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Capital inflows and euro area long-term interest rates

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Abstract

Capital flows into the euro area were particularly large in the mid-2000s and the share of foreign holdings of euro area securities increased substantially between the introduction of the euro and the outbreak of the global financial crisis. We show that the increase in foreign holdings of euro area bonds in this period is associated with a reduction of euro area long-term interest rates by about 1.55 percentage points, which is in line with previous studies that document a similar impact of foreign bond buying on US Treasury yields. These results are relevant both from a euro area and a global perspective, as they show that the phenomenon of lower long-term interest rates due to foreign bond buying is not exclusive to the United States and foreign inflows into euro area debt securities may have added to increased risk appetite and hunt-for-yield at the global level.

JEL No: E43, E44, F21, F41, G15.

Keywords: Capital flows, long-term interest rates

Non-technical summary

There is a large literature that focuses on how international capital flows contributed to the unusually low levels of US long-term interest rates in the mid-2000s, which former Chairman of the Federal Reserve Board Alan Greenspan referred to as a "conundrum". The coincidence of large capital inflows and low levels of long-term interest rates is however not a characteristic specific to the United States in the mid-2000s. In fact, capital flows into the euro area were particularly large in the mid-2000s and the share of foreign holdings of euro area securities increased substantially while the level of long-term interest rates was very low also in the euro area.

Against this background, the question arises whether a similar mechanism as the one that was behind the downward impact of foreign inflows into US securities might also have been at play in the euro area. The main objective of this paper is therefore to assess whether foreign purchases of euro area bonds since the introduction of the euro and in the run-up to the global financial crisis had a significant impact on euro area long-term interest rates.

The results indicate that, all else equal, the increase in foreign holdings of euro area bonds from the first quarter of 2000 to mid-2006 led to a decrease in euro area long term interest rates of around 1.55 percentage points over the long run, which is in line with other studies' findings on the impact of foreign bond buying on US long-term interest rates. These results are relevant both from a euro area and a global perspective, as they show that the phenomenon of lower long-term interest rates due to foreign bond buying is not exclusive to the United States and foreign inflows into euro area debt securities may have added to increased risk appetite and hunt-for-yield at the global level. Moreover, and in addition to the implications for monetary policy which needs to take into account the role of international capital inflows and global liquidity, the results are also relevant for macroprudential policy and financial stability. Further research avenues could therefore focus on developing macro models that explore the role of capital flows and link the developments in long-term interest rates across different countries, including both advanced and emerging economies.

1 Introduction

There is by now a large literature that focuses on how international capital flows contributed to the unusually low levels of US long-term interest rates in the mid-2000s, which former Chairman of the Federal Reserve Board Alan Greenspan referred to as a "conundrum" (Greenspan, 2005). According to the "global savings glut" hypothesis (see Bernanke, 2005, 2007) large — and possibly excessive — net savings in some regions of the world — in particular in emerging economies in Asia but also in oil exporting countries — triggered large net capital inflows into US securities which ultimately exerted downward pressure on US long-term interest rates. Specifically, Warnock and Warnock (2009) estimate that foreign official inflows into US Treasuries lowered 10-year Treasury yields by about 80 basis points in the twelve months ending May 2005.

The coincidence of large capital inflows and low levels of long-term interest rates is however not a characteristic specific to the United States in the mid-2000s. Figure 1 shows a strong comovement between euro area and US long-term interest rates with both series declining in the first half of the 2000s and up until end-2006. Over the same period, foreign purchases of both euro area and US securities were steadily increasing until end-2006 (see Figure 2).

[Insert Figures 1 and 2 here]

This evidence points to the possibility that the same mechanism that was behind the downward impact of foreign inflows into US securities might also have been at play in the euro area. Yet, to our knowledge there is so far no study which examines the impact that foreign bond buying in the first half of the 2000s had on long-term interest rates of the euro area or, more generally, of advanced economies other than the United States. This is striking for a number of reasons.

First, the question arises whether the results that have been found to hold for the United States can be generalised to other developed economies. This would further strengthen the evidence in favour of the hypothesis that there is a causal link going from foreign bond buying to long-term interest rates as it would show that the correlation that is documented for the United States is not due to characteristics which are specific to the United States and not easily controlled for in a single country framework, such as the role of US dollar reserve accumulation by Chinese authorities in the context of China's US-dollar pegged exchange rate regime.

In the pre-crisis period foreign acquisition of US debt securities was largely accounted for by Chinese residents and in particular the Chinese official sector. This reflects the accumulation of foreign exchange reserves by Chinese authorities under the US dollar-pegged exchange rate regime. The empirical literature on the link between foreign bond buying and long-term interest rates typically emphasises the usefulness of isolating purchases of the foreign official sector, as these are likely to be non-financially motivated and hence argued to be independent from yields. This in turn would allow for establishing a direction of causality from foreign bond buying to long-term interest rates. However, foreign official sector purchases might still respond to shocks which at the same time affect yields and hence the observed correlation may not reflect a causal link between the two variables. This is in particular the case for purchases of foreign official authorities that aim at maintaining a fixed bilateral exchange rate. For example, monetary policy shocks that negatively affect both interest rates and the exchange rate of the bond-issuing country may trigger bond purchases by the authorities of the pegging country in order to stem the appreciation pressure of the bilateral exchange rate vis-à-vis the bond-issuing country (and thereby also preserve the value of its foreign exchange reserves in domestic currency). This, in turn, could generate a negative correlation between foreign inflows and interest rates in the data which does however not reflect causality.

The euro area is arguably not affected by this potential bias stemming from large scale bond buying by authorities of large economies whose currencies are pegged to the currency of the bond-issuing economy. At the same time, the euro area is sufficiently "similar" to the United States to allow for a meaningful comparison given the size of the euro area economy and its financial market. Importantly, the euro is an important issuer of domestic currency denominated debt to global investors and has by now gained a track record as a reserve currency successfully continuing the heritage of the Deutsche Mark also during the crisis.[1]

Moreover, while the euro has not caught up with the US dollar in foreign exchange reserve portfolios, the euro area is already financially more open than the United States according to conventional measures. In particular, between 2003 and 2006 which corresponds to the period under inspection in this analysis, euro area cross-border positions (excluding intra-euro area holdings) exceeded those of the United States by on average about 60 percent of GDP (although the statistics might be partly contaminated by the effect

[1] See ECB (2014)

of round-tripping of euro area asset holdings through the United Kingdom).[2] Furthermore, the shares of foreign ownership in the total outstanding securities of all issuers are similar for both the United States and the euro area standing at around 25 percent in mid-2006 (see Table 1).

[Insert Table 1 here]

These stylised facts taken together with the process of growing financial integration, where international markets play an increasingly larger role in determining long-term interest rates, also exemplify that understanding the effects of foreign bond buying on euro area long-term interest rates is not only relevant to understand developments in the euro area itself but also globally. By contributing to an environment of low interest rates, these inflows might have led to increased risk taking in a hunt-for-yield context at the global level. Thus, understanding the funding process of the euro area is of the essence to get a more comprehensive picture of the global flow-of-funds.

Finally, since the euro area, in contrast to the United States, recorded a roughly balanced current account throughout the period under review, the significant foreign inflows into euro area securities also highlight the importance of understanding gross financial flows and stocks and the implications of the important linkages they establish (see Lane and Milesi-Ferretti, 2007).

The main objective of this paper is therefore to assess whether foreign purchases of euro area bonds since the introduction of the euro and in the run-up to the global financial crisis had a significant impact on euro area long-term interest rates. In order to take into account endogeneity issues, we follow Bandholz et al. (2009) and Beltran et al. (2013) and use a parsimonious vector error correction model (VECM) to estimate the effect of foreign holdings on euro area long-term interest rates. The results indicate that, all else equal, the increase in foreign holdings of euro area bonds from the first quarter of 2000 to mid-2006 led to a decrease in euro area long term interest rates of around 1.55 percentage points. These results are in line with other studies' findings on the impact of foreign bond buying on US long-term interest rates.

The remainder of this paper is organised as follows. Section 2 briefly discusses how capital flows affect long-term interest rates. Section 3 describes the data including our measure of foreign holdings. Section 4

[2] In the three-year periods 1999–2002, 2003–2006 and 2007–2010 the ratio of total foreign assets and liabilities to GDP amounted to 198, 254 and 336 percent, respectively, in the euro area compared to 140, 192 and 285 percent, respectively, in the United States according to IMF IFS data.

presents the econometric evidence and Section 5 performs several robustness checks of the baseline model. Finally, Section 6 concludes.

