Foreign exchange reserve diversification and the "exorbitant privilege"*

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Abstract

We assess the global macroeconomic implications of the emergence of the euro as an international reserve currency by developing a large scale new-Keynesian dynamic general equilibrium model of the world economy, calibrated to the euro area, the US, China, Japan and the rest of the world. Results show that an increase in global demand for euros would favor euro area aggregate demand and economic activity because of the positive wealth effect associated with the increase in euro-denominated asset prices and the fall in the euro area interest rate. If the larger demand for euros is associated with a lower demand for dollars, in the US the economic activity and aggregate demand would decrease, while the external balance would improve. Countries accumulating reserves, China in particular, would continue to show a trade surplus, as exports towards the euro area would increase. The Chinese economy reaps net benefits when Japan and rest of the world increase their reserves, and China maintains a fixed exchange rate regime vis-à-vis the dollar, as it faces a real exchange rate appreciation, low interest rates and higher domestic aggregate demand. This is even more evident in the scenario featuring a reduction of Chinese foreign exchange holdings.

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1 Introduction

The current international monetary system is often described as a non-system of floating exchange rates in which some countries attempt to maintain fixed exchange rates — or to manage their exchange rate movements mainly against the US dollar — by accumulating exchange rate reserves in the form of internationally traded assets (Fahri, Gourinchas and Rey, 2011, Palais-Royal Initiative, 2011). Some events, such as the Asian crisis, have left a long shadow over the present, in the shape of large foreign exchange reserves accumulated by Asian economies, particularly China. After a short-lived break in 2008, reserve accumulation has resumed.

The IMF's currency composition of official reserves database (COFER) shows that there has been very little change in the shares that countries allocate to dollar reserves as opposed to other currencies. On the basis of this survey, if one looks at only reported dollar holdings, the demand for dollar denominated assets seems to be slowing down with respect to the overall increase in foreign exchange rate reserves and consequently the dollar share appears to be declining rapidly (Fig. 1). Yet, there is a large – and increasing – share of "unallocated" reserves, that is of unknown composition, most of which is held by China and oil-exporting countries and is commonly taken as being largely denominated in U.S. dollars. Assuming that 60% of those "unallocated" holdings are dollars (e.g. Chinn and Frankel, 2008) yields an increase in dollar denominated assets almost unabated.[1]

The motives behind this reserve accumulation pointed out in policy discussions are polarized between a precautionary and a mercantilist motive and are beyond the scope of this paper.[2] But, irrespectively of the motivations, the increase in reserves has happened by "channeling domestic savings away from local uses and into international capital markets" (Bernanke, 2005). Indeed, the impulse responses of a simple VAR of the Chinese economy show that a shock to foreign exchange holdings is followed by a statistically significant decline in private consumption (Fig. 2).[3]

[1] There are two important observations. These shares incorporate valuation changes, and so when the dollar looses value against other currencies, that shows up in the shares. Truman and Wong (2006) have argued that one should also look at the constant value, or "quantity", shares. Bagnall (2013) has calculated the quantity shares for the dollar from the end of 2010 through the end of 2012, the quantity share (adjusted for the effects of changes in exchange rates on the stock of reserves) of the US dollar has decreased slightly for all countries from about 64 percent to 63 percent of all reported foreign exchange reserves. While this two-year snapshot shows a slight decline in official holdings of US dollar assets, the dollar's share has been steadily decreasing at least since 1999.

[2] For a quantitative and theoretical assessment on, respectively, the relative importance and mechanics of the two motives see Aizenman and Lee (2007).

[3] See the Appendix for details.

In the future an international monetary system in which the dollar continues to play a dominant dollar is not guaranteed. In fact, against the large demand for the dollar and for dollar-denominated assets, the fiscal capacity of the United States — which defines its capacity to provide reserve assets — is bound to decline relative to the size of the global economy (Obstfeld, 2011). Beyond the exchange rate regime, it is the ability to provide liquidity in times of global economic stress that defines the issuer of the reserve currency. This ultimately depends on the issuer's fiscal capacity. In a growing world, then, the United States will inevitably lose its reserve currency monopoly.

At the same time, the debate about global exchange rate arrangements has intensified over the past few years, partly driven by global imbalances and large cross border capital flows connected to sharp exchange rate movements. The severe shock the world economy has suffered and the possibility that this may lead to structural changes in the international monetary system have renewed the focus on the status of the dollar as the main global reserve currency.[4] More recently, the stand-off of the U.S. Congress on the debt ceiling and the risk of a default of the Treasury on its obligations may reduce the demand for dollar denominated assets, if not spur a diversification of global exchange rate reserves away from the dollar.

Therefore, it may only be a matter of time before the world reserve composition will become more diversified (Eichengreen, 2011). The consolidation of a multipolar international monetary system would be potentially stabilizing for the world economy, as it would expand the fiscal capacity underlying the provision of safe assets (Fahri et al., 2011). In a multipolar system, moreover, countries that issue reserve assets will be able to benefit from the liquidity premium only as long as their fiscal capacity allows them to maintain their status as issuers of reserve assets. The resulting fiscal competition may then be beneficial as it would encourage prudent fiscal policies so as to preserve fiscal capacity. To the extent that it increases the substitutability among different reserve assets, a multipolar system would also limit the fluctuations in exchange rates and interest rates.

[4] It has been argued that global imbalances have contributed to the recent financial crisis, and that since the current international monetary system has allowed these imbalances to persist, it has in some way played a role (Obsfeld and Rogoff, 2009; Catte et al., 2011). In particular, it is argued that the demand for low-risk dollar assets for foreign exchange reserves lowered the returns on these assets, and sent financial institutions off in search for yield and that, as a result, they turned to the securitized mortgages and other complex products of financial innovation. When the crisis hit, troubles quickly spread across countries in the form of a sudden slowdown or reversal of capital flows and in liquidity shortages, particularly dollar liquidity, as investors scrambled to reduce risk exposures and to deleverage. The massive injection of global liquidity in the economy and the cooperation of fiscal and monetary authorities successfully averted an even more dramatic worldwide collapse in economic activity. Still, the vulnerabilities of the current international monetary system have remained unsolved.

If several currencies are widely used internationally as medium of exchange and/or unit of account, then it may well be desirable for a country to hold liquidity in all of those currencies, regardless of moderate changes in their relative values. Which reserve currencies will compete with the dollar? Given the size of their economies, only the euro and the renminbi are viable candidates. The euro, after its debut saw a rapid increase in its use in international transactions, related to the rapid integration of euro money markets, government bond markets, equity markets and banking and the large issuance of euro-denominated corporate bonds. As a result, the euro in its first decade advanced quickly into the ranks of the top reserve currencies, also considering the fact that about a quarter of COFER's unallocated reserves may be denominated in euro (Chinn, 2012). This process came abruptly to a halt in 2010 with the emergence of the sovereign debt crisis that has severely dented the expectations of the euro's future. But if the solution to the crisis renews the confidence in European institutions, that may also give a new boost to its role as an international reserve currency. In the longer term also the renminbi may become an international currency, as this is a stated goal of Chinese authorities. However, the prospects for its internationalization will likely encounter major challenges, also related to the process of liberalization of capital controls (Eichengreen, 2013).

In this paper we assess the global macroeconomic effects of a shock to the demand of foreign exchange reserves in a bipolar international monetary system, one in which not only the US dollar but also the euro act as international reserve currencies. The effects of this shock are studied with a large scale new Keynesian dynamic general equilibrium model of the global economy, calibrated to the euro area, the US, China, Japan and the rest of the world. Building on a recent contribution by Canzoneri, Cumby, Diba and Lopez-Salido (2013, henceforth CCDLS), we introduce in the model, otherwise standard, bonds that are accumulated in official foreign currency reserves and that provide liquidity services to households, as they facilitate transactions for consumption purposes. We assume that there are two internationally traded bond, one issued by the US government and denominated in US dollars, the other issued by the euro area public sector and denominated in euros; furthermore, there are three government bonds (one for each other currency area) that are not internationally traded. Alongside the domestic government and the international bonds, households in each country can also invest in domestic private sector bonds whose rate of return — the CCAPM rate — does not incorporate any liquidity services and, as such, is higher than the yield on government bonds. Given the international liquidity service they provide, in the model government bonds in reserve currency areas pay a low rate of interest; this reflects their non-pecuniary return, i.e. the fact that investors value the liquidity and safety of key currency bonds (see

Krishnamurthy and Vissing-Jorgensen, 2012). As in CCDLS (2013), in this model the "exorbitant privilege" is the combination of the non-pecuniary externality embedded in Government bond yields in key currency areas and asymmetric global portfolios: the non resident holders of key currency bonds pay a bond seigniorage tax to the key-currency Treasuries.

We simulate several scenarios. We initially assume that the authorities of China, Japan and rest of the world decide to simultaneously increase their official reserves in US dollars and euros by one percent, thus keeping constant the shares of dollars and euros in their portfolios ("so far, so good" scenario). We compare this scenario with one featuring a one percent reduction in US dollar reserves which is more than offset by a correspondingly larger increase in euro reserves ("rebalancing" scenario), so that overall reserves still increase by one percent. To further assess the impact on China, which is the main holder of US dollar reserves, we simulate alternative scenarios where reserve management is asymmetric among foreign exchange reserve holders. In particular we assume, in turn, that: (1) China is the only country increasing reserves in dollars and euros; (2) Japan and rest of the world increase their reserves, but China maintains a fixed nominal exchange rate against the US dollar by endogenously setting its reserves ("Bretton Woods II" scenario); (3) China reduces its reserves in dollars and euros while Japan and rest of the world keep increasing their own.

Our main results are as follows. First, an increase in the demand for euro reserves would lower euro interest rates, appreciate the euro's exchange rate and boost domestic aggregate demand and the trade deficit in the euro area. Second, similar results hold for the US as long as the US dollar reserves also increase. Third, countries increasing their reserves would experience higher output and face trade surpluses vis-à-vis the US and the euro area. Fourth, the Chinese economy reaps net benefits when Japan and rest of the world increase their reserves, and China maintains a fixed exchange rate regime vis-à-vis the dollar, as it faces a real exchange rate appreciation, low interest rates and hence higher domestic aggregate demand. This is even more evident in the scenario featuring a reduction of Chinese foreign exchange holdings.

Overall, increasing demand for euros as reserve currency would increase aggregate demand in the euro area as it would reap some of the "exorbitant privilege" so far enjoyed by the United States. This shift would not hurt the US economy as long as the US dollar reserves increase as well and would not greatly affect macroeconomic outcomes in reserve holding countries. We also quantify country-specific welfare costs or benefits of these different scenarios. In particular, we measure, under perfect foresight, the fraction of permanent consumption that must be given up in order to equal the welfare attained in a particular scenario to that of the initial steady state. An increase in the demand for euro reserves raises permanently Euro area residents' welfare up to 0.02 percentage points of consumption in each quarter. Gains are highest when the euro area reaps some of the "exorbitant privilege" so far enjoyed by the United States. Countries increasing their reserves correspondingly face costs, which amount up to 0.015 percentage points of quarterly consumption for China and Japan, due to their elevated stock holdings. The Chinese economy reaps benefits, in terms of higher permanent consumption levels, that are highest (up to 0.02 ppts) in the scenario featuring a reduction of Chinese foreign exchange holdings.

Our contribution differs from CCDLS (2013) in that they limit their analysis to a two-country model featuring a key reserve asset and study the effects of a sell-off of foreign official holdings in the non reserve country, showing that the costs to the key currency country are substantial and that no alternative monetary or fiscal policies in the key currency country would reduce the costs significantly. Our focus is different, as we concentrate on the macroeconomic effects of a recomposition of official foreign exchange portfolios away from one currency and towards another.

We do not examine the implications of optimal asset allocation (e.g. Devereux and Sutherland, 2007), but rather we take the asset shares as given and study the effects of an exogenous change in foreign exchange portfolio choices of the official sector. Our paper thus contributes to the literature on the "exorbitant privilege" of the United States (Gourinchas and Rey, 2007). The role of international currencies and their importance in determining portfolios and asset price movements is an area of active research in a general equilibrium set up with a rich asset structure has been studied by Devereux and Shi (2009) and Gourinchas, Rey, and Govillot (2010). By assuming imperfect substitutability of domestic and foreign assets, our model also builds on an older literature started by Kouri (1976), who focuses on the effects of changes in portfolio preferences and the implications of imperfect substitutability between assets for shocks to the current account; more recently, the roles of imperfect substitutability and valuation effects, have also been emphasized by Obstfeld (2004) and Blanchard Giavazzi, and Sa (2005) in the analysis of U.S. current account deficits.

The rest of the paper is organized as follows. Section two reports the main features of the model setup, including the calibration. Section three contains the results of the main simulations and of the sensitivity exercises. Section five recaps the results in terms of welfare. Finally, Section five concludes.

2 Model setup

We build up and simulate a five region-dynamic general equilibrium model of the world economy, calibrated to the euro area, the US, China, Japan and the rest of the world (RW). In line with other large scale models, ours includes nominal and real rigidities, distinguishes between tradables and nontradables, allows for home bias in consumption and investment, local currency pricing, incomplete financial markets. As such, the model fully characterizes the dynamics of the trade balance, current account and real exchange rate.[5] In line with the purpose of the paper, and following the theoretical framework by Canzoneri, Diba and Lopez-Salido (2013) we assume that countries accumulate official reserves, in the form of US and euro area government bonds, respectively denominated in US dollars and euros. In China, Japan and RW the households use domestic money, domestic public sector bonds (denominated in local currency and not internationally traded) and US and euro area public sector bonds.

Households consume a final good, which is a composite of intermediate nontradable and tradable goods. The latter are domestically produced or imported. Forward-looking households trade also a one-period nominal bond, denominated in domestic currency, issued in zero net supply. They also own domestic firms and use another final good (different from the final consumption good) to invest in physical capital, which is rented to domestic firms in a perfectly competitive market. All households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive labor markets by charging a markup over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce the two final goods (consumption and investment goods) and monopolistically competitive firms that produce the intermediate goods. The two final goods are sold domestically and are produced combining all available intermediate goods using a constant-elasticity-of-substitution (CES) production function. The two resulting bundles can have different composition. Intermediate tradable and nontradable goods are produced combining domestic capital and labor, that are assumed to be mobile across sectors. Intermediate tradable goods can be sold domestically and abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We also assume that markets for tradable goods are segmented, so that firms can set country-specific prices (one for each market). Similarly to other DSGE models, we

[5] The model is line with the dynamic general equilibrium model of the euro area and the world economy EAGLE (Gomes, Jacquinot and Pisani, 2010) and with dynamic general equilibrium model of the world economy GEM developed by the IMF (see Laxton, 2008, and Pesenti, 2008).

include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption, production and prices react in a gradual way. On the real side, habit preferences and quadratic costs prolong the adjustment of households consumption and investment, respectively. On the nominal side, quadratic costs make wages and prices sticky.[6]

2.1 Households and international liquidity

Government bonds denominated in reserve currencies are imperfect substitutes for money and domestic government bonds in each of the non-reserve countries. Hence private households in each of the non-key currency countries hold at any time both domestic money balances, domestic government bonds and reserve currency government bonds, which are the only internationally traded bonds. In practice one can think of the need to hold these government bonds as a way to store, alongside domestic money balances, the liquidity or deposits needed by households for their transactions purposes. Thus, both money and government bonds provide transaction services.[7] It is possible to imagine a richer model including optimizing banks managing the deposits of households, by allocating them between different asset classes (money and government bonds), which would subsume the more simplified setup assumed here, where households *directly* hold a composite of money balances and government bonds to satisfy their transaction needs period by period.[8]

Alongside the government bonds, households in each country issue non-contingent nominal one-period bonds. These bonds are issued in zero net supply, and except for the ones denominated in US currency, are not traded across countries; they offer a "risky" yield, the CCAPM rate, i.e. in contrast to the bonds issued by the US government they do not embody any liquidity premium. The endogenous spread between this yield and

[6] See Rotemberg (1982).

