

# BANK BALANCE SHEETS IN THE FINANCIAL CRISIS

D. Giannone, M. Lenza, H. Pill and L. Reichlin

**Abstract:** This paper analyses time series data on the aggregate balance sheet of euro area monetary financial intermediaries (MFIs) from January 1999 to April 2011. In analysing bank behaviour following the failure of Lehman Brothers in September 2008, we find that, after taking into account business cycle conditions: (1) net financial flows among domestic banks have been substituted with central bank intermediation across the Eurosystem balance sheet to an unusual extent as a result of the introduction of the ECB's non-standard monetary policy measures; (2) the observed decline of MFIs domestic assets and liabilities with respect to non-banks is in line with historical regularities, suggesting that this central bank intermediation helped to insulate financial flows to households and firms from the turmoil in interbank markets; and (3) interbank activity during the post-Lehman period is characterized by an unusual decline of transactions with non-residents (largely offshore banks), which offers motivation for increased central bank cooperation in supporting global liquidity conditions.

**Keywords:** Bank balance sheets, non-standard monetary policy, central banks.

**JEL codes:** E42, E58, F33, F42.

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## 1. Introduction<sup>1</sup>

The ongoing financial crisis has refocused the attention of macroeconomists on bank behaviour. Banks played a central role in the creation and propagation of the financial tensions associated with the Great Recession of 2008-10. This is especially true in the euro area, where banks continue to play a predominant role in the intermediation of financial flows from savers to investors.<sup>2</sup>

In previous work (starting with Lenza et al., 2009), we documented the evolution of European bank balance sheets – as reflected in euro area money and credit flows – during the financial crisis, with a focus on the period following the failure of Lehman Brothers in September 2008. In particular, we explored the impact of the non-standard policy measures introduced by the ECB on the evolution of key macroeconomic and financial aggregates. On the basis of this analysis, we concluded that these policy measures played an important role in stabilising euro area financial flows and the wider macroeconomy, largely by substituting financial markets that had become dysfunctional on account of information problems with intermediation across the central bank balance sheet.

In this paper we extend and deepen that analysis in two important and interrelated directions.

First, we strive to provide richer and more direct evidence on the nature and impact of substitution between private interbank activity and central bank intermediation. Such substitution lies at the heart of our explanation of how the ECB's non-standard monetary policy measures have worked.<sup>3</sup> While this account of the transmission of the ECB's actions has become commonplace over the past few years, empirical analysis offering direct evidence of such substitution is scarce. In our own previous

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<sup>2</sup> To illustrate, in the euro area about 75% of the external financing of the non-financial corporate sector comes from banks, compared with an equivalent figure of only 25% in the United States.

<sup>3</sup> See Trichet (2009) for the ECB's official accounts of the design and impact of its non-standard measures.

work (Giannone et al., 2011a,b; cf. Fahr, et al., 2012; Peersman, 2011), we have largely explored the macro impact of the non-standard measures in a relatively reduced form manner, while abstracting from the specific channels of transmission. In this paper, we aim at augmenting this analysis by offering a more structural empirical account of the transmission process.

Second, building on the analysis of interbank data derived from aggregate euro area bank balance sheet in Giannone et al. (2012), we analyse behaviour in the interbank market during the post-Lehman period in a more disaggregated manner. In particular, we distinguish between intra-euro area bank flows (i.e. transactions between banks resident in the euro area) and transactions with the rest of the world (to which we argue financial institutions outside the euro area are the main counterparties). Aside from adding to our understanding of the propagation mechanisms, this distinction may be important from a policy perspective. In particular, it offers some insight into the importance of cross-border liquidity provision – such as that provided via inter-central bank foreign exchange swaps – during the financial crisis. Fahri et al (2011) have argued that such facilities should become permanent features of the international financial architecture.

To anticipate our results, we provide (what we believe to be) the first direct econometric evidence of substitution of central bank intermediation for interbank activity owing to the ECB's non-standard policy actions. This substitution is substantial, but not one-for-one. We explain this feature of the data on the basis that the ECB needs to intermediate the necessary *net* interbank transactions, but not the much larger set of *gross* transactions that characterised the euro money market ahead of the financial crisis. Moreover, we show that transactions with non-residents (we argue, largely with non-resident financial institutions) have fallen in both a statistically and economically more significant manner than other interbank transactions. This feature of how the wholesale money market contracted post-Lehman lends credence to those arguing for greater central bank cooperation in crisis management.

The remainder of the paper is organised as follows. In Section 2 we provide an analytical account of financial market intermediation focusing on the interbank market. In Sections 3 and 4 we describe the data and our econometric approach, before presenting and discussing our results in Section 5. The final section concludes by outlining some of the policy implications of our findings.

## **2. Analytical framework**

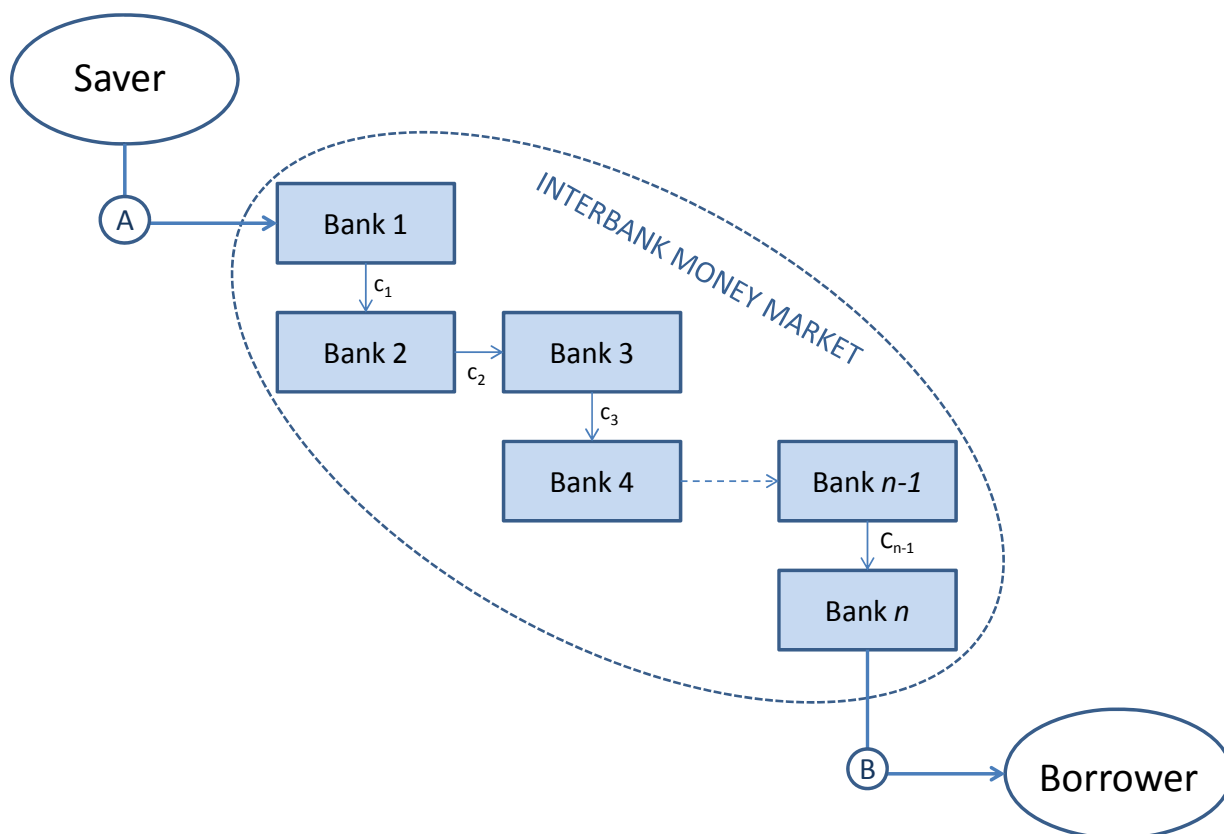
Traditionally, banks have served the function of intermediating financial flows from savers to investors. With financial innovation, intermediation has become more convoluted, a process that accelerated as the pace of bank credit expansion picked up in 2004-07.