2 Capital flows and long-term interest rates

Warnock and Warnock (2009) and Bertaut et al. (2012) are among the first to document an economically large and statistically significant impact of foreign purchases of US government bonds on long-term interest rates. In particular, Warnock and Warnock (2009) argue that foreign purchases of US government bonds have contributed importantly to the low levels of US interest rates prior to the global financial crisis and estimate the total impact at around 80 basis points.

It is important to note that both studies regress 10-year US Treasury bond yields on foreign official sector purchases of US Treasury bonds as well as on holdings of US Treasury and US government agency bonds by means of OLS, arguing that — while total foreign purchases and holdings of US Treasury and Agency bonds might be endogenous to their yields — foreign official sector purchases and holdings should be exogenous. In order to explicitly address the issue of non-stationarity and endogeneity, Warnock and Warnock (2009) however also conduct robustness tests by estimating a VECM as in Bandholz et al (2009) and Beltran et al (2013), which all confirm an economically and statistically significant impact of foreign buying on US long-term interest rates.

The theoretical contributions reconciling the observed impact of asset demand on long-term interest rates with the expectations hypothesis generally emphasise the role of risk premia, i.e. the excess return over the expected future short-term interest rates that investors demand to hold an asset with a fixed long-term yield. There are two main types of models that explain how demand effects can have an impact on long-term interest rates.

On the one hand, portfolio balance theories show that by reducing the amount of a given maturity and thereby duration risk available in the market, purchases of long-term securities reduce the premium investors demand for that specific duration risk. This can be the case either because the marginal buyer of this specific duration risk who is dealing in the market is willing to pay a higher price for it, or alternatively because the average buyer decreases exposure to the specific duration risk and therefore demands a lower compensation to hold it (see Gagnon et al., 2010, Neely, 2010 and Bauer and Neely, 2012). Importantly, these effects are not necessarily confined to the asset being purchased but may also spill over to other assets.

On the other hand, preferred habitat models focus on heterogeneous investor preferences and imperfect substitutability between maturities and asset classes (see Vayanos and Vila, 2009). In these models, there are broadly two types of investors: those with preferences for specific maturities and risk-averse arbitrageurs. Faced with a demand shock in a given maturity that decreases yields, arbitrageurs will move along the yield curve looking for alternative higher yielding investment opportunities, while other investors with a preference for that specific maturity will stay put. The behaviour of arbitrageurs is the key mechanism of propagation of shocks to a specific maturity along the yield curve, the extent of which will however depend on their risk aversion. When risk aversion is high, arbitrageurs will be less willing to invest in other maturities and hence propagation will be low and demand shocks at longer maturities will produce larger impacts at the long end of the curve. Greenwood and Vayanos (2010) study two events that led to pressures in specific parts of the yield curve — the UK Pension Reform in 2004 and the Treasury buybacks in 2000 and 2001 — and conclude that demand and supply effects were important drivers of yields. Moreover, high risk aversion of arbitrageurs also implies that monetary policy will be less effective as forward rates will under-react to changes in short-term rates.

3 Data

The ECB publishes a quarterly stock series and a monthly flow series of euro area inward portfolio investment by foreign investors in its balance of payments and international investment position statistics. The flow series starts in January 1999 and the stock series starts in March 1999. Importantly, the series exclude intra-euro area flows and stocks, i.e. only transactions and holdings involving non-euro area residents are included.[3]

[3]Balance of payments statistics are however known to be subject to round-tripping issues. Given that balance of payments and international investment position statistics are compiled on a locational basis and following the residency concept, they also include transactions carried out by foreign branches of euro area investors located outside the monetary union, which should ideally be excluded from the analysis. In particular, the significant financial trade and cross-border positions between the euro area and the United Kingdom – about 50 percent of all assets and liabilities in end-2007, according to Milesi-Ferretti et. (2010) – as well as the strong presence of euro area banks' affiliates in the United Kingdom, suggest that a non-negligible

The series are further broken down into equity and debt securities and, therein, long-term debt securities (bonds and notes) and short-term debt securities (money market instruments). Since a breakdown for bonds and notes issued by the general government sector is only available from 2006 onwards at the quarterly frequency for both flows and stocks – the share of foreign ownership is roughly 23 percent of the total outstanding in June 2006 – we use inward portfolio investment in bonds and notes issued by *all* sectors[4]. The data do not identify the residence nor the sector of the foreign investor.[5]

We proceed to construct a series of *monthly* stocks of euro area bonds and notes issued by all domestic sectors and held by foreign residents, including both the foreign private sector and the foreign official sector. We start with the first available stock observation which is for March 1999 and end the sample in December 2006 to avoid any effects stemming from the emergence of the first financial market tensions before the outburst of the global financial crisis[6]. The series is constructed by accumulating monthly flows, interpolating to monthly frequency the remaining non-flow stock variation (price and exchange rate variations and other adjustments) and adding it to the observed quarterly stocks. Taking S_t as an observed quarterly stock (i.e., either March, June, September or December), our monthly stock for the two months per each quarter for which no data is available is given by:

$$S_{t+1} = S_t + fl_{t+1} + \frac{1}{3} nfl_{t,t+3} \tag{1}$$

and

$$S_{t+2} = S_{t+1} + fl_{t+2} + \frac{1}{3} nfl_{t,t+3} \tag{2}$$

amount of financial flows and holdings are likely to ultimately reflect the purchases of euro area securities by euro area investors. However, there is no way to disentangle these flows from those of UK investors or other investors who choose to use the United Kingdom as a platform to invest in the euro area.

[4]Sectoral detail is available for MFI inflows on a monthly basis but also only since 2006.

[5]The only alternative source that is able to partially shed light on the identity of the holder of euro area securities (in terms of residence and to a limited extent in terms of sector) is the Coordinated Portfolio Investment Survey (CPIS) published by the IMF. Countries report to the CPIS their holdings of foreign securities and derived liabilities are computed from the holdings data. However, the CPIS only provides annual stocks for the years 1997 and 2001–2011 and no flows are recorded. Moreover, only a limited number of countries report data and in particular some important emerging markets including China as well as many oil exporters do not participate in the survey. Therefore, the derived portfolio investment liabilities of the euro area are significantly underreported. Milesi-Ferretti et al. (2010) document that the discrepancy between euro area portfolio investment liabilities as derived from the CPIS and total portfolio investment liabilities of the euro area recorded in its international investment position as published by the ECB amounted to USD 3,500 billion in 2007.

[6]Although our focus is on the pre-crisis period, we also discuss the results for the extended sample encompassing the post-crisis period as a robustness check.

where $nfl_{t,t+3}$ is the non-flow component, which is given by

$$nfl_{t,t+3} = S_{t+3} - S_t - \sum_{i=1}^{3} fl_{t+i}. \quad (3)$$

This measure of monthly stocks is an observed value for the months that coincide with the end of each quarter. For the remaining months, it combines observed flows and evenly spreads out the non-flow component. Accumulating flows to observed stocks is also a standard technique employed by statisticians whenever observed (or better data) are not available.

As a measure of long-term interest rates we use 10-year government benchmark bond yields as published by the ECB. The series is derived by weighting the yields of euro denominated government benchmark bonds issued by the central governments of euro area countries and included in the ECB eligible asset database with the monthly outstanding amounts of these bonds.[7] We use the 3-month Euribor rate as a measure of short-term interest rates. As a measure of inflation expectations we use realised seasonally adjusted HICP inflation excluding energy and food, since core inflation is often argued to be a better predictor of future inflation than headline inflation (see Kiley, 2008). We use realised inflation as data on break-even inflation are only available from the mid-2000s and survey-based inflation measures are subject to certain limitations regarding the timing of data and the forecast horizon covered (see ECB, 2011).

Figure 3 plots the 12-month cumulated first differences of the term premium – i.e. the difference between the long- and the short-term interest rates – and the foreign holdings variable between March 2000 and December 2006. The figure shows that, in general, periods of rapid growth in foreign holdings are associated with a fall in the term premium. The most prominent examples of the latter are the period starting in the first quarter of 2000 and ending in the third quarter of 2001 and the period starting in the third quarter of 2004 and ending in the first quarter of 2006. To the contrary, the term premium rebounded in end-2001 and beginning 2002, as well as in end-2003 and beginning 2004, when foreign holdings were growing at a more modest pace.

