International liquidity shocks and the European sovereign debt crisis: Was euro area unconventional monetary policy successful?

Mary M. Everett[1]

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JEL: F65, G21, G15, H63
Keywords: European sovereign crisis, cross-border banking, sovereign debt, international shock transmission, non-standard measures, ECB liquidity

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1 Introduction

This paper investigates the effectiveness of the ECB's unconventional monetary policy in mitigating the consequences of the European sovereign debt crisis on euro area banks supply of credit to the real economy. The escalation of the European sovereign debt crisis led international investors to reallocate their portfolios away from euro area banks, manifesting in a liquidity shock to their international funding. In particular, euro area banks witnessed a sharp retraction by wholesale investors, most notably US money market funds, from their US affiliates. To alleviate interbank funding stress, among its unconventional monetary policy measures, the ECB established two 36 month Long-Term Refinancing Operations (VLTROs), in December 2011 and February 2012, and injected in excess of €1 trillion euro into the euro area financial system.

To explore the influence of the international liquidity shock and the VLTROs on private sector credit supply, the empirical analysis in this paper exploits a monthly panel dataset of 247 euro area banks, between 2008 and 2013. The empirical findings confirm that euro area bank exposure to stressed European sovereigns resulted in a liquidity shock to their international funding. The liquidity shock was reflected in a contraction by non-euro area investors from euro area banks, as well as a retraction by wholesale investors from the US affiliates of euro area banks. The results also provide empirical support for the hypothesis that internationally active banks play a role in transmitting liquidity shocks across borders and into domestic economies. Moreover, the empirical analysis shows that the VLTROs launched in December 2011 were limited in their effectiveness to stem the decline in credit supply to real economy. The second round of VLTROs in February 2012, however, had a beneficial effect on the supply of credit to households and non-financial corporates. For the relatively most affected banks, defined as those suffering from the international liquidity shock and accessing ECB liquidity, the VLTROs did not mitigate the decline in credit supply to their non-financial corporates.

Analysing the response of bank balance sheets to liquidity shocks necessitates the separate identification of credit demand and credit supply factors. Euro area banks were not isolated in experiencing negative effects from the sovereign debt crisis. Deteriorating euro area macroeconomic conditions, associated with declining borrowers' incomes and asset values, negatively affected their creditworthiness. The consequential balance sheet contraction for borrowers not only increased their probability of loan default but also reduced the eligibility of their collateral for new loans. To capture the shift in credit demand a number of measures are considered as controls.

Following De Santis and Surico (2013), in their study of monetary policy transmission, economic growth is included as a determinant of credit demand. The unemployment rate is

also considered as a macroeconomic factor that measures the state of the economy and is a driving factor of loan demand (Bassett et al., 2014). In addition, the results from the ECB's Bank Lending Survey (BLS), which provides insight to credit demand and supply conditions and the factors underpinning related changes, are included as alternate measures for credit demand. Furthermore, similar to Khajwa and Mian (2008) country, time and country-time fixed effects are also incorporated in the empirical analysis as controls for shifts in credit demand.[1]

The theoretical motivation underpinning this research relates to two strands of literature. First, the bank-sovereign nexus includes a number of channels through which this interconnectedness has implications for bank balance sheets (Committee on the Global Financial System, 2011). The willingness of a bank to hold sovereign debt stems from its key attributes, namely liquidity and safety. Increased sovereign risk, reflected in rising yields on sovereign bonds, has repercussions for the balance sheets of banks. The related fall in prices on sovereign bonds leads to a reduction in the mark-to-market value of bank assets, has negative consequences for their capital, and therefore, their ability to leverage. Furthermore, an increase in sovereign risk will reduce the eligibility of sovereign bonds as collateral to secure funding in the interbank market and with central banks.

Second, the mechanism through which the shock to international funding is transmitted to domestic credit supply is considered in the spirit of the banking model of Khajwa and Mian (2008). Their framework, based on the equilibrium of loan supply and demand, facilitates the identification of a credit supply shock following a bank balance sheet shock. The banking model of Buch and Goldberg (2014), which extends the theoretical model of Khajwa and Mian (2008), suggests the reaction of a bank to a liquidity shock depends on the strength of its balance sheet. The key innovation in this model is the inclusion of a term which captures the extent of a bank's response to shifts in liquidity risk. The role of official liquidity in offsetting the effects of a liquidity shock is also incorporated into the banking model of Buch and Goldberg (2014).

This paper builds on the empirical literature that considers the ability of a bank to mitigate the effects of a funding shock depends on the structure and strength of its balance sheet. Cornett et al. (2011) study the effects of the liquidity shock during the global financial crisis on US bank lending. They find that banks with comparatively illiquid assets reduced lending relative to banks whose funding base was drawn from stable sources including core deposits and capital. Using bank-level data, Ceterolli and Goldberg (2012b) illustrate how a parent bank's holdings of asset-backed commercial paper affects the lending activity of their branches.

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[1]Other authors adopting this approach include: Schnabl, 2012; De Haas and van Horen, 2012; Popov and van Horen, 2012; and Ongena et al., 2012.

In principle, a decline in credit supply should, therefore, be more prevalent for banks with greater exposure to impaired or illiquid assets and are subject to increased liquidity risk.

The literature on the transmission of bank liquidity shocks to the real economy demonstrates how banks experiencing liquidity shortages (for example through contractionary monetary policy) supply less credit (Bernanke and Blinder, 1998). A number of studies highlight the role banks play in international shock transmission. Peek and Rosengren (1997) analyse the effects of the Japanese banking crisis in the 1990s, and find the US branches of Japanese banks reduced lending as a result of the fall in their parents' capital. Schnabl (2008) shows how the Russian 1998 crisis spilled over into Peru through reduced lending by foreign banks. Ongena et al. (2013) study the effects of shocks from banks to the real economy during the global financial crisis, and find that internationally active banks contract their credit supply relatively more than purely domestic banks. Ceterolli and Goldberg (2011) show that shocks to advanced countries' banks were transmitted to emerging markets through the internal capital markets of international banks.

A number of recent studies have explored the effects of the European sovereign debt crisis on the lending activities of affected banks. Popov and Van Horen (2013) demonstrate how banks exposed to impaired European sovereigns had lower syndicated lending relative to less exposed banks. The negative effect of increasing sovereign risk on the US funding of European banks and related consequences for their US lending has been found by Correa et al. (2012).

In a study related to this paper, Darracq-Paries and De Santis (2013) examine the effect of the VLTROs on the macroeconomy. Applying a panel VAR to euro area Member States, they find that the VLTROs are positively associated with credit supply during the first half of 2012. Similarly, Gambacorta et al. (2014) analyse the effectiveness of unconventional monetary policy on macroeconomic conditions across eight advanced countries. These authors find that an expansionary unconventional monetary policy provides a temporary but effective increase in economic output and prices.

By studying the consequences of bank exposure to impaired sovereigns for their international funding, this paper makes a number of contributions to these strands of literature. First, it confirms that the withdrawals experienced by euro area banks from international investors were attributable to their interconnectedness to stressed European sovereigns. Second, consistent with the findings in the related literature, the evidence suggests that international liquidity shocks do spill over into the domestic economy through a reduction across both bank liquid assets and credit supply. Finally, the second injection of ECB's unconventional monetary policy in the form of VLTROs alleviated the decline in credit supply to both households and non-financial corporates.

The remainder of the paper is structured as follows. The conceptual and theoretical background is presented in Section 2. Section 3 describes the data. The empirical approach

is outlined in Section 4. Section 5 presents the econometric specification. The results are reported and discussed in Section 6. Finally, Section 7 concludes.

2   Conceptual background

Following a protracted period of cross-border banking inflows to the euro area, the escalation of the European sovereign debt crisis is associated with the continued contraction of foreign funding, which commenced during the global financial crisis (Figure 1). In contrast, for non-euro area European banks, the period post the global financial crisis witnessed a rebound in foreign funding. The focus of this section is on the expansion and subsequent contraction of euro area cross-border bank funding.

The evolution of internationally sourced funding has played an important role in the expansion and contraction of domestic private sector credit in the euro area (Figure 2). Cross-border funding as proportion of domestic credit was 88 per cent on the eve of the introduction of the euro, peaked at 126 per cent in June 2007, and had fallen back to pre-euro levels of 87 per cent by end-2013. This shift in bank funding toward international sources amplified the credit booms in a number of euro area countries in the mid-2000s, including Ireland and Spain (Lane and McQuade, 2014; BIS, 2011).

Euro area bank demand for US dollar denominated assets exceeded their supply of retail deposits leading the US wholesale funding market, particularly money market funds, to become a key financing jurisdiction for the US-based affiliates of euro area banks (Figure 3).[2] A wide range of euro area banks, in particular French banks, were notably active in this US dollar funding market (Ivashina et al., 2012).