For example, using U.S. flow of funds data Adrian and Shin (2010a,b) demonstrate how intra-financial sector leverage built up over that period. Focusing on the balance sheets of U.S. broker/dealers (investment banks), they show how the low level of short-term interest rates and relatively steep yield curve, in an environment where volatility was perceived as low, encouraged banks to lend to one another so as to extract some of the ‘carry’ available along the yield curve. Much of this financing took the form of repos of securitised assets.<sup>4</sup> Adrian and Shin demonstrate how the build-up of intra-banking sector leverage was associated with the creation of longer intermediation chains, i.e. the flow of resources from non-bank saver to non-bank borrower passed through an increasing number of banks (for a stylised representation, see Figure 1).

**Figure 1: Stylised representation of interbank money market**

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<sup>4</sup> See Gorton and Metrick (2009).



Much the same story can be applied to the euro area, with the important caveat that the structure of the European banking sector – in particular, the predominance of universal banks, which combine the activities of U.S. commercial and investment banks within a single entity – implied that the build-up of intra-financial sector leverage and lengthening of intermediation chains were phenomena that affected the entire banking sector. This process has been documented by Altunbas et al. (2009) and Carbó-Valverde et al. (2012), among others. In Europe, the rapid expansion of bank credit in the middle of the 2000s was thus associated with increasing reliance on wholesale sources of funding. And, with deepening financial integration inside the European Union and the wider process of financial globalisation beyond, these wholesale flows were often cross-border (both within the euro

area and between the euro area and other jurisdictions, notably London given its status as an international financial centre).<sup>5</sup>

Bank funding has thus become less stable in the face of financial and real shocks. Retail deposit holders (households and non-financial corporations) could be relied upon to maintain a steady level of funding to support the financing of bank loans through the business cycle. But wholesale funding from other banks, from the rest of the financial sector (notably shadow banks) and from overseas tended to be more flighty, imparting a pro-cyclical bias to the expansion of financial intermediation.<sup>6</sup> Moreover, the accumulation of intra-financial sector leverage created systemic vulnerability: if one institution chooses to shrink its balance sheet, the resulting withdrawal of wholesale funding puts pressure on others to do likewise (and so on). A self-sustaining spiral of forced deleveraging could ensue (Brunnermeier and Pedersen, 2009).

In order to develop an insight into the behaviour of intra-financial flows during the financial crisis, we exploit the *aggregate* bank balance sheet data for the euro area. Traditional monetary and credit aggregates are derived from the *consolidated* bank balance sheet.<sup>7</sup> The consolidated data net out intra-MFI positions: in terms of Figure 1, they capture financial flows from the private sector into the banking system (**A**) and out again to the private sector (**B**) (i.e., traditional bank deposits and loans respectively). But the consolidated data exclude all the intervening transactions among banks ( $\mathbf{c}_1 \dots \mathbf{c}_n$ ).<sup>8</sup> By contrast, the aggregated bank balance sheet does *not* net out these interbank transactions: rather the flow of loans from one bank to another ( $\mathbf{c}_1 \dots \mathbf{c}_n$ ) are summed and included on the asset side, while the counterpart deposits (not shown in Figure 1) are included on the liability side. Should

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<sup>5</sup> See Forster et al. (2011).

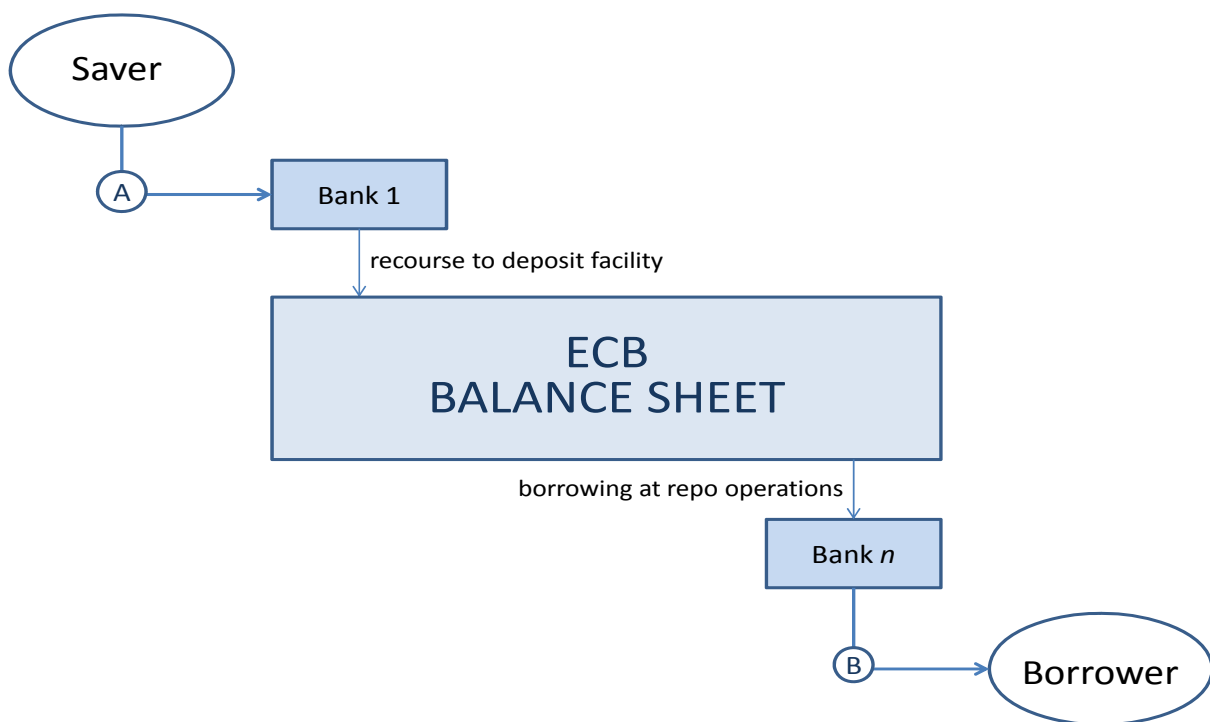
<sup>6</sup> See Shin and Shin (2011).