[Insert Figure 3 here]

[7] We use end-of-period yields as they contain all the relevant information of the given month and using monthly averages could introduce smoothness in the data that may lead to residual autocorrelation (see Gujarati, 1995)

4 Econometric evidence

4.1 Vector error correction model

Since a series that identifies foreign official sector transactions and holdings of euro area securities is not available and therefore our measure of flows and stocks of euro area portfolio investment inflows into long-term debt securities also includes private investors, exogeneity of holdings to yields cannot be assumed. Thus we estimate a parsimonious VECM along the lines of Bandholz et al. (2009), Beltran et al. (2013) and Warnock and Warnock (2009), which is appropriate to deal with non-stationary but cointegrated variables. Given that we are chiefly interested in the level relationship, using financial stocks is more appropriate than flows. Note however that in the short-run dynamics foreign holdings are differentiated and therefore largely reflect the variation of financial flows, however in addition to a valuation component. The system can be written as follows:

$$\Delta\mathbf{Y}_t = \underbrace{\sum_{k=1}^{n}\mathbf{\Gamma}_k\Delta\mathbf{Y}_{t-k}}_{\text{short-run}} + \underbrace{\mathbf{\Pi}\mathbf{Y}_{t-1}}_{\text{long-run}} + \epsilon_t \tag{4}$$

where $\mathbf{Y}_t$ is a vector containing the endogenous variables, $\mathbf{\Gamma}_k$ is the matrix of the short-run coefficients and $\mathbf{\Pi}$ the matrix of the long-run coefficients.

Initial tests show that the null hypothesis of a unit root cannot be rejected for the four variables in the March 1999 to December 2006 period. Moving to the model estimation, we first estimate an unrestricted VAR with the four variables. We then look at the usual lag length criteria to choose the appropriate number of lags. Both the Schwarz and Hannan-Quinn criteria indicate that one lag is sufficient while other criteria point to twelve lags. We focus on the most restrictive criteria given the small sample size of 94 observations from March 1999 to December 2006. We run cointegration rank tests using one lag and find that both the trace and maximum eigenvalue statistics indicate that one relationship between the four variables exists (see Table 2). We estimate a VAR with the same variables in differences and look again at the lag length criteria, which point to one lag as being enough. Accordingly, we specify a VECM with one cointegration equation and allowing for one lag in the short-run dynamics. Finally, we test for residual autocorrelation of the VECM of which we find no evidence.

[Insert Table 2 here]

With these results, the VECM simplifies to the following equation:

$$\begin{pmatrix} \Delta i_t^l \\ \Delta i_t^s \\ \Delta \pi_t^e \\ \Delta FH_t \end{pmatrix} = \mathbf{\Gamma} \begin{pmatrix} 1 \\ \Delta i_{t-1}^l \\ \Delta i_{t-1}^s \\ \Delta \pi_{t-1}^e \\ \Delta FH_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha^l \\ \alpha^s \\ \alpha^\pi \\ \alpha^{FH} \end{pmatrix} (1 \beta^s \beta^\pi \beta^{FH} \kappa) \begin{pmatrix} i_{t-1}^l \\ i_{t-1}^s \\ \pi_{t-1}^e \\ FH_{t-1} \\ 1 \end{pmatrix} + \epsilon_t \tag{5}$$

where i^l is the long-term interest rate, i^s is the short-term interest rate, π^e is expected inflation and FH is our measure of foreign holdings of euro area debt securities normalised by nominal GDP.

4.2 Results

The VECM estimates are displayed in Table 3. The level coefficients are all significant and have the expected signs. Long-term interest rates increase in the short-term interest rate as well as inflation expectations and decrease with foreign holdings. The coefficients on the short-term interest rate and inflation expectations suggest that a one percentage point increase in these variables is associated with a 0.25 and 0.43 percentage point increase in the long-term interest rate, which is close to the estimates obtained by Bandholz et al. (2009) and Warnock and Warnock (2009).[8] The coefficient on foreign holdings indicates that a one percentage point increase in foreign holdings of euro area debt securities lowers the long-term interest rate by about 13 basis points. Finally, the error correction term for the long-term interest rate is also statistically significant, as is also the error correction term of the short-term interest rate. The error correction coefficient of expected inflation turns out to be insignificant which is unsurprising given that we proxy it with realised inflation which we do not expect to respond contemporaneously to the system. The error correction coefficient for foreign holdings is also insignificant suggesting that foreign holdings are weakly exogenous in the system, in line with the results in Bandholz et al. (2009).

[Insert Table 3 here]

[8] The coefficient estimates for the short-term interest rate in Bandholz et al. (2009) and Warnock and Warnock (2009) are -0.21 and -0.34, and the coefficient estimates for inflation expectations are -0.55 and -0.54.

We look again at our coefficient on foreign holdings and the coefficients of other studies to see how our results for the euro area compare with those of similar studies based on US data. In order to get a meaningful comparison across the available studies we take into account the different scales used in the normalisation of foreign holdings as well as the different time samples and compute the total impact of the change in foreign holdings for a common time period. We choose the period ranging from March 2000 to June 2006. The reason is that in this study as well as the studies based on US data, the holdings series are constructed by augmenting stock data which are not available on a monthly basis with monthly flow data. In order to base the comparison on the data with the best quality we prefer to identify dates when for both economies the stock data are available. While for the euro area stock data are available for each quarter, for the United States stock data are compiled less frequently in the Treasury International Capital System survey. The two survey dates that are closest to the beginning and the end of our sample are March 2000 and June 2006.

Column 2 of Table 4 indicates the foreign holdings variable used, column 3 reports the scale measure, columns 5 and 6 the initial and final foreign holdings values and finally column 7 the total impact which results from the coefficient multiplied by the change from the initial to the final stock. Our results indicate that, all else equal, the increase in foreign holdings of euro area long-term debt securities decreased euro area long-term interest rates by 1.55 percentage points in the period. Our estimate for the total impact falls within the same ballpark as those of other studies, albeit somewhat higher.

[Insert Table 4 here]

There are a few candidate explanations for the higher estimated impact in the case of the euro area. First of all, our measure of foreign holdings is more encompassing than that of other studies since it includes *all* domestic issuer sectors vis-à-vis *all* foreign holding sectors. To the contrary, other US studies only include official foreign holdings of the domestic government sector — except for Bandholz et al. (2009) who include all foreign holding sectors and also estimate a somewhat higher impact than the other US studies. Second, Beltran et al. (2013) argue that the long-term impact in Bertaut et al. (2012) may be downward biased because of the exogeneity assumption of foreign official holdings. The intuition is that in periods of heightened uncertainty, safe haven flows into US Treasuries by global investors will put downward pressure on US long-term interest rates and upward pressure on the dollar exchange rate. This, in turn, reduces the need for reserve accumulation in the form of US Treasuries for some monetary authorities which otherwise regularly intervene to counter domestic appreciation pressures. Finally, cross-border flows due to round-tripping which ultimately reflect the buying of euro area securities by euro area residents might lead to an upward bias of the estimated impact.

4.3 Foreign vs domestic holdings

Given the data limitations discussed and our foreign holdings measure, it is not clear to which extent the results obtained in the previous subsections might be driven by (i) foreign official inflows into euro area safe assets and/or (ii) round-tripping, whereby purchases recorded in extra-euro area financial centres such as London ultimately represent purchases of domestic residents. One way to address this issue is to investigate if the relationship we found is specific to foreign holdings only or whether foreign and domestic holdings are driven by similar forces. If, in fact, significant differences can be found, then these should alleviate the concerns that the relationship found regarding foreign holdings stems from such round-tripping practices.

For this purpose, as an initial step, we compute domestic holdings as a residual of the monthly total outstanding amount of euro area long-term debt securities issued by all resident sectors, and our measure of foreign holdings of euro area long-term debt securities. With the latter measure, we firstly run a model with the same variables as in our benchmark specification but using *domestic* instead of foreign holdings. We proceed following the same steps as previously. Lag length criteria point to one lag as being sufficient for the VAR. Cointegration tests indicate that one relationship between the four variables exists (see Table 5). Finally, lag length criteria regarding the VAR in differences also indicate that one lag is sufficient. The results for the VECM with these characteristics are displayed in Table 6. In broad terms, although the coefficients in the cointegration equation – and in particular that on the domestic holdings variable – have the expected signs and are all significant, the error correction term is not, thus indicating that the long-term relationship between these variables does not hold.

