends on the degree of financial integration across economies and whether the ZLB is reached. The question whether the ZLB is reached is important because the inability of short-term interest rates to reach an equilibrium implies that GDP reactions tend to endogenously react to account for this fact. Our empirical results confirm this finding for Spain, the UK and Canada, with the latter two being among the group predominant US investors of foreign bonds.

[Fig. 9 about here.]

The responses of prices appear to be rather muted (see Fig. 10), being insignificant for the vast majority of countries considered. Both shocks only exert insignificant effects on prices for all countries but Mexico, which displays a longer lasting negative reaction of prices. In addition, Chile and the United Kingdom exhibit a slight negative reaction on impact.

[Fig. 10 about here.]

Demand shocks generate a rather heterogeneous pattern of exchange rate responses across countries. [13] The response to demand shocks in Western countries is on average negative on impact, but after about two years the real exchange rate depreciates. Asian currencies appreciate during the first four quarters, with the exception of China which shows a depreciation only on impact. Exchange rates in Latin America behave similar to Asia, with Argentina being an exception. For Argentina, the currency depreciates on impact and appreciates after around six quarters for a few periods. The Canadian and Australian currencies appreciate while the Yen depreciates. Overall, the impact on the real exchange rate is quite heterogeneous across countries and regions. This finding might also be driven by the rather loose identification scheme adopted, where we assume that real exchange rates depreciate on average, as opposed to the restriction that all countries display a depreciation on impact.

On the other hand, a positive increase in the supply of safe assets lead to a (although muted) currency depreciation for most of the countries, except Mexico and Japan. It appears that a shortage of safe assets due to a shrinking supply lead to an exchange rate appreciation as noted in Caballero, Farhi, and Gourinchas (2016), but not for all countries, in particular the appreciation is much more evident in Western and developed countries, rather than emerging economies (see Fig. 11). The exchange rate response to demand shocks is rather short lived. One possible explanation is that monetary policy authorities in some EMEs and AEs fear large and volatile capital inflows, therefore they lower the policy rate with the aim to prevent the exchange rate to further appreciate. Indeed, Gourinchas and Obstfeld (2012) show that a surge in

[13] The figure reports the exchange rate expressed as the foreign value of the dollar. Therefore, a decrease in the exchange rate means an appreciation of foreign currency against the dollar.

capital inflows lead to strong exchange rates fluctuations that are capable of pushing the country into a financial crisis in the event of a sudden stop, making macroeconomic policy more difficult.

[Fig. 11 about here.]

Demand shocks generate a negative response of short term interest rates in Western Europe, some Latin American countries and Australia (see Fig. 12). This indicates the procyclicality of the monetary policy response as short-term interest rates decrease during periods of sustained GDP growth. Asian short-term interest rate responses are statistically insignificant. This effect can also be found for the UK and Japan because of the implementation of unconventional monetary policies. The strongest reaction is found in Latin America, where short-term interest rates drop by around 20 basis points, with the exception of Chile. Supply shocks, again, appear to have limited impact on short-term interest rates. Indeed, Caballero, Farhi, and Gourinchas (2016) shows that that at the ZLB, the international transmission of shocks occurs via the exchange rate and global output channels.

[Fig. 12 about here.]

The response of the risk spread is shown in Fig. 13. Risk spreads decrease on impact to a one standard deviation positive demand shock in Western Europe and other developed economies. The impact is negative also for Mexico, but only after five quarters. By contrast, risk spreads do not react in a statistically significant fashion for most Asian countries considered. Only Thailand shows a negative reaction at the tenth quarter. Interestingly, Japan also displays a statistically insignificant reaction to demand shocks, but it turns positive and statistically significant around the tenth quarter. Supply shocks have no impact on the risk spread, with the exception of Spain where it persistently decreases by around five basis points, measured through the median response. Clearly, the risk spread is driven by demand shocks, implying that US investors require a lower risk premium to invest in foreign assets. The increase in the perceived safety of foreign assets encourages US investors to reallocate part of their capital from domestic assets into foreign assets. Moreover, the ZLB and unconventional monetary policy reduced the availability of safe assets for US investors, pushing the re-allocation of the US bond portfolio towards foreign countries. Similar findings are found in Burger, Sengupta, Warnock, and Warnock (2015). They show that global push factors such as low US long-term interest rates and quantitative easing policies encourage the re-allocation of the international bond portfolio of US investors, who increasingly invested in emerging market local currency bonds. Different from Burger, Sengupta, Warnock, and Warnock (2015), we find only a marginal impact of risk spreads on emerging countries because our study focuses on the overall bonds acquired by US residents in dollar-denominated assets, rather than local currency.

[Fig. 13 about here.]

Equity prices respond positively to a one standard deviation positive demand shock in all countries in our sample (shown in Fig. 14). The reaction is strong in many countries with equity prices increasing by about four per cent on average. The positive reaction is also persistent for about one to two years. The only exception proves to be Spain, where a small increase occurs only on impact but it immediately turns negative afterwards. Similar results appears in Shin (2012), Mendicino and Punzi (2014), Punzi and Kauko (2015) and Sá and Wieladek (2015) who show that capital inflows lead to asset booms in the receiving country. A one standard deviation positive supply shock leads to a negative reaction of equity prices in only 50 per cent of our country sample. The rest of our sample reports a statistically insignificant response to supply shocks. Moreover, the impact, where significant, is quite smaller in magnitude relative to the impact caused by demand-sided shocks.

[Fig. 14 about here.]

5 Conclusion

In this paper we investigate the possible sources of the shortage of US safe assets. By adopting an empirical macroeconomic framework, we ask whether the shortage is due to insufficient supply or excess demand. We explore the international transmission of the US shortage of safe assets during the periods of the ZLB with the aim to evaluate the impact on the US economy and the rest of the world when interest rates are constrained by zero.

We estimate a Bayesian variant of the Global VAR (GVAR) model over the period 1994-2014 at quarterly frequencies and consider 34 countries. The GVAR model allows us to analyze the economic implications of safe assets shortage in the US economy and investigate the consequences for the rest of the world. To identify supply shocks, we update data from Gorton, Lewellen, and Metrick (2012) until 2013. Their measure is constructed as the sum of US government debt and the safe component of private financial debt. On the demand side, we use data from Bertaut and Tryon (2007) and Bertaut and Judson (2014) to evaluate US investors' increasing demand for foreign safe assets.

We find that decreasing supply of US safe assets affects only GDP in the US economy. At the international level, this effect spills over to other countries and foreign output also falls, as predicted in Caballero, Farhi, and Gourinchas (2015) and Caballero, Farhi, and Gourinchas (2016). However, we would like to stress that this finding only holds for a relatively limited set of countries in our dataset. On the other hand, we find sizable macroeconomic effects of demand-sided shocks. The increasing preference of US investors with respect to foreign bonds during the ZLB leads to a persistent output increases and to a rather short-lived decrease in the volatility index VIX, which allows equity price to increase at a given confidence level in financial markets. Internationally, foreign countries are assumed to experience strong capital inflows stemming from the US. Such surge in foreign funding affects foreign output in a positive fashion and leads

to pronounced increases in equity prices. Interest rates in foreign economies tend to decrease in order to avoid adverse effect on the home countries' currency. Demand shocks definitely exert a much stronger impact on the US and the global economy.

The limitation of this study lies in the fact we only evaluate the US investment portfolio. A fruitful avenue of further research would include the evaluation not only of the issuance of US safe assets but the issuance of safe assets by a large panel of countries.

References

Bernanke, B., et al. (2007): "Global imbalances: recent developments and prospects," *Bundesbank Lecture speech, September*, 4, 18.

Bernanke, B. S., et al. (2005): "The global saving glut and the US current account deficit," Discussion paper.