<sup>7</sup> Strictly we use the balance sheet of euro area monetary financial institutions (MFIs), The MFI sector consists of euro area credit institutions (essentially banks), plus money market funds and some parts of the government sector (e.g. post office banks). For the purposes of this article, we use 'banks' as a synonym for MFIs.

<sup>8</sup> By construction, interbank positions should consolidate to zero: a short-term loan from bank X to bank Y is equivalent to a deposit placed by bank Y at bank X.

the interbank market seize up (for example, owing to concerns about counterparty credit risk and the resulting adverse selection, as modelled by Heider et al., 2009), the central bank can step in to intermediate the underlying flow of financial resources from savers to borrowers across its own balance sheet (see Figure 2). This is our characterisation of the ECB's non-standard measures. An immediate implication of facilitating financial transactions in this way has been a substantial expansion of the ECB balance sheet.

Figure 2: Stylised representation of central bank intermediation



In essence, the non-standard policy measures represent an attempt to use the central bank as a *de facto* central counterparty for wholesale financial transactions. By so doing, the ECB replaces the frozen private interbank market, ensures that the flow of resources from private sector savers to borrowers is maintained, and thereby sustains the necessary flow of credit to the real economy. Through these means, the central bank is able to ensure that disruptions to real economic activity caused by a

‘sudden stop’ (Calvo and Reinhart, 2000; Caballero, 2009) in financial flows are minimised. In the course of intermediating these flows, the central bank’s balance sheet will expand, as recourse to its refinancing facilities by those banks making the loans is matched by build-up of reserve holdings by other banks receiving savings deposits.

Shin and Shin (2011) extend the analysis of Adrian and Shin by considering the role played by offshore money markets in the financing of ‘overborrowing’ episodes in emerging markets (McKinnon and Pill, 1997, 1998). A large literature is devoted to the analysis of these overborrowing phenomena: a key stylised fact is that domestic credit expansion increases rapidly in an initial ‘boom’ phase, typically financed by large capital inflows from abroad. In such circumstances – which reflect experience prior to the Asian financial crisis of the late 1990s or the Mexican tequila crisis earlier in that decade – when that external financing seizes up, the domestic financial sector collapses, triggering a ‘bust’ in the real economy.

While the euro area has shown a balanced current account in recent years (and certainly during the financial crisis) and is thus not dependent on *net* capital inflows from abroad, the globalisation of financial markets over recent decades has increased the *gross* flows of capital between the euro area and the rest of the world. Unfortunately, our data set does not distinguish between non-resident banks and non-banks in capturing euro area banks’ transactions with the rest of the world. But we believe that a large part of these transactions with non-residents reflect transactions with offshore banks.<sup>9</sup> In particular, London’s role as an important financial centre for the euro area would lead to such an outcome. This conjecture is supported by the close correlation (in both levels and changes)

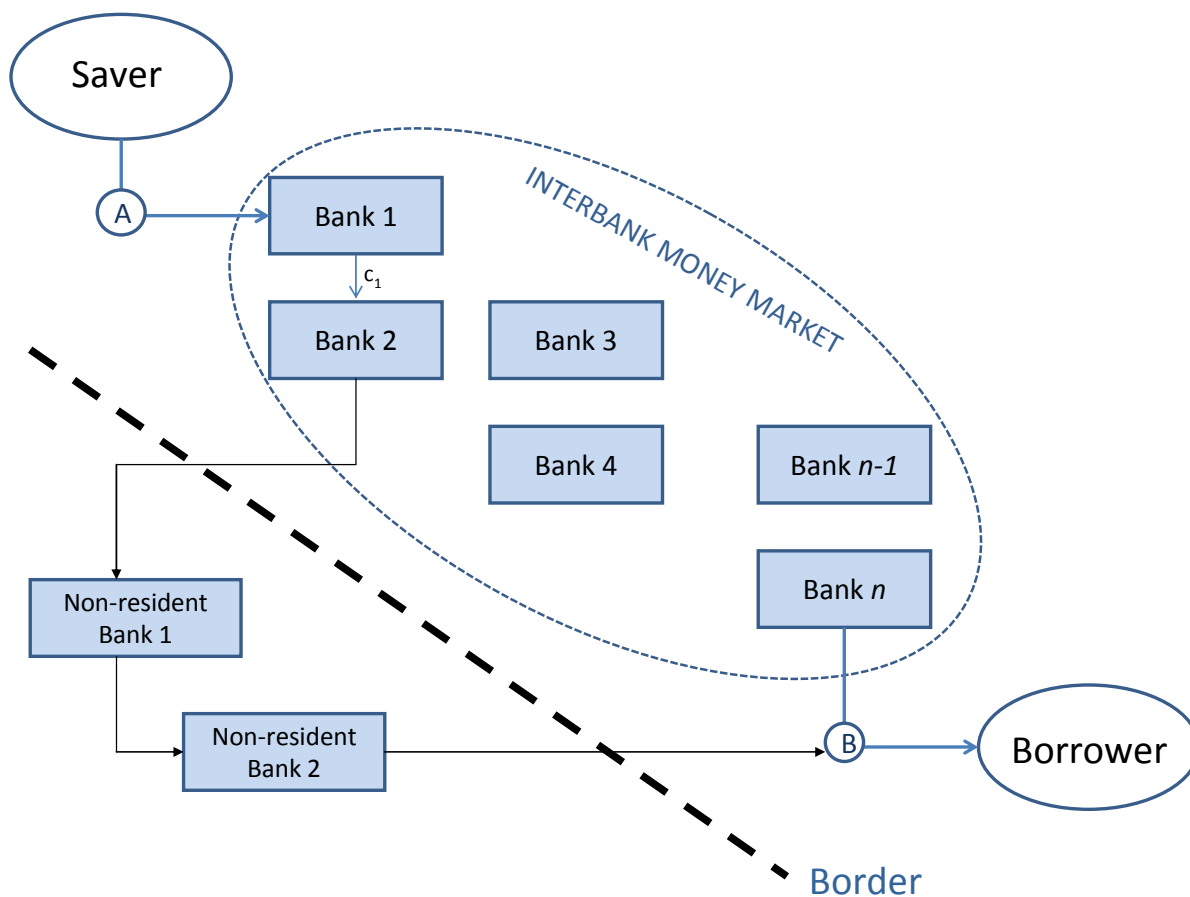
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<sup>9</sup> The data show that 70% of total non-resident deposits with euro area banks are deposits by non-resident banks. Of the remaining, non-resident non-banks account for around 25% and governments the remainder. Non-resident banks’ deposits show a protracted decline (from EUR 3150bn to EUR 2300bn) post-Lehman, whereas non-resident non-banks’ deposits revert to trend after an initial post-Lehman fall. These data therefore support our conjecture that the evolution of non-resident flows with the euro area banks in the period of focus in our study is driven strongly by interbank transactions and therefore falls naturally in our wider analytical framework.