While the proceeds of this US funding were employed for a range of purposes, including local lending in the US market, it was also channelled back to the headquarters of euro area banks who reinvested it across two asset categories. First, part of the US sourced funding was reinvested back in the US market through their acquisition of US assets, including asset-backed securities (Bertaut et al., 2011; Bernanke et al., 2011). Second, euro area banks also employed this US sourced funding to expand their domestic assets, through increased lending either directly in US dollars to facilitate the demand for US dollars for exporting companies, or by swapping it into euro and meeting increasing local credit demand (Blowers and Forsman, 2013). It is worth noting the path of funds from US-based affiliates may not have been direct between the US and the euro area as offshore intermediaries and financial centres are frequently used to channel funds globally (Lane and Milesi-Ferretti, 2011; Gourinchas and Obstfeld, 2012).

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[2]Baba et al., 2009; Correa et al., 2012.

The dynamics of this international financial intermediation between banks active in global financial markets and domestic banking systems operating in the retail credit market is consistent with the liquidity management of globally active banks, who employ their internal capital markets to allocate liquidity across the banking group (Ceterolli and Goldberg, 2012a). The evolution of euro area bank foreign funding and domestic credit developments complement the Bruno and Shin (2014) theoretical model of global banking, whereby global banks draw on dollar funding from US money market funds, disseminate it internationally through cross-border lending to domestic banks, who in turn employ this foreign funding in local credit markets.

A number of developments in 2011 led US investors to retract their financing of the US affiliates of euro area banks, manifesting in a liquidity shock to their balance sheets. The introduction of a regulatory requirement in the US for money market funds to disclose their asset portfolios, restrained euro area banks ability to fund their operations from this group of wholesale investors (Correa et al., 2012). Moreover, the escalation of the European sovereign debt crisis in summer 2011, driven by the rising sovereign borrowing costs for Spain and Italy, led US investors to assess their exposures to euro area banks, reflected in the increasing costs of US dollar-euro swaps. The widening of the Euribor OIS, a measure of interbank counterparty risk, mirrored the increasingly scarce liquidity at this time.[3] Stress in the interbank market was also evident in US dollar and Sterling money markets, indicated by the increased spreads in the Libor OIS USD and Libor OIS GBP (Figure 4). The interconnectedness between euro area banks and their sovereigns is evident in the 90 day rolling correlations between the Libor OIS USD and the sovereign credit default swaps, where sharp increases in the correlation are evident as the sovereign debt crisis intensified (Figure 5).

Declines in the correlations are associated with the timing of extended and enhanced central bank actions, including, in November 2011, the broadening of the US dollar swap line by the US Federal Reserve in cooperation with a number of central banks at a reduced price.[4] Bilateral currency swap arrangements were also established between the ECB and a range of central banks, including Bank of Canada, Bank of England, Bank of Japan, Federal Reserve and Swiss National Bank. To alleviate funding stress in the interbank market, as part of the ECBs unconventional monetary policy measures, two VLTROs were established, each with a maturity of 36 months and the possibility of repayment after one year. Across the two 36 month liquidity operations, €489 billion was provided to 523 banks in December 2011, and 800 banks drew on €530 billion in February 2012.

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[3]The Euribor/Libor OIS is the spread between the interbank rate and the overnight index swap of corresponding maturity.

[4]The price of swaps was reduced from Libor OIS USD +100 basis points to Libor OIS USD + 50 basis points.

3 Data

To comprehensively analyse whether euro area banks' exposure to stressed European sovereigns manifested as a liquidity shock to their international funding, and to assess the success of the ECB's unconventional monetary policy measures, a dataset is constructed from a number of micro-level bank databases.

3.1 Sovereign exposures

European bank exposures to stressed European sovereigns are extracted from the results of the European Banking Authority's (EBA) stress tests. These results, published for each participating bank on a consolidated group basis, contain information on banks' exposure to individual countries' sovereign debt. Balance sheet information, including total assets and capital, is also included. To capture the exposure of individual bank i to stressed European sovereigns the following specification is considered:

$$Exposure_{it} = \sum_k \frac{SovDebt_{ikt}}{Capital_{it}} \tag{1}$$

where $k \, \epsilon \, \{$Greece, Ireland, Italy, Portugal, Spain$\}$ and t is December 2010. Banks' exposures at December 2010, $SovDebt$, scaled by their total capital, $Capital$, are employed as these reflect the balance sheet of banks in advance of the escalation of the European sovereign debt crisis during 2011 (Popov and van Horen, 2013). Individual banks' exposures to stressed European sovereigns, ranked by balance sheet size, are presented in Table 1. The exposure of larger banks whose parents are based in core European countries are found to have relatively lower holdings of stressed countries' sovereign debt. The banks located in stressed countries, which tend to be comparatively smaller in size but are of systemic local importance, have higher relative exposure to their own sovereigns. For example, the data show that Deutsche Bank held sovereign debt issued by each of the stressed sovereigns at end-2010, whereas Allied Irish Bank (AIB), Ireland's second largest bank, was also exposed to each stressed sovereign but its holdings were skewed towards its own sovereign.

3.2 Bank balance sheets

Individual bank balance sheet data for euro area banks are taken from a proprietary ECB database (IBSI). This database contains monthly balance sheet information for 244 banks resident in 17 euro area countries over the period August 2007 to December 2013. These data

are based on the residency principle, and are collated according to a methodology similar to balance of payments and international investment position statistics (IMF BPM6, 2011). A primary advantage of this approach is that it provides for the exclusion of securitisations, write-offs and valuation effects (price and exchange rate movements), thereby facilitating an accurate measure of international funding growth and the supply of credit. This is an important feature of the dataset given the extent of non-transaction based effects on banks' balance sheets during the period under review. The annual growth rate a_t for balance sheet items is calculated using the following formula:

$$a_t = [\prod_{i=1}(1 + \frac{F^M}{L_{t-1i}}) - 1] \qquad (2)$$

where F^M is the monthly flow or transactions of the balance sheet item in question and L represents the outstanding stock of total assets.

Banks with extreme changes in total assets are excluded from the data. To remove outliers from the dataset, all dependent variables are topped and tailed at the 1st and 99th percentile. Merging these data with the EBA bank data and data cleaning reduces the sample of banks to 150 individual banks which are part of 61 consolidated banking groups.

3.3   Unconventional monetary policy

These data are merged with information on banks access to the ECB's VLTROs in December 2011 and February 2012. Information on whether a bank participated in these VLTROs is sourced from a Central Bank of Ireland's database. A dummy variable for each VLTRO is constructed, taking a value of 1 if a bank took part in the operations implemented in December 2011 (*VLTRO1*) and February 2012 (*VLTRO2*), and 0 otherwise.

3.4   Additional data

Relevant balance sheet data not included in the IBSI database, including Tier 1 capital ratios, loan provisioning, income, total assets, CDS spreads and customer deposits on a consolidated banking group basis are sourced from Bloomberg and Thomson Reuters Datastream, under the assumption that banks resident in the 17 euro area countries can rely on their banking group for support. Conditions in the interbank market are represented by the Libor USD OIS, measured as the spread between the LIBOR USD three month rate and the USD three month overnight index swap, and is sourced from Bloomberg.

A number of controls for credit demand are included in the empirical analysis. Monthly macroeconomic conditions are captured by economic output, proxied by industrial production, and unemployment and are sourced from Eurostat. The ECB's Bank Lending Survey reports changes in bank loan demand by non-financial corporates and households on a quarterly basis. These private sector borrowers also provide information as to what factors drive their shifts in demand, including using substitutes for bank credit.

Finally, the EBA data is merged with euro area banks' funding in the US via their US-based affiliates. This is proxied by the balance sheets of these banks, sourced from the Federal Reserve Structure and Share Data for the US Offices of Foreign banks. Of the 90 banks covered by EBA stress tests, 45 banks across 11 countries are found to have US-based affiliates whose activities are covered by this dataset.

The final data sample is a monthly panel of 150 euro area banks over the period 2008 to 2013. Table 2 provides the summary statistics and description of the main variables employed in the empirical analysis.

4 Empirical approach

To analyse the effect of euro area bank exposures to stressed European sovereigns on their international funding, the dependent variable is $IntFunding$ of euro area bank i, which is the annual flow of funding from non-euro area investors. The funding of bank i in the US market is also considered, $IntFunding^{US}$, and is measured as the annual change in the log of the assets of the US affiliate of euro area bank i.

The explanatory variable, $Exposure$, is the holdings of euro area bank i of stressed European sovereigns' debt. A negative sign this variable is indicative that the exposure of bank i to stressed European sovereigns negatively effects its international funding. $LiborOIS$ represents the liquidity risk faced by euro area bank i, reflecting the level of perceived counterparty risk of default in the interbank market which is common across all euro area banks, and is given by the Libor OIS in the US money market. The high correlation between the LIBOR OIS in the US and sterling money markets imply this is an appropriate measure (Figure 4).

The main variable of interest, is the interaction term, $Exposure * LiborOIS$, which captures the response of euro area bank i to a liquidity shock depending on the exposure on its balance sheet to stressed European sovereigns. A negative and significant sign on this interaction term would suggest a negative sensitivity of international investors to euro area banks exposed to stressed European sovereigns during a period of heightened tensions in the interbank market.

To account for the specific characteristics of euro area bank i which may account for

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heterogeneous developments across bank balance sheets, a range of bank-level controls are included.