Bertaut, C., L. P. DeMarco, S. Kamin, and R. Tryon (2012): "ABS inflows to the United States and the global financial crisis," *Journal of International Economics*, 88(2), 219–234.

Bertaut, C. C., and R. Judson (2014): "Estimating US cross-border securities positions: New data and new methods," *FRB International Finance Discussion Paper*, (1113).

Bertaut, C. C., A. Tabova, and V. Wong (2014): "The Replacement of Safe Assets: Evidence from the US Bond Portfolio," *FRB International Finance Discussion Paper*, (1123).

Bertaut, C. C., and R. W. Tryon (2007): "Monthly estimates of US cross-border securities positions," *FRB International Finance Discussion Paper*, (910).

Bruno, V., and H. S. Shin (2015): "Capital flows and the risk-taking channel of monetary policy," *Journal of Monetary Economics*, 71, 119–132.

Burger, J. D., R. Sengupta, F. E. Warnock, and V. C. Warnock (2015): "US investment in global bonds: as the Fed pushes, some EMEs pull," *Economic Policy*, 30(84), 729–766.

Caballero, R. J. (2006): "On the macroeconomics of asset shortages," Discussion paper, National Bureau of Economic Research.

Caballero, R. J., and E. Farhi (2014a): "On the role of safe asset shortages in secular stagnation," *Secular Stagnation: Facts, Causes and Cures*, p. 111.

——— (2014b): "The safety trap," Discussion paper, National Bureau of Economic Research.

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2008): "An Equilibrium Model of "Global Imbalances" and Low Interest Rates," *American Economic Review*, 98(1), 358–93.

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2015): "Global Imbalances and Currency Wars at the ZLB.," Discussion paper, National Bureau of Economic Research.

——— (2016): "Safe Asset Scarcity and Aggregate Demand," *The American Economic Review*, 106(5), 513–518.

Caballero, R. J., and A. Krishnamurthy (2008a): "Collective risk management in a flight to quality episode," *The Journal of Finance*, 63(5), 2195–2230.

——— (2008b): "Knightian uncertainty and its implications for the TARP," in *Financial Times Economists Forum*.

Caballero, R. J., and A. Krishnamurthy (2009): "Global Imbalances and Financial Fragility," *American Economic Review*, 99(2), 584–88.

Canova, F. (2005): "The transmission of US shocks to Latin America," *Journal of*

Applied econometrics, 20(2), 229–251.

Chudik, A., and M. Fratzscher (2011): "Identifying the global transmission of the 2007–2009 financial crisis in a GVAR model," *European Economic Review*, 55(3), 325–339.

Crespo Cuaresma, J., M. Feldkircher, and F. Huber (2016): "Forecasting with Global Vector Autoregressive Models: A Bayesian Approach," *Journal of Applied Econometrics*, p. forthcoming.

Dedola, L., and G. Lombardo (2012): "Financial frictions, financial integration and the international propagation of shocks," *Economic Policy*, 27(70), 319–359.

DeLong, J. B. (2012): "This Time, It Is Not Different: The Persistent Concerns of Financial Macroeconomics," *Rethinking the Financial Crisis*, pp. 14–36.

Devereux, M. B., and A. Sutherland (2011): "Evaluating international financial integration under leverage constraints," *European Economic Review*, 55(3), 427–442.

Devereux, M. B., and J. Yetman (2010): "Leverage constraints and the international transmission of shocks," *Journal of Money, Credit and Banking*, 42(s1), 71–105.

Favilukis, J., S. C. Ludvigson, and S. Van Nieuwerburgh (2014): "Foreign ownership of US safe assets: good or bad?," Discussion paper, National Bureau of Economic Research.

Feldkircher, M., and F. Huber (2015): "Changes in US Monetary Policy and its Transmission over the last Century," Oesterreichische Nationalbank, mimeo.

Feldkircher, M., and F. Huber (2016): "The international transmission of US shocksEvidence from Bayesian global vector autoregressions," *European Economic Review*, 81, 167–188.

Forbes, K. J., and F. E. Warnock (2012): "Debt-and equity-led capital flow episodes," Discussion paper, National Bureau of Economic Research.

Fratzscher, M. (2012): "Capital flows, push versus pull factors and the global financial crisis," *Journal of International Economics*, 88(2), 341–356.

Galesi, A., and S. Sgherri (2009): *Regional financial spillovers across Europe: a global VAR analysis*, no. 9-23. International Monetary Fund.

George, E. I., D. Sun, and S. Ni (2008): "Bayesian stochastic search for VAR model restrictions," *Journal of Econometrics*, 142(1), 553–580.

Gorton, G., S. Lewellen, and A. Metrick (2012): "The Safe-Asset Share," *American Economic Review*, 102(3), 101–06.

Gourinchas, P.-O., and M. Obstfeld (2012): "Stories of the Twentieth Century for the Twenty-First," *American Economic Journal: Macroeconomics*, 4(1), 226–65.

Gourinchas, P.-O., and H. Rey (2007): "From world banker to world venture capitalist: US external adjustment and the exorbitant privilege," in *G7 Current Account Imbalances: Sustainability and Adjustment*, pp. 11–66. University of Chicago Press.

Johnson, K. H. (2009): *Gross or net international financial flows: understanding the financial crisis*. Council on Foreign Relation.

Krishnamurthy, A., and A. Vissing-Jorgensen (2012): "The aggregate demand for treasury debt," *Journal of Political Economy*, 120(2), 233–267.

——— (2015): "The impact of Treasury supply on financial sector lending and stability," *Journal of Financial Economics*, 118(3), 571–600.

Mendicino, C., and M. T. Punzi (2014): "House prices, capital inflows and macroprudential policy," *Journal of Banking & Finance*, 49, 337–355.

Mendoza, E. G., and M. E. Terrones (2008): "An anatomy of credit booms: evidence from macro aggregates and micro data," Discussion paper, National Bureau of Economic Research.

Obstfeld, M. (2012): "Does the current account still matter?," Discussion paper, National Bureau of Economic Research.

Perri, F., and V. Quadrini (2011): "International recessions," Discussion paper, National Bureau of Economic Research.

Pesaran, M. H., T. Schuermann, and S. M. Weiner (2004): "Modeling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model," *Journal of Business and Economic Statistics, American Statistical Association*, 22, 129–162.

Portes, R. (2011): "The safe asset meme," .

Punzi, M. T., and K. Kauko (2015): "Testing the global banking glut hypothesis," *Journal of Financial Stability*, 19, 128–151.

Sá, F., and T. Wieladek (2015): "Capital inflows and the US housing boom," *Journal of Money, Credit and Banking*, 47(S1), 221–256.

Schularick, M., and A. M. Taylor (2012): "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008," *American Economic Review*, 102(2), 1029–61.

Shin, H. S. (2012): "Global banking glut and loan risk premium," *IMF Economic Review*, 60(2), 155–192.