[7] The role of bonds in providing transaction services has been quantified by Krishnamurthy and Vissing-Jorgensen (2012). Intuitively, a number of financial institutions, besides banks, use government bonds to manage their day-to-day liquidity holdings. Recently, both the IMF(2010, 2012) and the BIS (2011) have included government bonds among the different indicators relevant for measuring liquidity at both the domestic and international level. A number of "private-label" assets compete, to different degrees and with time-varying relevance, with government bonds in the provision of liquidity services, as highlighted among other by Bernanke et al. (2011). Similarly Chen et al. (2012), highlight the importance of the components of global liquidity, distinguishing between core and noncore liabilities. Their focus is also on the impact of liquidity on financial and economic stability. We do not take up these very interesting issues in the present work.

[8] A richer model along these lines with the full specification of a banking sector that directly manages the deposits of households by optimally allocating them between different asset classes (cash, government bonds and private-sector loans) is developed for a closed-economy setup in Canzoneri et al. (2008).

the one on the government bonds reflects the non-pecuniary return of the transactions services - the liquidity premium - embodied by the government bonds.[9]

We further assume that the non-contingent bonds denominated in US dollars can be traded internationally, provided that national households transacting in the international bond market incur some intermediation costs.[10] Introducing these internationally tradable "non-liquid" bonds alongside the government bonds that both provide transactions services and serve as reserve currency bonds, allows us to account for those components of the countries' net foreign asset positions (NFA) that do not fall into the international safe asset share of a country's portfolio. As such, each country's NFA consists of two types of assets: the safe or liquid component - held both by private agents and by the domestic authorities as foreign reserves - and the "non-liquid" or riskier one, issued in US dollars and exchanged worldwide among private agents.[11]

2.1.1 US households

In the US there is a continuum of households h on the interval $[0, n_{US})$. The intertemporal utility of the representative household h at time t is:

$$U_t^{US}(h) \equiv E_t \Sigma_{j=t}^{\infty} \beta^j \left\{ \frac{\left(C_j^{US}(h) - \xi C_{j-1}^{US} \right)^{1-\sigma}}{1-\sigma} - \frac{N_j^{US}(h)^{1+\chi}}{1+\chi} \right\} \tag{1}$$

where E is the expectation operator, $0 < \beta < 1$ is the discount factor, $C_j^{US}(h)$ is consumption of the final (nontradable) good and $N_j^{US}(h)$ measures household's labor effort. The term C_{j-1}^{US} reflects previous period' consumption and the parameter $0 \leq \xi \leq 1$ accounts for external consumption habits. The intertemporal elasticity of substitution is $1/\sigma > 0$, while the inverse of the Frisch labor supply elasticity is $\chi > 0$. As all

[9] An alternative interpretation is that optimizing households can always derive a stochastic discount factor to price any possible risky asset that does not provide transactions services. Under this interpretation this pricing kernel - the consumption CAPM (CCAPM) rate - simply reflects households' ability to evaluate at any time how much of the return received on their asset holdings reflects a liquidity premium with respect to a hypothetical risky asset which does not embody any liquidity premium. Under this alternative interpretation one can think of the CCAPM rate as a "shadow" rate - the marginal rate of substitution between current and expected (i.e. across all possible future states of nature) consumption net of any liquidity premium - on a hypothetical risky one-period nominal bond that is not actually traded among agents.

[10] As is well known in the literature (see for example Faruquee et al., 2007), besides introducing a risk-premium on international borrowing and lending, the main purpose of these financial intermediation costs is to guarantee that international net asset positions follow a stationary process and the economies converge asymptotically to a welldefined steady state.

[11] In order not to further complicate the model's setup, we assume that *only* private bonds issued in USD encompasses this "non-liquid" component of the NFA. This assumption could clearly be relaxed.

households within each country are identical, we will drop all household indices in the following presentation and discussion of the model.

The budget constraint of the representative US household is:

$$
\begin{aligned}
& M_t^{US} - M_{t-1}^{US} + B_t^{US} - B_{t-1}^{US}(1 + r_{t-1}^{US}) \\
& + B_{PR,t}^{US} - B_{PR,t-1}^{US}(1 + r_{PR,t-1}^{US}) \\
& + B_t^{EA,US}/S_t^{EA} - B_{t-1}^{EA,US}/S_t^{EA}(1 + r_{t-1}^{EA}) \\
& = W_t^{US} N_t^{US} + r_t^{K,US} K_{t-1}^{US} + D_t^{US} \\
& - \left(1 + \tau_t^{US}\right) P_t^{US} C_t^{US} - P_{I,t}^{US} I_t^{US} + TR_t^{US}
\end{aligned}
$$

where M^{US} is money holdings, B^{US} is domestic government bond holdings paying a net interest rate r^{US}, B_{PR}^{US} are private non-contingent nominal one-period bonds paying the standard CCAPM net interest rate r_{PR}^{US}, and $B^{EA,US}/S^{EA}$ is the dollar amount of euro government bonds held by US households earning a net interest rate r^{EA}.[12] On the right-hand-side W^{US} are wages, $r^{K,US}K^{US}$ is the income from renting the stock of physical capital K^{US} to domestic firms at the rate $r^{K,US}$, D^{US} are dividends from ownership of domestic firms, τ^{US} is the transactions cost, P^{US} is the consumption price index, I^{US} is investment in physical capital and P_I^{US} the related price index, TR^{US} are lump-sum transfers.

As in CCDLS[13] we assume transactions costs that are proportional to consumption and with a factor of proportionality that is an increasing function of velocity:

$$
\tau_t^{US} = \begin{cases} \left(\frac{A^{US}}{v_t^{US}}\right)\left(v_t^{US} - \bar{v}^{US}\right)^2 & \text{for} \quad v_t^{US} > \bar{v}^{US} \\ 0 & \text{for} \quad v_t^{US} \leq \bar{v}^{US} \end{cases} \tag{2}
$$

where $\bar{v}^{US}$ is the satiation level of velocity and $A^{US} > 0$ is a cost parameter. Velocity depends in turn on consumption and (effective) money holdings:

$$
v_t^{US} = \frac{C_t^{US}}{\tilde{M}_t^{US}} \tag{3}
$$

[12] These bonds are traded internationally, as explained in the introduction, and as such they also appear in the households' budget constraints belonging to regions other than the US. See for example the discussion of the representative EA household's budget constraint in the next subsection.

[13] Transactions costs are originally introduced by Schmitt-Grohe and Uribe (2004) in their analysis of optimal monetary and fiscal policy in a New-Keynesian setutp.

where the the effective money holdings $\tilde{M}_t^{US}$ is:

$$\tilde{M}_t^{US} = \left(M_t^{US}\right)^{\zeta_1^{US}} \left(B_t^{US}\right)^{\zeta_2^{US}} \left(B_t^{EA,US}/S_t^{EA}\right)^{1-\zeta_1^{US}-\zeta_2^{US}} \tag{4}$$

where $B_t^{EA,US}$ is the amount of euro government bonds (S_t^{EA} is the nominal exchange rate defined as number of euros per dollar). The parameter $\zeta_1^{US}, \zeta_2^{US} \in [0,1]$ measures the importance of money and US government bonds in facilitating transactions. Household's optimality conditions with respect to consumption C, money M, domestic government bond B^{US} and euro area bond $B_t^{EA,US}$ holdings are:[14]

$$\left(C_t^{US} - \xi C_{t-1}^{US}\right)^{-\sigma} = \Lambda_t^{US}\left[1 + 2A^{US}\left(v_t^{US} - \bar{v}^{US}\right)\right] \tag{5}$$

$$1 - A^{US}\left[\left(v_t^{US}\right)^2 - \left(\bar{v}^{US}\right)^2\right]\zeta_1^{US}\frac{\tilde{M}_t^{US}}{M_t^{US}} = \beta E_t\left[\frac{\Lambda_{t+1}^{US}}{\Lambda_t^{US}}\frac{P_t^{US}}{P_{t+1}^{US}}\right] \equiv \frac{1}{\tilde{R}_t^{US}} \tag{6}$$

$$1 - A^{US}\left[\left(v_t^{US}\right)^2 - \left(\bar{v}^{US}\right)^2\right]\zeta_2^{US}\frac{\tilde{M}_t^{US}}{B_t^{US}} = \beta R_t^{US} E_t\left[\frac{\Lambda_{t+1}^{US}}{\Lambda_t^{US}}\frac{P_t^{US}}{P_{t+1}^{US}}\right] \equiv \frac{R_t^{US}}{\tilde{R}_t^{US}} \tag{7}$$

$$1 - A^{US}\left[\left(v_t^{US}\right)^2 - \left(\bar{v}^{US}\right)^2\right]\left(1 - \zeta_1^{US} - \zeta_2^{US}\right)\frac{\tilde{M}_t^{US}}{B_t^{EA,US}} = \beta R_t^{EA} E_t\left[\frac{\Lambda_{t+1}^{US}}{\Lambda_t^{US}}\frac{P_t^{US}}{P_{t+1}^{US}}\frac{S_t^{EA}}{S_{t+1}^{EA}}\right] \tag{8}$$

where Λ^{US} is the marginal value of wealth, $R^{US} \equiv 1 + r^{US}$ is the gross interest rate on liquid bonds and $\tilde{R}_t^{US}$ is the standard (gross) CCAPM rate, i.e. the return on a non-contingent nominal bond.[15] Equation (5) states that the marginal value of wealth is lowered by the transactions costs. Equation (6) states that the current value of money holdings, which yield zero returns, but provide transaction services (the left-hand-side of the equation), should be equal to the present value of the return on saving (the right-hand-side of the equation) - the stochastic discount factor. Similarly, equation (7) shows that the presence of a liquidity premium decreasing in the stock of government

[14] The remaining first order conditions are availble upon request.

[15] Note that as in equilibrium this bond must be in zero net supply we drop it, for simplicity, from the above budget constraint. Alternatively, one can interpret all of the above optimality conditions with respect to each asset (money and bonds) as providing returns in deviation from the risky or CCAPM rate, $\tilde{R}_t$. The deviation is determined by the fact that each asset, i.e. both money and bonds, provide non-pecuniary transactions services.

bonds outstanding (left-hand-side) determines the spread between the interest rate on government bonds and that on a risky asset (right-hand-side). A similar intuition applies to equation (8). Thus, optimality conditions with respect to asset holdings show that interest rates differ from a standard model in which assets are perfect substitutes, due to the presence of transactions services, and that these liquidity premia are affected by the size of the asset stocks outstanding in each period.

2.1.2 Euro area households

Households in the euro area solve a problem similar to the one of the US households. The intertemporal utility function is similar to the one reported in equation (1). The budget constraint is:

$$
\begin{aligned}
& M_t^{EA} - M_{t-1}^{EA} + B_t^{EA} - B_{t-1}^{EA}(1 + r_{t-1}^{EA}) \\
& + S_t^{EA} B_t^{US,EA} - S_t^{EA} B_{t-1}^{US,EA}(1 + r_{t-1}^{US}) \\
& + S_t^{EA} B_{PR,t}^{US,EA} - S_t^{EA} B_{PR,t-1}^{US,EA}(1 + r_{PR,t-1}^{US}) \left(1 - \Gamma_{PR,t}^{EA}\right) \\
& = W_t^{EA} N_t^{EA} + r_t^{K,EA} K_{t-1}^{EA} + D_t^{EA} \\
& - \left(1 + \tau_t^{EA}\right) P_t^{EA} C_t^{EA} - P_{I,t}^{EA} I_t^{EA} + TR_t^{EA}
\end{aligned}
$$

where, as before, S^{EA} is the nominal exchange rate of the euro vis-à-vis the US dollar (number of euros per one dollar). Unlike US households, euro area households hold not only bonds issued the domestic public sector, B^{EA} (that pay a net interest rate r^{EA}), but also those issued by the US public sector, $B^{US,\,EA}$ and by the US private sector, $B_{PR}^{US,EA}$, subject to incurring a financial intermediation cost Γ_{PR}^{EA}.[16] The transaction cost is similar to the one holding for the US (see equation 2). In a symmetric way to the US, the euro area private households' effective money holdings, $\tilde{M}_t^{EA}$, are defined as:

$$
\tilde{M}_t^{EA} = \left(M_t^{EA}\right)^{\omega_1^{EA}} \left(B_t^{EA}\right)^{\omega_2^{EA}} \left(S_t^{EA} B_t^{US,EA}\right)^{1-\omega_1^{EA}-\omega_2^{EA}} \tag{9}
$$

[16] We assume that all the costs incurred due to this financial intermediation service accrue as a revenue to the forward-looking or Ricardian households that reside in the US. In line with most of the literature our intermediation cost assumes the following functional form: $\Gamma_{PR}^{J} = \frac{\phi_1 \left[\exp^{\phi_2\left(S_t^J B_{PR,t}^J / GDP_t^J - \bar{B}_{PR}^J\right)} - 1\right]}{\exp^{\phi_2\left(S_t^J B_{PR,t}^J / GDP_t - \bar{B}_{PR}\right)} + 1}$ where $\bar{B}_{PR}^J$ is the "desired" net asset position in the "non-liquid" bond of the region J expressed as a ratio of its own GDP. A thorough discussion of this functional form can be found in Pesenti (2008).

where with $0 < \omega_1^{EA}, \omega_2^{EA} < 1$. The effective money holdings include not only domestic money M^{EA} and public sector bonds B^{EA}, but also US public sector bonds $B^{US,EA}$:

$$1 - A^{EA}\left[\left(v_t^{EA}\right)^2 - \left(\bar{v}^{EA}\right)^2\right]\omega_1^{EA}\frac{\tilde{M}_t^{EA}}{M_t^{EA}} = \beta E_t\left[\frac{\Lambda_{t+1}^{EA}}{\Lambda_t^{EA}}\frac{P_t^{EA}}{P_{t+1}^{EA}}\right] \tag{10}$$

$$1 - A^{EA}\left[\left(v_t^{EA}\right)^2 - \left(\bar{v}^{EA}\right)^2\right]\omega_2^{EA}\frac{\tilde{M}_t^{EA}}{B_t^{EA}} = \beta R_t^{EA} E_t\left[\frac{\Lambda_{t+1}^{EA}}{\Lambda_t^{EA}}\frac{P_t^{EA}}{P_{t+1}^{EA}}\right] \tag{11}$$

$$1 - A^{EA}\left[\left(v_t^{EA}\right)^2 - \left(\bar{v}^{EA}\right)^2\right]\left(1 - \omega_1^{EA} - \omega_2^{EA}\right)\frac{\tilde{M}_t^{EA}}{S_t^{EA} B_t^{US,EA}} = \beta R_t^{US} E_t\left[\frac{\Lambda_{t+1}^{EA}}{\Lambda_t^{EA}}\frac{P_t^{EA}}{P_{t+1}^{EA}}\frac{S_{t+1}^{EA}}{S_t^{EA}}\right] \tag{12}$$

The above optimality conditions are analogous to the corresponding ones for the US households. Combining the linearized versions of the last two optimality conditions shows that in this model there is a departure from the standard uncovered interest-parity condition (UIP), due to the imperfect substitutability of US and euro area bonds.

2.1.3 Households in China, Japan and the RW

Equations for the households in the other three regions are similar to the ones previously reported. In particular, they hold not only domestic money and government bonds, but also US and euro area government bonds; moreover, US and euro area government bonds provide liquidity services. So in each region J ($J = China$, $Japan$, RW) the effective money holdings is:

$$\tilde{M}_t^J = \left(M_t^J\right)^{\omega_1^J}\left(B_t^J\right)^{\omega_2^J}\left(S_t^J B_t^{US,J}\right)^{\omega_3^J}\left(S_t^{J,EA} B_t^{EA,J}\right)^{1-\omega_1^J-\omega_2^J-\omega_3^J} \tag{13}$$

where ω_1^J, ω_2^J, ω_3^J are parameters $(0 < \omega_1^J, \omega_2^J, \omega_3^J < 1)$, S_t^J and $S_t^{J,EA}$ are respectively the nominal exchange rates vis-à-vis the US dollar and the euro (number of local currency per unit of dollar and euro) and M^J, B^J, $B^{US,J}$, $B^{EA,J}$ are respectively the amounts of domestic money, domestic government bonds, US government bond and euro area government bonds.