[Insert Tables 5 and 6 here]

In a second specification, we extended the previous model to include both foreign and domestic holdings of euro area long-term debt securities. Cointegration tests now point to the existence of two cointegration equations (see Table 5) – the remaining lag length criteria give the same indications as before. Since now two long-term relationships exist, restrictions are needed to estimate the VECM. We associate the first cointegration equation with foreign holdings and the second with domestic holdings. Accordingly, we impose the coefficient on domestic holdings to be zero in the first equation and the coefficient on foreign holdings to be zero in the second equation; in both cases, we normalize all coefficients by the coefficient on the long-term interest rate.

The resulting VECM is displayed in Table 7. Again, in both cases the coefficients in the cointegration equations have the expected signs and are significant. However, while the error correction term for the first cointegration equation has the expected negative sign, the coefficient on the second equation has a positive sign. Thus, not only does the long-term relationship between the interest rates and inflation variables with domestic holdings not hold, but also the benchmark relationship with foreign holdings holds despite the inclusion of the additional variable.

[Insert Table 7 here]

In a final estimation, we check whether the euro area issuer sector is relevant for our analysis. We run the specification with both foreign and domestic holdings on corporate yields of different ratings. Specifically, the yields are taken from Datastream and pertain to 7 to 10 year securities issued by the euro area corporate sector, encompassing AAA, AA, A and BBB ratings.[9] Cointegration tests (not provided) rule out a long-term relationship for A and BBB ratings; in turn, tests are inconclusive for AAA and AA ratings – see Table 5. The respective VECM results, displayed in Table 8 confirm that the long-term relationship does not exist as, once more, and in both cases, the error correction term is not significant.

[Insert Table 8 here]

To sum up, these estimations point to a differentiated relationship between euro area long-term interest rates and domestic/foreign holdings. Furthermore, they also show that the issuer sector is relevant, as the long-term relationship is circumscribed to general government yields. Taken together, this evidence

[9] These series initial data point is January 2000.

indicates that foreign official inflows are likely to have a significant role in total foreign inflows into euro area general government long-term debt securities. In this sense, these results are consistent with those of other US studies, namely Beltran et al. (2013), who find that, within foreign holdings of US Treasury bonds, only those of official entities are associated with lower yields.

5 Robustness checks

5.1 Trend in data

Given that our foreign holdings variable is trending upwards throughout the whole sample and long-term interest rates are trending downwards, the results could partly reflect a combination of these two trends. To test whether this is the case, we re-run the model including a linear trend t in the cointegration relation of the benchmark model in equation 5. We get qualitatively the same results regarding the cointegration tests (see Table 2). The VECM results which are displayed in Table 9 suggest that our findings are not driven by a combination of trends. First, the trend coefficient β^t is not statistically significant. Second, despite the inclusion of the trend, the coefficient on the level of foreign holdings is still statistically significant, indicating that there is an effect of foreign holdings on long-term interest rates over and above that of the trend in the data. Furthermore, all other level coefficients in the model remain broadly in line with the results obtained in the benchmark model.

[Insert Table 9 here]

5.2 Sample size

Given that our sample is smaller than that typically used in studies based on US data we repeat the exercise using the autoregressive distributed lag (ARDL) approach of Pesaran and Shin (1999) taking advantage of the small sample properties of this method. Despite being asymptotically equivalent, there are two reasons why the Johansen procedure and ARDL might yield different results. First, whereas the Johansen approach relies on maximum likelihood to estimate the model, ARDL uses OLS. Second, ARDL is a uni-equation model, in contrast to the VECM system of Johansen. Our ARDL specification can be written as:

$$\Delta i_t^l = \gamma_1 + \gamma^l \Delta i_{t-1}^l + \gamma^s \Delta i_{t-1}^s + \gamma^\pi \Delta \pi_{t-1}^e + \gamma^{FH} \Delta FH_{t-1} + \delta^l i_{t-1}^l + \delta^s i_{t-1}^s + \delta^\pi \pi_{t-1}^e + \delta^{FH} FH_{t-1} + \epsilon_t \quad (6)$$

where the coefficients have the same interpretation as before.

In order to determine whether a cointegration relationship in the period under consideration exists we rely on the bounds approach as described in Pesaran et al. (2001). Specifically, this approach is valid regardless of whether the regressors are $I(0)$, $I(1)$ or mutually cointegrated. For this reason, the authors provide two sets of asymptotic critical values for the two extreme cases, i.e., when (i) the regressors are all purely $I(1)$ and (ii) the regressors are all purely $I(0)$. Therefore, a conclusive test inference can only be drawn whenever the test statistics falls outside of the critical value bounds. If, to the contrary, the test statistics falls within the mid-range defined by the critical value bounds, no conclusion can be taken and prior knowledge of the integration order of the underlying regressors is needed.

We test the joint significance of the coefficients in the cointegration equation based on the critical values provided in Pesaran et al. (2001). Specifically, we use Table CI(iii) in the paper since the specification includes an unrestricted intercept and no trend and $k = 3$ given that we are regressing long-term interest rates on three explanatory variables. The F-statistic testing for the null hypothesis $\delta^l = \delta^s = \delta^\pi = \delta^{FH} = 0$ yields 4.38, which is higher than the critical value for $I(1)$ regressors at the 5 percent level and therefore we can conclusively reject the null hypothesis that a level relationship does not exist.

To compare the ARDL results with those obtained in our benchmark model, we normalise the lagged level coefficients by the yield coefficient and include an error correction term, which amounts to rewriting the model as follows:

$$\Delta i_t^l = \gamma_1 + \gamma^l \Delta i_{t-1}^l + \gamma^s \Delta i_{t-1}^s + \gamma^\pi \Delta \pi_{t-1}^e + \gamma^{FH} \Delta FH_{t-1} + \alpha(i_{t-1}^l + \beta^s i_{t-1}^s + \beta^\pi \pi_{t-1}^e + \beta^{FH} FH_{t-1}) + \epsilon_t. \quad (7)$$

As shown in Table 9, the coefficient on foreign holdings is almost the same as that obtained using the Johansen method in our benchmark model. Moreover, the remaining coefficients are broadly in line with our previous results.

5.3 Global factors and US long-term interest rates

Boivin and Gianonni (2008) show that the correlation between US long-term interest rates and global factors (including measures of economic activity, prices, short- and long-term interest rates of the United States' 15 largest trading partners) increases significantly in the period between 1984 and 2005. Similarly Diebold et al. (2008) and Kaminska et al. (2011) show that global inflation and the global business cycle affect long-term interest rates of advanced economies in addition to domestic factors. Against this background the question arises whether the downward impact we are assigning to foreign holdings of euro area securities on long-term interest rates is in fact driven by other factors, such as the environment of lower global inflation and lower business cycle volatility in the period under consideration.

Since the global variables should be reflected in US long-term interest rates, we use the latter as a proxy for global factors and check how their inclusion affects the results of our benchmark model. Moreover, Favero and Giavazzi (2008) and Chinn and Frankel (2005, 2007) argue that euro area long-term interest rates follow US long-term interest rates. Van Landschoot (2008) also finds empirical evidence supporting the claim that US interest rates have a significant impact on European interest rates. It is however out of the scope of this paper to address the question of causality between euro area and US long-term interest rates. For this reason, we check whether our results are robust to the inclusion of US long-term rates both taken as exogenous and endogenous.

First, we add end-of-period 10-year US Treasury bond yields taken from Bloomberg as an exogenous variable to our benchmark model. Results are displayed in Table 10. The coefficients are robust to the inclusion of the US long-term interest rate. In particular, the long-term coefficient on our foreign holdings variable – while slightly lower – remains significant. In turn, the coefficient on US long-term interest rates has the expected positive sign, indicating that an increase (decrease) in the US interest rate leads to an increase (decrease) in that of the euro area.

[Insert Table 10 here]

Turning to the second case, we expand the original set of euro area variables in the baseline model by including the same variables for the United States as endogenous. In addition to the 10-year US Treasury bond yields as a measure of long-term interest rates, we use the 3-month Libor rate as a measure of short-term interest rates and seasonally adjusted inflation excluding energy and food from the US Bureau of Labour Statistics, taken from the Federal Reserve Economic Data of the Federal Reserve Bank of St. Louis.