between non-resident assets and liabilities of the euro area banks: if London acts as a conduit for interbank flows from one euro area bank to another, the non-resident assets and liabilities of euro area banks in aggregate should move closely together. As captured in a stylised manner in Figure 3 (see next page), non-resident transactions complicate the potential role of central bank intermediation in substituting for interbank transactions. This will be especially important if euro area bank transactions with non-residents are denominated in currencies other than the euro (see Section 5 of this paper for some evidence on this point). While (at least in principle) the ECB can expand the euro-denominated portion of its balance sheet without limit so as to substitute central bank intermediation for bank-to-bank transactions should markets freeze, this is not the case for transactions in other currencies. The ECB is the ultimate creator of euro liquidity: but it cannot create dollars or sterling as to providing funding in those currencies to euro area banks should their market sources of foreign currency financing dry up. This is where central bank cooperation and the provision of liquidity between central banks in the form of foreign exchange swaps may prove important. If the Federal Reserve is prepared to supply U.S. dollars to the ECB in large (or even potentially unlimited) amounts via such FX swaps and the ECB is able to distribute this liquidity to euro area banks, then the ECB can also intermediate non-resident and/or foreign currency denominated transactions should the relevant private markets become dysfunctional. This appears to have proved an important element of the collective central bank response to the financial crisis, especially in late 2008 and (for euro area banks in particular) in November 2011.

**Figure 3: The role of non-resident transactions**



Based on the discussion in the section, two key empirical questions emerge. First, can we find evidence of substitution from market intermediation into central bank intermediation of interbank transactions during the financial crisis, which would support our explanation of how the ECB's non-standard measures worked? And second, to what extent is the fall in interbank activity concentrated in transactions with non-resident banks (and in foreign currency), which – other things equal – would make the ECB's interventions less effective and require a more cooperative strategy from the wider international central bank community to support liquidity provision across a range of internationally-relevant currencies? These are the issues that we address in the empirical analysis that follows.

### 3. Data and design of the empirical analysis

As discussed, our analysis exploits data on the aggregate balance sheet of euro area main financial institutions (MFIs). We combine these data with macroeconomic indicators for the euro area and some US indicators to capture the international business cycle. In total we have twenty-five variables (see Table 1). For the euro area macroeconomy, we include industrial production and unemployment, prices for goods and assets and interest rates at different maturities and, for the US, industrial production and the short term interest rate. Balance sheet variables are aggregated in such a way as to be able to distinguish between assets and liabilities to domestic and to non-resident counterparties, and between transactions vis-a-vis other banks and central banks (the Eurosystem). The resident sector includes firms, households, government, other financial institutions (OFI), insurance companies and pension funds (ICPF) and money market funds (MMF), whereas we do not have this breakdown for the non-residents. We also include bank equity and capital.

**Table 1: Description of the database**

<b>Variables</b>	<b>Transformations</b>
Industrial production	Log-levels
Consumer prices (HICP)	Log-levels
Unemployment rate	Levels
Producer prices	Log-levels
Industrial production, US	Log-levels

Consumer Prices, US	Log-levels
Federal funds rate, US	Levels
Euribor 3 months	Levels
2 years bond rates	Levels
5 years bond rates	Levels
10 years bond rates	Levels
Stock prices, DJ Eurostoxx	Log-levels
Stock prices, banks	Log-levels
Credit to residents	Log-levels
Credit to non-residents	Log-levels
Interbank credit, residents	Log-levels
Domestic equity	Log-levels
Non-residents equity	Log-levels
Other assets	Log-levels
Liabilities to residents	Log-levels
Liabilities to non-residents	Log-levels
Interbank liabilities, residents	Log-levels
Liabilities vs Eurosystem	Log-levels
Remaining liabilities	Log-levels
Capital	Log-levels

**Note:** The resident sector is the sum of disaggregated data on firms, households, government, other financial institutions (OFI), insurance companies and pension funds (ICPF), money market funds (MMF). This disaggregation is not available for the non-residents sector, which includes both the interbank and the non-bank sectors. In terms of instruments, credit to residents, non-residents and interbank credit is obtained as the sum of loans and debt securities. Liabilities to residents and non-residents are obtained as the sum of deposits and debt securities.

The sample covers the period from January 1999 to April 2011 and thus includes two cycles: the 2008-2009 “Great Recession”; and the slowdown at the start of the millennium, which was milder and not associated with a financial crisis. The Great Recession has been dated in December 2007 for the US and in the first quarter of 2008 for the euro area (see the NBER and CEPR chronologies respectively). The recession thus starts almost a year *before* the banking crisis triggered by the collapse of Lehman Brothers in September 2008. After Lehman’s failure, the global recession deepened and only ended (according to the dating mentioned above) in June 2009. The Great Recession therefore ranks as the longest and deepest economic downturn since the 1930s.

Financial and macroeconomic developments during this period have interacted in a complex and dynamic manner. The causal connections between them are unclear. In particular, it difficult to

ascertain whether the shrinkage of banks' balance sheets during the crisis should be attributed to: (1) the severity of the slowdown; or (2) to some unusual adjustment in the size and composition of financial intermediation. In the U.S., Chari et al. (2008) take the former view: they claim that the dynamics of financial indicators can be explained on the basis of business cycle developments and can be considered "normal" once those are taken into account. But most other accounts (e.g. Gorton and Metrick, 2011) adopt the latter explanation, attributing a leading role to financial factors.

In our analysis we do *not* aim at establishing causality between financial and real factors. We have a more modest but nonetheless important goal: to identify changes in the relationship between financial intermediation and the rest of the euro area economy. Features of this relationship that have changed during the crisis may potentially be related to a lasting structural change, rather than just to temporary or cyclical developments. Establishing the stylised facts of this episode is an important first step in coming to more structural economic explanations of events.

We assess the stability of the relationship between financial intermediation and the rest of the economy by means of a counterfactual experiment. First, we estimate a dynamic model of the joint behaviour of bank balance sheet and macroeconomic variables in the pre-crisis data (until August 2008). Second, we then forecast the bank balance sheet variables, conditional on: (1) the economic relationships prevailing before the Lehman collapse (reflected in the model parameters estimated using the data until August 2008); (2) the pre-crisis history of all variables; and (3) the observed outcomes of the subset of variables representing the macroeconomic environment until the end of the sample in April 2011 (i.e. using as conditioning assumptions the first eight variables in Table 1; these capture real economic conditions, short term interest rates and consumer and production price inflation in both the euro area and the U.S.). Finally, we compare the *observed* path of key bank balance sheet variables with the *simulated* distribution of their counterfactual paths. This amounts to

using the pre-crisis part of the sample as a “benchmark” against which we analyze more recent behaviour during the financial crisis.