Size represents the size of euro area bank i and is given by the log of its total assets. Larger banks are expected to be less sensitive to liquidity shocks, and may be relatively better placed to access alternative sources of external funding when faced with an international liquidity shock. The expected sign on this coefficient is positive.

The capital of euro area bank i, *Capital*, is given by its Tier 1 capital. Better capitalised banks are considered to have access to alternative funding sources to mitigate the effects of an international liquidity shock, therefore a positive sign is anticipated on this variable.

An indicator of the stability of funding of euro area bank i is also included, denoted by *Deposits*. Customer deposits are considered to be a relatively stable source of funding, and banks more reliant in this source of funding are also those more likely to be insulated from a liquidity shock to their international funding.

Measures of the health of euro area bank i are also included, whereby relatively weaker banks may be more vulnerable to international liquidity shocks. Included are *Income*, which is the net income of euro area bank i, and *LoanProvisions* measured as the level of euro area bank $i's$ provisioning for impaired loans. Banks with weaker balance sheets are likely to lend less given their motivation to rebalance their portfolio away from risky assets. The financial markets' perception of euro area bank i's default risk is measured by its CDS spreads, *CDS*.

Next, the asset portfolio of individual euro area bank i is considered. Total assets, *Assets*, are measured as the total assets of euro area bank i at time t. Assets are decomposed into: *Loans*, which comprises the flow of credit of bank i to euro area borrowers; *HHLoans* and *NFCLoans* represent the flow of credit to households and non-financial corporates, respectively; the change in the liquid assets of bank i is given by *Liquid*, and reflects the growth in bank $i's$ interbank lending (loans and debt securities) and private sector debt securities, and *Foreign* reflects the growth in the non-euro area assets of bank i at time t. All of these variables are normalised by the outstanding stock of total assets in the previous period.

Official liquidity can serve to improve a bank's ability to extend loans to its domestic borrowers during a period of credit contraction. To empirically account for the ECB's unconventional monetary policy measures in the form of 3 year LTROs two dummy variables are included for each euro area bank, taking a value of 1 if euro area bank i drew on ECB liquidity in December 2011, *VLTRO1*, and/or in February 2012, *VLTRO2*, and 0 otherwise. A positive sign on the VLTRO dummies suggests that the ECB's unconventional monetary policy measure was successful in mitigating the effects of the international liquidity shock on the lending of euro area bank i, whereas a negative sign is indicative that the enhanced official liquidity did not offset the effects of liquidity shock to the international funding of bank i as a result of its exposure to stressed European sovereigns.

In terms of controls for credit demand, $CreditDemand$, a range of measures common in the related literature are considered: the log of industrial production is included as a proxy for the economic output of country j; the log of the unemployment rate of country j at time t; and the results of the ECB's BLS as measures for shifts in credit demand from households and non-financial corporates.

To account for unobservable country level factors that potentially affect euro area countries demand for international funding and domestic assets portfolios, country fixed effects are included. In addition, to account for the possibility that banks' balance sheet composition are driven by time-invariant bank-specific unobservable factors such as risk appetite, business model or funding strategy, bank fixed effects are included. To capture time-specific changes in bank balance sheets common across all banks, time fixed effects are included.

5 Empirical specification

The empirical specification follows that of Cornett et al. (2011) and Ceterolli and Goldberg (2012b). The econometric model considers that the international funding of bank i is dependent on bank i's exposure to stressed European sovereigns, liquidity risk, as well as a range of controls for the other characteristics of bank i, its home country j, and year t. The main regression specification is given as:

$$
\begin{aligned}
IntFunding_{ijt} \;=\; & \beta_1 Exposure_{ijt} * LiborOIS_t + \beta_2 Exposure_{ijt} + \beta_3 LiborOIS_t \\
& + \theta X_{ijt} + \gamma B_i + \delta C_j + \tau T_t + \epsilon_{ijt}
\end{aligned}
\tag{3}
$$

where $IntFunding$ is the international funding of euro area bank i, $Exposure$ is the exposure of euro area bank i to stressed European sovereigns, $LiborOIS$ is a proxy for liquidity risk and reflects liquidity conditions in the interbank money market, X_{ijt}, B_i, C_j, and T_t are vectors of time-varying bank-level control variables, bank fixed effects, country fixed effects and time fixed effect, respectively, and ϵ is the error term.

To explore the effect of the international liquidity shock on the asset portfolios of euro area banks, the empirical approach of Ceterolli and Goldberg (2012b) is followed, where the international liquidity shock, $IntLiqShock$ is instrumented by the right side of equation (3) to capture the changes in international funding related the exposure of bank i to stressed European sovereigns during a period of raised interbank tensions. The second stage estimates of the 2SLS are given by the following specification:

$$\begin{aligned}
\Delta Assets_{ijt} = \quad & \beta_1 IntLiqShock_{ijt} + \beta_2 VLTRO1_{ij} + \beta_3 VLTRO2_{ij} \\
& + \beta_4 VLTRO1 * IntLiqShock_{ijt} + \beta_5 VLTRO2 * IntLiqShock_{ijt} \quad (4) \\
& + \theta X_{ijt} + \gamma B_i + \delta C_j + \tau T_t + \epsilon_{ijt}
\end{aligned}$$

where $\Delta Assets$ represents change in the assets in bank i's portfolio, and can be decomposed into total loan growth, domestic asset growth, liquid asset growth and foreign (non-euro area) asset growth:

$$\Delta Assets_{ijt} = [\frac{\Delta Loans_{ijt}}{Assets_{ijt-1}}, \frac{\Delta Domestic_{ijt}}{Assets_{ijt-1}}, \frac{\Delta Liquid_{ijt}}{Assets_{ijt-1}}, \frac{\Delta Foreign_{ijt}}{Assets_{ijt-1}}] \quad (5)$$

whereby $Loans$ can further broken down into $HHLoans$ and $Loans$ representing loans to households and non-financial corporates, respectively. $VLTRO1$ and $VLTRO2$ represent the access of euro area bank i to the ECB's 36 month LTROs in December 2011 and February 2012. The interaction terms between the VLTRO facilities and the international liquidity shock, $VLTRO * IntLiqShock$, are included to capture the asset portfolio management of banks that experienced a decline in international funding and accessed the ECB's VLTRO facilities in the aftermath of the liquidity shock. X_{ijt}, B_i, C_j and T_t are vectors of time-varying bank-level control variables, bank fixed effects, country fixed effects and time fixed effect, respectively. The control variables include a number of controls for demand (including economic output and unemployment) and the ECB's BLS indices which gauge shifts in credit demand. Finally, ϵ is the error term.

6 Regression results

6.1 International liquidity shock

Table 3 reports the results of the regressions based on specification (3), where the dependent variable is the growth in euro area bank cross-border non-euro area funding. The panel regressions consist of a balanced dataset of 150 banks, and are based on monthly data from 2008 to 2013.

The estimates demonstrate that euro area bank exposure to stressed sovereigns manifested in a contraction in their international funding. In column (1), the estimates suggest that euro

area banks exposed to stressed European sovereigns experienced a decline in their cross-border funding during a period of heightened tensions in the interbank money markets. To address the possibility that euro area bank holdings of stressed sovereign debt and appetite for international funding are driven by time-invariant unobservable factors specific to each bank (for example risk preferences, business strategy, and home bias towards euro area debt), bank fixed effects are included in the regression results reported in column (2). To allay concerns that changes in cross-border non-euro area funding capture a change in euro area banks' demand for international funding, an interaction between fixed effects of the parent bank's country and time fixed effects is also included. This interaction term should control for unobserved changes in demand across the home countries of US-based affiliates of European banks.

In column (3), bank specific shocks are controlled for, and the negative effect of euro area bank exposure to stressed European sovereigns during a period of tensions in the interbank money market continue to hold. The positive and significant signs on $Exposure$ in columns (2) and (3) suggest euro area bank exposure to stressed European sovereign debt is positively related to their international funding during non-stressed periods, possibly due to the use of sovereign debt as collateral for secured funding in the interbank market. $Size$ and $Capital$ enter column (3) with positive and significant signs, indicating larger and better capitalised banks are associated with greater funding from non-euro area investors. This could also indicate that bigger banks draw on funding from internal capital markets located outside the euro area, for example UK subsidiaries.

In column (4) the sample of banks is narrowed to include French banks, motivated by their reliance on international funding. French banks with exposures to stressed sovereigns during a period of increased dollar costs led to decline in their cross-border funding from non-euro area investors. The next consideration is whether the findings in the baseline regression are driven by the retraction of international investors from banks resident in stressed countries due to the deterioration in their macroeconomic environment. When banks located in stressed countries and French banks are both excluded from the regression in column (5), the coefficient on $Exposure * LiborOIS$ is no longer significant but reports the correct negative sign.

To the extent that euro area banks experienced a significant contraction in their international funding in the US during the European sovereign debt crisis, the effect the exposure of euro area banks had on the funding of their US-based affiliates is considered. In Table 4 the estimates are reported for specification (3), with the growth in the US funding of the affiliates of euro area banks as the dependent variable.[5]

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[5]The control variable CDS is excluded from these regressions due to the unavailability of data prior to 2008.

