Liquidity hoarding behavior during the financial crisis. Empirical evidence from the European banking system

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Abstract

Generally, the incentives of banks to stock liquid assets are driven by two reasons: the precautionary motive and the speculative motive. Using bank-specific balance sheet data this paper provides empirical evidence of the main drivers of liquidity hoarding behavior in the European banking system during 2004-2011. We propose a time-varying approach to distinguish between liquidity hoarding and non-hoarding banks. The methodology is based on the First Difference GMM estimator of Arellano and Bond (1991) which accounts for persistency of the dependent variable, endogeneity, heteroskedasticity and autocorrelation. The bank specific data used in our analysis reveals the precautionary motives of European banks to hoard liquid assets. Funding constraints, structural balance sheet risk, investment portfolio risk, specialization and profitability are key determinants of the hoarding behavior. The findings are relevant both for the individual risk management of banks as well as for the financial supervisory authorities in designing an efficient macroprudential supervision framework.

1. Introduction

During the most recent financial crisis, the banking system experienced a series of disruptions in the interbank market which gave rise to the liquidity hoarding phenomena. This action reflects the tendency of banks to accumulate highly liquid assets. Generally, the incentives of banks to hoard liquid assets are driven by two reasons: precautionary motive and speculative motive (Gale and Yorulmazer , 2013).

Regarding the European financial markets, the temporary liquidity crisis was coupled with the sovereign debts crisis. As a consequence of inefficient and too permissive prudential regulations, financial institutions have taken on way too much debt in their pursuit for revenues. The mismanagement of the poorly regulated trading portfolio, the deteriorating quality of the credit portfolio due to economic slowdown along with the poor management of liquidities were the primary causes that European banks were highly vulnerable to the extreme events that the 2008 financial crisis brought on.

Due to asymmetric information and increased counterparty risk a number of banks preferred to reduce lending and to provision liquidity buffers (Heider, 2009). In this new context, the estimation of liquidity behavior in the banking system becomes of great importance both for the individual risk management of banks as well as for the financial supervisory authorities in designing an efficient macroprudential supervision framework.

In this spirit, the aim of this paper is to provide empirical evidence on the main determinants of liquidity hoarding behavior in the European banking system. The sample consists of 73 European banks which are analyzed during the 2004-2011 period through a series of bank-specific variables.

To distinguish between liquidity hoarding and non-hoarding banks we propose a time-varying approach by taking into account the exceeding of a certain threshold of the liquid assets to deposits and short term funding ratio. The higher this ratio, the more likely is a bank to become a liquidity hoarder. The sample is split into liquidity hoarding and non-hoarding banks using the 75^{th} quantile of this ratio as threshold.

The incentives of liquidity hoarding are assessed through a dynamic panel specification, using the First Differenced Generalized Method of Moments (FD-GMM) estimator of Arellano and Bond (1991). The method produces unbiased and consistent estimates in unbalanced panels with “large N, small T” (Arellano and Bond (1991). The methodologies used by our predecessors range from panel OLS with FE (Berrospide, 2012), panel VAR, impulse-response functions (de Haan and van den End, 2013), panel GMM (de Haan and van den End, 2013; Aspachs et al., 2005; Bonfim and Kim, 2012). Our methodology is in line with Dinger (2009) and Delechat et al. (2012) which account for dynamic panel specifications and endogeneity.

Among the possible determinants of liquidity hoarding behavior provided by the theoretical and empirical literature we consider bank specific risk variables, specialization and profitability. The results reflect the precautionary motive for hoarding liquidity. Banks provision liquidity buffers to face future funding and liquidity constraints, reduction in the lending activity and tightening of the net interest margin. Also, the lower the size of banks and the capitalization, the larger the incentives of hoarding liquid assets.

Liquidity hoarding behavior using bank-level data is also investigated in Berrospide (2012) for the US banking system, Delechat et al. (2012) for Central American banks, de Haan and van den End (2013) for Dutch banks, Acharya and Merrouche (2010) for UK banks. In respect with some hypothesis, our results are similar with those obtained by these studies, but we also found some particularities regarding the hoarding behavior in the European banking system.