If the observed path of bank balance sheet variables since Lehman’s failure lies in the tails of the forecast distributions (or even out of the distribution), we can conclude that developments in the banking sector during the financial crisis are difficult to reconcile with those in the rest of the economy. Potentially, this may be due to structural changes in the financial sector brought about by the crisis. On the contrary, the finding of no significant change is evidence that, although larger in size, the shocks that have affected the economy in the last four years are similar in nature to those that have driven the economy in the preceding ten years. Moreover, the transmission of these shocks has not changed substantially. In other words, if the observed and simulated paths are similar, we interpret this as evidence that the relative importance of real and financial shocks has remained the same through the financial crisis, at least once one has conditioned on the introduction of non-standard monetary policy measures by the ECB, which have served to substitute interbank transactions with central bank intermediation.

Notice also that, by conditioning on real economy variables, we ensure that we capture the size of the shocks that would have caused the recent recession *if it were due to the shocks that have typically generated recessions in the euro area*. For example, if credit shocks were traditionally associated to a recession, we would be implicitly conditioning on credit shocks developments from August 2007 onward in order to assess whether such variables have behaved in line with the historical regularities.

#### **4. Econometric Model**

Using the data set described in the previous section, we estimate an empirical model of the euro area economy. Let  $X_t$  be the vector including the  $n$  variables defined in Table 1 (all variables are in log-

levels, except for variables expressed in rates or with negative levels that are in levels). We estimate a VAR model with  $p$  ( $=13$ ) lags:

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + \dots + A_p X_{t-p} + e_t$$

where  $e_t$  is a normally distributed multivariate white noise with covariance matrix  $\Sigma$ .

The large dimension ( $n=25$  and  $p=13$ ) of our VAR model implies that we face an issue of overfitting due to the large number of parameters (“curse of dimensionality”). We address this issue by shrinking the model's coefficients toward those of the naïve and parsimonious random walk with drift model,  $X_{it} = \delta_i + X_{i,t-1} + e_{it}$ . De Mol et al. (2008) and Banbura et al. (2010) have shown that this approach reduces estimation uncertainty without introducing substantial bias. This is achieved thanks to the tendency for macro time series to co-move over the business cycle, which creates scope for the data to point “massively” in the same direction against a naïve prior model that does not allow for any dynamic interaction. The resulting model offers a parsimonious but reliable estimate of the complex dynamic interactions among the macro, monetary and financial variables included in the data set.

More in details, we use a Normal-Inverted Wishart prior centred on a random walk model.

For  $\Sigma$ , the covariance matrix of the residuals, we use an inverted Wishart with scale parameter given by a diagonal matrix  $\Psi$  and  $d=n+2$  degrees of freedom. This is the minimum number of degrees of freedom that guarantees the existence of the prior mean of  $\Sigma$ , which is equal to  $\Psi/(d-n-1)=\Psi$ .

For the constant  $A_0$  term we use a flat prior. For the autoregressive coefficients ( $A_1 \dots A_p$ ), we use the Minnesota and the sum of coefficients priors originally proposed by Litterman (1980) and Doan et al. (1984) respectively. For what concerns the Minnesota prior, conditional on the covariance matrix of the residuals, the prior distribution of the autoregressive coefficients is normal with the following means and variances:

- $E[(A_1)] = I_n$  while  $E[(A_2)] = \dots = E[(A_p)] = \mathbf{0}_{n,n}$
- $\text{Cov}[(A_s)_{ij}, (A_r)_{hm}] = \lambda^2 \Sigma_{ih} / (s^2 \Psi)$  if  $m=j$  and  $r=s$ , zero otherwise.

Notice that the variance of this prior distributions decays with the lag, and that coefficients associated with the same variables and lags in different equations are allowed to be correlated. The factor  $1/s^2$  is the rate at which the prior variance decreases with increasing lag length and  $\Sigma_{ij}/\Psi_{ii}$  accounts for the different scale and variability of the data. Finally, the key hyperparameter is  $\lambda$ , which controls the scale of all the prior variances and covariances, and effectively determines the overall tightness of this prior. For  $\lambda = 0$  the posterior equals the prior and the data do not influence the estimates. If  $\lambda \rightarrow \infty$ , on the other hand, posterior expectations coincide with the Ordinary Least Squares (OLS) estimates.

For what concerns the sum of coefficients priors, the additional one we impose on the autoregressive coefficients, it is the same as performing “inexact differencing”: i.e., it is a simple modification of the Minnesota prior involving linear combinations of the VAR coefficients. More precisely, rewrite the VAR equation in error correction form:

$$\Delta X_t = A_0 - (I_n - A_1 - \dots - A_p) Y_{t-1} + B_1 \Delta Y_{t-1} + \dots + B_{p-1} \Delta Y_{t-p+1} + e_t.$$

A VAR in first differences implies the restriction  $(I_n - A_1 - \dots - A_p) = 0$ . We follow Doan et al. (1984) and set a prior that shrinks  $\Pi = (I_n - A_1 - \dots - A_p)$  towards zero. This can be understood as “inexact differencing” and in the literature it is usually implemented by adding dummy observations. The tightness of this additional prior is controlled by the hyperparameter  $\mu$ . As  $\mu$  goes to infinity the prior becomes diffuse while, as  $\mu$  goes to 0, we approach the case of exact differencing which implies the presence of a unit root in each equation.

Summing up, the setting of these priors depends on the hyperparameters  $\lambda$ ,  $\mu$  and  $\psi$ , which reflect the informativeness of the prior distribution for the model’s coefficients. These parameters have



been usually set on the basis of subjective considerations or rules of thumb. We instead follow the theoretically grounded approach proposed by Giannone et al. (2010). This involves treating the coefficients of the prior as additional parameters, in the spirit of hierarchical modelling. As hyperpriors we use proper but almost flat distributions.<sup>10</sup> In this set up, the marginal likelihood evaluated at the posterior mode of the hyperparameters is close to its maximum.

The counterfactual exercise is performed as follows. We simulate the model's parameters from their full posterior density, hence accounting for the estimation uncertainty of the hyperparameters. This approach is implemented using a simple Markov chain Monte Carlo algorithm. In particular, we use a Metropolis step to draw the low dimensional vector of hyperparameters. Conditional on a value of the hyperparameters, the VAR coefficients can then be drawn from their posterior, which is Normal-Inverse-Wishart (see Giannone et al., 2010, for the details of this procedure). Since we are interested in conditioning on the economic relationships prevailing before the Lehman collapse, the posterior is computed using the data until August 2008.

For any given draw of the model's parameters from their posterior density, the draws from the counterfactual exercise are computed as conditional forecasts in which the conditioning information is given by: (1) the pre-crisis history of all variables in the model; (2) the macroeconomic developments observed during the crisis; and (3) the observed outcomes of the subset of variables representing the macroeconomic environment until the end of the sample in April 2011.