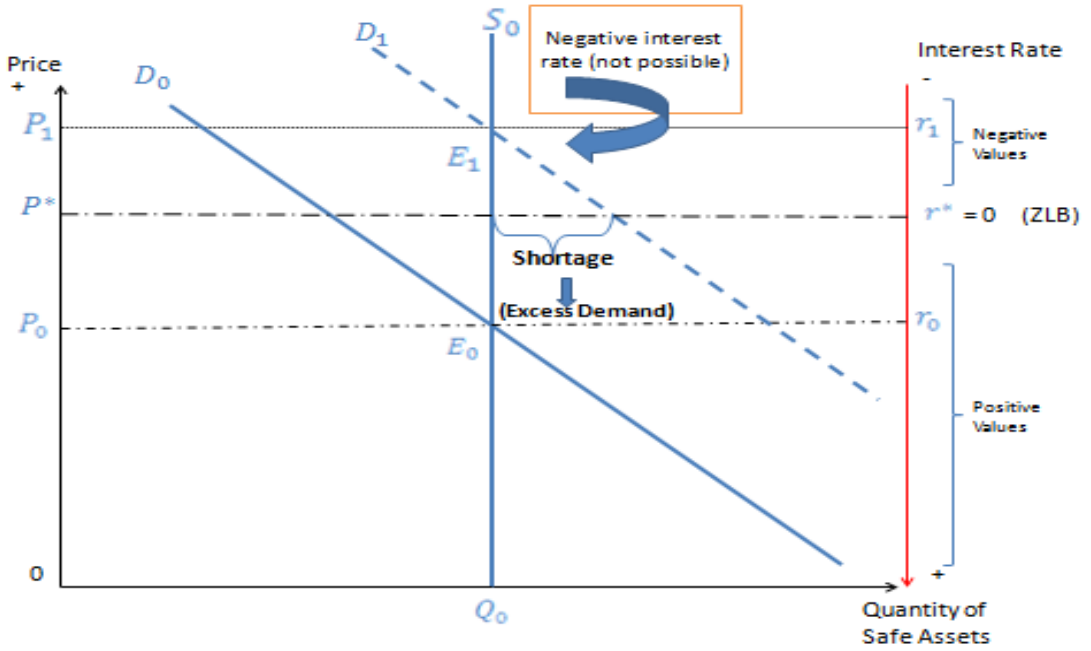
Uhlig, H. (2005): "What are the effects of monetary policy on output? Results from an agnostic identification procedure," *Journal of Monetary Economics*, 52(2), 381–419.

Table 1: Sign Restrictions

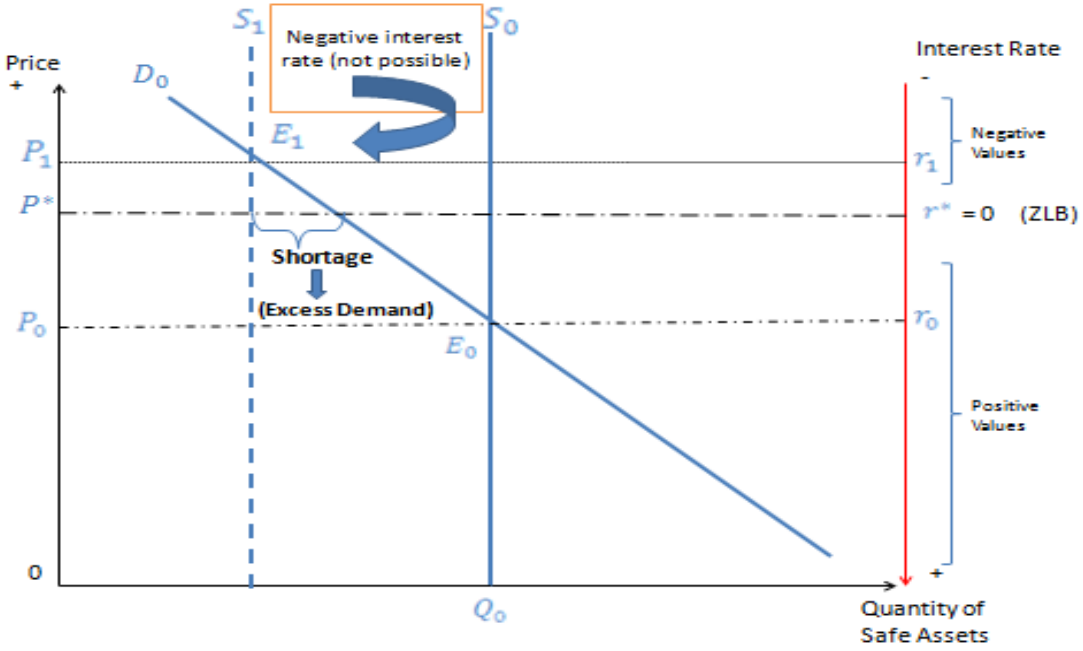
Variables	Supply Shock (1)	Demand Shock (2)
SA/GDP	-	*
R^{US}	0	0
R^*	?	?
Y	-	+
Y^*	?	?
π	?	?
π^*	?	?
$RiskSpread$	+	-
$Claims$	*	+
Eq	?	?
VIX	?	?
ϵ	-	-

Responses marked with $*$ are not included in the GVAR and responses marked with ? are left unrestricted. SA/Y indicates safe assets to GDP, R^{US} and R^* are the short term interest rate in the US and abroad, Y and Y^* are the US GDP and foreign GDP, π and π^* is inflation in the US and abroad, $RiskSpread$ is the risk premium, $Claims$ is the US capital outflow, Eq is real equity price, VIX is the volatility indicator and ε is the real exchange rate.

Fig. 1: Safe Assets Market.



Panel (a): Positive Demand Shock



Panel (b): Negative Supply Shock

Fig. 2: U.S. safe assets as a share of GDP.