2.1.4 Non-Ricardian households

As is by now standard in the literature, we further assume that in each region a share of households has no access to financial markets. We label this, following most of the literature, liquidity-constrained consumers. They simply finance their consumption by relying exclusively on their labor incomes. Similar to the Ricardian or foward-looking households, they can optimally set their wages to exploit their market power. However unlike for the Ricardian households, their optimal choices are purely static and do not entail forward-looking components. As such their consumption in each period is simply dictated by their wage income:

$$C^J_{NR,t} = W^J_t N^J_t \tag{14}$$

where C^J_{NR} denotes consumption by the representative Non-Ricardian household in region J.In the following we will assume that the shares of the households without any access to capital markets differs across the different regions.[17]

2.2 Monetary and Fiscal Policy Rules

In the following we will consider a variety of monetary and fiscal policy rules. As a matter of reference we describe in this section the benchmark policy rules.

2.2.1 US fiscal policy

The US government's flow budget constraint is

$$M^{US}_t + B^{US}_{G,t} + B^{EA,US}_{G,t}/S^{EA}_t = M^{US}_{t-1} + R^{US}_{t-1} B^{US}_{G,t-1} + R^{EA}_{t-1} B^{EA,US}_{G,t-1}/S^{EA}_t + P^{US}_t G^{US}_t + TR^{US}_t$$

where B^{US}_G is the total supply of US government bonds, $B^{EA,US}_G$ is the stock of US official reserves in euro denominated government bonds, and G^{US}_t is the public consumption. By assumption, public consumption is exogenous, it is kept constant at its initial steady state level and falls on the national final good. Lump sum transfers TR^{US} assure fiscal solvency:

$$TR^{US}_t - \overline{TR}^{US} = -\varphi^{YS}_b \left(B^{US}_{G,t-1} - \bar{B}^{US}_G \right) \tag{15}$$

where $\varphi^{US}_b > 0$ is a parameter that determines the "stringency "of the fiscal policy rule, i.e. the speed at which debt is returned to the target level.

[17] For the sake of simplicity we do not consider distortionary taxes. The only taxes in our model are lump-sum, as explained in the next subsection.

2.2.2 Fiscal policy in other regions

The government in the euro area holds US government bonds as reserves, while the governments in China, Japan and the RW hold both euro area *and* US government bonds as reserves. Thus, for the euro area we have:

$$
\begin{aligned}
&M_t^{EA} + B_{G,t}^{EA} + S_t^{EA} B_{G,t}^{US,EA} \\
&= M_{t-1}^{EA} + R_{t-1}^{EA} B_{G,t-1}^{EA} + R_{t-1}^{US} S_t^{EA} B_{G,t-1}^{US,EA} + P_t^{EA} G_t^{US} + TR_t^{EA}
\end{aligned}
$$

where B_G^{EA} is the bond issued by the euro fiscal authority and denominated in euros, while $B_G^{US,EA}$ denotes reserves holdings of dollars which are assumed to be exogenous.

A similar budget constraint holds for the government in China, Japan and the RW:

$$
\begin{aligned}
&M_t^J + B_{G,t}^J + S^{EA,J} B_{G,t}^{EA,J} + S_t^J B_{G,t}^{US,J} \\
&= M_{t-1}^J + R_{t-1}^J B_{G,t-1}^J + S^{EA,J} R_{t-1}^{EA} B_{G,t-1}^{EA,J} + R_{t-1}^{US} S_t^J B_{G,t-1}^{US,J} + P_t^J G_t^J + TR_t^J
\end{aligned}
$$

where B_G^J is the bond issued by the local government in local currency, while $B_G^{US,J}$ and $B_G^{EA,J}$ represent dollar- and euro-denominated reserves, both exogenously set[18]. It assumed that in each country transfers endogenously adjust to stabilize the corresponding domestic public debt according to a (fiscal) rule similar to (15).

2.2.3 Monetary policy

In each economy a standard Taylor rule holds. For the US, it is:

$$
\log\left(R_t^{US}/\bar{R}^{US}\right) = \rho_R^{US} \log\left(R_{t-1}^{US}/\bar{R}^{US}\right) + \left(1-\rho_R^{US}\right)\varphi_\pi^{US} \log\left(\Pi_t^{US}/\bar{\Pi}\right) \tag{16}
$$

where $\rho_R^{US} > 0$ is a parameter capturing inertia in the monetary policy conduct while $\varphi_\pi^{US} > 0$ is the parameter measuring the response of the policy rate to the domestic inflation rate Π^{US} (variables are expressed as deviation from the corresponding steady state variables, denoted by an upper-bar). Similar Taylor rules hold for the other regions.

[18] We assume that the reserves follow exogenous $AR(1)$ processes.

2.3 Calibration

In Tables 1 to 7 we summarize the (quarterly) calibration of the model. We illustrate the values of the parameters affecting the relevant steady-state values of the main endogenous variables and their dynamics. They are set according to the empirical evidence or existing literature. Also, following similar steps as in CCDLS (2013) we set the unknown parameters of transactions costs and the transactions technology to match key monetary and fiscal statistics in the data.

We calibrate the model to the Euro area (EA), the United States (US), China (CH), Japan (JP) and the rest of the world (RW). Table 1 reports the model implied great ratios for the five countries and areas that we consider in the model.[19] In the Table we show separately the consumption shares of forward-looking and liquidity-constrained consumers. To calibrate these shares we follow N'Diaye et al. (2009). These authors assume in the calibration of their multi-country model that the share of consumers facing liquidity constraints in China is approximately twice as large as in the remaining regions.

Table 2 shows preference and technology parameters. Preferences are the same across households of different countries and areas. We set the discount factor so that the steady-state annualized real interest rate on risky (or "non-liquid") assets, i.e. the CCAPM rate, is about 7 percent. Together with the lower interest rate on the government bonds which in our model command an endogenous liquidity premium, the resulting steady state liquidity premia on government bonds - assumed to be equal across all areas - amount to 3.6 percentage points.[20] The habit persistence parameter is set to 0.85, the intertemporal elasticity of substitution to 1.0 and the Frisch elasticity to 0.50. We assume a quarterly depreciation rate of capital to 0.02, consistently with an annual depreciation rate of 8 percent.

As for the final goods baskets, the degree of substitutability between domestic and imported tradables is higher than that between tradables and non-tradables, consistently with the existing literature. In particular, we set the (long-run) elasticity of substitution between tradables and non-tradables to 0.5 while the long-run elasticity between domestic and imported tradables is set to 2.5.

Table 3 reports nominal and real rigidities. We set the Rotemberg (1982) price and

[19] Our calibration is meant to replicate the great ratios computed from the national accounts data for 2012. More in genereal all of the national accounts data that we replicate in the calibration is computed using data from the International Monetary Fund's World Economic database. Unless otherwise stated, all data that we consider are for 2012.

[20] While this value is admittedly too high for Japan, it seems consistent with the average values for liquidity premia reported for the other countries in our model, as can be seen, e.g., in Table 5.5 of the World Development Indicators published by the World Bank.

wage adjustment parameters in the domestic tradable and non-tradable sector to 400. This value for quadratic adjustment costs in prices is roughly equivalent to a four-quarter contract length under Calvo-style pricing, as highlighted, among others, by Faruquee et al. (2007). Moreover, with the chosen value we are able to get a sufficiently hump-shaped response of wages and prices. For real rigidities, we set the parameters of the adjustment costs on investment changes to 3.5 in all countries.

The bias towards the tradable bundle is lower in the consumption basket than in the investment basket. The weight of domestic tradable goods in the consumption and investment tradable baskets is different across countries, to match multilateral import-to-GDP ratios. In particular, we rely on the United Nations' Commodity Trade Statistics (COMTRADE) data on each region's imports of consumer and capital goods, to derive a disaggregated steady-state matrix delineating the pattern and composition of trade for all regions' exports and imports. We then set the weights of bilateral imports to match this trade matrix, reported in Table 4. It is interesting to note that trade with the RW region clearly dominates trade patterns for all the other countries.

The net foreign asset positions and steady state values for the interest rates on government bonds are exogenously pinned-down, while export and import quantities as well as international relative prices consistently adjust.[21] Note that due to the presence of USD and EUR government bonds that provide transactions services internationally and act as official reserves we report both overall NFA positions (that include both the outstanding net stocks in these reserve currency bonds and in the other 'riskier' components of the NFA) and a measure of the NFA which includes only privately issued assets. These show that the US is a net debtor in government bonds and a net creditor in privately-issued assets. China's net position in privately-issued assets is instead negative, whereas the EA exhibits a balanced position and Japan's creditor status is more than halved, compared to its overall NFA position. The values chosen for the parameters governing the dynamics of these "non-liquid" components of the NFA, ϕ_1 and ϕ_2, are reported at the end of this table.

Table 5 contains price and wage markup values. We identify the non-tradable and tradable intermediate sectors in the model with the services and manufacturing sectors in the data, respectively. In each region the markup in the non-tradable sector is higher than that in the tradable sector and labor market, which we instead assume to be equal. Our values are in line with other existing similar studies, such as Bayoumi et al. (2004),

[21] The indeterminacy of the steady state net foreign asset position is standard in open economy models with representative households and incomplete international financial markets. See, for example, Pesenti (2008). To the opposite, along the transition dynamics the net foreign asset position endogenously adjusts to the given shock.

Faruqee et al. (2007), Everaert and Schule (2008). Many, if not all, of these studies refer to Jean and Nicoletti (2002), Oliveira Martins et al. (1996) and Oliveira Martins and Scarpetta (1999) for estimates of markups.[22]

In Table 6 we report the parameters used in the two policy rules: for monetary policy rules, where the interest rate reacts to the its lagged value (inertial component of the monetary policy), inflation and output growth (see equation 16), as well as for fiscal policy (see equation 15), where we set the steady state lump-sum tax rates to be consistent with the corresponding stocks of general government debt levels. The parameter governing the speed of adjustment to these debt target values, equal across countries, is chosen so as to stabilize the debt levels in the long run.

Finally, in Table 7 we report the asset stock values used for calibrating the parameters entering the transactions costs and transactions technology involving money and government bonds held by private agents. We follow similar steps as in CCDLS (2013), in that we set the unknown parameters of transactions costs and the transactions technology to match key monetary and fiscal statistics in the data. Thus, we first compute the ratios reported in Table 7 (i.e. $M^J/B^J, M^J/B^{R_i,J}$ where $J = EA, US, CH, JP, RW$ and $R_i = EA, US$) using the data available on currency in circulation, total general government debt levels and, for the United States and the euro area, on foreign private holdings of government debt issued in US dollars and in euros. The specific data sources used to compute these stocks are reported in an Appendix. These stock ratios, together with the transactions costs (τ), which we set to 0.8 percent of consumption, and with our choice of the liquidity premium, jointly pin down the parameters entering the transactions costs and transactions technology (i.e. the cost parameters A^J, the satiation levels of velocity v^J, and the shares of the various assets (denoted above by ζ and ω) in the definitions of the effective transactions balances, $\tilde{M}^J$).[23] We also compute foreign official holdings of US and EA government bonds to calibrate separately the stocks of foreign official reserves ($B_G^{R_i,J}$). These values are also reported in Table 7.

3 Results

In what follows we simulate the model to assess the macroeconomic implications of an increase in US dollar and/or euro reserves in countries other than the US and the euro area. In each of the following scenarios we assume, for comparative purposes, that the aggregate level of reserves in each region other than the US and the euro area is

[22] See also Organization of Economic Co-operation and Development (1997).

[23] The value chosen for the steady state transactions costs is in line with CCDLS (2013).

increased by 1 percentage point. In the first scenario, it is assumed that China, Japan and the RW permanently and simultaneously increase their reserves by one percent, equally distributed between euro and dollar denominated government bonds. Second, a one percent increase in overall reserves is achieved via a one percent decrease in US dollar reserves and a more than offsetting increase in euro ones[24]. All simulations start from 2012 and are run under perfect foresight. As such, there is no uncertainty, policies are fully credible and households and firms perfectly anticipate the future. We assume that the monetary and fiscal policy authorities in both countries follow the benchmark policy rules specified above (equations 16 and 15). Thus, as the monetary authorities follow an interest rate rule the changes in official reserves holdings are not sterilized interventions, as they are not perfectly offset by variations in domestic government bonds.[25] As such authorities in China, Japan and the RW finance their purchases (sales) of official reserves through temporary issuance (purchase) of domestic government bonds and tax increases (cuts).[26]

3.1 "So far, so good" scenario

Figure 3 shows current account and exchange rate responses when China, Japan and the RW increase by one percent their official reserves by raising not only their official holdings in dollars, but also those in euros, by one percent of the corresponding initial level. Obviously the euro and the dollar appreciates versus all other currencies, as the demand for euro and dollar increases. The euro depreciates vis-à-vis the US dollar as in absolute terms the demand for the latter increases relatively to demand for the former: i.e. the euro depreciates because a one percent increase in US dollar reserves is larger than a corresponding increase in euros, given that the initial holdings of dollars are larger than those of euros relative to the size of the respective asset supplies. Consistently with the exchange rate appreciations, the US and euro area trade deficits worsen.

Note also that current accounts move on impact more than the corresponding trade balances. This results from valuation effects, whereby the initial real depreciation trans-

[24] Thus, in this last scenario, the increase in euro denominated reserves is calibrated in such a way that for a given 1 percent decrease in the level of US dollar denominated reserves the resulting increase in the aggregate level of reserves amounts to 1 percentage point. As reserves in euro are much lower than the corresponding ones in US dollars, this scenario *de facto* corresponds to a very asymmetric variation in the size of reserves.

[25] As explained also in CCDLS (2013) if the monetary authorities were instead to follow a constant money growth rule then the official reserves changes (i.e. the purchases or sales) would be sterilized foreign exchange interventions.

[26] The tax increases are dictated by the benchmark fiscal policy rule, which requires that over time the debt be stabilized at its target value.

lates into valuation gains on the outstanding positions in reserve currency bonds held by China, Japan, RW, and the euro area. In the latter case this is particularly striking: the current account improves on impact, due to the valuation effects on its dollar denominated bond holdings, and subsequently turns and stays negative, as the trade balance, which immediately falls on impact, progressively dominates the current account dynamics. Also for China, Japan, and the RW the initial responses of the current accounts, when compared to the corresponding movements in the respective trade balances, are initially strongly affected by the valuation effects.

Figure 4 reports results for the US economy. GDP and aggregate demand gradually increase. Consumption increases at the peak by slightly more than 0.03 percent, investment by nearly 0.15 percent with respect to their respective initial steady state values. US exports decrease because of the dollar appreciation, while US imports increase because of the higher domestic aggregate demand and the dollar appreciation. The increase in US aggregate demand is driven by the higher demand for US assets by foreign authorities, which raises the dollar value of domestic bonds in US households' portfolios. The latter also experience an increase in their purchasing power, associated with the appreciation of the dollar. Moreover, the higher demand for US assets reduces the US interest rate on a permanent basis, making borrowing cheaper in domestic assets and increasing the seigniorage collected by the US government from abroad on the low interest rate bonds that it issues. The reduction in the US interest rate, as already highlighted in CCDLS (2013), reduces the lump-sum tax burden (or equivalently increases the lump-sum transfers) faced by US residents (not shown) further sustaining their consumption.[27] Differently than in CCDLS in our model with capital, the fall in the US interest rate on the liquid bonds, which corresponds to the monetary policy rate pictured in Figure 4, by also pushing down the CCAPM rate favors investment spending. Simultaneously, US households increase their holdings of euro area bonds, that pay a relatively high interest rate, and their holdings of money. The overall liquidity held by households, that closely tracks the holdings of US bonds, slightly decreases. However, measured in terms of the interest rate spread (not shown) - the difference between the risky CCAPM rate and the rate on the bonds embodying liquidity services - aggregate liquidity conditions in the US relax following the shock: the spread rises on average, but both interest rates fall, more so the liquid bond rate than the CCAPM rate.

Figure 5 shows results for the euro area. There are positive (but smaller than in the US) effects on GDP, domestic consumption and investment, while net exports decrease,

[27] Note that US consumption increases both with respect to domestically produced and imported goods.

as the euro appreciates against currencies other than the US dollar. As for the US, euro area households' consumption and investment increase because of the persistent decrease in the interest rate and the appreciation of the euro. The latter are associated with the permanent change in international households' portfolios. Households decrease their position in US bonds, whose expected returns have decreased, at the expense of the asset shares in euro denominated bonds and domestic money holdings. Overall liquidity does not greatly change, but again the interest rate spread faced by euro area residents rises, driven by *falls* both in the liquid and in the CCAPM rates.