There is no measure of foreign holdings of US debt securities that would be directly comparable to the series constructed for the euro area. First, balance of payments data for the US are not available at the monthly frequency. Second, balance of payments statistics and international investment position data published by the Bureau of Economic Analysis do not provide flow or stock measures of total liabilities of long-term debt securities that would be consistent with our measures for the euro area. At the same time, stocks published by the IMF – which are consistent with our measure – are published only at the annual frequency. We therefore resort to the monthly stocks of foreign holdings of US securities constructed by Bertaut and Tryon (2007) based on a combination of annual survey data and monthly flow data from the Treasury International Capital System (TICS) database. Specifically, we use holdings of Treasuries, Agencies and corporate bonds scaled by GDP (in order to be consistent with the scaling applied to the euro area foreign holdings measure).

Before adding the US data to our bechnmark model, we test whether our US data are appropriate by running our benchmark model with US data only. The VECM results are presented in Table 11. Our foreign holdings coefficient turns out to be almost identical to that in Bandholz et al (2009) – 0.088 and 0.081 respectively – which provides the only study that does not use a split between official and private holdings of US securities.

[Insert Table 11 here]

We then proceed with the model including both euro area and US long-term interest rates as endogenous. Lag length criteria point to either one or three lags. Cointegration tests indicate that three cointegration relations exist, except for the trace test when using one lag which favours five relations (see Table 12). Lag length criteria on the same VAR in differences indicate no lags or one lag. We therefore proceed with three cointegration relations for parsimony and estimate two VECMs: one with no short-run dynamics and a second with one lag. To estimate the VECMs we impose the following restritions: (i) we define the first cointegration equation to be the euro area model – i.e., forcing the coefficients on the US variables to be zero and normalising the remaining by the coefficient on the euro area long-term interest rate – (ii) the second cointegration equation the US model – i.e., forcing the coefficients on the euro area variables to be zero and normalising the remaining by the coefficient on the US long-term interest rate – and (iii) the last cointegration equation establishes a relationship between both long-term interest rates – i.e., forcing all variables to be zero except both euro area and US long-term interest rates (normalized by the euro area rate). The global model results are displayed in Table 13. The long-term coefficients continue to have the expected signs and are close to those of our benchmark model, confirming robustness of our results to the inclusion of these additional US variables.

[Insert Tables 12 and 13 here]

5.4 Financial crisis period

Following Beltran et al. (2013) we extend the sample to also cover the period since the outburst of the global financial crisis. As they point out, the high levels of volatility during the financial crisis including the Lehman collapse, the drying out of interbank markets, unconventional monetary policies such as the Fed's Large Scale Asset Programmes or the ECB's Securities Market Programme and the announcements with regard to Outright Monetary Transactions, may have had an impact on the relations we are exploring in this paper. Moreover, in the particular case of the euro area, the sovereign debt crisis is an additional factor, as our analysis is based on measures of long-term interest rates and foreign holdings which are effectively composed of information pertaining to the different euro area countries.

We run cointegration tests for our model extending the euro area sample beyond December 2006 in six-month blocks. As our analysis is based on foreign buying by all sectors, whereas Beltran et al. (2013) differentiate between foreign official and private buying, our results would not be directly comparable. We therefore also run rolling cointegration tests for the US model, however, using the measure of monthly stocks of foreign holdings of US securities constructed by Bertaut and Tryon (2007). It turns out that in both cases the cointegration relationship breaks when the sample is extended to include data up to December

2008.

This break in the relationship between foreign purchases and long-term interest rates could reflect the choice of our measure of foreign holdings. Figure 4 plots the measure used in the econometric analysis, i.e. foreign purchases of debt issued by *all* sectors, against the foreign purchases of debt issued by the general government which is only available from 2006 onwards at the quarterly frequency. It turns out that both measures start to diverge around the last quarter of 2008, suggesting that the decoupling of private from public liability flows led to a weakening of the relationship between foreign purchases issued by all sectors and the level of benchmark long-term interest rates.

[Insert Figure 4 here]

5.5 Other exogenous factors

In a last robustness check, we also add the euro area industrial production index to proxy for GDP growth and the VIX to proxy for risk aversion as exogenous variables. Results are displayed in Table 10. There is no qualitative change to the overall results and the coefficient estimate on the measure of risk aversion is statistically significant and economically plausible suggesting that yields on government bonds decrease when risk aversion is high.

6 Conclusion

Foreign ownership of securities issued by euro area residents has increased considerably since the introduction of the euro and in the run up to the global financial crisis. We set out to see whether the increase in cross-border holdings had an impact on long-term interest rates, as is already documented for the United States in several studies. We show that there is in fact a statistically significant impact: all else equal, the increase in foreign holdings in the period led to a decrease in euro area long-term interest rates of 1.55 percentage points.

These results are relevant both from a euro area and a global perspective, as they show that the phenomenon of lower long-term interest rates due to foreign bond buying is not exclusive to the United States and foreign inflows into euro area debt securities may have added to increased risk appetite and hunt-for-yield at the global level. In particular, in addition to the implications for monetary policy which needs to take into account the role of international capital flows and global liquidity, the results are also relevant for macroprudential policy and financial stability. Further research avenues could therefore focus on developing macro models that explore the role of capital flows and link the developments in long-term interest rates across different countries, including both advanced and emerging economies.

References

[1] Bandholz, H., J. Clostermann and F. Seitz (2009), "Explaining the US bond yield conundrum", Applied Financial Economics, Vol. 19(7), pp. 539–50.

[2] Bauer, M. D. and C. J. Neely (2012), "International Channels of the Feds Unconventional Monetary Policy", Federal Reserve Bank of St. Louis, Working Paper No. 2012-028A

[3] Beltran, D., M. Kretchmer, J. Marquez and C. Thomas (2013), "Foreign Holdings of U.S. Treasuries and U.S. Treasury Yields", Journal of International Money and Finance, Vol. 32, pp. 1120–1143

[4] Bernanke, B. S. (2005), "The Global Saving Glut and the U.S. Current Account Deficit", speech delivered at the Sandridge Lecture, Virginia Association of Economists, Richmond, Va., March 10.

[5] Bernanke, B. S. (2007), "Global Imbalances: Recent Developments and Prospects", speech delivered at the Bundesbank Lecture, Berlin, Germany, September 11.

[6] 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, Vol. 88(2), pp. 219–34.

[7] Bertaut, C., R. Tryon (2007), "Monthly Estimates of U.S. Cross-Border Securities Positions", Board of Governors of the Federal Reserve System International Finance Discussion Papers No. 910.

[8] Boivin, J. and M. P. Giannoni (2008), "Global Forces and Monetary Policy Effectiveness", National Bureau of Economic Research, Inc NBER Working Papers 13736.

[9] Chinn, M. and J. Frankel (2005), "The euro area and world interest rates", Wisconsin and Harvard mimeo.

[10] Chinn, M. and J. Frankel (2007), "Debt and interest rates - the US and the euro area", Economics Discussion Paper 2007-11.

[11] Diebold, F. X., C. Li and V. Z. Yue (2008), "Global yield curve dynamics and interactions: A dynamic Nelson-Siegel approach", Journal of Econometrics, Vol. 146(2), pp. 351–63.

[12] ECB (2011), "Inflation expectations in the euro are: a review of recent developments", European Central Bank, Monthly Bulletin February 2011.

[13] ECB (2014), "The international role of the euro", European Central Bank.

[14] Favero, C. and F. Giavazzi (2008), "Should the euro area be run as a closed economy?", American Economic Review, Papers and Procedings Vol. 98(2), pp. 138–145.

[15] Gagnon, J., M. Raskin, J. Remache and B. Sack (2010), "Large-scale asset purchases by the federal reserve - did they work?", Federal Reserve of New York Staff Report 441.

[16] Greenspan, A. (2005), "Testimony before the committee on banking, housing, and urban affairs of the US Senate on February 16, 2005."

[17] Greenwood, R. and D. Vayanos (2010), "Price pressure in the government bond market ", American Economic Review, Papers and Procedings Vol. 100, pp. 585–590.

[18] Gujarati, D. N. (1995), "Basic Econometrics, 3rd edn,", McGraw-Hill, Singapore.

[19] Kaminska, I., A. Meldrum and J. Smith (2011), "A global model of international yield curves: no-arbitrage term structure approach", Bank of England Working Paper No. 419.

[20] Kiley, M. T. (2008), "Estimating the common trend rate of inflation for consumer prices and consumer prices excluding food and energy prices, 2003-2007", Board of Governors of the Federal Reserve System, Finance and Economics Discussionr Series No. 2008-38.