Consistent with the results reported in Table 3, the regression estimates in column (1) suggest that euro area banks exposed to stressed European sovereigns experienced a decline in their US sourced funding during a period of heightened tensions in the US dollar interbank market. Controlling for bank-specific shocks, bank risk appetite and time-varying credit demand across countries in columns (2) and (3), the coefficient on the $LiborOIS$ reports a negative and significant sign, suggesting an increase in the perceived probability of counterparty default risk in the interbank market leads to a contraction in US-sourced funding for the US affiliates of euro area banks. A 10 basis point increase in the Libor OIS is associated with a 3 per cent decline in the US funding of euro area banks US affiliates.

The estimates in column (4) focus on French banks and suggest their exposure to stressed sovereigns at the period of heighted stress in the interbank market resulted in a retraction by wholesale investors in the US from their US affiliates. The negative and significant coefficient on the interaction terms indicates a 10 per cent in increase $Exposure * LiborOIS$ resulted in a 12 per cent decline in their US funding. The sample of banks is reduced to banks resident in non-stressed countries, excluding French banks, in column (5), and similarly the coefficient on the interaction term $Exposure*LiborOIS$ enters the regression with a negative and significant sign.

6.2 Tracing the effect to bank asset portfolios and the real economy

Next, the effects of the international liquidity shock on euro area bank asset portfolios are considered. Exclusive of euro area bank sovereign assets, the effects of the international liquidity shock on the asset portfolio of euro area banks are reported in Table 5.

Columns (1) to (6) show the results from the second stage of a 2SLS regression based on specification (4), where $IntFunding$ is instrumented by the variables $Exposure * LiborOIS$, $Exposure$ and $LiborOIS$. This term $IntLiqShock$ represents the predicted values from specification (3) and aims to capture the extent to which the changes in international funding of euro area bank i is influenced by its exposure to stressed European sovereigns during a period associated with heightening interbank market tensions.

The pattern on the coefficient on $IntLiqShock$ in Table 5 suggests the liquidity shock to euro area bank international funding led to a decline in their asset growth across most instruments. The magnitude of the international liquidity shock is largest for the growth in $\Delta Loans$ which comprises the supply of credit to financial corporates (including banks and non-bank financial corporates) as well as to the private sector in the euro area. The effects of the international liquidity shock on lending to the real economy are considered in columns (2) and (3), where the dependent variables are the credit supply to households and non-financial

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corporates, respectively. Having controlled for credit demand, by including economic output, the results in columns (2) and (3) indicate that credit supply to the real economy was affected by the liquidity shock to euro area bank international funding.

Liquid assets are also negatively affected by the international liquidity shock, and to a greater extent than lending to the real economy, indicating that when faced with a liquidity shock, banks dispose of their most liquid assets first. To examine whether the effects of the international liquidity shock differed across euro area banks' domestic and foreign portfolios, the growth in domestic and foreign assets are considered in columns (5) and (6). Consistent with the results in columns (1) to (4), a negative effect of the international liquidity shock is found for euro area banks' domestic assets in the regression results presented in column (5). The coefficient on $IntLiqShock$ is reported with the correct sign but is insignificant in column (6) suggesting euro area banks protected their foreign assets, including their intra-group funding, during the European sovereign debt crisis.

The focus of this paper is to examine the spillovers of the international liquidity shock to the real economy. In this context, the robustness of the results for credit supply to households and non-financial corporates is next explored, by including a range of alternative controls for credit demand in the estimations reported in Table 6. Included in column (1) and (2) as a control for credit demand is the rate of unemployment. An increase in the rate of unemployment is found to negatively affect credit supply to both households and non-financial corporates. The indices from the ECB's BLS, which provide insight to conditions for bank credit, are included in columns (3) and (4). Shifts in credit demand motivated by borrowers' access to alternative non-bank sources of credit are measured by indices sourced from the ECB's Bank Lending Survey in columns (5) and (6). In columns (7) and (8) an interaction term between time fixed effects and country fixed effects is included to account for within-country time varying differences in demand. Overall, the results suggest the international liquidity shock to euro area banks negatively affected the supply of credit to households, but was not a significant determinant of the decline in non-financial corporate credit growth.

6.3   Success of VLTROs

To investigate the role of unconventional monetary policy, the results of the estimation of specification (4) inclusive of the VLTROs are shown in Table 7. In columns (1) and (2) the dependent variable is household credit supply and in columns (3) and (4) is non-financial corporate credit supply. The coefficients on $VLTRO1$ is both negative and significant across both household and non-financial corporate credit supply growth, suggesting the initial round of VLTROs in December 2011 was not successful in mitigating the effects of the sovereign debt crisis on bank credit supply to the real economy. In columns (2) and (4) when bank

specific time varying characteristics are included, the coefficient reported on the $VLTRO2$ variable is positive and significant for both categories of borrowers, indicating the second round of VLTROs in February 2012 were successful in increasing the supply of credit to the real economy.

The coefficient on the interaction term $VLTRO * IntLiqShock$ is included to assess whether access to the VLTRO facility mitigated the effects of the liquidity shock to banks international funding on their credit supply. The coefficient on $VLTRO2 * IntLiqshock$ enters column (2) with a positive and significant sign. This suggests banks that were affected by the liquidity shock and drew on alternative funding sources facilitated through the VLTRO liquidity, this funding had a positive effect on their household credit supply. In contrast, for those banks affected by the international liquidity shock and accessed the VLTRO facilities did not increase their supply of credit to non-financial corporates during this period.

Table 8 reports the sensitivity analysis for these results. As an alternative measure of credit demand, the rate of unemployment is included. The coefficient on this control for credit demand enters all regressions with a negative and significant sign, indicating an increase in the unemployment rate contributes to a contraction in credit supply to both households and non-financial corporates. Throughout columns (1) to (4) the results are consistent with the previous findings.

Further to the supply of credit to the non-financial private sector, the VLTROs also provided euro area banks with arbitrage and carry trade opportunities (Cour-Thimann and Winkler, 2012). To investigate the effects of euro area bank borrowings under the VLTRO liquidity operations and their investment in government securities, the estimates of specification (4) with transactions in government securities as the dependent variable are reported in Table 9.[6] Overall the results suggest that the first VLTRO facility is positively associated with an increase in purchases of euro area government securities. Evidence in support of the second VLTRO providing arbitrage and carry trade opportunities is only found in column (1). These findings no longer hold, however, in column (4) when demand is controlled for through by including the interaction between time and country fixed effects, indicating unobservable shifts in demand at the country level influenced euro area bank speculative investment in government bonds.

6.4 Discussion of results

In summary, the results confirm that euro area banks with greater exposure to stressed sovereign debt during a period of elevated liquidity risk in the interbank money market ex-

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[6]It is not possible to distinguish between the maturities of government securities purchased requiring the assessment of arbitrage and carry trade opportunities to considered in unison.

perienced a liquidity shock to their international funding, from non-euro area investors and US wholesale investors. This finding is consistent with the related research on the effects of the European sovereign debt crisis on the liquidity of internationally active banks. Correa et al., (2012) document how the increase in European sovereign risk created an obstacle to the financial intermediation of European bank branches and subsidiaries in the US, in particular vis-á-vis US money market funds.

In addition, the retraction in international funding is found to be particularly pronounced for French banks. These results provide empirical evidence in support of the observations in the literature that the sharp reduction in US money market fund exposure to French banks in mid-2011 was a consequence of their exposure to stressed European sovereigns (Caruana and Van Rixtel, 2013; Ivasina et al., 2012).

The international liquidity shock is found to have negatively affected euro area bank domestic assets but not foreign assets. These findings are in line with those of the EBA, that the liquid assets of European banks denominated in US dollars were of lower quality relative to their European asset portfolio (Blowers and Forsman, 2013). An alternative explanation for this finding is that global banks actively manage their liquidity across their banking group, by allocating liquidity through their internal capital markets (Ceterolli and Goldberg 2012a, 2012b). Correa et al. (2012) provide empirical evidence of this internal liquidity management by European banks during the sovereign debt crisis, whereby European parent banks allocated funding to their US affiliates in the aftermath of the contraction by US wholesale investors.

Euro area banks primarily responded to the international liquidity shock through a combined reduction of both liquid assets and less liquid assets in the form of credit, where the effect was most pronounced for the latter asset category. In tracing the effect of the international liquidity shock to the real economy, credit supply to households and non-financial corporates is negatively affected. In line with the related literature, these results illustrate that cross-border funding facilitates the transmission of international liquidity shocks, and has consequences for domestic bank credit supply (Schnabl, 2012; Peek and Rosengren, 2000; Cetorelli and Goldberg, 2011).

Partial evidence is found in support for the ECB's unconventional monetary policy in the form of the VLTROs. ECB liquidity via the VLTRO operations in December 2011 is not found to have relieved the funding strains of euro area banks. Controlling for credit demand, this round of VLTROs is not found to have been effective in supplying credit to households and non-financial corporates.