Figures 6 shows the effects of the increase in reserves for the main domestic macroeconomic variables in China (in Japan and the RW results are similar and are omitted to save on space). Differently from the US and euro area, the households in these regions are decreasing their consumption, while their national authorities are financing the permanent increase in official reserves denominated in US dollars by issuing more domestic currency government debt and by increasing taxation. Households do not completely offset the increase in currency reserves, as assets are imperfect substitutes, because of liquidity services.[28] As such, the adjustment to the new equilibrium is driven through the exchange rate depreciation and the change in real and asset allocations. The real exchange rate depreciation has a relative negative wealth effect, as it makes US and euro area goods more expensive and as the fall in interest rates induced by the shock - both on foreign and domestic bonds - reduces the (real) interest payments on Chinese, Japanese, and RW households' bond holdings. It also has a positive valuation effect, because the depreciation makes the initial holdings of foreign assets, denominated in dollars and euros, more valuable in domestic currency. The wealth effect clearly dominates over the valuation effect. The result is that Chinese, Japanese, and RW households increase their saving and reduce aggregate demand for consumption and investment to finance the increase in US dollar reserves. GDP falls slightly, notwithstanding the increase in net exports. Gross exports mainly increase towards the US and the euro area, because they benefit from the US dollar and euro appreciation and the increase in US and euro area aggregate demand. Imports decrease, mainly from the US and the euro area, because of the dollar and euro appreciation and the decrease in domestic aggregate demand. Following the increase in reserves, households reduce their holdings of US dollars and euros, because the corresponding returns have decreased (the decrease in US bonds is larger because of the larger decrease in the expected return). They increase the amount

[28] In case of perfect substitutability the additional demand in reserves would be fully accommodated by households without any effect on relative returns and exchange rates. A swap between authorities and households would simply occur.

of domestic money and domestic bonds. Overall liquidity does not greatly change. As in the previous case the spread (not shown) measuring the liquidity premium rises, but contrary to what happens in the US, it is driven by fall in the liquid bond rate and a rise in the CCAPM rate.

To sum up, the increase in official demand of US dollars and euros favors the appreciation of the two currencies, the deterioration of the US and euro area current account and trade balance, and the increase in aggregate demand in the two regions, financed by the increase in borrowing. The remaining regions show an increase in their trade surpluses against the euro area and the US.[29]

3.2 "Rebalancing" scenario

We now assume that China, Japan and the RW still increase their aggregate reserves holdings by one percent, but this is obtained by decreasing the amount of dollars (by one percent) and increasing the amount of euros (so that overall reserves increase by one percent).

As shown in Figure 7 the euro now strongly appreciates against other currencies, US dollar included. This implies a larger deterioration of the euro area trade balance, by 0.14 percent of GDP at its peak, because of the large crowding-out of euro area tradables.[30] The US trade balance, instead, improves, by 0.02 percent.

Figure 8 shows the outcome for the US economy. The interest rate in the US increases, because of the decrease in demand for US bonds by foreign central banks. As a consequence, US consumption and investment decrease and drive down US GDP. The contraction of US aggregate demand is compensated in part by the increase in net exports, favored by the exchange rate depreciation. Now households in the US reduce their holdings of euros, whose return is lower, and domestic money, and increase the holdings of domestic government bonds, whose returns have increased.

The euro area variables show a dynamics opposite to the US one (see Figure 9). Euro area interest rates decrease because of the increase in global demand of the euro area bonds. The exchange rate appreciation and lower euro area interest rate have positive effects on euro area GDP, because they induce an increase in consumption and investment. Consistently, households reduce their holdings of domestic bonds and

[29] Results are qualitatively similar if the increase in reserves is only in US dollars. In fact, the euro area, being a reserve currency region, partly benfits from the increased demand in official reserves, even if it is exclusively directed towards reserves denominated in US dollars, as the induced changes in asset prices and their returns determine an increase in the global private demand for euro denominated bonds.

[30] As before note that the dynamics of the current account is intially dominated by the large valuation effects.

increase their demand of money and US bonds. The appreciation of the euro area exchange rate has negative effects on tradables' price competitiveness. As a result, euro area net exports decrease.

Figure 10 shows results for the Chinese economy (for Japanese and RW economies results are similar to those for China and to save on space we do not report them). Exports increase, favored by the depreciation of the exchange rate against the euro while imports decrease. The increase in exports is due to the higher euro area aggregate demand, while in previous simulations it was associated with the increase in the US aggregate demand as well.

To conclude, there is a rebalancing of global aggregate demand in favor of euro area aggregate demand, as the latter benefits from the increasing global demand of euros. By contrast, US aggregate demand is damaged by the reduction of global demand for US dollars. The external balance of the euro area deteriorates, to satisfy the increase in demand for euros. Symmetrically, the US external balance improves. Relative to the simultaneous increase in US dollar and euro reserves, the macroeconomic rebalancing between the US and the euro area is now more pronounced, it can hurt the US aggregate demand and greatly expand aggregate demand in the euro area. This implicitly suggests that a gradual approach to the rebalancing of reserves is preferable, as it has less destabilizing effects on the euro area and the US economies.

3.3 Asymmetric reserve management

In previous simulations it was assumed that China, Japan and the RW simultaneously increased their reserves in US dollars and euros or rebalanced their reserves towards the euro. Their macroeconomic performance was similar. In the case of increase reserves their exchange rates depreciated and their gross and net exports increased towards the US and the euro area. In the case of rebalancing of reserves towards the euro their exchange rates appreciated against the dollar but depreciated versus the euro; their net exports still increased, albeit to a lower extent larger exports towards the euro area are partially offset by smaller exports towards the US. We now compare that scenario of symmetric increase in foreign exchange reserves among non-reserve economies with another in which the management of foreign exchange reserve is asymmetric. These new scenarios aim to evaluate whether a changing demand composition of foreign exchange reserves that is heterogeneous across countries affects the configuration of global imbalances and drives an heterogeneous macroeconomic performance across the main regions of the world economy.

In particular we simulate four scenarios. In the first one, China is the only region to exogenously increase its reserves in euros and dollars by one percent. In the second one, Japan and the RW increase their reserves of euros and dollar by one percent, but China does not (it keeps them constant at the corresponding initial levels). Third, the previous scenario is run under the assumption that China pegs its exchange rate to the US dollar (and its exchange rate reserves become endogenous). Finally, we assume that China decreases its reserves by one percent, while the other non-reserves countries keep increasing their foreign exchange rate holdings by one percent.

3.3.1 Unilateral Chinese increase in reserves

We now consider the case of China being the only region to increase its reserves of euros and dollars. As in the benchmark simulations, the increase is equal to one percent of the initial levels.

Figure 11 reports the responses of nominal exchange rates and current account balances. The depreciation of the Chinese exchange rate vis-à-vis the US dollar is large (0.18 percent). It is also considerable vis-à-vis the euro and other currencies (that depreciate against the dollar to a much lower extent). The Chinese trade balance improves by close to 0.05 percent. Other countries face trade deficits, in particular the US. The reason is the price-competitiveness gain of China tradables, associated with the exchange rate depreciation.

The effects on the US and euro area macroeconomic variables are similar to those reported in the previous section (we do not report them to save on space). They are expansionary but less strong, as the overall increase in euro and US dollar demand is now smaller (it is only China to increase its demand of euros and dollars by one percent). Relative to the case of cross-country simultaneous discretionary increase in reserves, results for the Chinese economy do not greatly change (see Figure 12). There is a persistent increase in net exports. The latter now increase not only towards the US and rest of the euro area, but also towards Japan and the RW, consistently the fall in GDP is even smaller. The reason is the larger depreciation of the Chinese currency. Effects on Japan and RW macroeconomic variables are very small (we do not report them to save on space). The main effect is on their (gross and net) exports, that are crowded-out by the renminbi depreciation.

3.3.2 "Bretton Woods II"

To assess the role of the exchange rate regime for the macroeconomic effects of the increase in global demand for euro and US dollar reserves, we now assume that Japan and RW increase their US dollar and euro reserves by one percent, while China keeps its nominal exchange rate fixed against the US dollar by appropriately adjusting its dollar reserves (that become endogenous). This scenario is designed to closely resemble the so-called "Bretton Woods II" system (Dooley, Folkers-Landau and Garber, 2003).

Figure 13 shows the results for trade balances and real exchange rates. Relative to previous simulations, the Chinese real exchange rate depreciates less, because the nominal exchange rate is pegged to the US dollar. Consistently, the Chinese trade balance deteriorates, as Chinese tradables lose price competitiveness. Effects on US, the euro area, Japan and the RW are similar to those obtained in the previous sections and to save on space they are not reported.[31] Figure 14 reports results for China. Consumption and investment now slightly increase in the medium run, because the lower depreciation of the real exchange rate has a lower negative wealth effect. Moreover, authorities sell their US dollar reserves to avoid the renminbi depreciation. This implies that there is no need to increase Chinese savings in the short run. Because of the real exchange rate appreciation and the increase in domestic aggregate demand, Chinese exports decrease and imports increase. The monetary policy rate initially increases, to stabilize the economy. Households decrease their holdings of US dollar- and euro-denominated bonds, because their expected returns have decreased. The amount of money and domestic public sector bonds decrease, as the public sector is selling its US dollar reserves in the short run to guarantee the fixed exchange rate vis-à-vis the US dollar.

3.3.3 China sells some of its reserves

Finally, we analyze the case in which China reduces its official holdings of foreign exchange reserves (by one percent), while Japan and RW keep increasing theirs (by one percent).

Results are more striking. The renminbi appreciates in real terms against all currencies, especially the yen, given that Japan is assumed to keep selling domestic for foreign currency (Figure 15). The euro is little changed against the dollar. As a consequence, trade balance deteriorates in China, while it improves in Japan and RW. In both reserve

[31] As in previous simulations, US and euro area exchange rates appreciate, their current account deteriorates and their aggregate demands increase. Symmetrically, Japan and the RW trade balances improve and their savings increase.

currency areas main macroeconomic aggregates are to a large extent unaffected, as the increased demand for dollars and euros in Japan and RW is offset by the reduction in China. If anything, consumption and investment slightly increase and net exports decrease both in the US and in the euro area. Notwithstanding the fall in net export, Chinese GDP increases as both consumption and investment benefit from the reduction in interest rates and the wealth effect brought about by an appreciated currency (Figure 16). Symmetrically, consumption and investments fall in Japan and RW as the financing of the increase in foreign exchange reserves weighs on the domestic sector.

4 Welfare

In this Section we briefly present our results in an alternative way, by measuring the country-specific welfare costs or benefits of the different scenarios that have been the focus of our work so far. In particular, we measure the fraction of permanent consumption that must be given up in order to equal the welfare attained in a particular scenario (e.g. the country-specific welfare in the "so far, so good" scenario) to that of the initial steady state. Note that this initial steady state does not correspond to an efficient steady state, it only reflects the initial calibration which, as described in Section 2.3, merely aims at matching some salient data features for the five countries that we are focusing on. To construct our welfare metric we closely follow Leith et al. (2012) and Rieth (2014). Thus, given our utility function, we compute the quarterly cost as a percentage of initial steady state consumption, Ψ, for a generic country J as follows:

$$\Psi = \left\{ 1 - \exp\left[(1-\beta)\, W_t^J + \frac{\bar{N}^{J1+\chi}}{1+\chi} - \log\left((1-\xi)\, \bar{C}^J \right) \right] \right\} * 100$$

where W^J is the welfare of country J under a particular scenario, computed as the discounted sum of household utility under perfect foresight conditional on the state of the economy in the initial period 0 being the initial nonstochastic steady state. Upper bars denote initial steady state values of the variables. Note that since our scenarios are all constructed as one-time permanent shocks, implying that the steady state permanently changes from period 1 onwards, Ψ measures the cost (or benefit) associated with a permanent change from the initial to the new and terminal steady state under perfect foresight.

The welfare costs that we obtain are presented in Table 8. The qualitative results presented for each scenario in the previous analysis, where we were focusing on the main macroeconomic aggregates, are largely confirmed. In particular it emerges that a build-up in official reserves always increases the welfare of the reserve currency countries, while it always hurts the accumulating countries. The benefits for the Euro area and the United States amount respectively to 0.004 and 0.008 percentage points of (initial steady state) consumption in each quarter, under the "so far, so good" scenario (row [1]). They are lower when we consider the scenarios under which only China (row [3]) or only Japan and the Rest of the world (row [4]) increase their US dollar and euro official reserves holdings; they are lowest, as one would expect, when in addition and at the same China is decreasing its reserves holdings (row [5]). In this latter case China would experience substantial welfare benefits, as its consumption would increase permanently by 0.02 percentage points in each quarter. A quantitatively similar welfare gain would accrue to the Euro area if it were to increase its share in global reserve holdings (row [2]). Under this "rebalancing" scenario, the concurrent decrease in US dollar denominated official reserves holdings would cost US citizens approximately 0.007 percentage points of consumption in each quarter. The costs, at least when measured in terms of foregone consumption, are even higher for those countries that are actively accumulating official reserves: permanent consumption losses are around 0.015 percentage points for Japan and China, while they are around one half or one-third this size for the Rest of the World block, due to its lower reserves stock holdings.

5 Conclusions

We have assessed the macroeconomic effects for the euro area, the US and China of different foreign exchange reserve management strategies in countries that have accumulated large holdings of foreign assets. In an international monetary system in which the euro plays a larger role, the euro area would benefit from lower interest rates. Interestingly, the US economic activity would not be damaged as long as the demand for the US dollars continues to increase. Finally, economic activity in countries other then the euro area and the US, China among them, would not be damaged in such bipolar system, as they will continue to benefit from the increase in net exports, which would increase towards the euro area.

A management of foreign exchange holdings that is asymmetric among non-reserve countries would not greatly modify the macroeconomic performance of the euro area and US economies, relative to the case of a symmetric increase. However, it would make asymmetric the macroeconomic performance of the countries holding reserves and increase imbalances between them. In particular, if China decreases its reserves, its economy benefits from the appreciation of its exchange rate, because of the associated positive wealth effect and because there is no need to increase savings in initial periods to finance the increase in foreign exchange reserves.

To simplify the analysis, in this paper we deliberately neglected exploring alternative formulations of several important features of the model, which would deserve to be analyzed in greater depth. For instance, the analysis may be extended to delve deeper into the degree of substitutability among the different assets and, in particular, of private bonds issued in international currencies. Moreover, we did not touch on the potential strategic interactions between international liquidity providers, between them and the holders of international reserves, and among reserve holders themselves in terms of the timing and/or extent of currency portfolios changes. These questions also raise important policy implications for international cooperation and coordination. We leave all these interesting issues for future research.

Appendix. A simple VAR of the Chinese economy

In this Appendix we report the impulse responses of a VAR estimation. The data set is that used by Kim and Lee (2013). It consists of six quarterly variables from 1992Q1 to 2013Q1, namely the stock of foreign exchange reserves (in US dollars), the renminbi/USD exchange rate, the trade balance, real GDP, real private consumption and real Government expenditures. All variables, except the trade balance, are in log-levels. We choose 4 lags, according to the Akaike information criterion. Our system is estimated using standard Bayesian techniques. In particular, we use a non-informative prior (Jeffrey's prior) distribution on parameter space and an inverse Wishart distribution as the conjugate prior for the covariance matrix. Antithetic acceleration is then used to improve convergence of the Montecarlo draws.

We use a simple Choleski identification featuring (in order) reserves, GDP, government expenditures, private consumption, the exchange rate and the trade balance. This is the same ordering used in Kim and Lee, except that we added foreign exchange reserves as first variable. Results are, however, robust to the ordering of the variables.

Figure 2 reports the responses to a 1-standard deviation positive shock to foreign exchange reserves. The 68 percent confidence bands are computed by Montecarlo integration. The responses are as expected. In particular, the exchange rate depreciates and trade surplus increases, but private consumption declines as domestic saving was likely funneled abroad, crowding out domestic borrowers.