[21] Lane, P. and G. M. Milesi-Ferretti (2007), "Europe and global imbalances", Economic Policy, 22(51), pp. 519–573.

[22] Milesi-Ferretti, G. M., F. Strobbe and N. Tamirisa (2010), "Bilateral financial linkages and global imbalances a view on the eve of the financial crisis", International Monetary Fund Working Paper No. 10/257.

[23] Neely, C. J. (2010), "The Large-Scale Asset Purchases Had Large International Effects", Federal Reserve Bank of St. Louis Working Paper No. 2010-018D.

[24] Pesaran, M. H. and Y. Shin (1999), "An autoregressive distributed lag modelling approach to cointegration analysis ", Chapter 11 in Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, Strom S (ed.). Cambridge University Press: Cambridge.

[25] Pesaran, M. H., Y. Shin and R. J. Smith (2001), "Bounds testing approaches to the analysis of level relationships ", Journal of Applied Econometrics Vol. 16, pp. 289–326.

[26] Treasury Department, Federal Reserve Bank of New York, and Board of Governors of the Federal Reserve System (2008), "Report on foreign holdings of US securities as of June 2007 ".

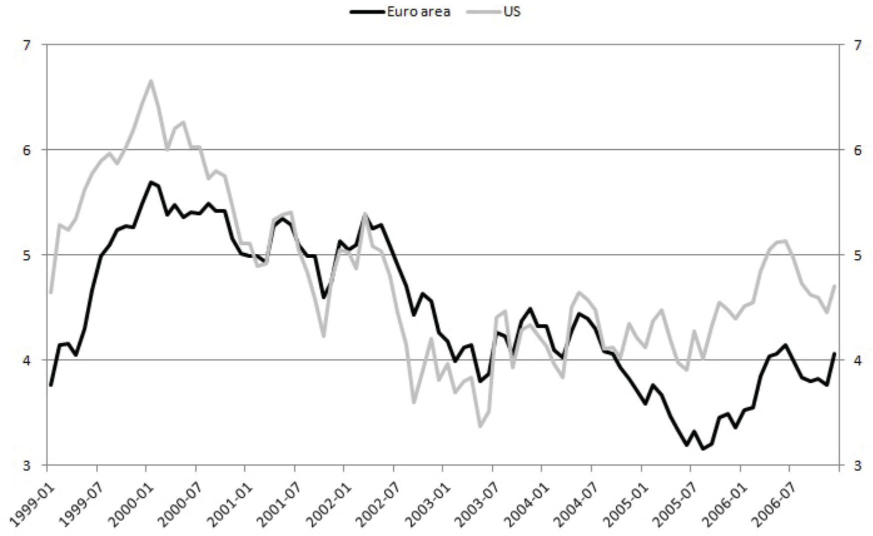
[27] Treasury Department, Federal Reserve Bank of New York, and Board of Governors of the Federal Reserve System (2012), "Report on foreign holdings of US securities as of June 2011 ".

[28] Van Landschoot, A. (2008), "Determinants of yield spread dynamics: euro versus US dollar corporate bonds", Journal of Banking and Finance Vol. 32, pp. 2597-2605.

[29] Vayanos, D. and J.-L. Vila (2009), "A preferred-habitat model of the term structure of interest rates", National Bureau of Economic Research, Inc NBER Working Papers 15487.

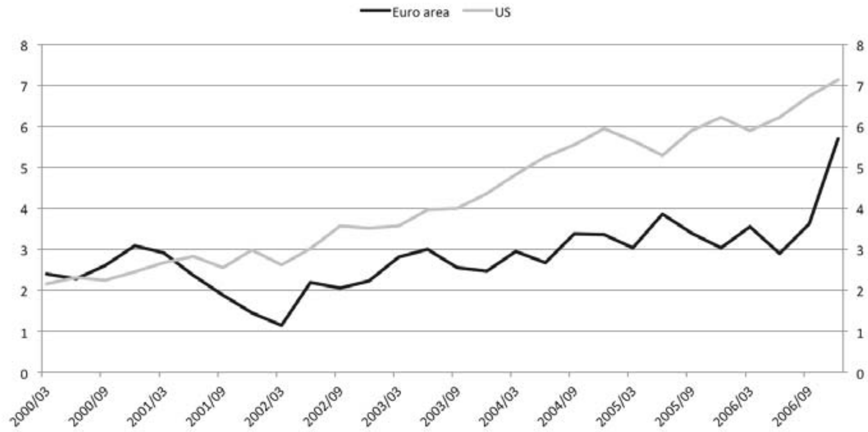
[30] Warnock, F.E., and V.C. Warnock (2009), "International capital flows and U.S. interest rates", Journal of International Money and Finance, Vol. 28, pp. 903–19.

Figure 1: Long-term interest rates
(percent, January 1999 – December 2006)



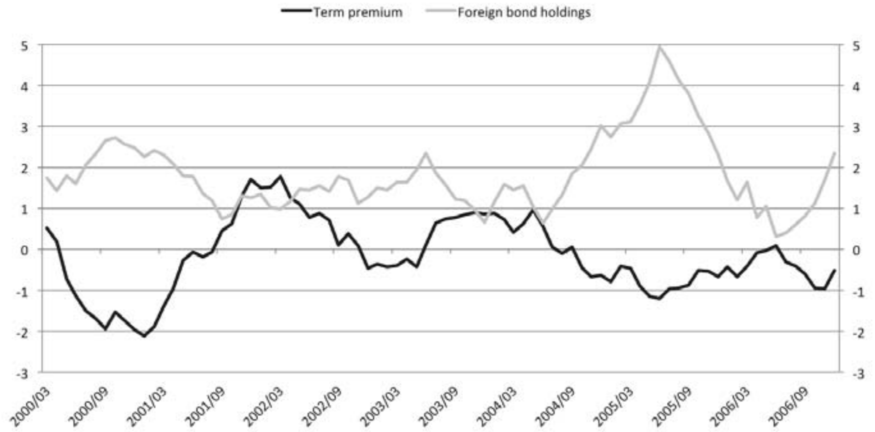
Source: ECB and Datastream.

Figure 2: Foreign bond inflows
(percentage of GDP, 4-quarter cumulated, 2000Q1 – 2006Q4)



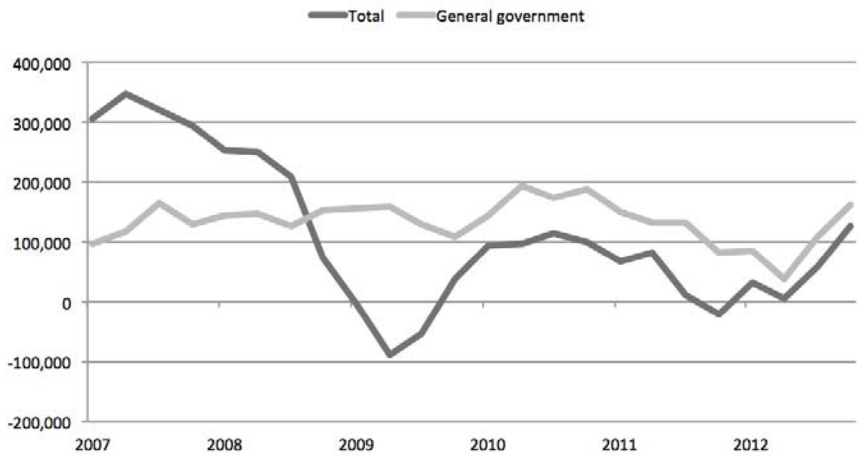
Source: ECB and IMF BOPS.

Figure 3: Term premium and foreign holdings
(percent and percentage of GDP, annual change, March 2000 – December 2006)



Source: ECB and authors' calculations.

Figure 4: Euro area debt securities liability flows
(4-quarter moving sums, 2007Q1–2012Q4)



Source: ECB.