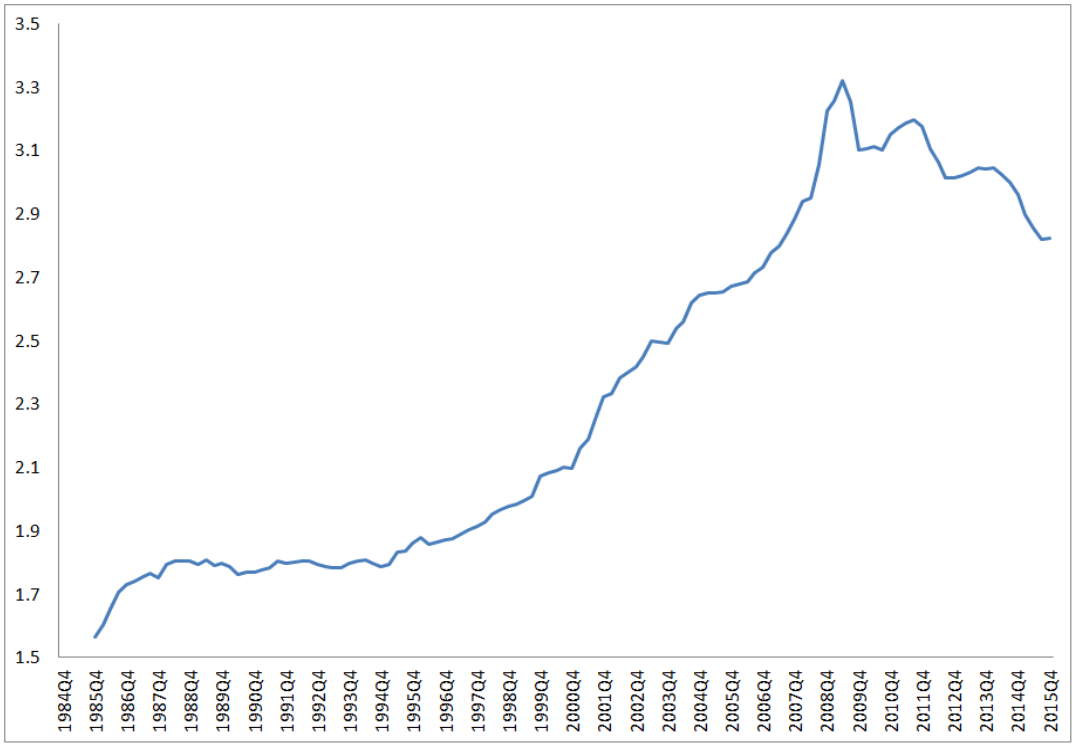


Fig. 3: U.S. Investment Portfolio

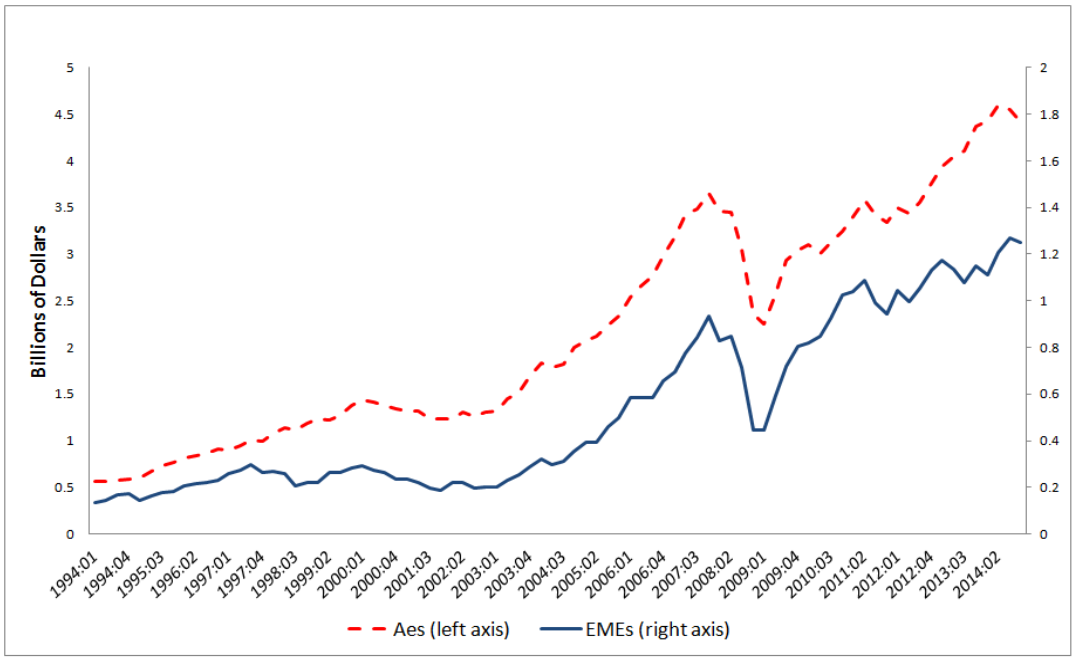


Fig. 4: U.S. Investment Portfolio

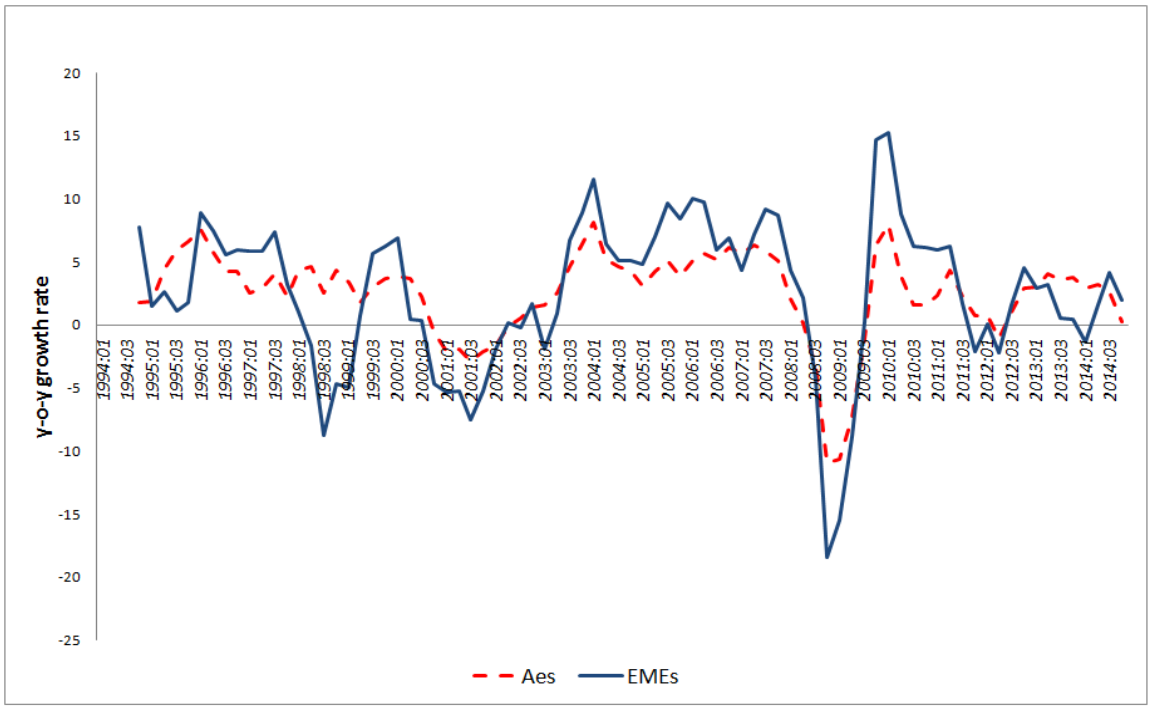


Fig. 5: U.S. Foreign Bond Portfolio