The conditional forecasts are obtained using the algorithm developed in Banbura et al. (2012). The procedure exploits the fact that the Vector Autoregressive model can be cast in a state-space form. Hence, the conditional forecasts can be computed using Kalman filtering techniques and the

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<sup>10</sup> As hyperpriors for  $\lambda$ ,  $\mu$  we choose Gamma densities with mode equal to 0.2, 1 and standard deviations equal to 0.4, 1 respectively. Our prior on  $\Psi$ , i.e. the prior mean of the main diagonal of  $\Sigma$ , is an Inverse-Gamma with scale and shape equal to  $(0.02)^2$ .

counterfactual simulations can be drawn using the simulation smoother of Carter and Kohn (1994). Finally, all our counterfactual simulations respect the budget constraint for which assets must be (approximately) equal to liabilities. This is done by retaining only those draws (amongst a total of 10000) that (approximately) respect the budget constraint.

## 5. Results and discussion

In Table 2 below we describe the bank balance sheet items. We focus on a few important dates in our sample, i.e. we provide a picture of our stylised bank balance sheet in January 1999, which is the beginning of our sample; in January of the two crisis years, 2008 and 2009; and in January of the two years of the recovery, 2010 and 2011.<sup>11</sup> The table also reports (for 2009, 2010 and 2011) the 2.5 % and 97.5 % quantiles of the counterfactual forecast distributions, as a measure of the width of the distributions. Any developments outside those quantiles, is identified as being ‘unlikely’ given historical regularities and, hence, it could reflect relevant changes in the features of financial intermediation.

**Table 2: Bank balance sheet items and key ratios**

<b>Variables</b>	<b>1999</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Credit to residents	7.36	12.47	13.37 13.01 - 13.63	13.37 13.26 - 15.01	<b>13.76</b> 13.97 - 17.29
Credit to non-Residents	1.57	4.83	<b>4.53</b> 4.80 - 5.99	<b>4.20</b> 4.96 - 8.01	<b>4.09</b> 5.00 - 11.24
Interbank credit, residents	3.96	7.43	8.11 7.2 - 8.6	7.81 7.03 - 9.79	7.49 7.12 - 12.00
Equity, residents	0.56	1.21	1.18 1.08 - 1.41	1.21 0.95 - 1.73	1.24 0.89 - 2.31
Equity, non-residents	0.08	0.32	0.28 0.23 - 0.43	0.28 0.15 - 0.64	0.30 0.09 - 0.90
Other assets	1.83	3.63	4.63 2.88 - 4.84	3.86 1.89 - 5.14	3.67 1.54 - 7.67
Liabilities to residents	7.77	13.59	14.50 14.15 - 14.85	14.83 14.68 - 16.56	<b>15.15</b> 15.37 - 19.06

<sup>11</sup> Notice that for 2011 we do not include months beyond April, implying that we exclude the deterioration of financial conditions in the euro area associated with the intensification of the sovereign debt crisis from the middle of that year.

Liabilities to non-residents	1.78	5.01	<b>4.69</b> 4.92 - 5.96	<b>4.30</b> 4.79 - 7.09	<b>4.28</b> 4.85 - 9.46
Interbank Liabilities, residents	3.85	7.13	<b>7.70</b> 6.95 - 8.32	<b>7.31</b> 6.81 - 9.66	<b>7.02</b> 6.86 - 12.19
Liabilities to Eurosystem	0.19	0.47	<b>0.78</b> 0.22 - 0.73	<b>0.77</b> 0.09 - 1.17	<b>0.68</b> 0.04 - 2.68
Remaining Liabilities	2.13	3.83	<b>4.52</b> 3.32 - 5.18	<b>3.90</b> 2.56 - 5.55	<b>3.82</b> 2.52 - 8.28
Capital	0.76	1.61	<b>1.77</b> 1.66 - 1.84	<b>1.92</b> 1.67 - 2.13	<b>2.04</b> 1.67 - 2.51
Residents/non residents Liabilities	4.36	2.71	<b>3.09</b> 2.43 - 2.94	<b>3.45</b> 2.25 - 3.26	<b>3.54</b> 1.87 - 3.49
Eurosystem/interbank liabilities, %	<b>4.84</b>	<b>6.58</b>	<b>10.15</b> 2.89 - 9.53	<b>10.52</b> 1.11 - 15.31	<b>9.64</b> 0.40 - 30.82

**Note:** Thousands of euro billions. The first six items are from the asset sides of banks balance sheets, while items seven to twelve reflect the liabilities side. The last two variables are the ratio of liabilities to resident relative to non-resident counterparts and (100 times) the ratio of liabilities to the eurosystem relative to liabilities to the domestic interbank sector. Red (blue) bold indicates figures below (above) the 2.5 (97.5)% quantile of the forecast distribution.

The key facts revealed by the table can be summarized as follows. Following the onset of financial crisis, two data features emerge in 2009 which were not expected given macroeconomic conditions: a drop in credit *and* liabilities to the non-resident sector; and an increase in Eurosystem intermediation. The former show a persistent decline, remaining well below the 2.5% quantile of the forecast distributions until the end of the sample, while the latter is higher than the 97.5% quantile of the distribution in 2009, but subsequently tends to go closer to the central tendency of the distribution. Interestingly, assets and liabilities to residents decline “significantly” only in 2011, with a two years delay after the Lehman-inspired intensification of the financial crisis.<sup>12</sup> Interbank credit and liabilities to residents remain inside the quantiles we report; however they show a marked decline and lie close to the lower boundaries of the forecast distributions. Notice, also, that the distributions of interbank variables tend to encompass wide forecast ranges, which is a possible indication that the association between interbank intermediation and the macro-economy is relatively weak and that the increasing size of the market can be seen, at least partly, as an exogenous development in financial innovation.