Evidence is found in support of the success of the VLTRO in February 2012 in preventing the decline in credit supply households and non-financial corporates. The heterogeneity in the effectiveness of this official liquidity on credit supply across the two VLTRO operations is likely associated with Mario Draghi's, the ECBs president, assertion on 9 February 2012

in advance of the second round of VLTROs, that there is *"no stigma whatsoever attached to these facilities"*. Consequently, a larger injection of official liquidity was evident in the second round of the VLTROs, with a greater number of euro area banks participating.

Better capitalised banks are associated with lower credit supply, most likely reflecting the EBA's requirement to meet higher Tier 1 capital ratios following the 2011 Capital Exercise. During this period of increasingly tighter financial regulation, better capitalised banks were not necessarily those best positioned to buffer the effects of the international liquidity shock during the sovereign debt crisis. The empirical estimates also show that for banks affected by the international liquidity shock, access to the ECB's enhanced liquidity facilities did not shield their credit supply, suggesting the decline in credit growth was most pronounced for weak banks reliant on international funding.

7   Conclusions

Greater interconnectedness between euro area banks and their sovereigns during the European sovereign debt crisis has increased the impetus to understand the implications of this relationship for credit supply to the real economy. This paper investigates the influence of euro area bank holdings for impaired sovereign debt on their international funding and traces the effect through to their credit supply by employing a bank-level monthly dataset of approximately 250 euro area banks between 2008 and 2013.

Controlling for bank risk, the empirical analysis finds that greater exposure to stressed European sovereigns is associated with a decline in cross-border funding from non-euro area investors and in the US funding of their US affiliates. Tracing the effects of this international liquidity shock through to the asset portfolio of euro area banks, the empirical analysis finds that there was a contraction in both liquid assets and credit supply. The ECB's unconventional monetary policy, in the form of the VLTROs, is found to have partially mitigated the effects of the sovereign debt crisis on euro area bank credit supply to households and non-financial corporates.

Overall these findings suggest that bank-sovereign nexus bound tightly during a period of elevated sovereign risk and propagated across borders through the international activities of euro area banks. The establishment of unconventional monetary policy by the ECB in response highlights the importance in future work in understanding the transmission mechanism of official liquidity to the real economy.

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Appendix: Figures and tables

Figure 1: Evolution of European banks' cross-border funding, 1985 – 2013
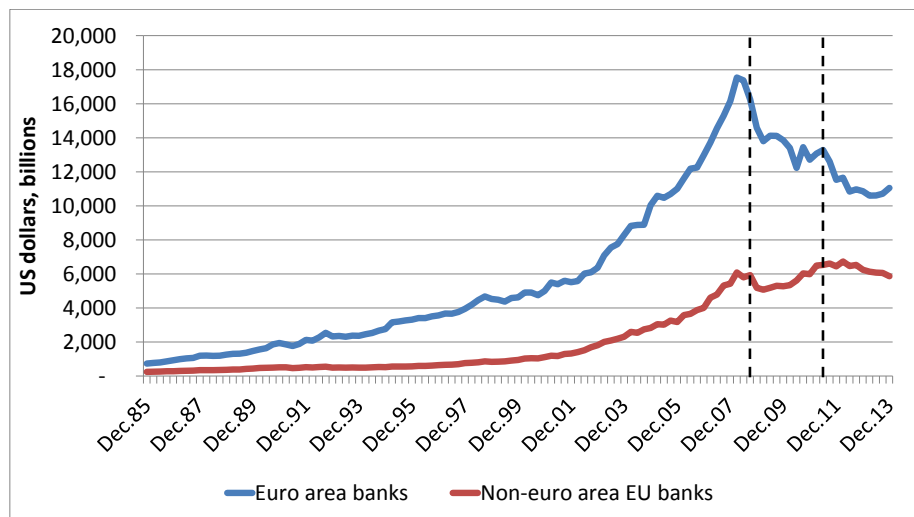
Notes: (i) Data are sourced from the Bank for International Settlements Locational Banking Statistics, (ii) Euro area countries include Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain.

Figure 2: Cross-border funding as a proportion of domestic private sector credit
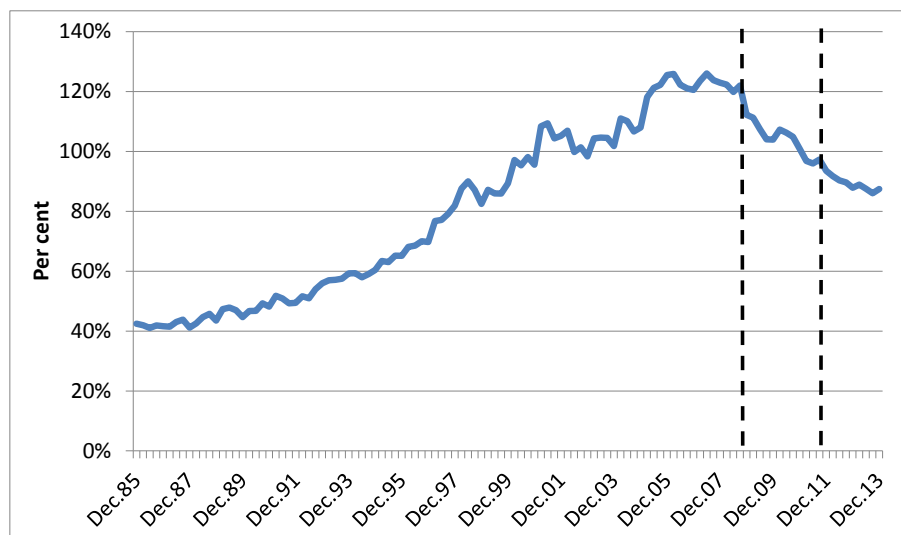
Notes: (i) Data are sourced from the Bank for International Settlements locational banking statistics and the credit to the private non-financial sector database, (ii) the black vertical lines represent September 2008 and August 2011, respectively.

Figure 3: Asset growth of foreign banks' US-based affiliates
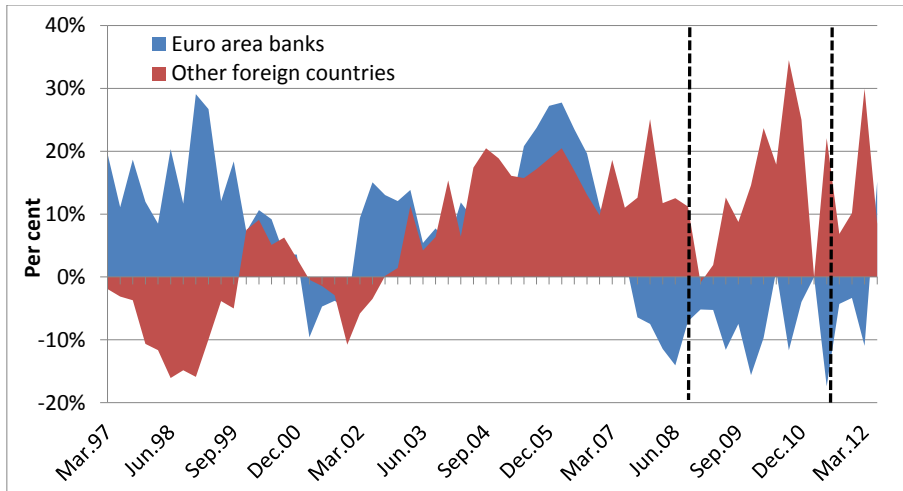
Notes: (i) Data are sourced from the Structure and Share Data for US Banking Offices of Foreign Entities published by the Federal Reserve Board, (ii) the black vertical lines represent September 2008 and August 2011, respectively.

Figure 4: Indicators of interbank market stress
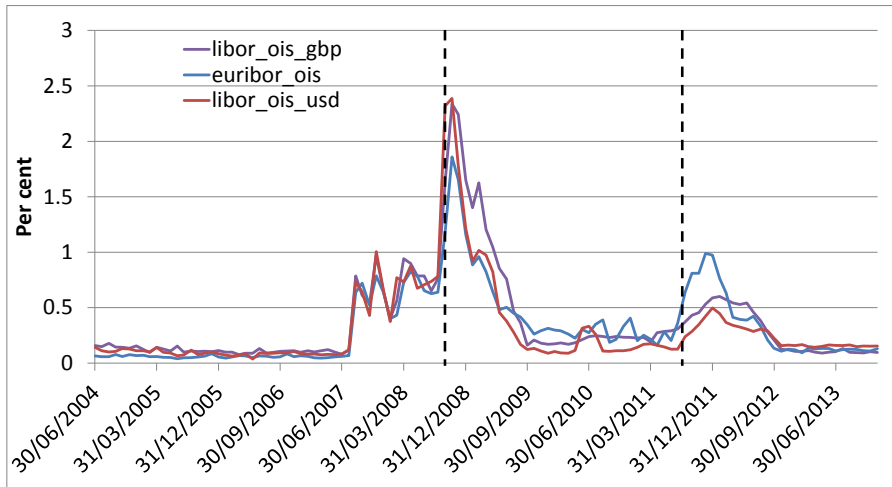
Data source: Bloomberg

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Figure 5: Correlations between Libor OIS USD and sovereign credit default swaps