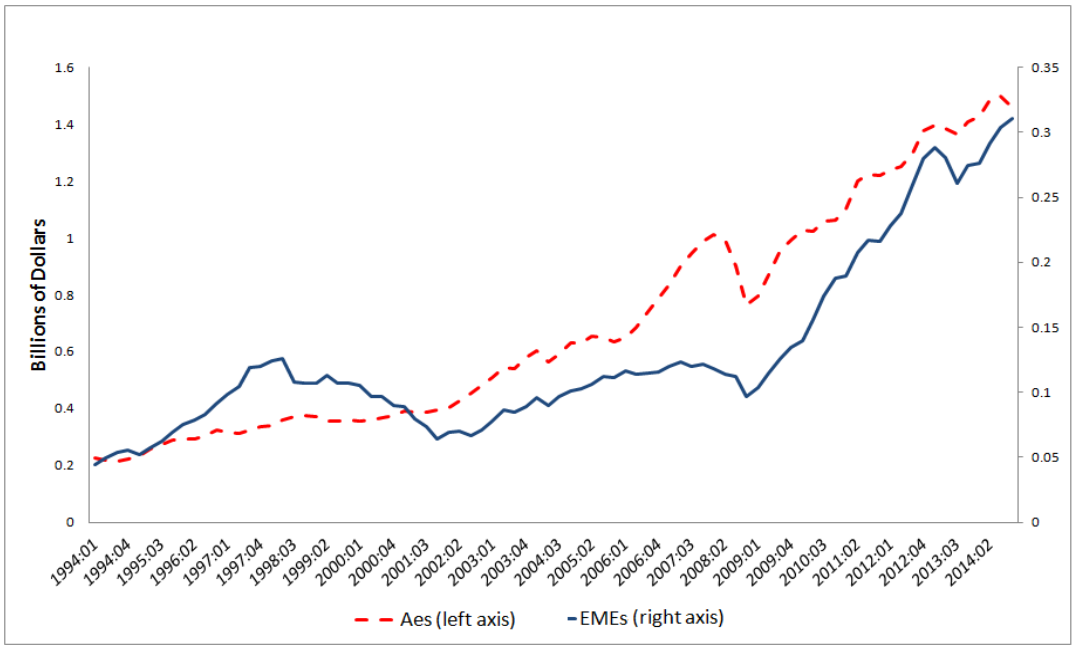


Fig. 6: U.S. Foreign Equity Portfolio

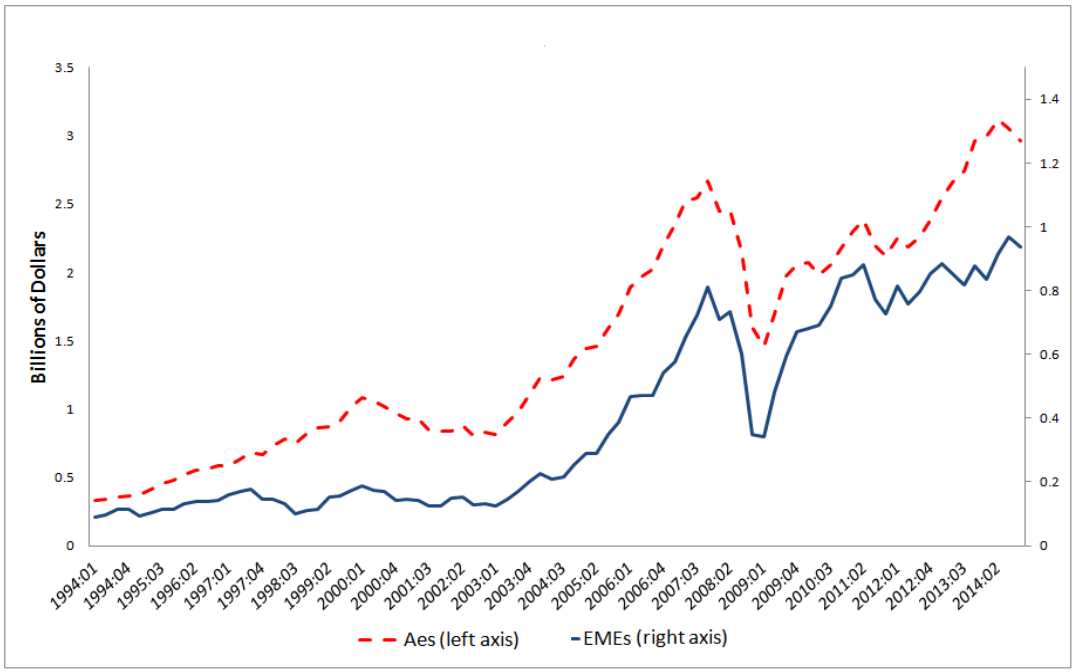
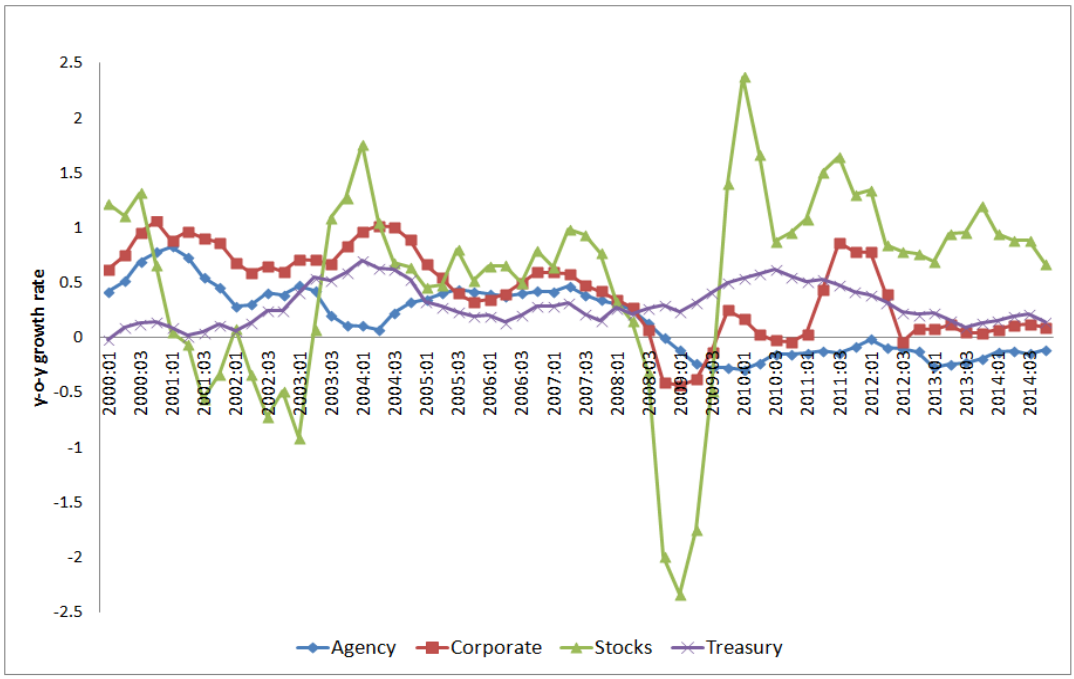
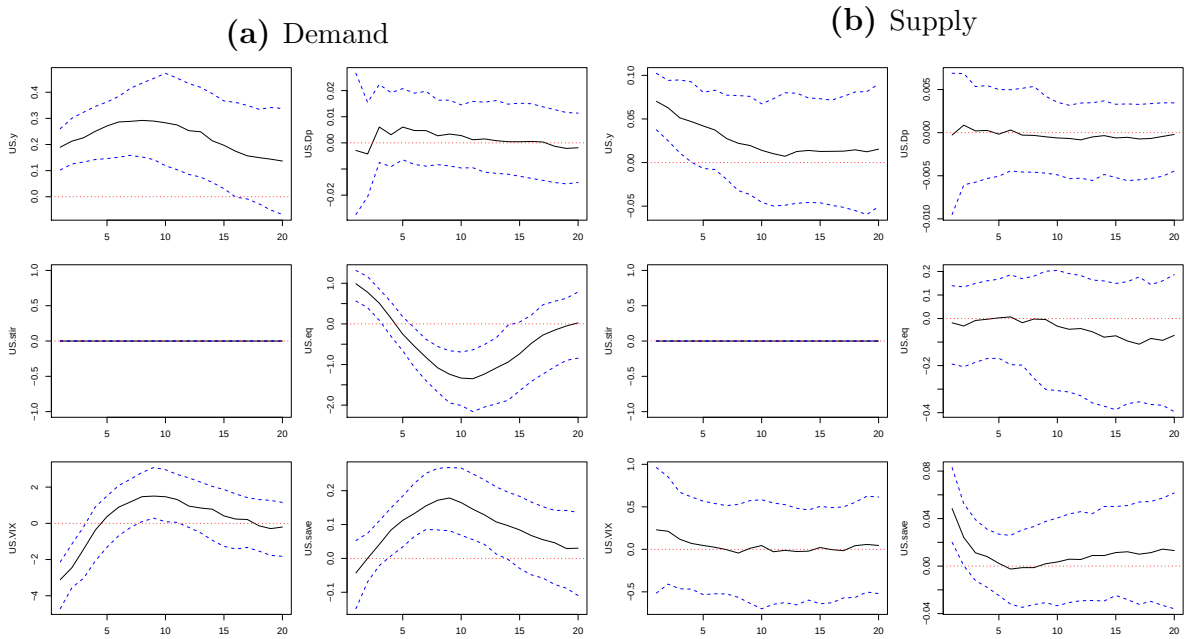