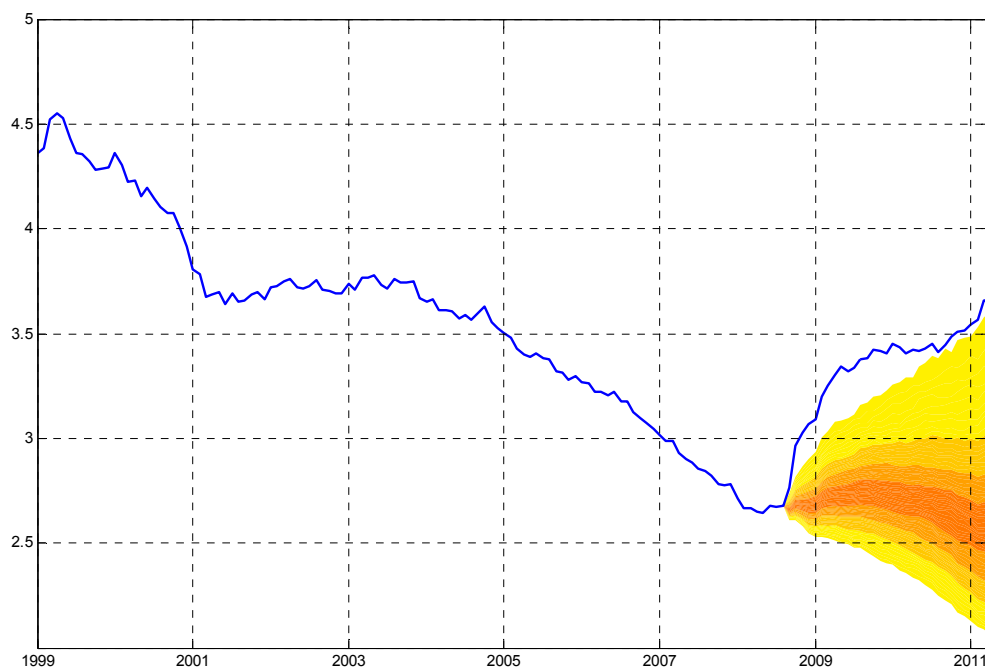
Two key ratios may help to shed further light on the two facts just discussed: the ratio of liabilities to residents over those to non-residents and the ratio of liabilities to the Eurosystem over domestic

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<sup>12</sup> On this point see also the evidence by Giannone et al. (2012), based on a different data source and model.

interbank liabilities. Below we plot the time series of these ratios since 1999 and, since September 2008, also the distribution of the forecasts. For the sake of comparability with Table 2, the lower boundaries of the forecast distributions refer to the 2.5 and 97.5% quantiles. Figure 4 shows the ratio of residents to non-residents liabilities.

**Figure 4: Ratio of liabilities to residents over liabilities of non-residents**



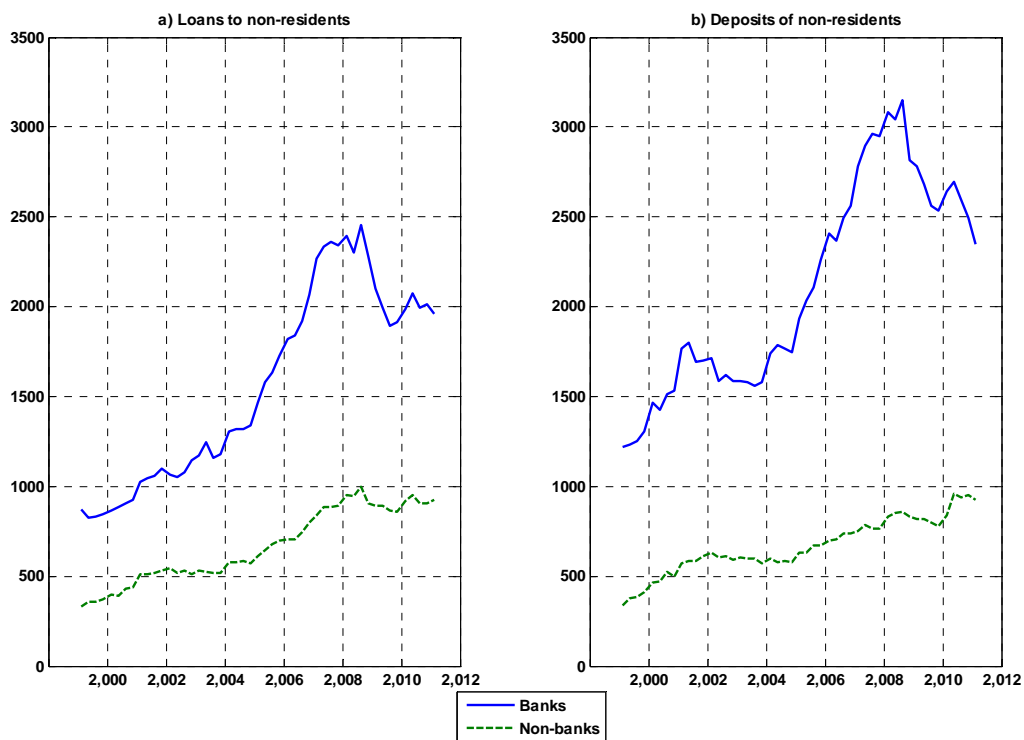
**Note:** The blue line describes the observed development in the ratio of liabilities to residents over liabilities to non-residents from January 1999 to April 2011. The figure reports also the distribution of the conditional forecasts (until the 2.5 and 97.5% quantiles) of the ratio.

Since 1999 we have seen a decline in the relative contribution of residents' funding of banks. This phenomenon has been associated with the increasing internationalization of European banks, linked to both financial integration and the increase in the international role of the euro (for some evidence on this point, see Forster et al., 2011). After a brief stabilization, following the mild recession of 2001, the trend continues until the end of 2008, at which point it is suddenly reversed. What we see

since then is not only the pro-cyclicality of a segment of international capital flows (see, for example, Broner et al., 2011) but also a retrenchment that is not explained by business cycle conditions: the observed path of the ratio is well below the boundaries of the fanchart.

Unfortunately our data set does not allow us to distinguish between banks and non-banks in that category. However, we have hints that the bulk in that category is represented by the former. Figure 5 shows quarterly data on loans and deposits for the non resident sector. We can clearly see that the banks sector is larger in general and it explains the entire decline since 2009. This supports the conjecture that the ‘sudden stop’ in international capital flows we have seen in the euro area is mostly explained by bank flows (on this point see also Milesi Ferretti and Tille, 2011).

**Figure 5: Decomposition of loans and deposits, non-resident sectors**



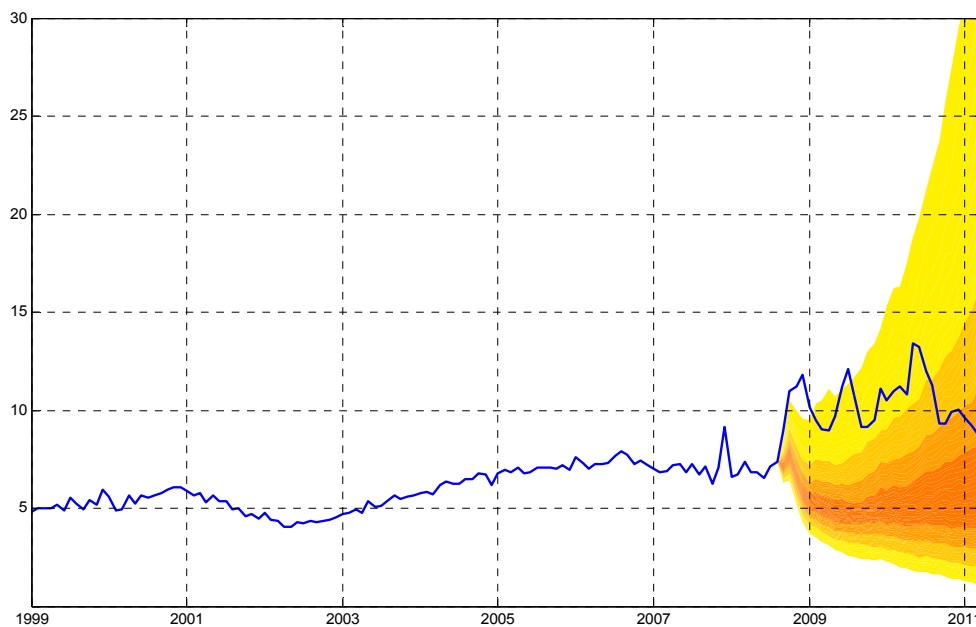
**Note:** Quarterly data from 1999Q1 to 2011Q1. Figures are expressed in euro billions. The blue solid line describes the observed developments in loans to (deposits of) bank while the green dashed line refers to non-banks (excluding government).