Table 1: Exposure of banks to stressed European sovereigns, end-December 2010

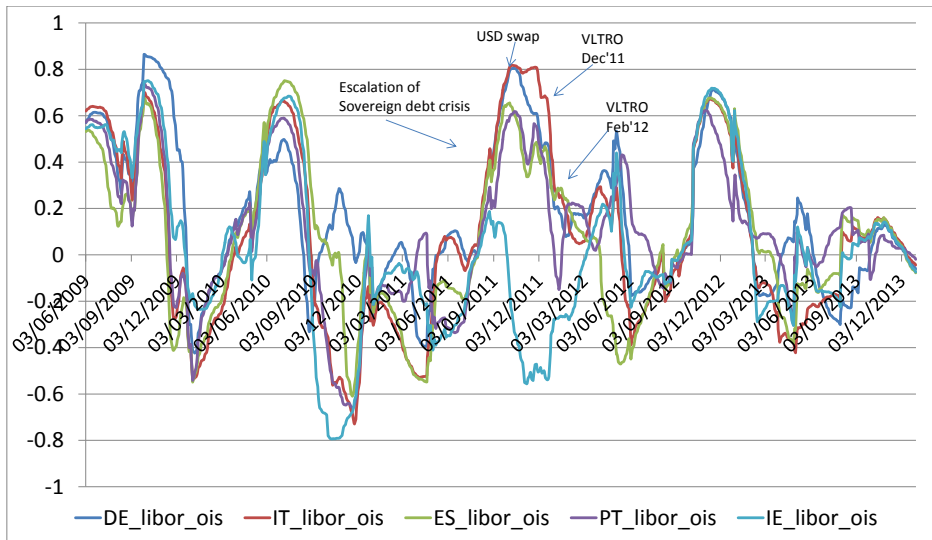| Institution name	Nationality	Total assets(€m)	Country of exposure					
			ES	GR	IE	IT	PT	Total
BNP PARIBAS	FR	2,003,234	0.08	0.09	0.01	0.46	0.04	0.68
DEUTSCHE BANK AG	DE	1,905,630	0.08	0.05	0.02	0.23	0.01	0.38
HSBC HOLDINGS plc	UK	1,783,199	0.02	0.01	0.01	0.11	0.01	0.16
BARCLAYS plc	UK	1,725,709	0.18	0.00	0.01	0.19	0.03	0.41
CREDIT AGRICOLE	FR	1,506,595	0.08	0.01	0.00	0.22	0.02	0.34
BANCO SANTANDER S.A.	ES	1,223,267	0.98	0.00	0.00	0.02	0.08	1.08
SOCIETE GENERALE	FR	1,053,839	0.16	0.09	0.03	0.29	0.03	0.60
BPCE	FR	1,003,626	0.03	0.04	0.01	0.16	0.01	0.24
LLOYDS BANKING GROUP	UK	951,826	0.00	0.00	0.00	0.00	0.00	0.00
ING BANK NV	NL	933,073	0.05	0.02	0.00	0.22	0.02	0.32
UNICREDIT S.p.A	IT	931,283	0.05	0.02	0.00	1.31	0.00	1.38
COMMERZBANK AG	DE	730,467	0.16	0.12	0.00	0.45	0.04	0.77
RBS GROUP PLC	UK	622,772	0.03	0.02	0.01	0.12	0.01	0.18
RABOBANK NEDERLAND	NL	607,483	0.01	0.01	0.01	0.01	0.00	0.04
INTESA SANPAOLO S.p.A	IT	576,962	0.03	0.02	0.00	2.18	0.00	2.23
NORDEA BANK AB (PUBL)	SE	542,853	0.00	0.00	0.00	0.00	0.00	0.01
BBVA	ES	540,936	1.85	0.00	0.00	0.14	0.02	2.01
DEXIA	BE	509,387	0.08	0.20	0.00	0.91	0.11	1.30
DANSKE BANK	DK	404,168	0.01	0.00	0.03	0.04	0.01	0.08
ABN AMRO BANK NV	NL	379,599	0.01	0.00	0.00	0.11	0.00	0.13
LB BADEN-WURTTEMBERG	DE	356,383	0.05	0.08	0.00	0.14	0.01	0.29
HYPO REAL ESTATE	DE	328,119	0.96	0.00	0.01	2.01	0.14	3.12
BFA-BANKIA	ES	327,930	1.95	0.00	0.00	0.00	0.00	1.95
DZ BANK AG	DE	323,578	0.54	0.09	0.01	0.35	0.13	1.12
BAYERISCHE LANDESBANK	DE	316,354	0.06	0.01	0.00	0.04	0.00	0.12
CAJA DE AHORROS Y PENSIONES DE BARCELONA	ES	275,856	2.96	0.00	0.00	0.11	0.00	3.07
KBC BANK	BE	267,053	0.11	0.04	0.02	0.44	0.01	0.62
BANCA MONTE DEI PASCHI DI SIENA	IT	246,799	0.04	0.00	0.00	4.99	0.03	5.07
SVENSKA HANDELSBANKEN AB	SE	240,202	0.00	0.00	0.00	0.00	0.00	0.00
NORDDEUTSCHE LANDESBANK -GZ-	DE	228,586	0.11	0.03	0.01	0.41	0.06	0.61
SKANDINAVISKA ENSKILDA BANKEN AB (PUBL)	SE	212,240	0.01	0.01	0.00	0.03	0.01	0.06
DNB NOR BANK ASA	NO	209,385	0.00	0.00	0.00	0.00	0.00	0.00
ERSTE BANK GROUP (EBG)	AT	205,938	0.01	0.03	0.00	0.05	0.01	0.11
SWEDBANK AB (PUBL)	SE	191,365	0.00	0.00	0.00	0.00	0.00	0.00
WESTLB AG, DUSSELDORF	DE	190,935	0.17	0.08	0.01	0.25	0.00	0.51
NYKREDIT	DK	175,703	0.00	0.00	0.00	0.01	0.01	0.02
HSH NORDBANK AG, HAMBURG	DE	150,930	0.04	0.02	0.00	0.16	0.01	0.24
BANCO POPOLARE - S.C.	IT	140,043	0.03	0.02	0.00	2.07	0.00	2.12
BANK OF IRELAND	IE	139,827	0.00	0.01	0.90	0.00	0.00	0.91
ALLIED IRISH BANKS PLC	IE	137,000	0.11	0.01	1.65	0.27	0.08	2.11
LANDESBANK BERLIN AG	DE	133,861	0.07	0.08	0.00	0.06	0.00	0.22
UBI BANC	IT	131,559	0.00	0.00	0.00	1.60	0.00	1.60
RAIFFEISEN BANK INTERNATIONAL	AT	131,173	0.00	0.00	0.00	0.05	0.00	0.06
DEKABANK	DE	130,304	0.05	0.02	0.01	0.07	0.01	0.15