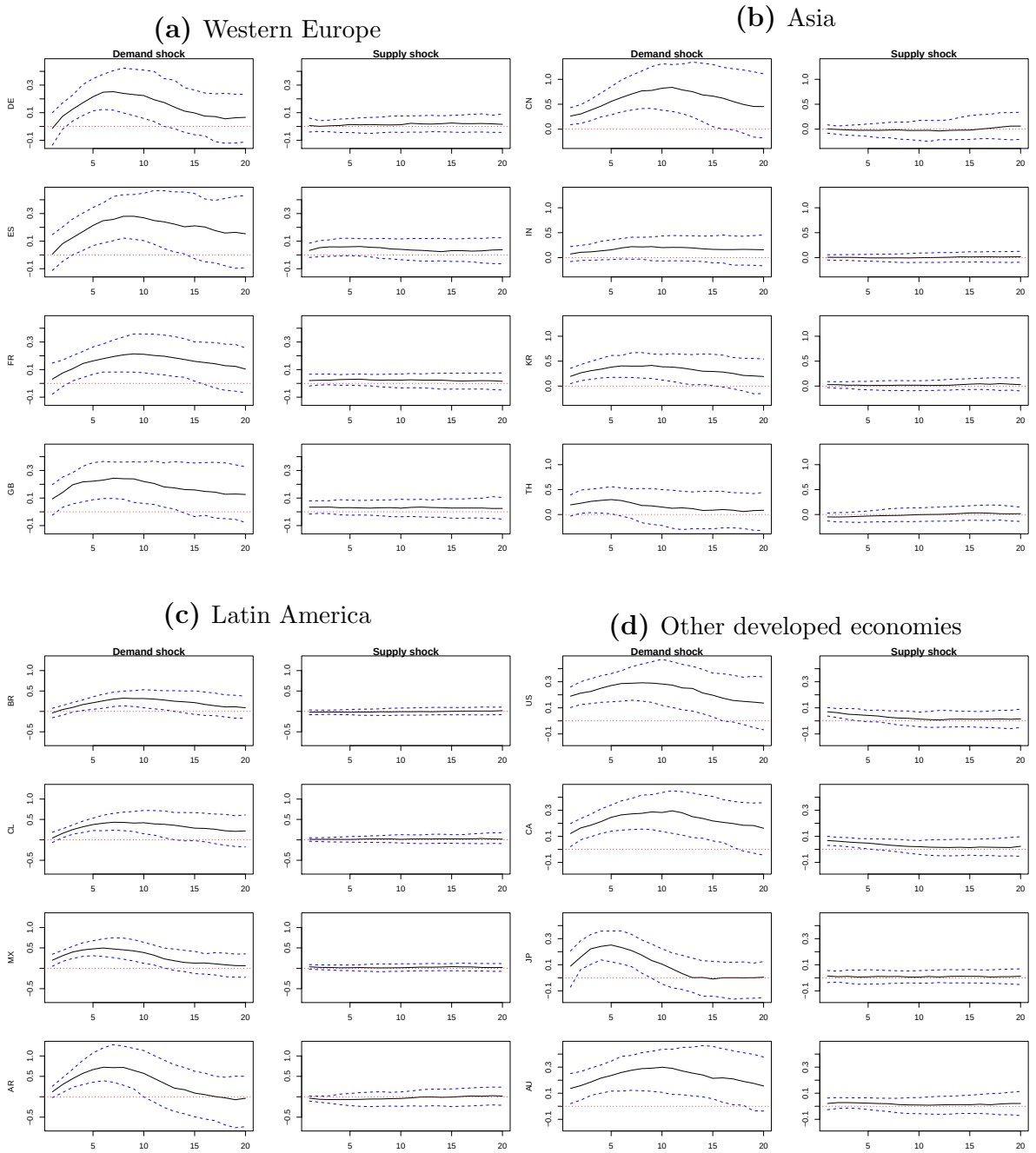
Fig. 7: Foreign Holdings of U.S. Investment Portfolio





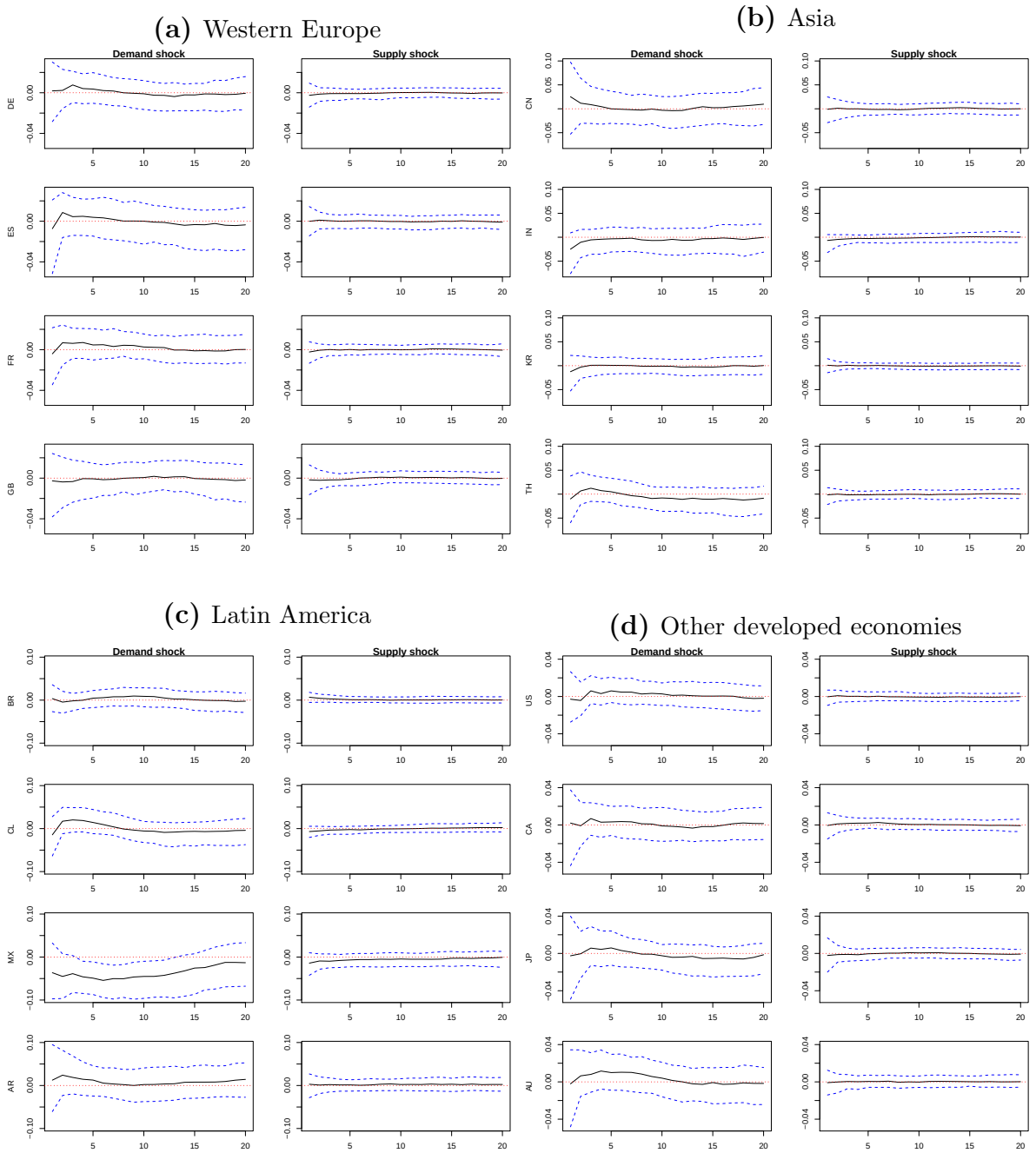
Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 8: US domestic reactions