This article contributes to the existing empirical literature in several ways. First, we investigate the liquidity hoarding behavior within a unique sample of European banks whose assets represent around 80% of the European banking system total assets. Second, we propose a time-varying approach to distinguish between hoarding and non-hoarding liquidity banks. Third, we explore bank-level data using the First Difference GMM estimator of Arellano and Bond (1991) which accounts for persistency of the dependent variable, endogeneity, heteroskedasticity and autocorrelation. Forth, we employ a series of robustness tests in order to check the validity of the results in the presence of different specifications: controlling for other potentially relevant variables, accounting for different period spans and allowing for different endogeneity specifications.

The remainder of paper is organized as follows. Section 2 presents the literature review. Section 3 discusses the data, hypothesis and potentially explanatory variables. Section 4 describes the methodology used. The empirical results are presented in Section 5 and the robustness check in Section 6. Section 7 concludes.

2. Literature review – theoretical and empirical background

The liquidity hoarding behavior of banks has been analyzed in several theoretical and empirical studies. The theoretical literature provides insight into banks' incentives to hoard liquidity, as well as the impact of this action on the financial system stability. Gale and Yorulmazer (2013) proposed a theoretical model of liquidity risk management by analyzing the impact of liquidity hoarding on banks efficiency. They determined an equilibrium situation where banks weigh between the cost of holding liquid reserves against the risk of experiencing fire sales or bankruptcy. At equilibrium, there is just the central bank that holds the cash reserves and act as a lender of last resort. The liquidity hoarding becomes inefficient only if there are still banks that need cash. As a function of the expected volatility of asset prices, both the precautionary and the speculative motives of holding cash reserves could increase the inefficiency of hoarding liquidity.

Considering the effects of fire sales on the portfolio rentability Acharya, Shin and Yorulmazer (2009) developed a theoretical framework regarding the ex-ante choice of banks between liquid risky assets. In equilibrium there could be a private benefit from the acquisition at fire sales, as well as a social benefit if hoarding reduces the cost from liquidation of assets to outsiders. Moreover, they found that in developed capital market economies liquid holdings of banks are under the socially optimal liquidity because of risk-shifting incentives. Also, in case of high costs associated with systemic crisis the socially optimal liquidity is above the privately optimal liquidity.

The liquidity hoarding behavior of banks may be of a systemic nature. In stress periods, if a number of banks decide to hoard liquidity and stop lending to others, a systemic event may appear. The impact of liquidity risk on systemic risk through different contagion channels is detailed in Kapadia et al. (2012). They developed an approach that deals with the interaction between shocks to fundamentals and funding liquidity risk. It is this interaction, which could enhance contagion in the financial system. By starting liquidity hoarding and asset fire sales actions, stressed banks can trigger down other banks.

The impact of liquidity hoarding on interbank market spreads is analyzed in the theoretical model of Heider, Hoerova and Holthausen (2009). The model accounts for asymmetric information regarding the counterparty risk that affects the banks' portfolio of liquid and illiquid investments, in order to determine possible causes for collapse of interbank markets. Their findings show that low interest rate spread, adverse selection and liquidity hoarding could jeopardize the functioning of interbank markets. In addition to this, liquidity hoarding could become more harmful for the interbank markets in the context of solvency contagion. Treating the banking system as a weighted directed network that accounts for the bilateral exposures between banks, Fourel et al. (2013) provides a theoretical framework in which the liquidity hoarding behavior causes shortages in interbank markets and default of counterparties. They derive a measure that estimates the contagion spillovers through the solvency channel by simulating different market shocks in line with liquidity hoarding behavior. Also, applying this method on the network formed by the 11th largest French banks, they found high resilience to market shocks and contagion effects.