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Table 1: Steady state national accounts (percent)

	EA	US	CHN	JAP	RW
Private consumption	54.3	58.5	38.8	55.1	56.7
Private investment	20.0	15.0	40.0	20.0	20.0
Public expenditure	20.0	20.0	20.0	20.0	20.0
Imports	23.8	14.3	22.2	14.8	19.2
Consumption goods	13.1	7.8	10.3	8.2	11.1
Investment goods	10.7	6.5	11.9	6.6	8.1
Public debt (% of yearly GDP)	92.8	102.7	26.1	238.0	80.8
Share of world GDP	14.1	21.1	14.9	9.2	40.7

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 2: Households and Firms Behavior

	EA	US	CHN	JAP	RW
Households					
Subjective discount factor	0.9901	0.9901	0.9901	0.9901	0.9901
Depreciation rate	0.02	0.02	0.02	0.02	0.02
Intertemporal elasticity of substitution	1.00	1.00	1.00	1.00	1.00
Habit persistence	0.85	0.85	0.85	0.85	0.85
Inverse of the Frisch elasticity of labor	2.00	2.00	2.00	2.00	2.00
Tradable Intermediate Goods					
Bias toward capital	0.40	0.40	0.50	0.40	0.40
Non-tradable Intermediate Goods					
Bias toward capital	0.35	0.35	0.45	0.35	0.35
Final consumption goods					
Substitution btw domestic and imp. goods	2.50	2.50	2.50	2.50	2.50
Bias toward domestic goods	0.52	0.83	0.34	0.67	0.77
Substitution btw tradables and non-trad.	0.50	0.50	0.50	0.50	0.50
Bias toward tradable goods	0.50	0.50	0.60	0.50	0.50
Final investment goods					
Substitution btw domestic and imp. goods	2.50	2.50	2.50	2.50	2.50
Bias toward domestic goods	0.28	0.59	0.24	0.47	0.60
Substitution btw tradables and nontr.	0.50	0.50	0.50	0.50	0.50
Bias toward tradable goods	0.50	0.50	0.70	0.50	0.50

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 3: Real and nomianl rigidities

	EA	US	CHN	JAP	RW
Real Rigidities					
Investment adjustment	3.50	3.50	3.50	3.50	3.50
Nominal Rigidities					
Households					
Wage stickiness	400	400	400	400	400
Manufacturing					
Price stickiness (domestically produced goods)	400	400	400	400	400
Price stickiness (imported goods)	400	400	400	400	400
Services					
Price stickiness	400	400	400	400	400

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 4: International linkages (percent of GDP)

	EA	US	CHN	JP	RW
Substitution between consumption imports	2.50	2.50	2.50	2.50	2.50
Imported consumption goods from					
EA	...	1.1	1.0	0.8	3.4
US	0.9	...	0.8	0.7	4.3
CHN	1.3	1.4	...	1.8	2.5
JAP	0.3	0.5	0.9	...	0.9
RW	10.5	4.9	7.6	5.9	...
Substitution between investment imports	2.50	2.50	2.50	2.50	2.50
Imported investment goods from					
EA	...	0.8	1.1	0.4	2.9
US	0.9	...	0.9	0.6	1.7
CHN	1.2	1.3	...	1.4	2.7
JAP	0.3	0.4	1.3	...	0.9
RW	8.4	4.0	8.6	4.3	...
Net foreign assets (%yearly GDP)	−17.6	−27.4	21.0	57.3	5.3
Net foreign assets (%yearly GDP) (1)	−22.9	14.6	2.6	34.3	−4.9
Financial intermediation cost function ($\phi_1; \phi_2$)	$0.15; 0.3$	$0.15; 0.3$	$0.15; 0.3$	$0.15; 0.3$	$0.15; 0.3$

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.
(1) net of private holdings of USD and EUR govt bonds

Table 5: (Gross) Price and wage markups

	EA	US	CHN	JAP	RW
Manufacturing (tradables) price markup	1.20	1.20	1.20	1.20	1.20
Services (non-tradables) price markup	1.30	1.30	1.30	1.30	1.30
Wage markup	1.20	1.20	1.20	1.20	1.20

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 6: Monetary and fiscal policy

	EA	US	CHN	JAP	RW
Inflation target	1.02	1.02	1.02	1.02	1.02
Interest rate inertia	0.87	0.87	0.87	0.87	0.87
Interest rate sensitivity to inflation gap	1.70	1.70	1.70	1.70	1.70
Interest rate sensitivity to output growth	0.10	0.10	0.10	0.10	0.10
Lump-sum tax sensitivity to debt gap	0.60	0.60	0.60	0.60	0.60

Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 7: Asset ratios

	EA	US	CHN	JAP	RW
Private agents					
curr. in circ./domestic govt bond holdings	0.27	0.22	0.48	0.06	0.19
curr. in circ./USD govt bond holdings	...	8.39	2.53	2.22	4.86
curr. in circ./EUR govt bond holdings	8.77	...	3.14	2.70	6.21
Official holdings					
of USD govt bonds (% of GDP)	...	3.87	16.40	16.00	6.80
of EUR govt bonds (% of GDP)	0.51	...	8.05	5.56	2.42

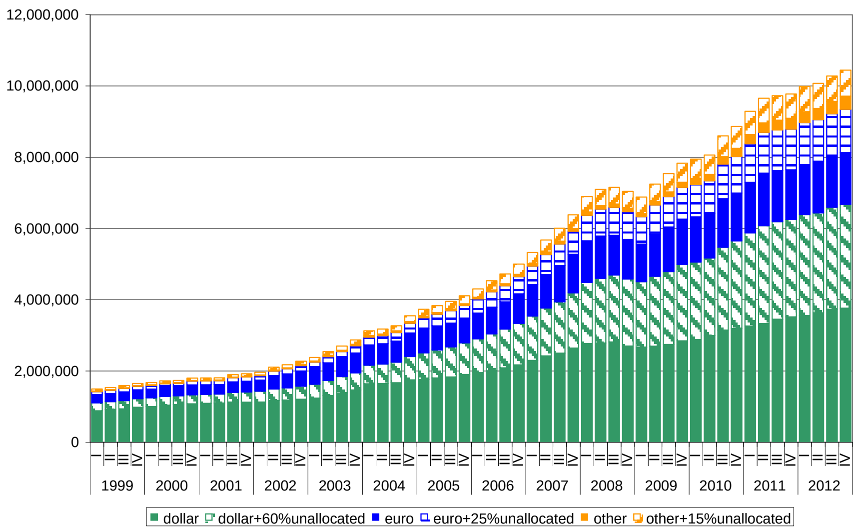
Note: EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world.

Table 8: Welfare

		EA	US	CHN	JAP	RW
[1]	"So far, so good"	-0.0040	-0.0078	0.0159	0.0141	0.0067
[2]	"Rebalancing"	-0.0229	0.0074	0.0156	0.0154	0.0053
[3]	Only CHN increases reserves	-0.0014	-0.0031	0.0198	0.0002	-0.0003
[4]	JAP and RW increase reserves, CHN pegs	-0.0025	-0.0049	-0.0034	0.0144	0.0065
[5]	JAP and RW increase reserves, CHN sells	-0.0011	-0.0016	-0.0238	0.0147	0.0063

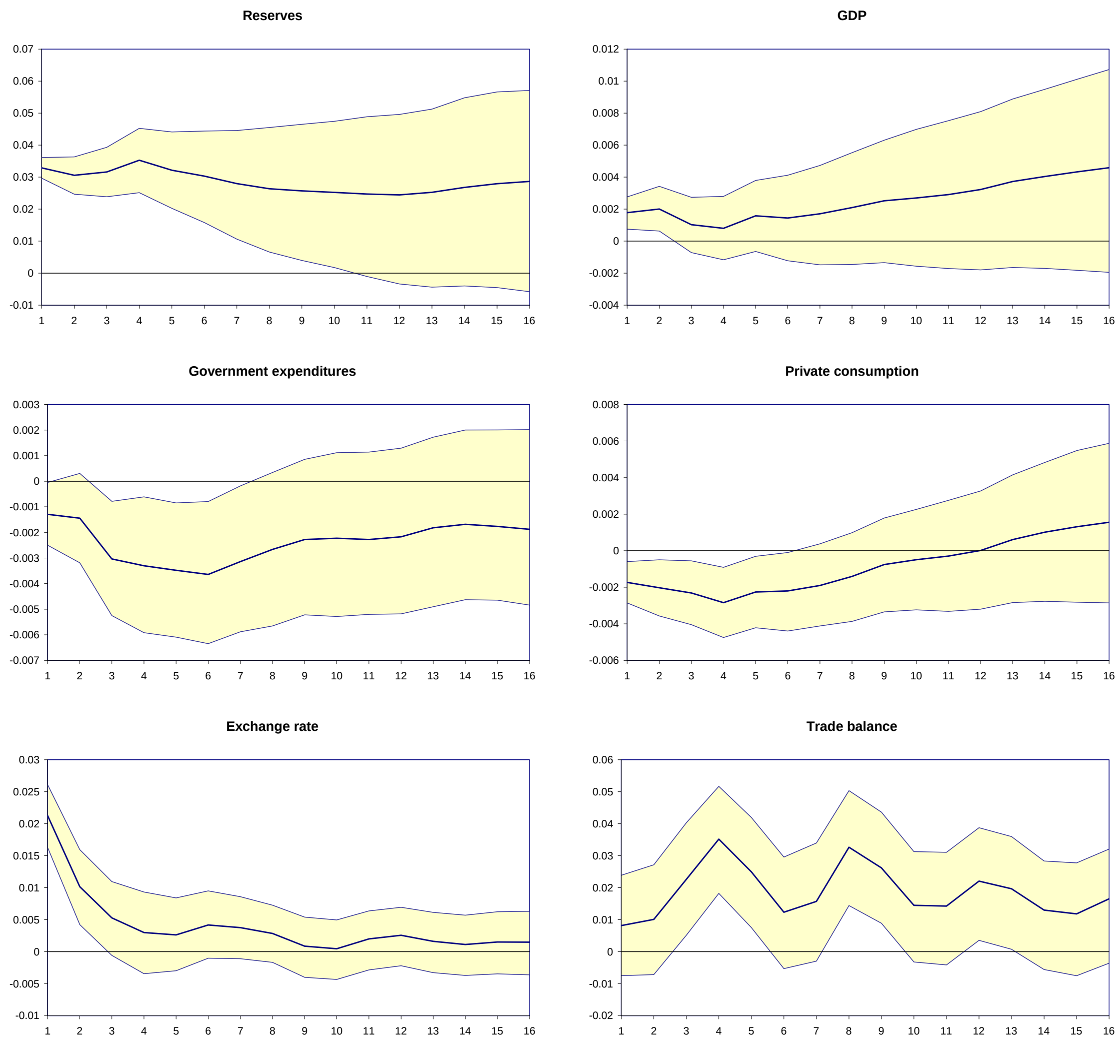
Note: percentage points; quarterly. EA=euro area; US=United States; CHN=China; JAP=Japan; RW=Rest of the world. Consumption equivalent i.e. fraction of permanent consumption that must be given up in order to equal welfare in the new regime (negative values imply that in the new regime welfare increases).

Figure 1: Global exchange rate reserve allocation



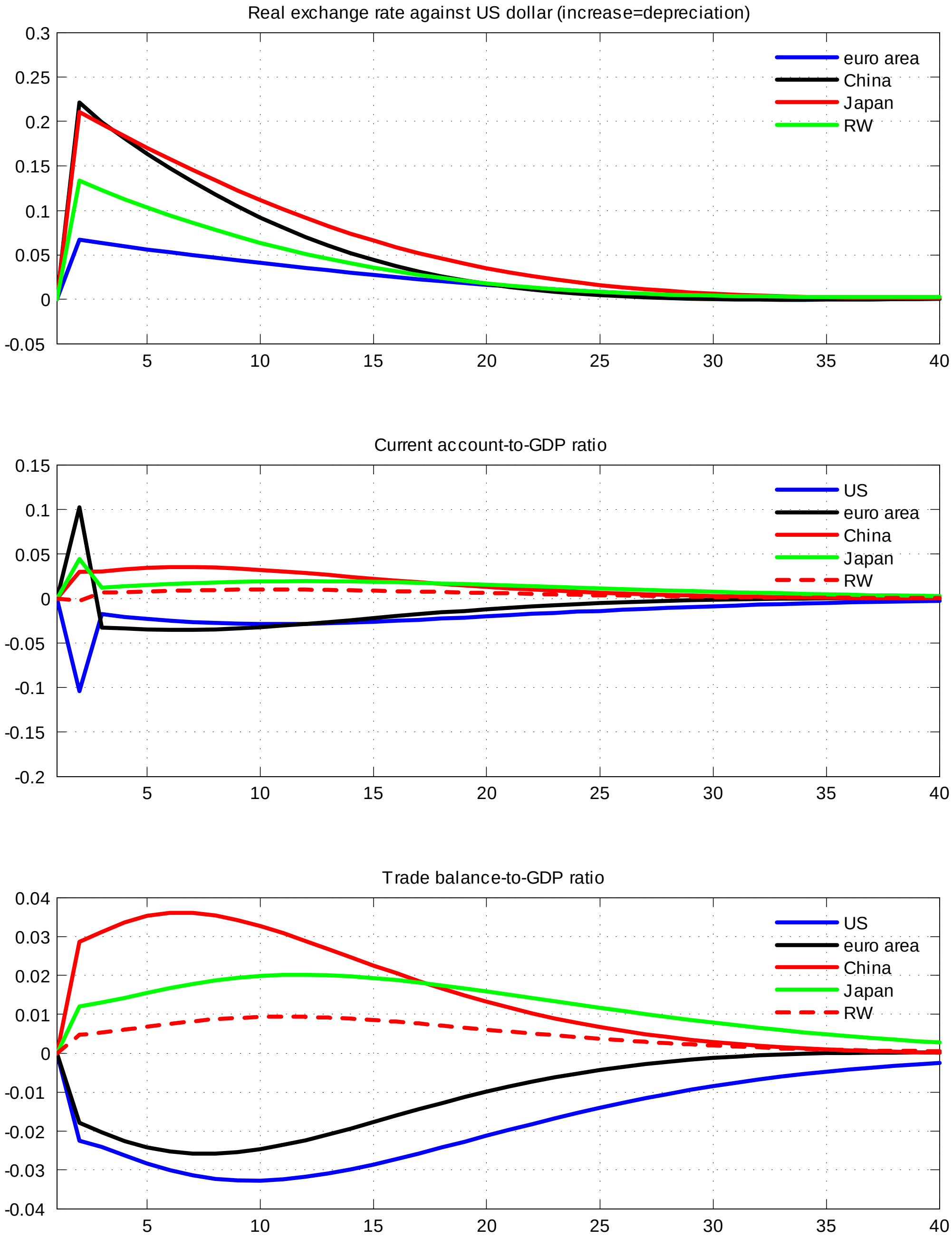
Source IMF COFER.
Note: in millions of U.S. dollars.