Table 1 continued

Institution name	Nationality	Total assets(€m)	ES	GR	IE	IT	PT	Total
BANCO POPULAR ESPANOL, S.A.	ES	129,183	1.30	0.00	0.00	0.03	0.09	1.43
CAIXA GERAL DE DEPOSITOS, SA	PT	119,318	0.03	0.01	0.00	0.00	0.98	1.03
NATIONAL BANK OF GREECE	GR	118,832	0.00	2.08	0.00	0.00	0.00	2.08
BCP	PT	100,010	0.00	0.20	0.06	0.01	1.82	2.10
BANCO DE SABADELL, S.A.	ES	96,703	1.94	0.00	0.01	0.00	0.02	1.98
ESPIRITO SANTO FINANCIAL GROUP	PT	85,644	0.01	0.07	0.00	0.02	0.60	0.68
EFG EUROBANK ERGASIAS S.A.	GR	84,199	0.00	2.14	0.00	0.02	0.00	2.17
CAIXA DESTALVIS DE CATALUNYA, TARRAGONA	ES	77,732	1.10	0.00	0.00	0.00	0.00	1.10
SNS BANK NV	NL	76,854	0.03	0.03	0.09	0.42	0.00	0.56
CAIXA DE AFORROS DE GALICIA, VIGO, OUREN	ES	75,941	1.78	0.00	0.00	0.07	0.05	1.90
OP-POHJOLA GROUP	FI	74,927	0.00	0.00	0.01	0.00	0.00	0.01
CAJA DE AHORROS DEL MEDITERRANEO	ES	74,834	7.68	0.00	0.02	0.03	0.01	7.74
GRUPO BANCA CIVICA	ES	71,902	1.43	0.00	0.00	0.00	0.00	1.43
GRUPO BMN	ES	70,397	1.13	0.00	0.00	0.00	0.03	1.16
ALPHA BANK	GR	66,798	0.00	1.07	0.00	0.00	0.00	1.07
PIRAEUS BANK GROUP	GR	57,680	0.00	2.82	0.00	0.00	0.00	2.82
EFFIBANK	ES	55,042	1.14	0.01	0.00	0.00	0.01	1.16
BANKINTER, S.A.	ES	53,476	1.73	0.00	0.00	0.00	0.00	1.73
IRISH LIFE AND PERMANENT	IE	48,541	0.00	0.00	1.74	0.00	0.00	1.74
CAJA ESPANA DE INVERSIONES, SALAMANCA Y	ES	46,120	3.46	0.00	0.00	0.00	0.01	3.47
OESTERREICHISCHE VOLKSBANK AG	AT	44,745	0.04	0.07	0.01	0.09	0.02	0.22
GRUPO BBK	ES	44,628	1.01	0.00	0.00	0.00	0.00	1.01
BANCO BPI, SA	PT	43,348	0.00	0.15	0.13	0.44	1.77	2.48
MARFIN POPULAR BANK PUBLIC CO LTD	CY	43,068	0.00	1.79	0.02	0.00	0.00	1.81
CAJA DE AHORROS Y M.P. DE ZARAGOZA, ARAG	ES	42,716	1.27	0.00	0.00	0.17	0.00	1.43
BANK OF CYPRUS PUBLIC CO LTD	CY	41,996	0.03	1.09	0.15	0.02	0.00	1.28
POWSZECHNA KASA OSZCZEDNOSCI BANK POLSKI	PL	35,673	0.00	0.00	0.00	0.00	0.00	0.00
OTP BANK NYRT.	HU	34,517	0.00	0.00	0.00	0.00	0.00	0.00
MONTE DE PIEDAD Y CAJA DE AHORROS DE RON	ES	34,263	1.18	0.00	0.00	0.12	0.01	1.31
JYSKE BANK	DK	32,635	0.01	0.03	0.01	0.00	0.01	0.06
ANTEQUERA Y JAEN BANCO PASTOR, S.A.	ES	31,135	1.64	0.03	0.00	0.07	0.08	1.82
CAIXA DESTALVIS UNIO DE CAIXES DE MANLL	ES	28,878	2.86	0.00	0.01	0.01	0.00	2.89
AGRICULTURAL BANK OF GREECE S.A. (ATEban	GR	26,807	0.00	53.57	0.00	0.00	0.00	53.57
CAJA DE AHORROS Y M.P. DE GIPUZKOA Y SAN	ES	20,786	0.79	0.00	0.00	0.00	0.00	0.79
SYDBANK	DK	20,158	0.00	0.00	0.01	0.00	0.00	0.00
GRUPO CAJA3	ES	20,144	1.34	0.00	0.01	0.00	0.00	1.35
WGZ BANK AG WESTDT. GENO. ZENTRALBK, DDF	DE	18,105	0.59	0.16	0.11	0.70	0.23	1.79
NOVA LJUBLJANSKA BANKA D.D. (NLB d.d.)	SI	17,736	0.03	0.03	0.02	0.13	0.02	0.23
TT HELLENIC POSTBANK S.A.	GR	16,783	0.00	4.26	0.00	0.00	0.00	4.26
BANCA MARCH, S.A.	ES	12,744	0.07	0.00	0.00	0.00	0.00	0.07
CAJA DE AHORROS DE VITORIA Y ALAVA	ES	8,644	0.81	0.00	0.00	0.00	0.00	0.81
BANK OF VALLETTA (BOV)	MT	6,382	0.00	0.03	0.02	0.01	0.01	0.06
CAJA DE AHORROS Y M.P. DE ONTINYENT	ES	931	0.11	0.00	0.00	0.00	0.00	0.11
COLONYA - CAIXA DESTALVIS DE POLLENSA	ES	351	1.34	0.00	0.00	0.00	0.00	1.34

This table shows the list of banks included in the EBA stress tests, their nationality, total assets and the exposure by bank to GIIPS scaled by total capital at end-December 2010.

Table 2: Summary statistics

Variable	Definition	Mean	Std. Dev.	Min.	Max.
US assets	Annual log change in US assets of euro area banks	-0.08	0.38	-1.56	1.10
Exposure	Euro area banks holdings of stressed sovereign debt	0.65	1.23	0.00	7.74
Libor OIS	Spread between Libor USD 3 moth rate and USD 3 month overnight index swap	0.39	0.51	0.09	2.32
Size	Log of total assets of euro area bank (consolidated)	13.32	1.18	10.74	15.10
Capital	Tier 1 capital of euro area bank	11.51	3.17	-6.10	21.50
Deposits	Customer deposits of euro area bank	0.38	0.15	0.00	1.18
Income	Net income of euro area bank scaled by total assets	0.00	0.01	-0.09	0.08
Provisions	Loan provisions of euro area bank scaled by total assets	0.33	0.52	-0.59	5.63
Bank CDS	Log of credit default swap of euro area bank	4.20	1.87	0.00	7.88
Cross-border funding	Annual flow of extra-euro area funding	0.01	0.43	-0.90	2.39
Household loans	Flow of household loans scaled by total assets (resident)	0.01	0.02	-0.04	0.08
NFC loans	Flow of NFC loans scaled by total assets (resident)	0.00	0.02	-0.10	0.06
Total loans	Flow of total loans scaled by total assets (resident)	0.02	0.24	-2.14	7.63
Domestic assets	Flow of total domestic assets scaled by total assets (resident)	0.03	0.24	-2.15	7.60
Liquid assets	Flow of liquid assets (debt and equity securities) scaled by total assets (resident)	0.02	0.22	-0.85	7.53
Foreign assets	Flow of foreign (extra-euro area) assets scaled by total assets (resident)	0.00	0.13	-0.73	3.41
Credit demand Household	Index of household demand for bank credit	-6.34	14.69	-80.00	38.00
Credit demand NFC	Index of NFC demand for bank credit	-7.38	17.62	-90.00	38.00
Non-bank credit Household	Index of household demand for non-bank sourced credit	-0.01	0.04	-0.50	0.08
Non-bank credit NFC	Index of NFC demand for non-bank sourced credit	0.00	0.04	-0.42	0.20
Unemployment	Log of unemployment rate	2.24	0.50	0.92	3.32
Industrial production	Log of monthly industrial production	4.55	0.16	3.82	4.91
VLTRO1	1/0 dummy variable if bank participated in VLTRO in December 2011	0.41	0.49	0.00	1.00
VLTRO2	1/0 dummy variable if bank participated in VLTRO in February 2012	0.41	0.49	0.00	1.00

Table 3: International funding and sovereign exposure

	(1) ΔInt funding	(2) ΔInt funding	(3) ΔInt funding	(4) ΔInt funding	(5) ΔInt funding
Exposure*Libor OIS	-0.194**	-0.282***	-0.352**	-2.777*	-0.571
	(0.06)	(0.06)	(0.14)	(0.90)	(0.79)
Exposure	0.013	0.059***	0.057**	-0.359	0.125
	(0.02)	(0.01)	(0.02)	(0.32)	(0.18)
Libor OIS	0.062*	0.484**	0.092	-0.672	0.384**
	(0.03)	(0.19)	(0.25)	(0.57)	(0.09)
Size			0.340**	-0.768**	0.413**
			(0.10)	(0.17)	(0.10)
Capital			0.029**	0.010	0.051**
			(0.01)	(0.05)	(0.01)
Deposits			-0.160	0.502	-0.392
			(0.21)	(0.55)	(0.27)
Income			-0.566	46.009**	-2.519
			(1.20)	(7.99)	(3.19)
Loan provisions			0.002	-0.419	0.260**
			(0.05)	(0.16)	(0.11)
CDS			0.016	-0.317	0.076
			(0.02)	(0.29)	(0.06)
Observations	7645	7645	5129	850	2451
R-squared	0.013	0.305	0.375	0.361	0.439
Adjusted R-squared	0.012	0.182	0.206	0.291	0.14
Bank fixed effects	N	Y	Y	Y	Y
Country*time fixed effects	N	Y	Y	N	Y
Time fixed effects	N	N	N	Y	N

This table shows the effect of euro area banks' exposure to stressed sovereigns on international funding. The dependent variable is the annual flow of monthly extra-euro area cross-border funding of euro area banks, over the period 2008 to 2013. Regression (4) narrows the data sample to French-owned banks and regression (5) narrows the sample to core countries' banks minus French-owned banks. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

Table 4: US funding and sovereign exposure

	(1) ΔUS funding	(2) ΔUS funding	(3) ΔUS funding	(4) ΔUS funding	(5) ΔUS funding
Exposure*Libor OIS	-0.264**	0.139	0.418*	-1.179**	-2.984**
	(0.08)	(0.14)	(0.21)	(0.06)	(0.99)
Exposure	0.039**	-0.048*	-0.053	0.064	0.786*
	(0.01)	(0.02)	(0.10)	(0.03)	(0.33)
Libor OIS	0.056	-0.302***	-0.289**	0.040	-0.163*
	(0.05)	(0.00)	(0.07)	(0.04)	(0.08)
Size			0.000	0.781	-0.046
			(0.47)	(0.28)	(0.54)
Capital			0.001	0.040*	-0.036
			(0.02)	(0.01)	(0.04)
Deposits			0.071	-0.400*	-1.345
			(0.74)	(0.11)	(1.60)
Income			-1.432	-22.344	-14.647
			(3.83)	(26.35)	(50.90)
Loan provisions			0.040	-0.064	-0.358
			(0.06)	(0.18)	(0.43)
Observations	802	802	574	61	284
R-squared	0.022	0.538	0.658	0.275	0.716
Adjusted R-squared	0.019	0.271	0.358	0.130	0.391
Bank fixed effects	N	Y	Y	Y	Y
Country*time fixed effects	N	Y	Y	N	Y