In line with the theoretical studies, there are several studies in empirical literature that analyze the main determinants of liquidity hoarding and the effects of this phenomenon on banks' portfolio choices and interbank market behavior. Berrospide (2012) study the liquidity hoarding determinants for a panel of US banking institutions using quarterly balance sheet data from Call Reports during 2005 and 2010. The empirical results provide evidence of the precautionary motive for hoarding liquidity in anticipation of future losses from securities write-downs. Accounting for money market spreads, in vulnerable periods higher loan loss reserves, higher capital, more deposits and higher unused commitments contribute to liquidity hoarding. Also, the precautionary motive has a significant influence on the lending contraction experienced by hoarding banks. Related to lending, similar results were obtained by de Haan and van den End (2013) when analyzing the 17 largest Dutch banks over a period from 2004 to 2010. In response to funding liquidity shocks, banks started to hoard liquidity, fire sale assets and reduce lending. Using two way Granger causality tests they found for six banks causality running from fire sales operations to liquidity hoarding.

The precautionary motive of liquidity hoarding is also developed in Acharya and Merrouche (2010). Analyzing the liquidity demand for large settlement banks in the UK they found evidence of high liquid holdings on calendar days with a large amount of payment activity during the sub-prime crisis. As a consequence, both the secured and the unsecured money markets registered an increase in the overnight interbank rates. De Socio (2012) found that liquidity risk was the main determinant for the increases in the 3-month Euribor–Eonia swap spread between 2007 and 2009, but after May 2009, the credit risk was the one responsible for the spread increases. Beirne (2012) examined the determinants of the spread between Eonia and the main policy rate of the European Central Bank and reached similar conclusions. Liquidity risk significantly influenced the spread after the Lehman Brothers collapse.

After assessing the determinants of banks' liquidity buffers in Central America the empirical findings of Delechat et al. (2012) reveal a demand for precautionary liquidity influenced by the banks' size, profitability, capitalization, and also by the financial development. The phenomenon is more pronounced in highly deposit dollarized economies due to the fact that high liquidity buffers may reinforce the monetary policy and market development.

In line with the portfolio management studies Bonfim and Kim (2012) analyze the main determinants of banks' management choices regarding the liquidity risk on a sample of 500 large European and north American banks, during 2002-2009. Allowing for potential interactions between banks, the empirical results show a herding behavior during the pre-crisis period. The incentives to herd are common for banks that engage in similar risk-taking strategies.

The internal management of liquid and illiquid assets portfolio held by banks could have important consequences on the stability of the entire banking system. The link between systemic risk and liquidity choices of banks is detailed in van den End and Tabbae (2012). Applying the "pecking order theory"[1] on a sample of Dutch banks they found that, in response to financial market shocks, banks first adjust the most liquid balance sheet items and only afterwards the less liquid items. Using cash-flow data from the Dutch supervisory liquidity report and balance sheet items they found evidence that the balance sheet adjustments made during the crisis have been pro-cyclical. Wu and Hong (2012) examined the way that liquidity risk affects bank failures through systematic and idiosyncratic channels. They proposed an econometric model that takes into account an insolvency condition and an illiquidity condition in a dynamic discrete-time hazard framework. The findings suggest that the systematic liquidity risk significantly predict the banks' failures during 2008-2009. Following the theoretical framework developed by Freixas and Holthausen (2005), Dinger (2009) analyzes the impact of transnational banks' liquidity behavior banking system liquidity risk. Empirical findings suggest that during vulnerable periods foreign-owned banks hold more liquid assets than the single-market banks[2]. Also, the author found evidence that the occurrence of aggregate liquidity shortages in emerging economies is reduced in the presence of transnational banks.

The macroeconomic determinants of liquidity buffers are explored in Aspachs et al. (2005) by analyzing a sample of 57 UK-resident banks, over the period 1985Q1 - 2003Q4. Using GDP growth and its interaction with several idiosyncratic factors they found evidence that UK banks had counter-cyclical liquidity policy which may be linked to financing constraints that arise from asymmetric information. Other authors like Berrospide (2012), Dinger (2009), Acharya, Shin and Yorulmazer (2009), Wu and Hing (2012) use macroeconomic data to explain liquidity holdings of banks.