Figure 2: China: inpulse responses to a one standard deviation shock to reserve holdings



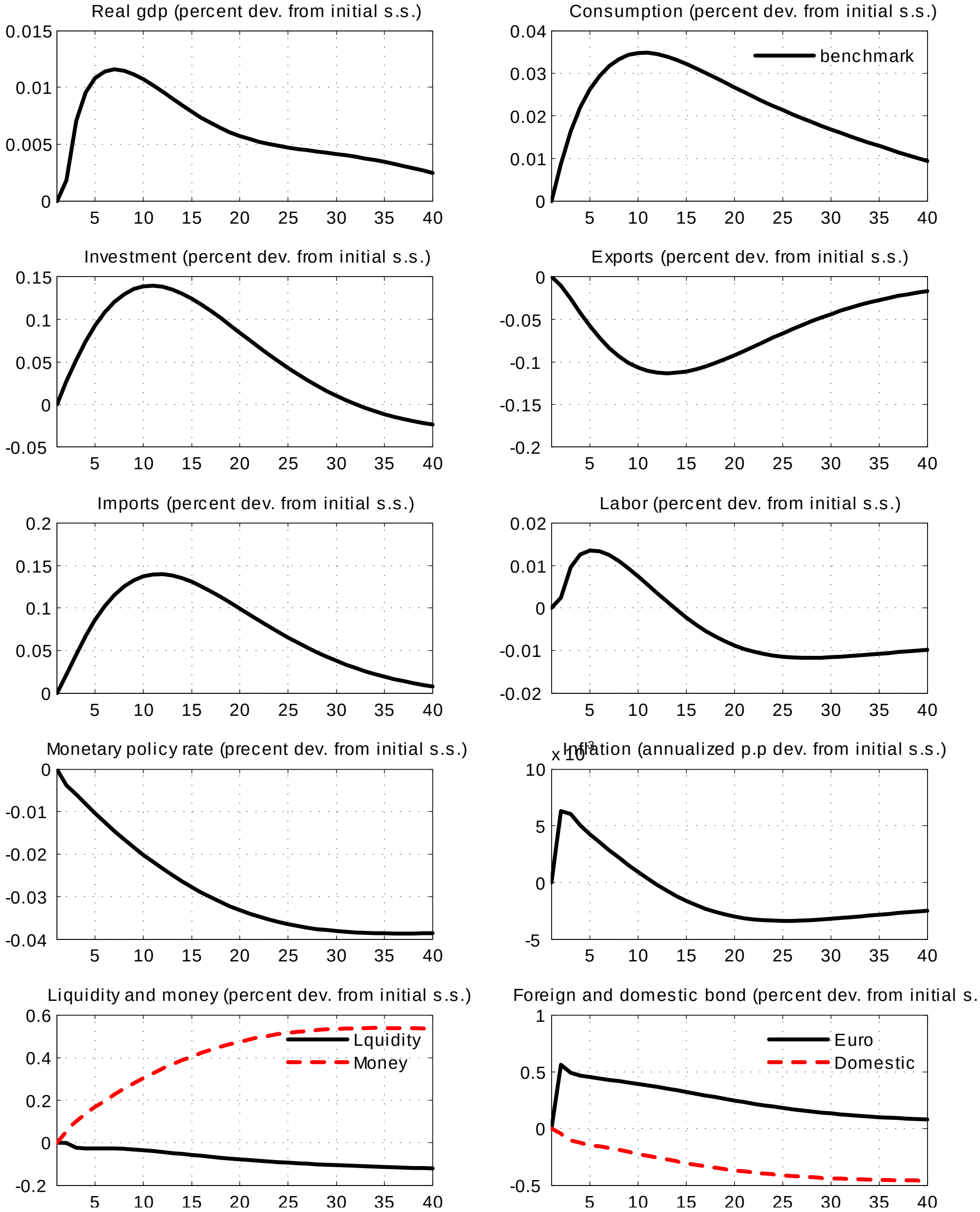
Note: percent. Bands represent 68% confidence interval.

Figure 3: CHN, JAP and RW accumulate reserves in dollars and euros



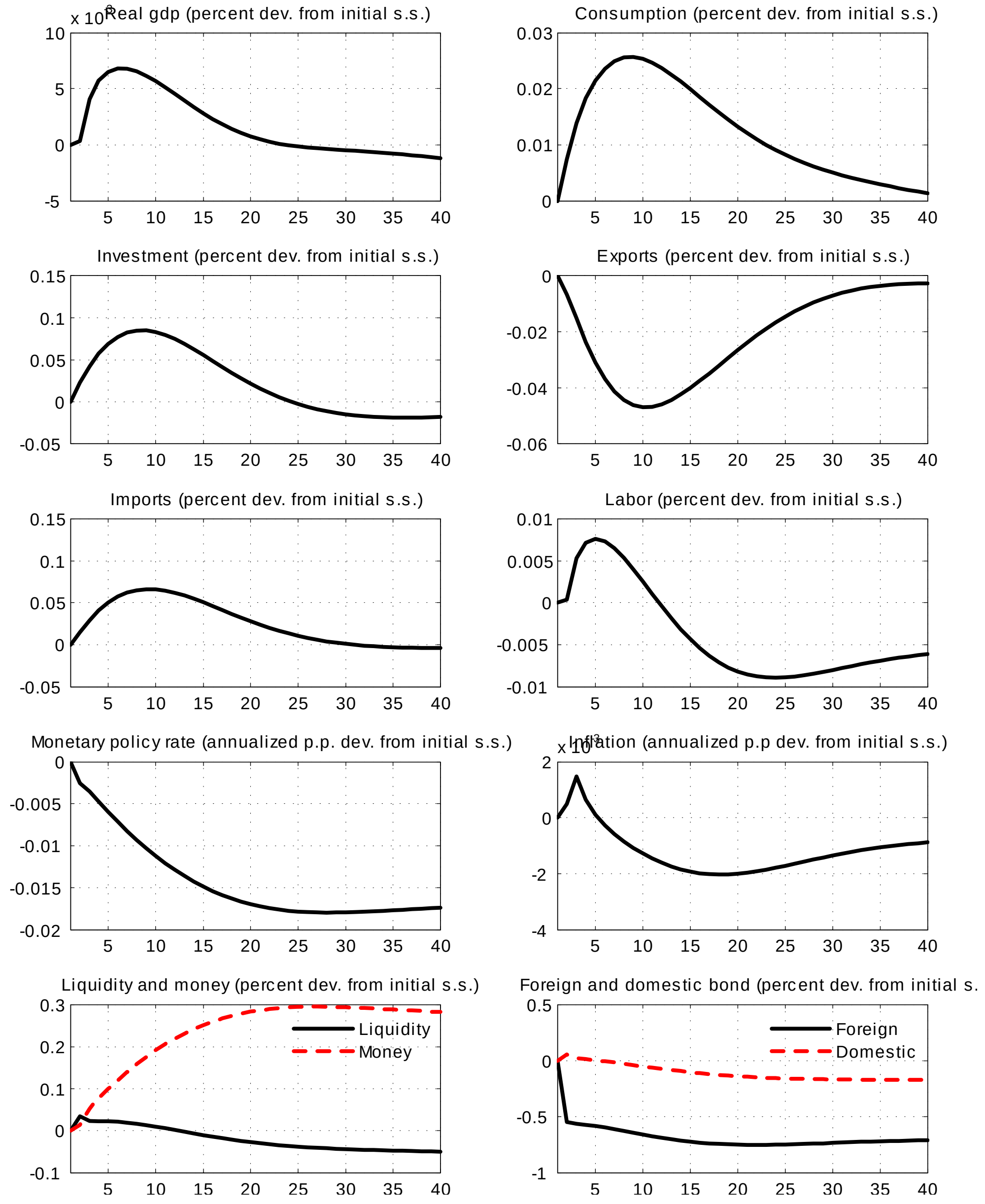
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 4: CHN, JAP and RW accumulate reserves in dollars and euros: US variables



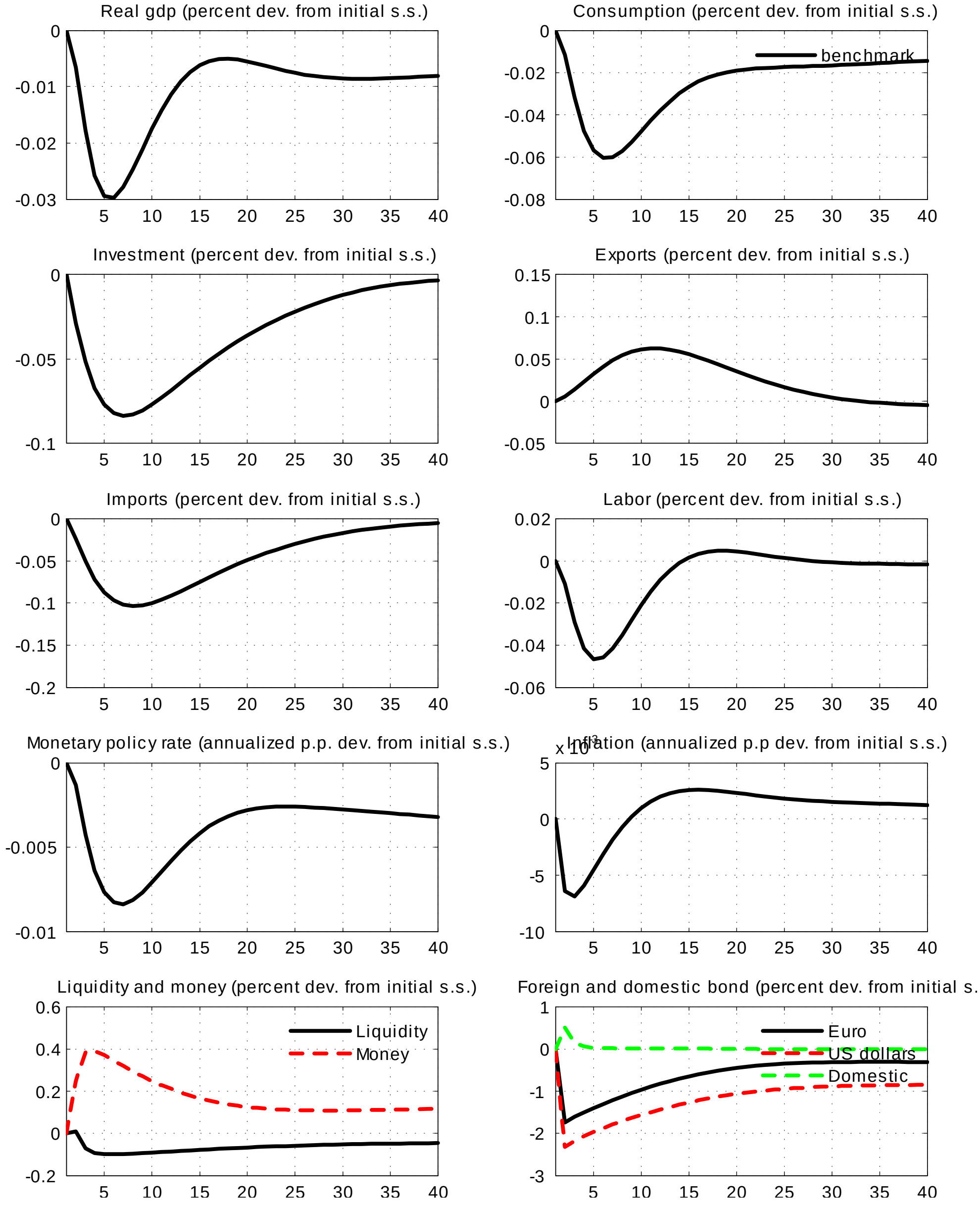
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 5: CHN, JAP and RW accumulate reserves in dollars and euros: EA variables



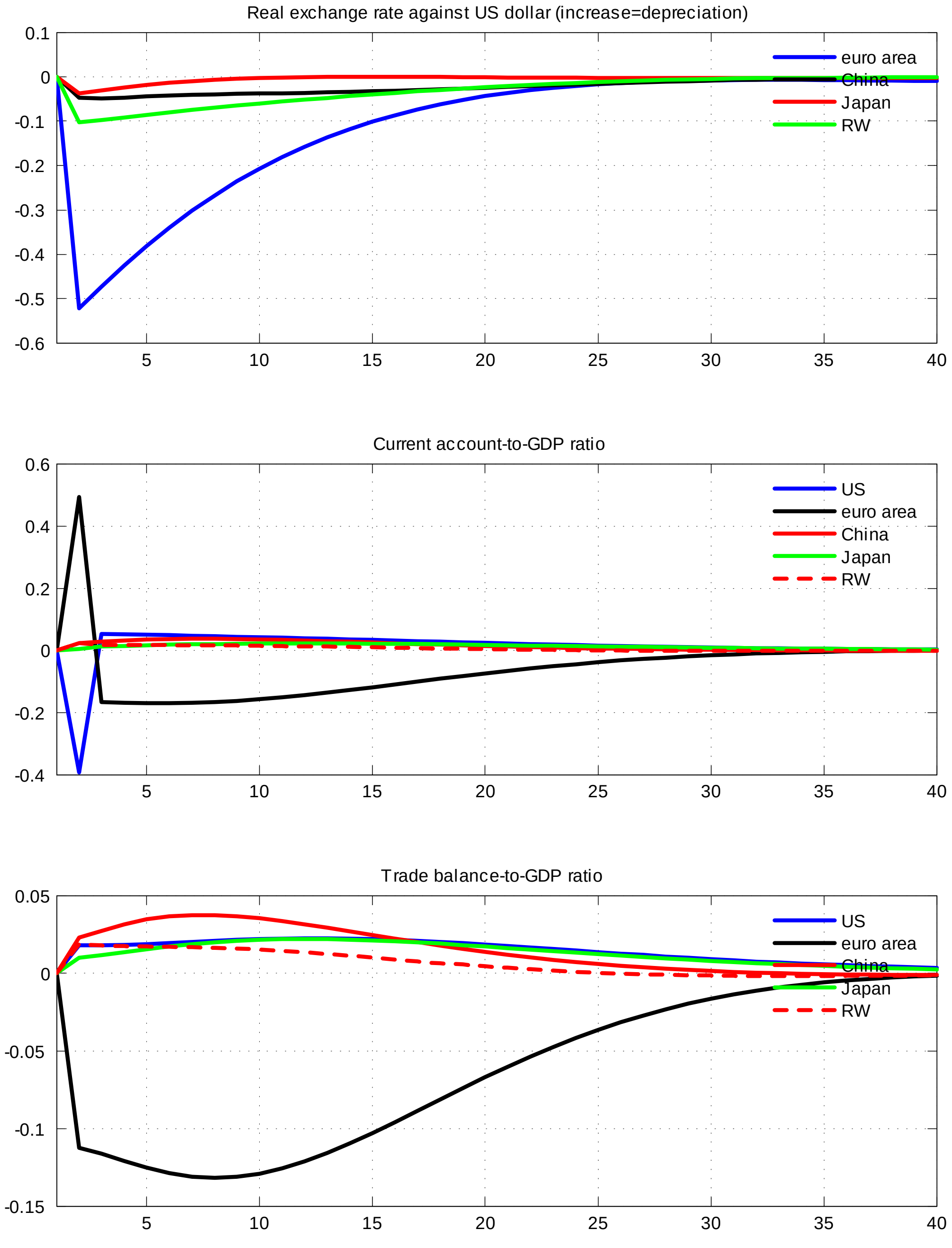
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; EA= euro area; RW=rest of the world.