Table 1: Foreign ownership of US and euro area debt securities

		Euro area	United States
All issuers	Outstanding	9,690	20,341
	of which foreign owned	2,571	4,732
	(in percent of outstanding)	(26.5)	(23.3)
	(in percent of GDP)	(31.1)	(35.5)
Total Government	Outstanding	4,353	9,044
	of which foreign owned	995	2,711
	(in percent of outstanding)	(22.9)	(30.0)
	(in percent of GDP)	(12.0)	(20.4)
Treasury	Outstanding		3,321
	of which foreign owned		1,727
	(in percent of outstanding)		(52.0)
	(in percent of GDP)		(13.0)
Agencies	Outstanding		5,723
	of which foreign owned		984
	(in percent of outstanding)		(17.2)
	(in percent of GDP)		(7.4)
Corporates	Outstanding	5,337	11,297
	of which foreign owned	1,576	2,021
	(in percent of outstanding)	(29.5)	(17.9)
	(in percent of GDP)	(19.1)	(15.2)

Source: Treasury Department et al. (2008, 2012) and ECB.
Note: Amounts in domestic currency unless otherwise indicated at end-June 2006.

Table 2: Cointegration tests

One lag				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.295	54.319	47.856	0.010
At most 1	0.139	22.216	29.797	0.287
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.295	32.103	27.584	0.012
At most 1	0.139	13.761	21.131	0.385
With trend				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.374	80.981	63.876	0.001
At most 1	0.176	38.349	42.915	0.133
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.374	42.631	32.118	0.002
At most 1	0.176	17.603	25.823	0.408

Note: * denotes rejection of the hypothesis at the 0.05 level.

Table 3: VECM results - benchmark model

Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}
	1	-0.247	-0.434	0.128
		$[-4.840]$	$[-4.564]$	$[11.524]$
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH
α	-0.230	0.161	0.074	-0.063
	$[-2.932]$	$[3.232]$	$[1.245]$	$[-0.422]$
Δi^l_{t-1}	0.316	0.101	0.014	-0.491
	$[2.921]$	$[1.483]$	$[0.170]$	$[-2.393]$
Δi^s_{t-1}	0.194	0.297	-0.034	0.383
	$[1.187]$	$[2.861]$	$[-0.273]$	$[1.236]$
$\Delta \pi^e_{t-1}$	-0.036	-0.087	-0.129	0.090
	$[-0.256]$	$[-0.971]$	$[-1.202]$	$[0.337]$
ΔFH_{t-1}	0.146	0.018	0.028	-0.035
	$[2.595]$	$[0.505]$	$[0.659]$	$[-0.330]$

Note: t-statistics in brackets.

Table 4: Impact of foreign holdings on long-term interest rates – March 2000 to June 2006

	FH variable	Scale	Coefficient	Initial	Final	Total Impact
This study	FH bonds	GDP	0.128	17.99	30.08	-1.548
Bandholz et al. (2009)	FH Treas	Outst	0.070	35.25	52.00	-1.173
Beltran et al. (2013), lower bound	FOH Treas	Outst	0.046	18.54	36.53	-0.828
Beltran et al. (2013), upper bound	FOH Treas	Outst	0.063	18.54	36.53	-1.133
Bertaut et al. (2009)	FOH Treas + Agenc	Outst	0.062	9.09	18.67	-0.875

Source: Authors' calculations. Initial is the stock in March 2000, final is the stock in June 2006, total impact is the coefficient times the change in the stock from March 2000 to June 2006.

Table 5: Cointegration tests

No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
Domestic holdings model				
Unrestricted cointegration rank test (Trace)				
None*	0.302	55.110	47.856	0.009
At most 1	0.138	22.009	29.797	0.298
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.302	33.101	27.584	0.009
At most 1	0.138	13.654	21.131	0.394
Foreign and domestic holdings model				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.316	84.111	69.819	0.002
At most 1*	0.271	49.105	47.856	0.038
At most 2	0.127	20.072	29.797	0.418
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.316	35.006	33.877	0.037
At most 1*	0.271	29.003	27.584	0.032
At most 2	0.127	12.451	21.132	0.504
Foreign and domestic holdings model - Corporate AAA				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.313	72.181	69.819	0.032
At most 1	0.275	41.368	47.856	0.177
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None	0.313	30.813	33.877	0.111
At most 1	0.275	26.393	27.584	0.070
Foreign and domestic holdings model - Corporate AA				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.324	72.697	69.819	0.029
At most 1	0.268	40.570	47.856	0.203
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None	0.324	32.127	33.877	0.080
At most 1	0.268	25.620	27.584	0.087

Note: * denotes rejection of the hypothesis at the 0.05 level.

Table 6: VECM results - domestic holdings

Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	DH_{t-1}
	1	-0.149	-0.725	0.177
		$[-2.133]$	$[-5.892]$	[9.241]
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔDH
α	-0.083	0.124	0.087	-0.456
	$[-1.297]$	[3.180]	[1.900]	$[-2.614]$
Δi^l_{t-1}	0.213	0.102	-0.008	0.784
	[1.917]	[1.518]	$[-0.097]$	[2.594]
Δi^s_{t-1}	0.023	0.275	-0.104	0.524
	[0.128]	[2.541]	$[-0.814]$	[1.078]
$\Delta \pi^e_{t-1}$	-0.108	-0.087	-0.142	0.098
	$[-0.737]$	$[-0.981]$	$[-1.349]$	[0.247]
ΔDH_{t-1}	0.050	0.002	0.009	-0.188
	[1.388]	[0.084]	[0.341]	$[-1.911]$

Note: t-statistics in brackets.

Table 7: VECM results - foreign and domestic holdings

	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	DH_{t-1}
Cointegration equation 1	1	-0.259	-0.430	0.126	-
		$[-5.527]$	$[-4.767]$	[13.493]	-
Cointegration equation 2	1	-0.163	-0.730	-	0.175
		$[-2.480]$	$[-6.020]$	-	[10.481]
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	ΔDH
α^1	-0.776	0.113	-0.168	-0.389	1.029
	$[-3.985]$	[0.869]	$[-1.090]$	$[-1.014]$	[1.815]
α^2	0.460	0.045	0.201	0.260	-1.163
	[3.054]	[0.449]	[1.691]	[0.878]	$[-2.656]$
Δi^l_{t-1}	0.322	0.096	0.016	-0.458	0.597
	[3.082]	[1.381]	[0.192]	$[-2.226]$	[1.960]
Δi^s_{t-1}	0.044	0.277	-0.092	0.343	0.448
	[0.267]	[2.539]	$[-0.713]$	[1.064]	[0.941]
$\Delta \pi^e_{t-1}$	-0.025	-0.084	-0.121	0.104	-0.075
	$[-0.188]$	$[-0.932]$	$[-1.130]$	[0.389]	$[-0.190]$
ΔFH_{t-1}	0.157	0.016	0.033	0.022	-0.353
	[2.779]	[0.422]	[0.734]	[1.196]	$[-2.144]$
ΔDH_{t-1}	-0.016	0.005	-0.005	-0.118	-0.076
	$[-0.455]$	[0.210]	$[-0.182]$	$[-1.663]$	$[-0.724]$

Note: t-statistics in brackets.

Table 8: VECM results - foreign and domestic holdings, corporate yields

Panel A: Corporate AAA yields					
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	DH_{t-1}
	1	-0.399	-0.530	0.147	-0.007
		$[-9.362]$	$[-6.996]$	$[4.656]$	$[-0.181]$
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	ΔDH
α	-0.015	0.264	0.045	-0.016	-0.033
	$[-0.266]$	$[9.947]$	$[1.071]$	$[-0.146]$	$[-0.209]$
Panel A: Corporate AA yields					
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	DH_{t-1}
	1	-0.417	-0.608	0.116	0.029
		$[-9.892]$	$[-8.097]$	$[3.768]$	$[0.750]$
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	ΔDH
α	-0.001	0.266	0.049	-0.019	-0.074
	$[-0.019]$	$[9.789]$	$[1.154]$	$[-0.180]$	$[-0.464]$

Note: t-statistics in brackets.

Table 9: VECM - alternative models

Panel A: model with trend					
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	β^t
	1	-0.298	-0.336	0.235	-0.018
		[-5.628]	[-3.356]	[3.563]	[-1.646]
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	
α	-0.249	0.178	0.056	-0.171	
	[-3.015]	[3.403]	[0.888]	[-1.098]	
Δi^l_{t-1}	0.336	0.086	0.019	-0.433	
	[3.060]	[1.230]	[0.231]	[-2.084]	
Δi^s_{t-1}	0.183	0.300	-0.002	0.503	
	[1.152]	[2.979]	[-0.013]	[1.673]	
$\Delta \pi^e_{t-1}$	-0.035	-0.089	-0.124	0.114	
	[-0.247]	[-0.996]	[-1.151]	[0.427]	
ΔFH_{t-1}	0.159	0.008	0.027	-0.018	
	[2.811]	[0.221]	[0.621]	[-0.164]	
Panel B: ARDL					
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	
	1	-0.202	-0.047	0.131	
		[-2.115]	[-0.232]	[6.530]	
Error correction	Δi^l				
α	-0.260				
	[-3.287]				
Δi^l_{t-1}	0.272				
	[2.469]				
Δi^s_{t-1}	0.071				
	[0.434]				
$\Delta \pi^e_{t-1}$	0.035				
	[0.243]				
ΔFH_{t-1}	0.133				
	[2.429]				

Note: t-statistics in brackets.