Turning to the substitution of market provision of liquidity by the central bank, Figure 6 shows the ratio between liabilities to the Eurosystem and domestic interbank liabilities. The chart provides a

quantitative account of the substitution of interbank activity with central bank intermediation across the euro-system balance sheet.

Liquidity provision by the Eurosystem has been weakly pro-cyclical, but the sharp increase since 2008 is clearly unusual in the sample. Although the distribution is quite widely spread, occasionally the values of the ratio in the 2009-2010 period are still above the 97.5% quantiles and, in general, they lie in the upper tails of the distribution.

**Figure 6: Ratio of liabilities to Eurosystem over domestic interbank liabilities**



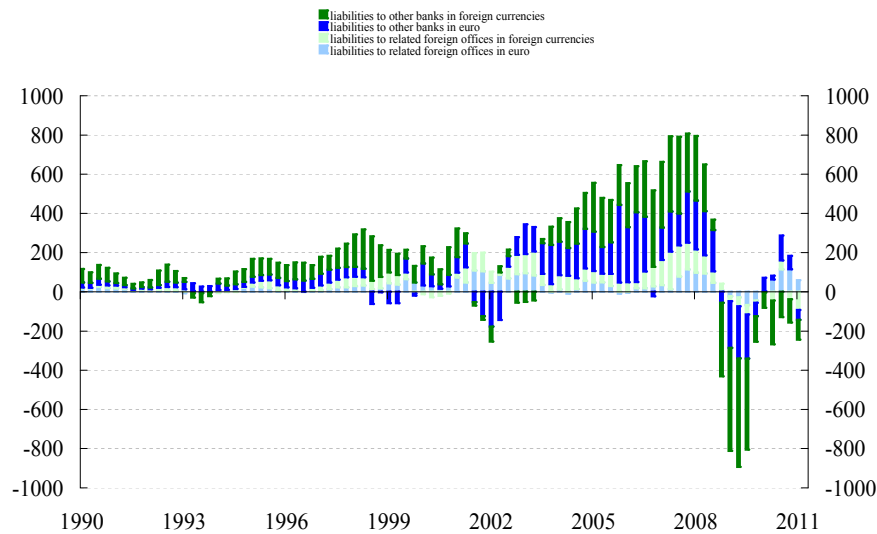
**Note:** The blue line describes the observed development in the ratio of liabilities to the Eurosystem over liabilities to the domestic interbank sector from January 1999 to April 2011. The figure reports also the distribution of the conditional forecasts (up to the 2.5 and 97.5% quantiles) of the ratio.

The increase in the intermediation role of the Eurosystem and the stability of MFI's domestic assets and liabilities are likely to be related. As explained in our earlier discussion, this substitution is less than one-for-one as the ECB replaces net flows rather than all gross flows. By keeping the inter-bank market alive the ECB has most likely allowed euro area banks to moderate and delay the contraction of activities with domestic counterparties.

Putting everything together the story we extract from the data is that while the behaviour of deposits and loans vis-a-vis residents in 2009 and 2010 is in line with business cycle conditions, this is not the case with the interbank market mostly because of the dynamics of loans and deposits to non-residents. Rather central bank intermediation has substituted – albeit not one-for-one – for wholesale transactions, as the Eurosystem has ensured that the necessary net flow of interbank transactions to maintain the flow of financing to the real economy is maintained by offering its own balance sheet as a conduit for that intermediation.

We can also use quarterly data to describe the structure of non-resident transactions with euro area banks. Figure 7 shows that the bulk of the decline is explained: (1) by ‘other banks’, i.e. not the offshore affiliates of Euro area banks; and (2) by activity in foreign currencies rather than euros. The unusual decline in interbank transactions observed during the financial crisis is not only driven by foreign banks, but also by transactions denominated in currencies other than euros. These FX transactions cannot be intermediated by the ECB without international coordination with foreign central banks, which can provide access to the other currencies needed to substitute for private intermediation.

**Figure 7: Structure of non-resident transactions with euro area banks**



**Note:** Source of the chart: ECB Monthly Bulletin, October 2011 (page 76). Data are expressed in terms of annual flows in billions. Source of the data: BIS.

## 6. Concluding remarks and policy implications

This paper has investigated the behaviour of euro area bank balance sheets during the recent financial crisis, with a focus on the period following the failure of Lehman Brothers in September 2008.

We base our analysis on a new data set containing monthly information on the aggregate balance sheet of euro area banks. Our exercise investigates the joint dynamic behaviour of these data with a set of macroeconomic indicators. A key feature of the data is that they contain information on gross positions within the banking sector, and can therefore shed light on the behaviour and role of the interbank market during the financial crisis.

Once we condition on business cycle conditions, we find that some features of financial intermediation through the euro area banking system replicate the regularities we identify in the pre-crisis sample. But other features of the data point to a persistent disruption stemming from the crisis.



Bank transactions with non-bank residents have remained remarkably stable. As in our previous work, we interpret this as evidence that the ECB's non-standard monetary policy measures have been successful. More specifically, in the post-Lehman period these non-standard measures have served to insulate the flow of credit to households and firms from the malfunctioning of the financial system in general, and the interbank money market in particular. In this paper, we show that, since 2009, central bank intermediation has replaced a large portion of interbank transactions, suggesting that the Eurosystem has adopted the de facto role of a central counterpart to clear wholesale money market activity. It has been this substitution that has served to insulate financing flows to the real economy.

We also show that it is bank transactions with non-residents (we believe largely offshore banks) that saw the most immediate and unprecedented decline after the collapse of Lehman. It is this decline that is both economically and statistically the most aberrant feature of the post-Lehman data. Moreover, we provide evidence that this decline mostly reflects a fall in loans and deposits with foreign banks denominated in currencies other than euros. This is a key feature since, while the ECB can create euro liquidity without limit to support euro denominated central bank intermediation, its ability to facilitate intermediation in foreign currency transactions relies on the provision of non-euro liquidity by the relevant other central banks.

These findings point to the importance of international provision of liquidity during financial crisis.

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