Figure 6: CHN, JAP and RW accumulate reserves in dollars and euros: CHN variables



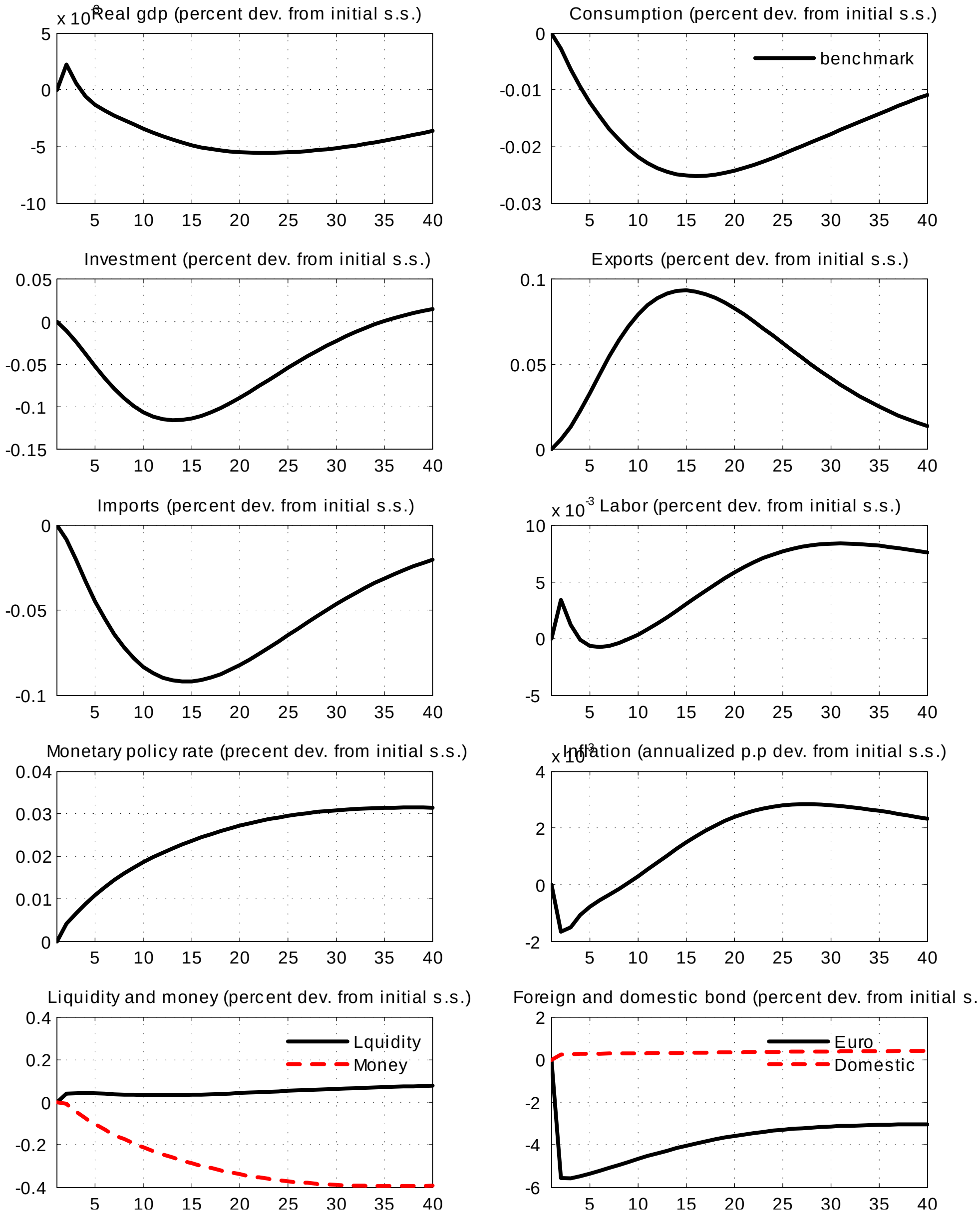
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 7: CHN, JAP and RW rebalance reserves into euro



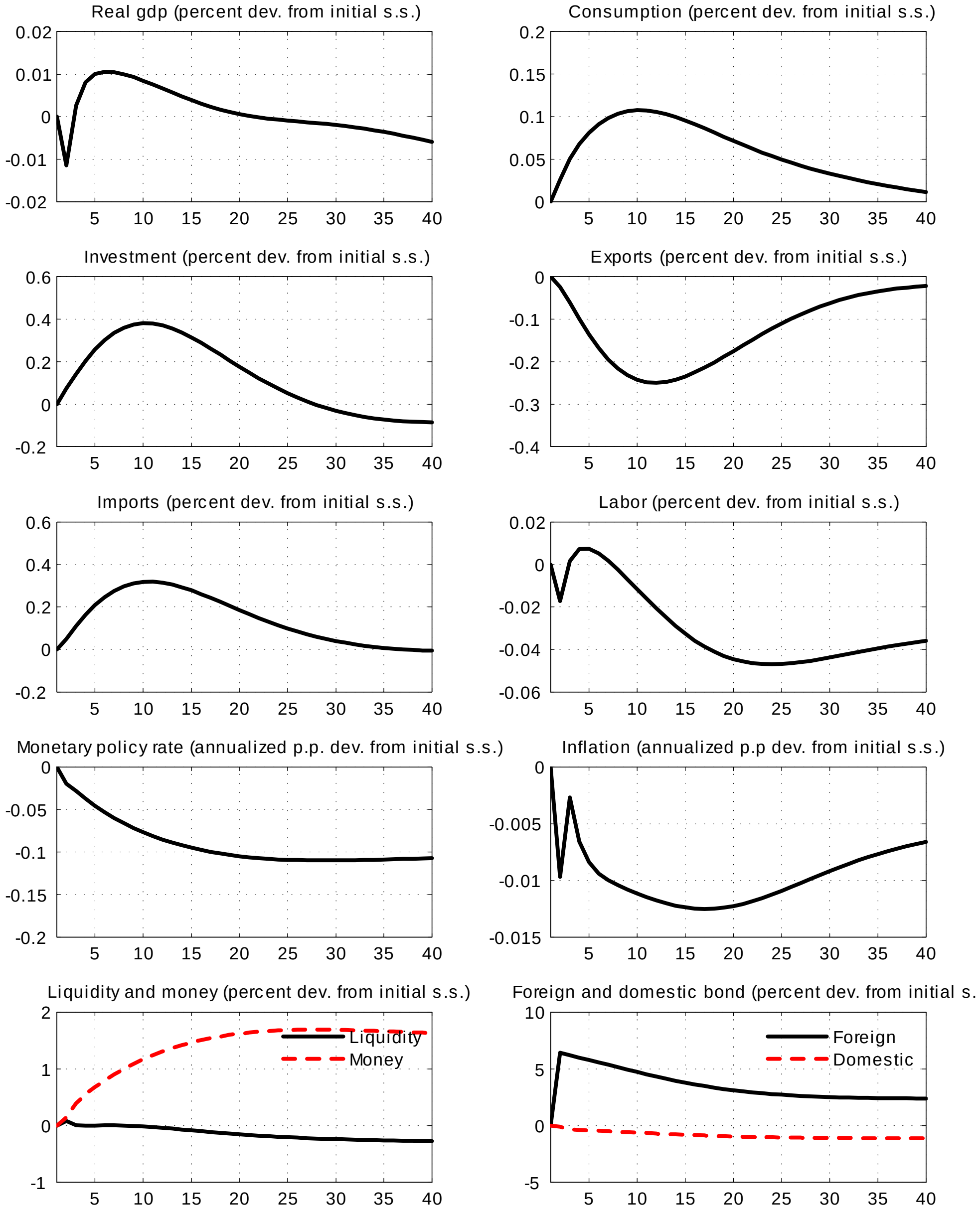
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 8: CHN, JAP and RW rebalance reserves into euro: US variables



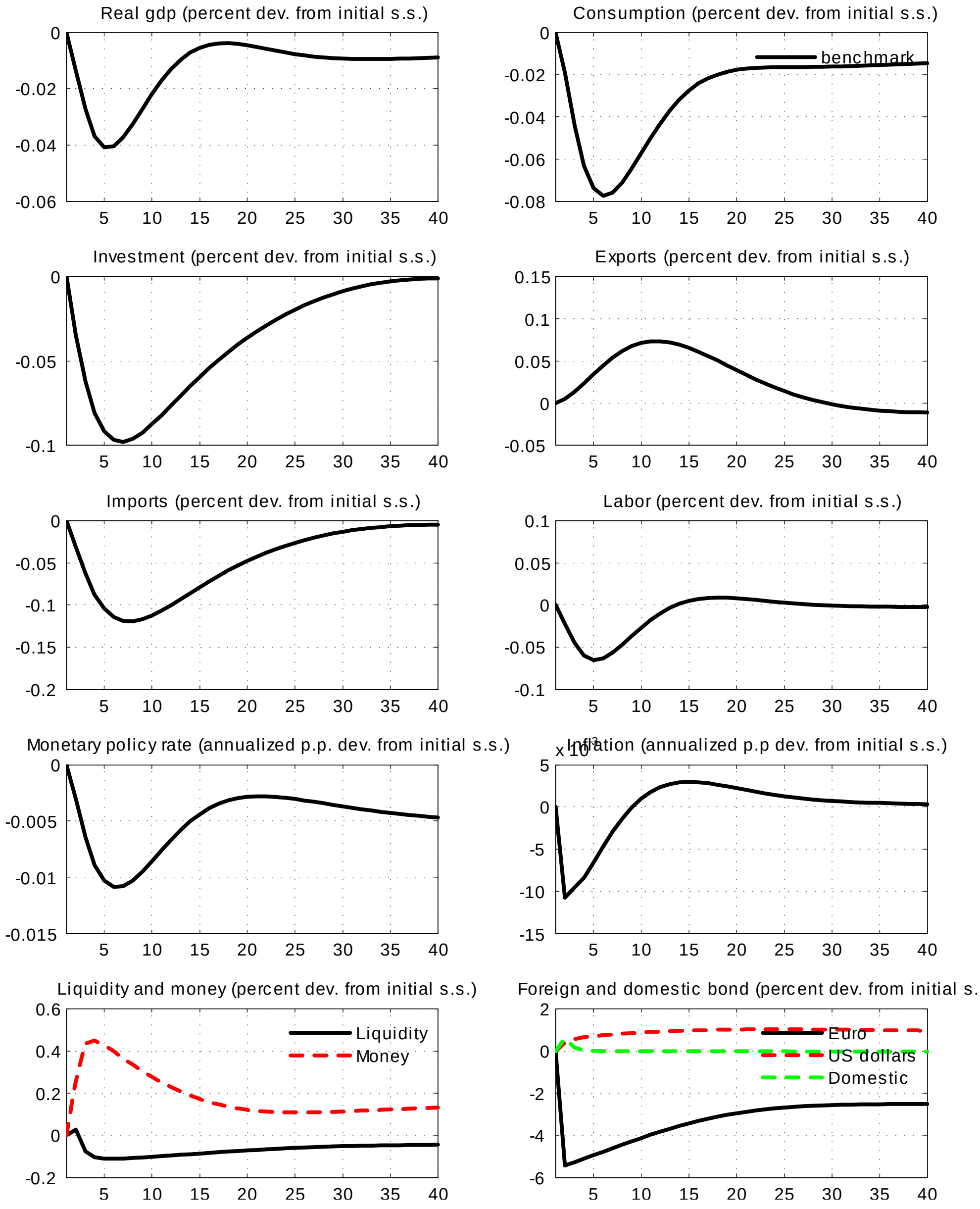
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 9: CHN, JAP and RW rebalance reserves into euro: EA variables



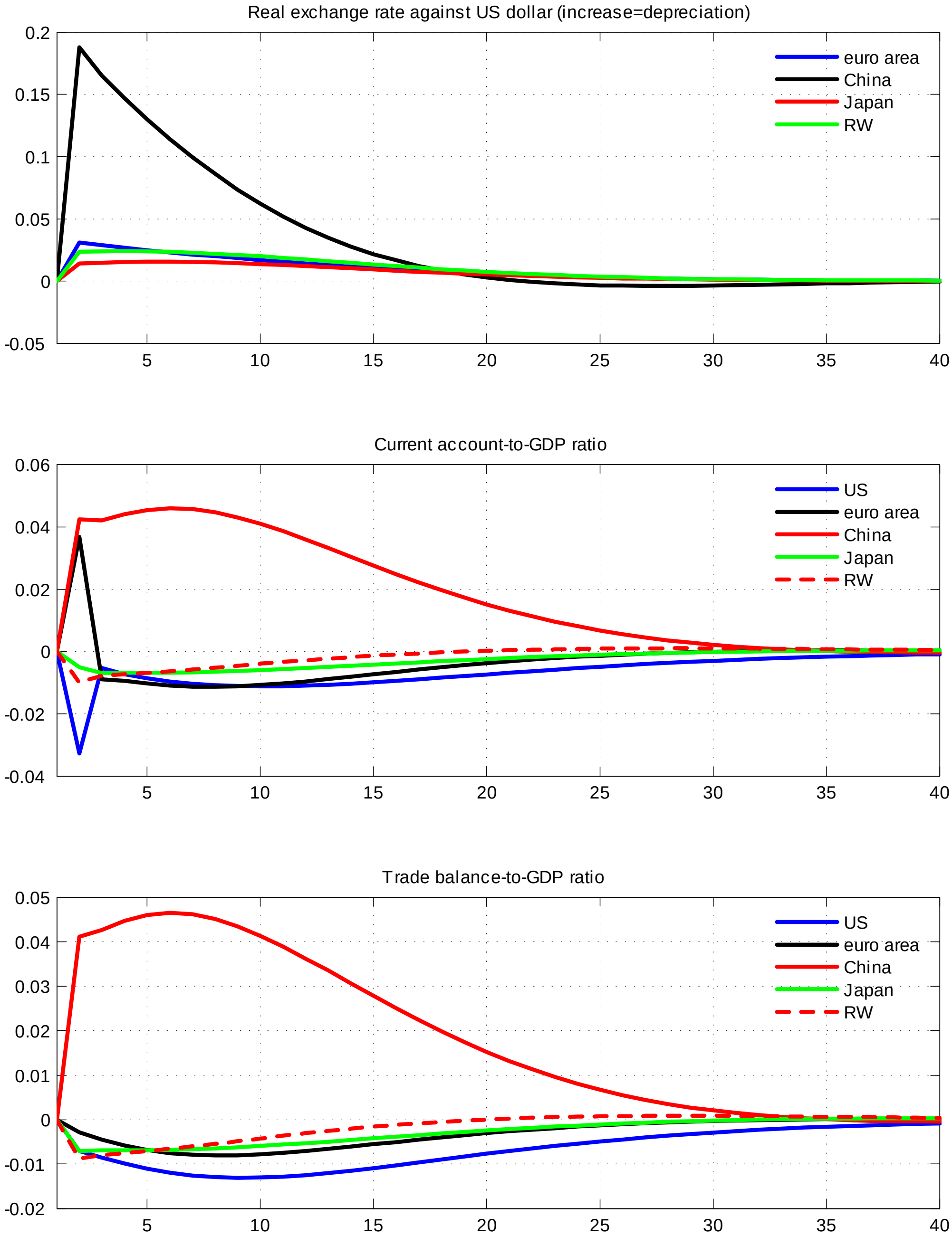
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; EA= euro area; RW=rest of the world.

Figure 10: CHN, JAP and RW rebalance reserves into euro: CHN variables



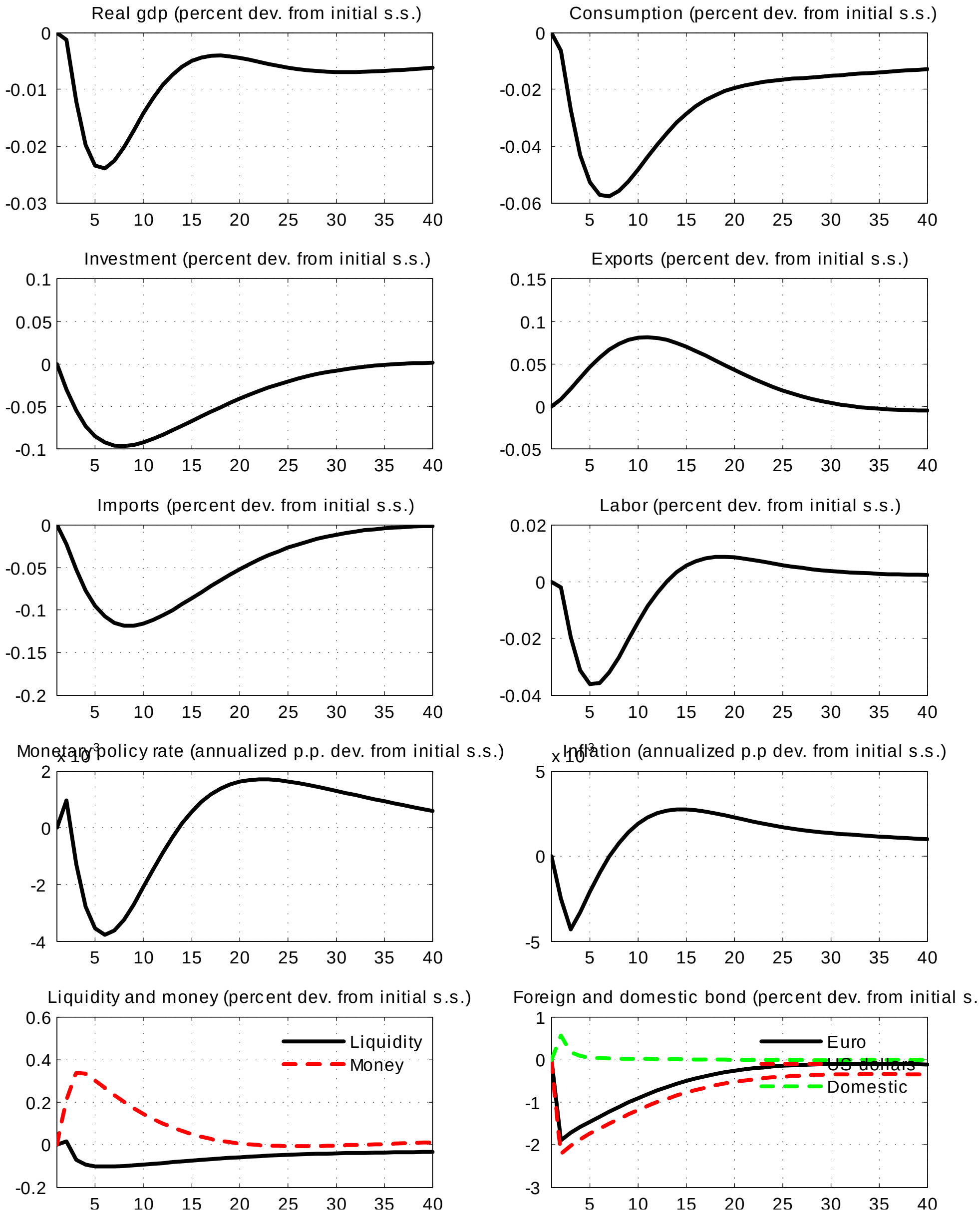
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 11: Only China accumulates reserves