Table 10: VECM results with control variables

Panel A: US long-term interest rates				
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}
	1	-0.111	-0.560	0.078
		[-2.991]	[-7.051]	[8.169]
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH
α	-0.439	-0.018	0.112	0.001
	[-8.419]	[-0.380]	[2.089]	[0.011]
Δi^l_{t-1}	0.054	0.116	0.029	-0.488
	[0.681]	[1.635]	[0.356]	[-2.361]
Δi^s_{t-1}	-0.008	0.443	-0.043	0.341
	[-0.081]	[4.763]	[-0.404]	[1.257]
$\Delta \pi^e_{t-1}$	-0.083	-0.077	-0.145	0.092
	[-0.804]	[-0.827]	[-1.363]	[0.339]
ΔFH_{t-1}	0.090	0.022	0.034	-0.035
	[2.195]	[0.591]	[0.810]	[-0.331]
i^{US}_{t-1}	0.285	0.050	-0.030	-0.023
	[9.499]	[1.851]	[-0.973]	[-0.295]
Panel B: industrial production and VIX				
Cointegration equation	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}
	1	-0.270	-0.453	0.151
		[-4.977]	[-4.443]	[9.725]
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH
α	-0.276	0.135	0.075	-0.143
	[-3.632]	[2.695]	[1.274]	[-0.975]
Δi^l_{t-1}	0.295	0.114	0.037	-0.475
	[2.812]	[1.657]	[0.453]	[-2.350]
Δi^s_{t-1}	0.155	0.312	0.011	0.350
	[0.990]	[3.022]	[0.094]	[1.160]
$\Delta \pi^e_{t-1}$	-0.042	-0.070	-0.131	0.081
	[-0.304]	[-0.776]	[-1.214]	[0.305]
ΔFH_{t-1}	0.134	0.017	0.028	-0.081
	[2.299]	[0.442]	[0.610]	[-0.723]
IP	-0.008	-0.001	0.004	-0.007
	[-2.476]	[-0.397]	[1.673]	[-1.160]
VIX	0.001	-0.000	0.001	0.005
	[0.407]	[-0.016]	[0.314]	[1.126]

Note: t-statistics in brackets.

Table 11: VECM results - US model

Cointegration equation	$i_{t-1}^{l,US}$	$i_{t-1}^{s,US}$	$\pi_{t-1}^{e,US}$	FH_{t-1}^{US}
	1	-0.126	-0.469	0.088
		[-3.227]	[-2.936]	[8.318]
Error correction	$\Delta i^{l,US}$	$\Delta i^{s,US}$	$\Delta \pi^{e,US}$	ΔFH^{US}
α	-0.169	0.158	0.148	0.254
	[-2.098]	[3.499]	[4.002]	[1.476]
$\Delta i_{t-1}^{l,US}$	0.228	-0.000	-0.100	-0.185
	[1.723]	[-0.003]	[-1.651]	[-0.653]
$\Delta i_{t-1}^{s,US}$	0.228	0.460	-0.155	-0.787
	[1.354]	[4.880]	[-2.009]	[-2.189]
$\Delta \pi_{t-1}^{e,US}$	0.133	-0.021	-0.084	0.185
	[0.623]	[-0.174]	[-0.860]	[0.407]
ΔFH_{t-1}^{US}	0.095	-0.010	0.021	-0.002
	[1.643]	[-0.302]	[0.789]	[-0.020]

Note: t-statistics in brackets.

Table 12: Cointegration tests - model with US rates

One lag				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.480	237.419	159.530	0.000
At most 1*	0.427	177.280	125.615	0.000
At most 2*	0.356	126.032	95.754	0.000
At most 3*	0.293	85.544	69.819	0.002
At most 4*	0.247	53.593	47.856	0.013
At most 5	0.195	27.506	29.797	0.090
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.480	60.139	52.363	0.007
At most 1*	0.427	51.247	46.231	0.013
At most 2*	0.356	40.488	40.078	0.045
At most 3	0.293	31.951	33.877	0.083
Three lags				
Unrestricted cointegration rank test (Trace)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.555	237.180	159.530	0.000
At most 1*	0.433	164.266	125.615	0.000
At most 2*	0.387	113.220	95.754	0.002
At most 3	0.230	69.222	69.819	0.056
Unrestricted cointegration rank test (Maximum Eigenvalue)				
No. cointegration relations	Eigenvalue	Trace statistic	0.05 critical value	p-value
None*	0.555	72.915	52.363	0.000
At most 1*	0.433	51.045	46.231	0.014
At most 2*	0.387	43.998	40.078	0.017
At most 3	0.230	23.498	33.877	0.493

Note: * denotes rejection of the hypothesis at the 0.05 level.

Table 13: VECM results - global model

				Panel A: no lag				
	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	$i^{l,US}_{t-1}$	$i^{s,US}_{t-1}$	$\pi^{e,US}_{t-1}$	FH^{US}_{t-1}
Cointegration equation 1	1	-0.543	-0.680	0.179	-	-	-	-
		[-10.071]	[-6.918]	[14.208]	-	-	-	-
Cointegration equation 2	-	-	-	-	1	-0.060	-0.079	0.004
	-	-	-	-		[-7.327]	[-3.269]	[1.832]
Cointegration equation 3	1	-	-	-	2.933	-	-	-
		-	-	-	[34.712]	-	-	-
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	$\Delta i^{l,US}$	$\Delta i^{s,US}$	$\Delta \pi^{e,US}$	ΔFH^{US}
α^1	-0.084	0.055	0.182	-0.017	-0.053	0.103	0.041	0.243
	[-1.801]	[1.657]	[6.768]	[-0.196]	[-0.758]	[2.628]	[1.189]	[2.580]
α^2	0.481	-0.321	-0.128	-0.016	0.176	0.898	0.060	-0.578
	[2.302]	[-2.165]	[-1.055]	[-0.041]	[0.558]	[5.072]	[0.391]	[-1.363]
α^3	-0.114	0.082	0.053	-0.001	-0.061	-0.209	-0.008	0.134
	[-2.283]	[2.320]	[1.838]	[-0.012]	[-0.815]	[-4.956]	[-0.206]	[1.321]
				Panel B: one lag				
	i^l_{t-1}	i^s_{t-1}	π^e_{t-1}	FH_{t-1}	$i^{l,US}_{t-1}$	$i^{s,US}_{t-1}$	$\pi^{e,US}_{t-1}$	FH^{US}_{t-1}
Cointegration equation 1	1	-0.476	-0.211	0.129	-	-	-	-
		[-7.139]	[-4.700]	[14.553]	-	-	-	-
Cointegration equation 2	-	-	-	-	1	-0.098	-0.595	0.116
	-	-	-	-		[-3.179]	[-5.062]	[11.030]
Cointegration equation 3	1	-	-	-	4.267	-	-	-
		-	-	-	[6.096]	-	-	-
Error correction	Δi^l	Δi^s	$\Delta \pi^e$	ΔFH	$\Delta i^{l,US}$	$\Delta i^{s,US}$	$\Delta \pi^{e,US}$	ΔFH^{US}
α^1	-0.498	0.074	0.062	-0.396	-0.347	-0.098	0.049	0.345
	[-4.230]	[0.823]	[0.820]	[-1.724]	[-1.860]	[-0.943]	[0.544]	[1.490]
α^2	0.157	-0.013	0.063	0.266	0.015	0.215	0.121	0.214
	[2.287]	[-0.253]	[1.429]	[1.991]	[0.140]	[3.543]	[2.307]	[1.587]
α^3	0.017	-0.004	0.005	-0.000	-0.004	0.000	0.003	-0.034
	[2.536]	[-0.762]	[1.246]	[-0.009]	[-0.402]	[0.070]	[0.628]	[-2.572]

Note: t-statistics in brackets. Short-run coefficients not reported.

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