This table shows the effect of euro area banks' exposure to stressed sovereigns on international funding. The dependent variable is the annual log change in the funding of European banks' affiliates in the US, over the period 2008 to 2013. Regression (4) narrows the data sample to French-owned banks and regression (5) narrows the sample to core countries' banks minus French-owned banks. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

Table 5: Effects of international liquidity shock on asset portfolio of euro area banks

	(1) ΔLoans	(2) ΔHH loans	(3) ΔNFC loans	(4) ΔLiquid assets	(5) ΔDomestic assets	(6) ΔForeign assets
International liquidity shock	-0.394**	-0.064**	-0.111***	-0.314**	-0.317**	-0.253
	(0.14)	(0.02)	(0.03)	(0.14)	(0.14)	(0.26)
Credit demand		0.003	0.008			
		(0.00)	(0.01)			
Size	-0.108	-0.022**	-0.016	-0.037	-0.078	-0.055
	(0.08)	(0.01)	(0.02)	(0.05)	(0.08)	(0.08)
Capital	0.002	0.000	-0.001**	-0.004	0.002	-0.004
	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Deposits	0.041	-0.02	0.002	0.054	0.063	0.011
	(0.08)	(0.02)	(0.03)	(0.08)	(0.08)	(0.04)
Income	-0.290	0.074	-0.222**	0.421	0.028	0.413
	(0.42)	(0.09)	(0.10)	(0.37)	(0.34)	(0.54)
Loan provisions	-0.002	-0.002	0.001	0.007	0.001	-0.005
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
CDS	0.003	0.001	0.002	-0.001	0.003	0.002
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Observations	4931	4622	4622	4931	4931	4931
Bank fixed effects	Y	Y	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y	Y	Y
Time fixed effects	Y	Y	Y	Y	Y	Y

This table shows the effect of the international liquidity shock on euro area banks' asset portfolio using IV regressions. The dependent variables are the supply of total credit, the supply of credit to households, the supply of credit to NFCs, the growth in liquid assets (debt and equity securities), the growth in total domestic assets and the growth in foreign (extra-euro area) assets, over the period 2008 to 2013. The IV analysis reported in the table contains the explanatory variable, international liquidity shock, is instrumented by *Exposure*Libor OIS*, *Exposure and Libor OIS*. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

Table 6: Effects of international liquidity shock on HH and NFC credit supply, alternative credit demand measures

	(1) ΔHH loans	(2) ΔNFC loans	(3) ΔHH loans	(4) ΔNFC loans	(5) ΔHH loans	(6) ΔNFC loans	(7) ΔHH loans	(8) ΔNFC loans
International liquidity shock	-0.040**	-0.036	-0.074**	-0.051	-0.076***	-0.056*	-0.057*	-0.008
	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
Credit demand	-0.014**	-0.018**	-0.004	-0.003	0.022	-0.017		
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)
Size	-0.011**	0.012	-0.025*	0.007	-0.026**	0.006	-0.024*	0.018*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Capital	-0.001	-0.001**	-0.001	-0.001**	-0.001*	-0.001**	-0.002*	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Deposits	-0.010	0.003	0.001	0.012	0.002	0.012	0.001	-0.001
	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Income	0.069	-0.061	-0.022	-0.116*	-0.017	-0.115	0.112	0.084
	(0.06)	(0.08)	(0.06)	(0.07)	(0.06)	(0.07)	(0.08)	(0.09)
Loan provisions	-0.001**	0.001	-0.002	-0.003	-0.002	-0.003	-0.001	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CDS	-0.001	0.000	0.001	0.001	0.001	0.001	-0.001	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	3879	3879	4629	4629	4629	4629	4879	4879
Bank fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y	Y	Y	N	N
Country*time fixed effects	N	N	N	N	N	N	Y	Y

This table shows the effect of the international liquidity shock on euro area banks' credit to households and NFCs. The dependent variables are households and NFC credit growth. The controls for credit demand are unemployment in (1) and (2), indices from the ECB's BLS survey in (3) and (4), non-bank sourced credit from the ECB's BLS survey in (5) and (6). All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

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Table 7: Effect of VLTROs on credit supply

	(1) ΔHH loans	(2) ΔHH loans	(3) ΔNFC loans	(4) ΔNFC loans
International liquidity shock	0.000	0.117*	-0.279**	-0.078**
	(0.06)	(0.06)	(0.14)	(0.04)
VLTRO1	-0.039***	-0.036***	-0.012**	-0.008***
	(0.00)	(0.00)	(0.01)	(0.00)
VLTRO2	0.027***	0.083***	-0.012***	0.050***
	(0.00)	(0.02)	(0.00)	(0.01)
VLTRO1* International liquidity shock	0.001	0.056*	-0.152**	-0.038**
	(0.03)	(0.03)	(0.08)	(0.02)
VLTRO2* International liquidity shock	0.004	0.095**	-0.190**	-0.055**
	(0.05)	(0.04)	(0.08)	(0.03)
Credit demand	0.009**	0.003	0.012	0.018***
	(0.00)	(0.01)	(0.01)	(0.00)
Size		0.012		0.008
		(0.01)		(0.01)
Capital		-0.002***		-0.001**
		(0.00)		(0.00)
Deposits		0.006		0.013
		(0.02)		(0.01)
Income		0.289***		-0.100
		(0.08)		(0.09)
Loan provisions		-0.005**		-0.006***
		(0.00)		(0.00)
CDS		0.000		0.000
		(0.00)		(0.00)
Observations	6873	4567	6873	4567
Bank fixed effects	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y

This table shows the effect of the VLTROs and international liquidity shock on euro area banks' credit to households and NFCs. The dependent variables are households and NFC credit growth. The control for credit demand is economic output. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

Table 8: Effect of VLTROs on credit supply, alternative credit demand measure

	(1) ΔHH loans	(2) ΔHH loans	(3) ΔNFC loans	(4) ΔNFC loans
International liquidity shock	0.063	0.052**	-0.235*	-0.131***
	(0.07)	(0.03)	(0.14)	(0.04)
VLTRO1	-0.047***	-0.045***	-0.022***	-0.020***
	(0.00)	(0.00)	(0.01)	(0.00)
VLTRO2	0.043***	0.081***	0.006	0.059***
	(0.00)	(0.01)	(0.01)	(0.01)
VLTRO1 * International liquidity shock	0.033	0.025**	-0.118*	-0.062**
	(0.04)	(0.01)	(0.07)	(0.02)
VLTRO2 * International liquidity shock	0.049	0.044**	-0.168*	-0.100***
	(0.05)	(0.02)	(0.09)	(0.02)
Credit demand	-0.022***	-0.018***	-0.028**	-0.029***
	(0.00)	(0.00)	(0.01)	(0.01)
Size		0.006		0.006
		(0.01)		(0.01)
Capital		-0.001**		0.000
		(0.00)		(0.00)
Deposits		-0.003		0.000
		(0.01)		(0.02)
Income		0.204**		-0.177*
		(0.07)		(0.11)
Loan provisions		-0.003**		0.000
		(0.00)		(0.00)
CDS		-0.001		0.000
		(0.00)		(0.00)
Observations	5659	3879	5659	3879
Bank fixed effects	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	Y

This table shows the effect of the VLTROs and international liquidity shock on euro area banks' credit to households and NFCs. The dependent variables are households and NFC credit growth. The control for credit demand is the unemployment rate. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.

Table 9: Effect of VLTROs on transactions in government securities

	(1) ΔGVT securities	(2) ΔGVT securities	(3) ΔGVT securities	(4) ΔGVT securities
International liquidity shock	-0.028**	0.052	0.058	0.155
	(0.01)	(0.05)	(0.12)	(0.15)
VLTRO1	0.007***	0.004**	0.004*	0.009
	(0.00)	(0.00)	(0.00)	(0.03)
VLTRO2	0.021***	0.010	0.012	0.048
	(0.00)	(0.01)	(0.03)	(0.04)
VLTRO1* International liquidity shock		0.024	0.023	0.070
		(0.02)	(0.06)	(0.07)
VLTRO2* International liquidity shock		0.044	0.056	0.128
		(0.03)	(0.09)	(0.12)
Size			-0.014	0.015
			(0.03)	(0.03)
Capital			-0.001	0.001
			(0.00)	(0.00)
Deposits			0.002	-0.015
			(0.01)	(0.03)
Income			0.120	0.310
			(0.28)	(0.26)
Loan provisions			-0.003	0.004
			(0.00)	(0.00)
CDS			0.001	0.004**
			(0.00)	(0.00)
Observations	7406	7406	4931	4931
Bank fixed effects	Y	Y	Y	Y
Country fixed effects	Y	Y	Y	N
Country*time fixed effects	N	N	N	Y

This table shows the effect of the VLTROs and international liquidity shock on euro area banks' transactions in government securities. The dependent variable is banks' transactions in government securities. All regressions are estimated with a constant (not reported). Standard errors are clustered by parent bank. Robust standard errors appear in the parentheses and ***, **, * correspond to significance at the one, five and ten per cent level of significance, respectively.