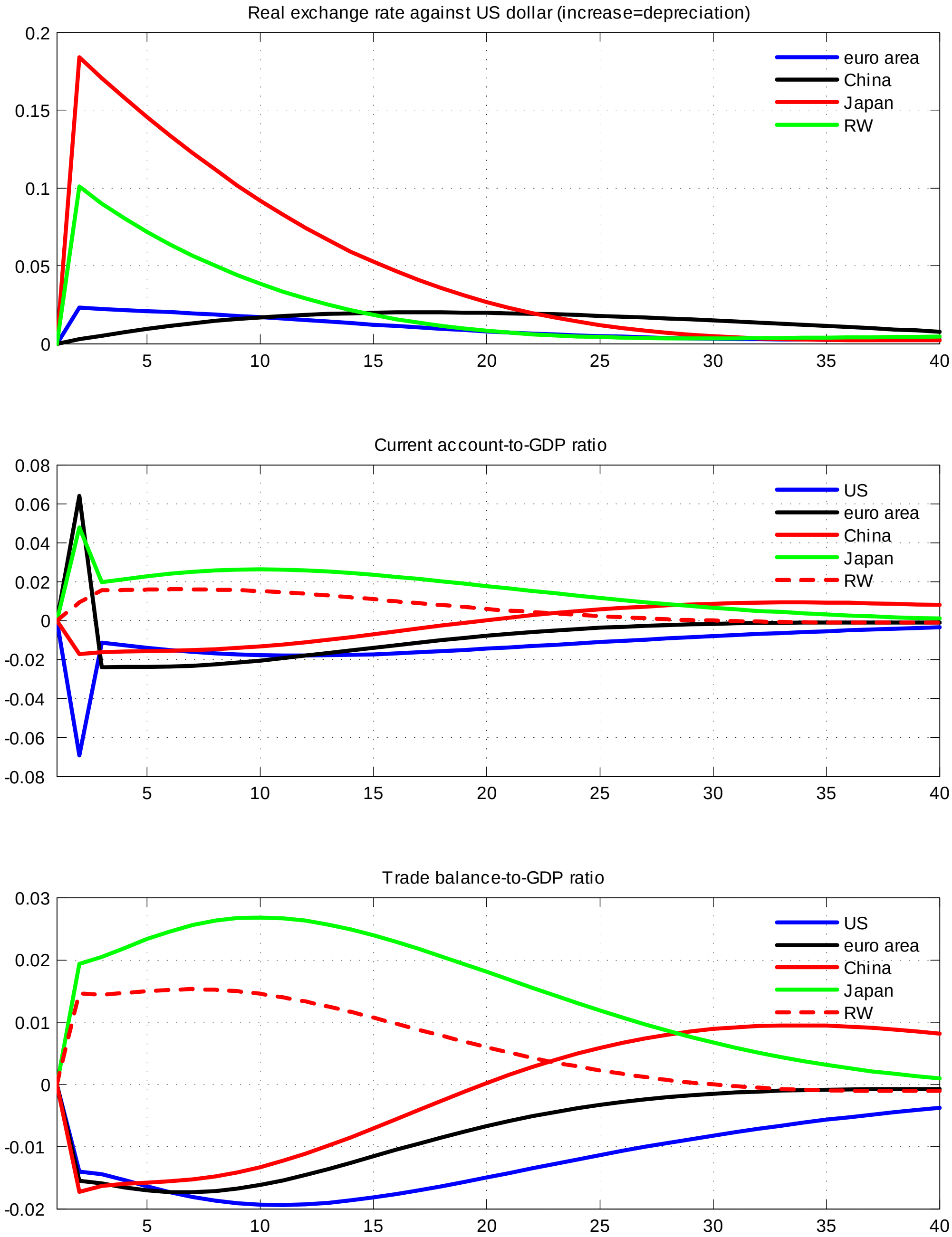
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. RW=rest of the world.

Figure 12: Only China accumulates reserves: CH variables



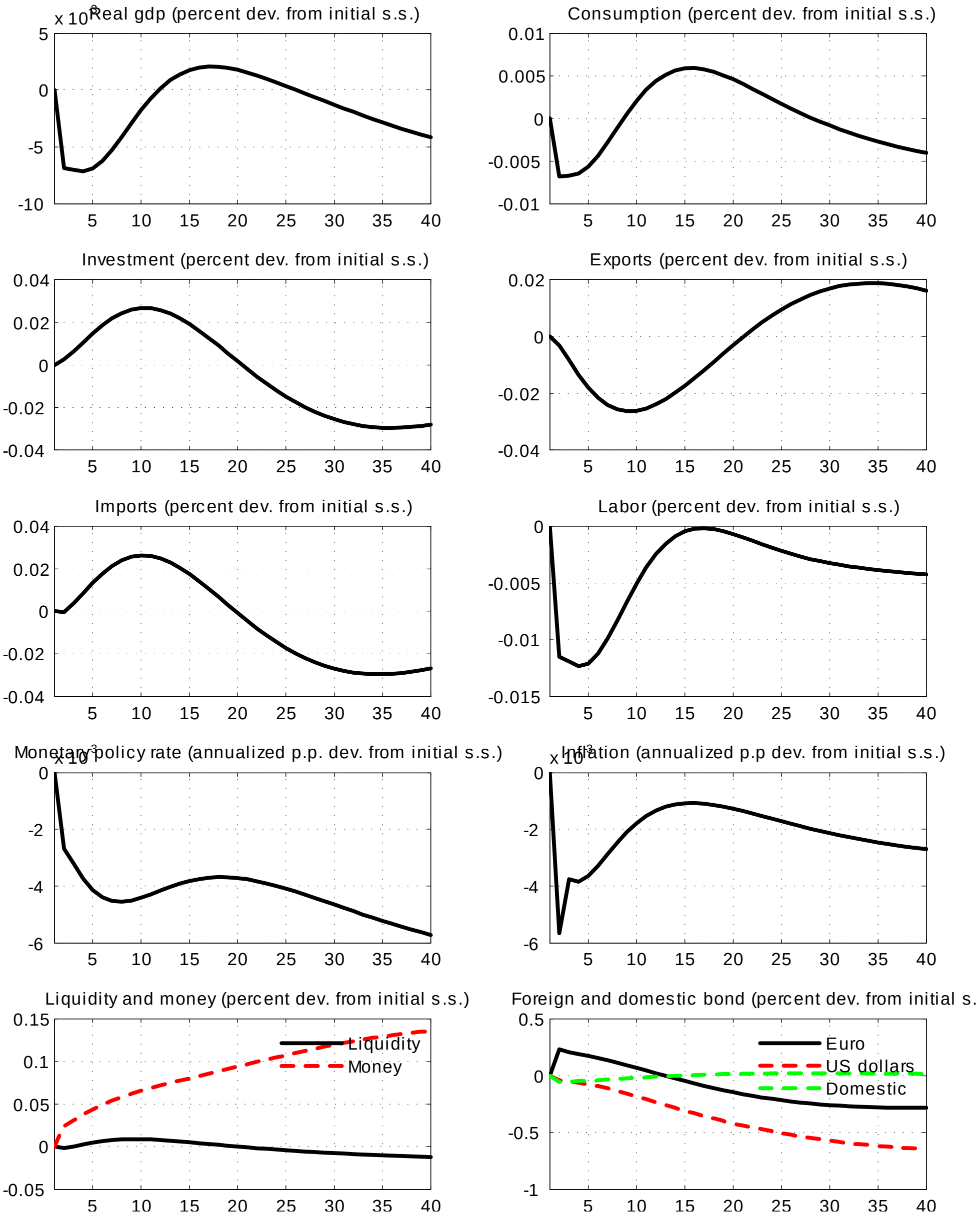
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; RW=rest of the world.

Figure 13: JAP and RW accumulate reserves, CHN pegs



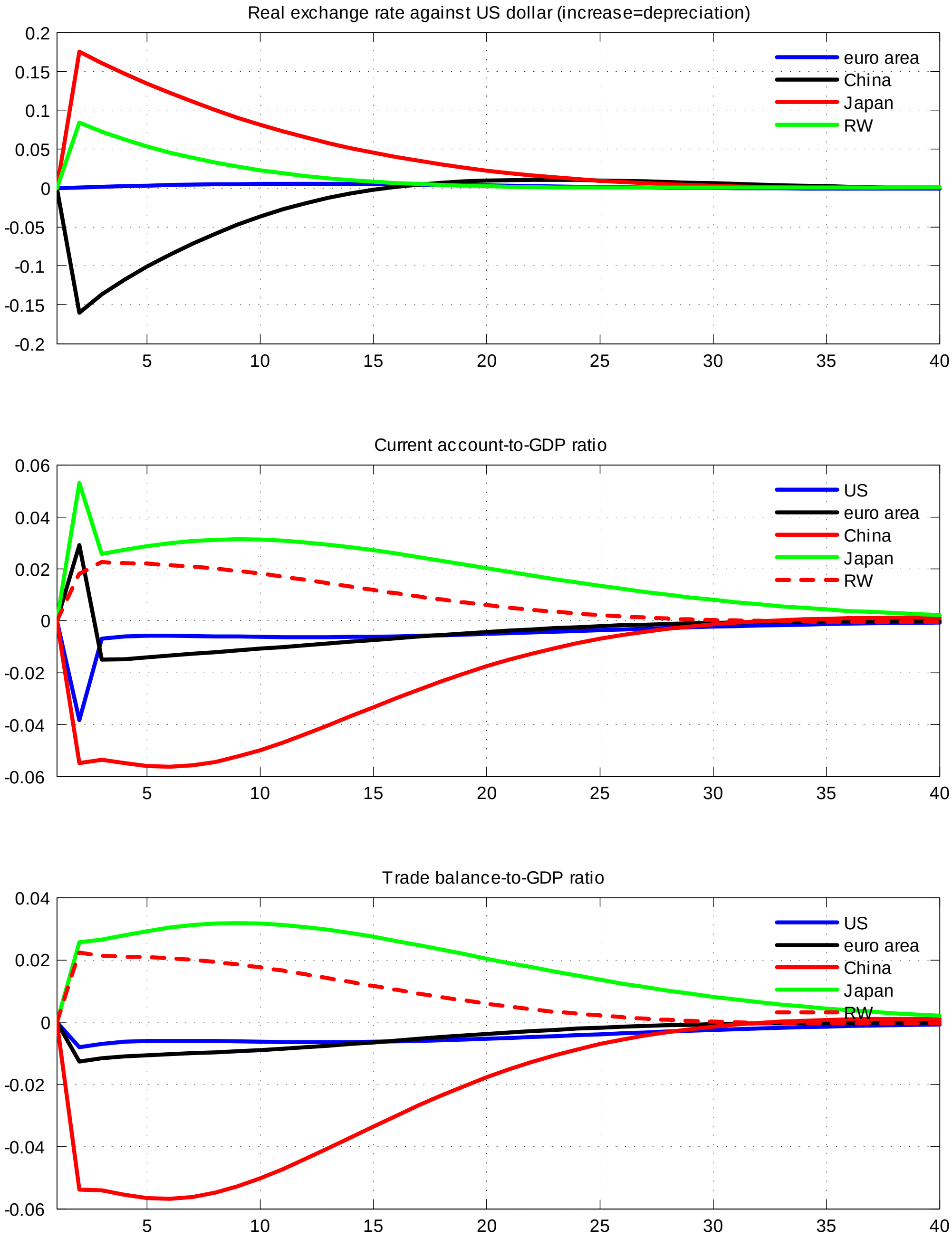
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 14: JAP and RW accumulate reserves, CHN pegs: CHN variables



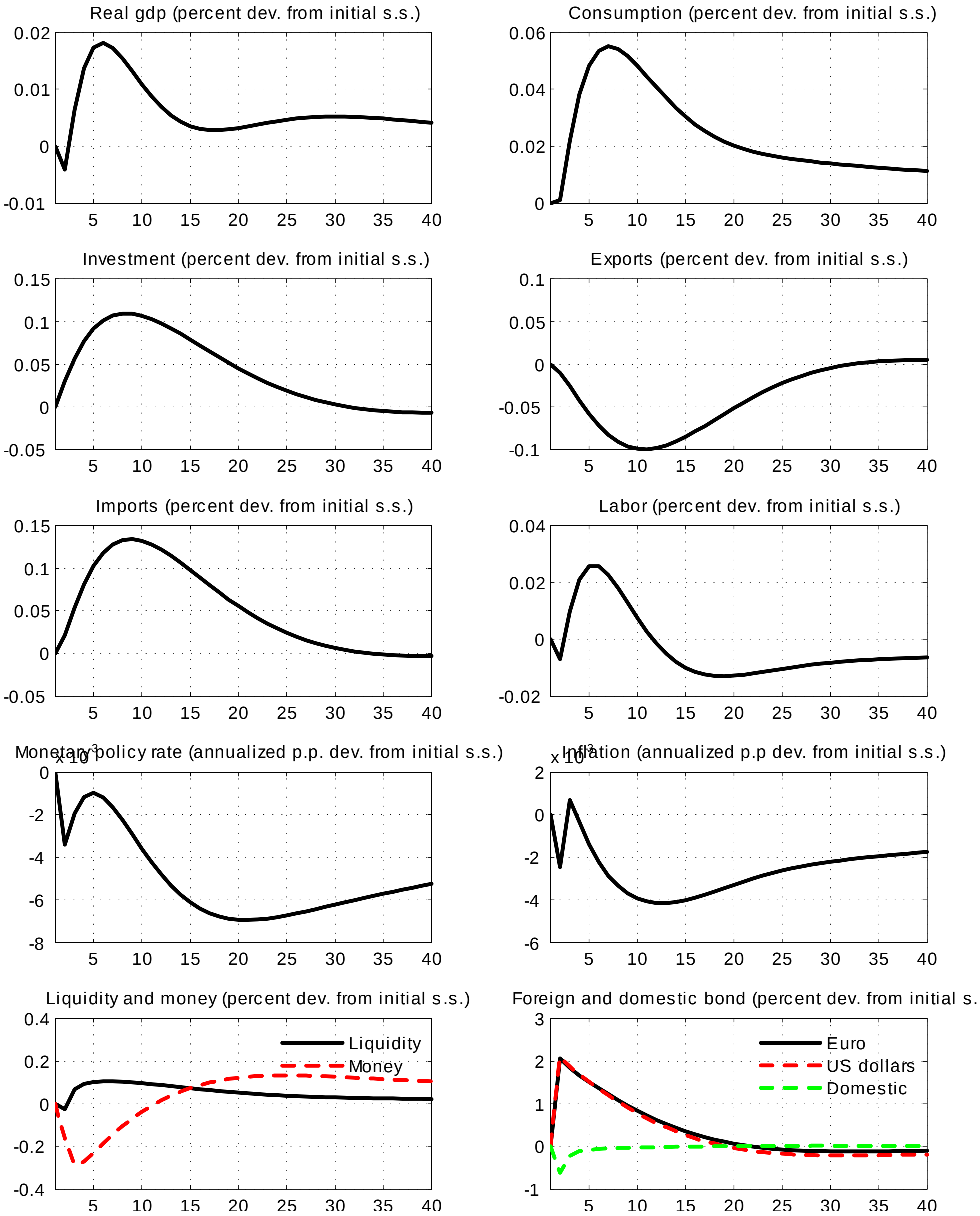
Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 15: JAP and RW accumulate reserves, CHN decumulates reserves



Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.

Figure 16: JAP and RW accumulate reserves, CHN decumulates reserves: CHN variables



Notes: horizontal axis, quarters; vertical axis, percentage points deviations from the baseline. CHN=China; JAP=Japan; RW=rest of the world.