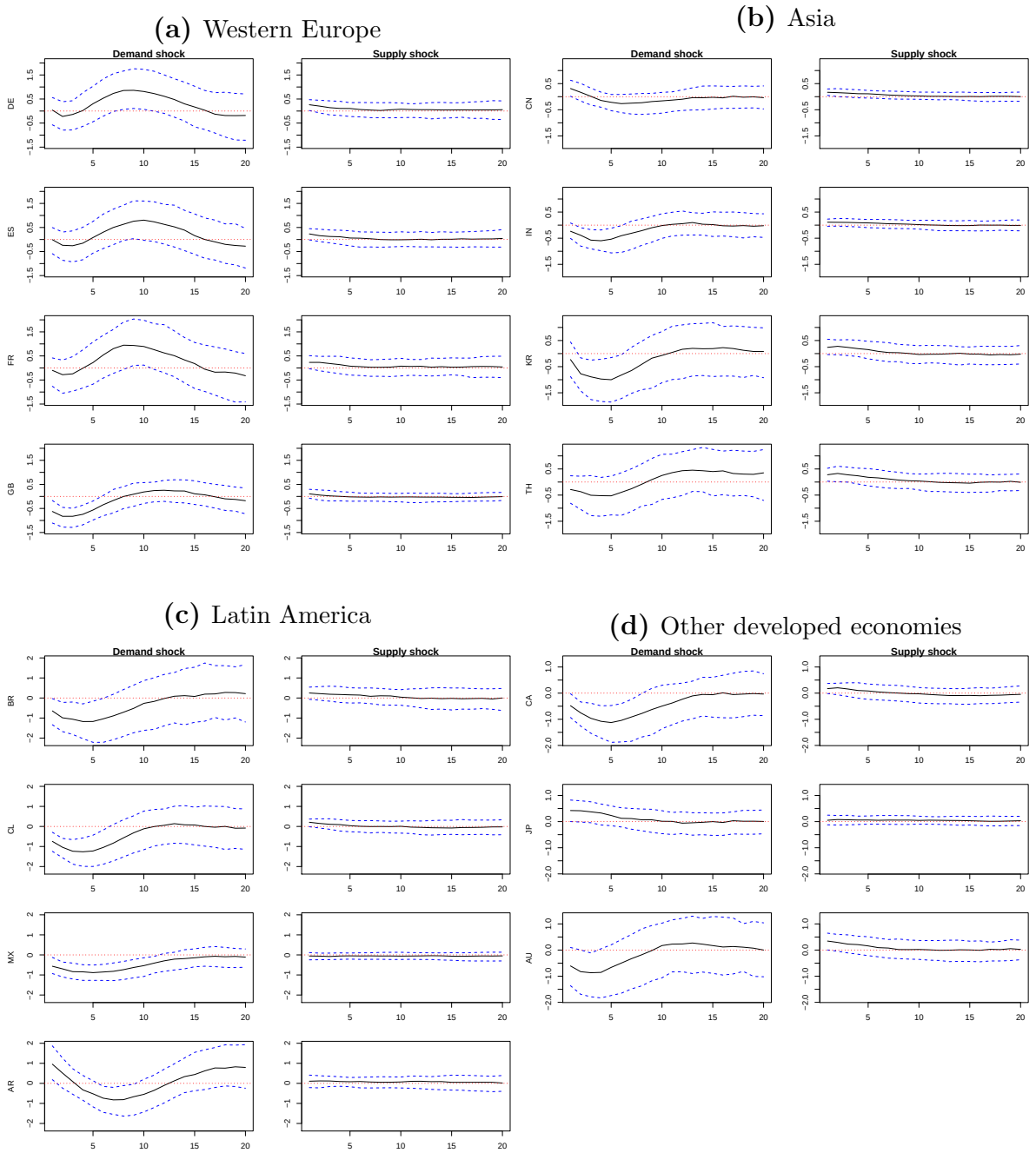
Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 9: Output reactions



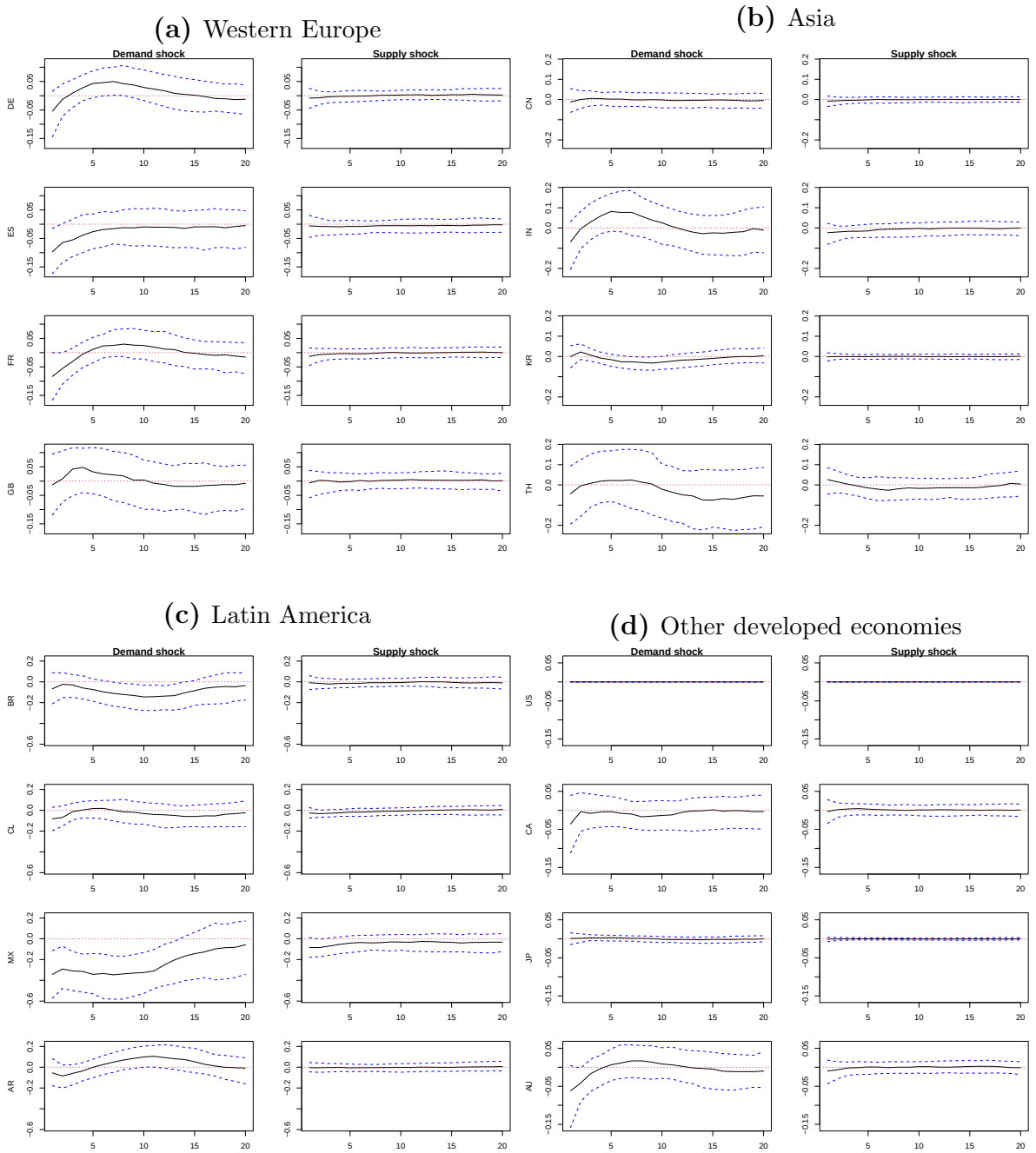
Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 10: Inflation reactions



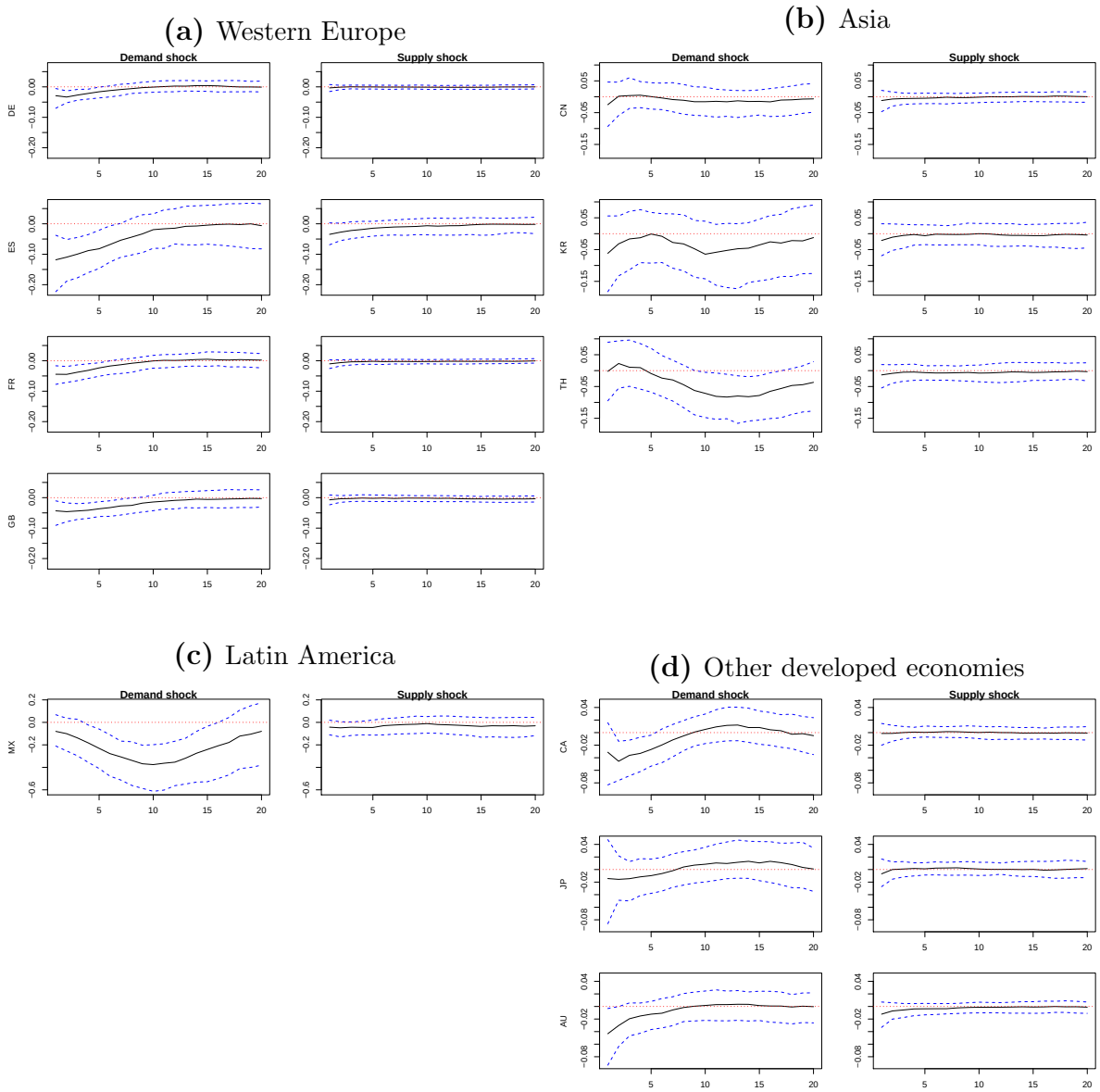
Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 11: Exchange rate reactions



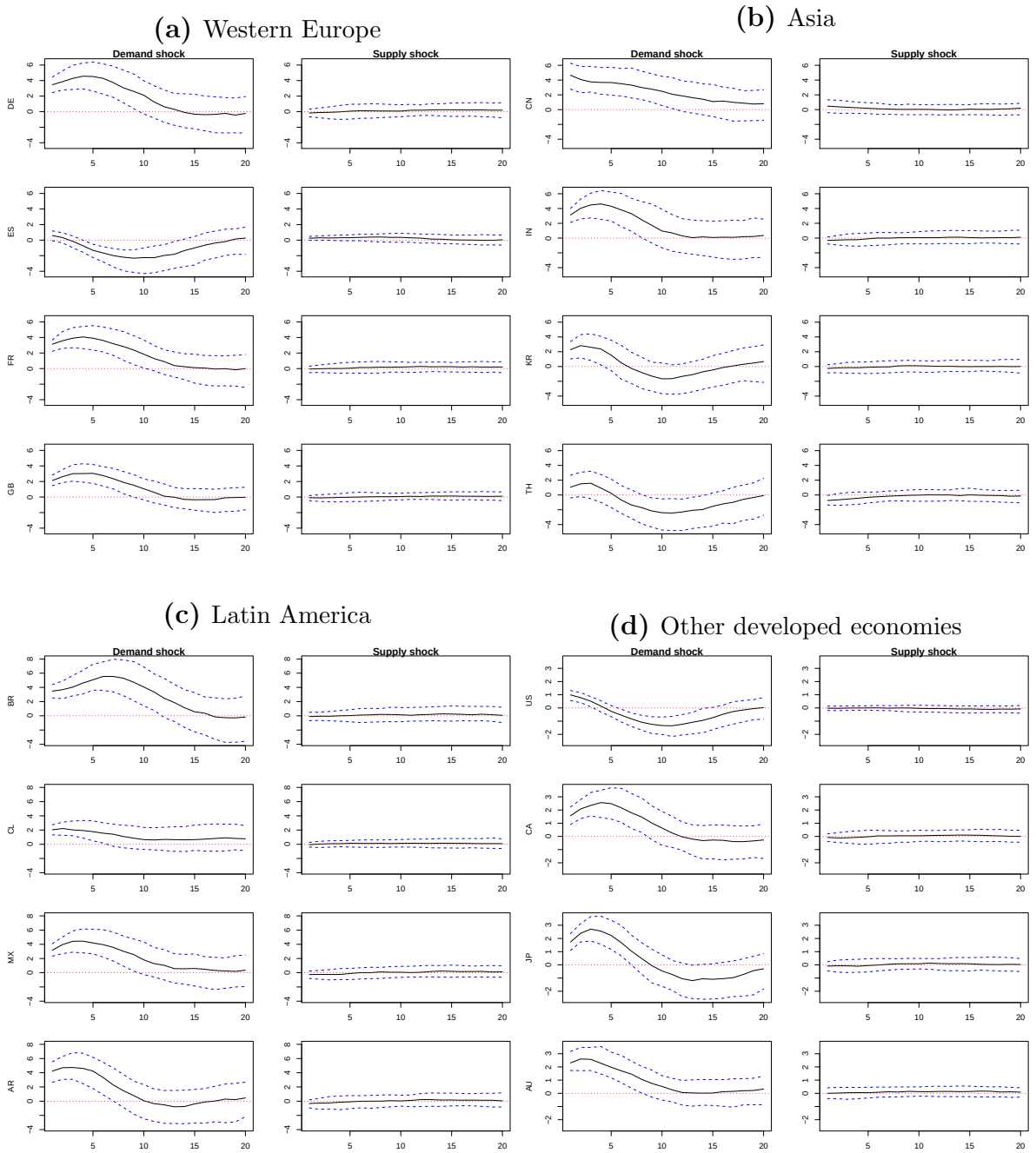
Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 12: Short-term interest rate reactions



Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 13: Risk spread reactions



Notes: Posterior distribution of impulse responses in percentage points. Median in black. Dotted blue lines correspond to the 16th and 84th percentiles. Results are based on 35,000 posterior draws. The red line indicates the zero line.

Fig. 14: Equity price reactions