3. Data specification and hypothesis

Dataset

The sample consists of 73 banks from the European Union which are internationally active and represent 17 European states (Table 1). At the end of 2011, their assets represent 79,58% of the total assets of the European banking system. We focus especially on large and medium banks engaged in both commercial and investment activities. Size variation is considerable within the sample (the biggest banks' total assets are more than 4.000 times larger than the smallest banks'

[1] The pecking order theory was developed by Myers and Majluf (1984) and applied in corporate finance. Further discussions on this theory could be found in Shyam-Sunder and Myers (1999).

[2] The argument for this hypothesis given in Freixas and Holthausen (2005) is that transnational banks have more diversified sources of liquidity in comparison with single-market banks

total assets). Also, only banks with more than 80% of the data available in the analyzed period were included in the analysis.

Insert Table1

The time period considered is that between 2004 and 2011, thus covering the pre-crisis and the crisis years. During this period, the European banking system experienced both expansion and contraction of lending and investment activities, liquidity buffers playing a key role during both regimes. Due to unavailability of quarterly observations for several variables, the data used has annual frequency and due to unavailability of yearly observations for some banks the panel is unbalanced.

Liquidity hoarding banks identification

An import step of this approach is the identification of liquidity hoarding banking institutions. Despite the number of papers that analyze the liquidity hoarding behavior of banks, there is scarce evidence of precisely measures that distinguish between hoarder and non-hoarder liquidity banks. In Berrospide (2012) liquidity hoarding banks are those that increased the ratio of liquid assets to total assets with more than 3 percentage points in the crisis compared to the pre-crisis period[3]. Other studies emphasize the liquidity herding behavior of banks, which is a concept distinct from hoarding because it focuses on both extreme positive and negative adjustments of liquidity positions. Den End and Tabbae (2012) derived a liquidity herding measure for banks that changes in several liquid balance sheet items (positive or negative) exceeding a given threshold. Bonfim and Kim (2012) compute a country level indicator that quantifies how much the liquidity choices of banks deviate from macroeconomic conditions[4].

In line with the studies above, we define the liquidity hoarding banks to be the financial institutions for which the liquid assets to deposits and short term funding ratio exceeds a certain threshold. The proposed threshold is the value corresponding to the 75th quantile of the distribution of liquid assets to deposits and short term funding ratio. Thus, the liquidity hoarding banks are the ones that register a liquidity ratio above the corresponding value of the 75th quantile, while the banks below this value are considered to not be hoarding liquidity (Table 2). In comparison with the liquidity herding indicators, our measure focuses just on the positives changes of the liquidity indicators. The measure is more similar with Berrospide (2012) but, in

[3] Berrospide (2012) also uses t 2.5 and 3.5 percentage points and the results are the same.

[4] The liquidity herding indicators of Den End and Tabbae (2012) and Bonfin and Kim (2012) are derived from herding measures used in financial markets by Graham (1999), Grinblatt et al. (1995), Scharfstein and Stein (1990) and in banking Uchida and Nakagawa (2007).

contrast to it, we use the quantile to distinguish among liquidity hoarding and non liquidity hoarding banks (Table 3).

Insert Table 2

Insert Table 3

On the one hand, the advantage of this measure is that it allows for a time-varying liquidity hoarding behavior of banks. On the other hand, the reason we focus on the liquid assets to deposits and short term funding ratio is due to the fact that it accounts for both the availability of liquid buffers as well as the risk of short term funding liquidity shocks. These features are of great importance especially during stress periods.

In line with this, the ratio of liquid assets to deposits and short term funding will be the dependent variable used in our approach (Table 4). The liquid assets buffer consists of three subcomponents: loans and advances to banks, trading securities and fair value through income, and cash and due from banks. All these items are high quality assets that can be hoarded by banks. On the other hand, this liquidity ratio takes into account the short term funding constraints expressed through customer and interbank deposits. The motivation for using this rate as proxy for liquidity risk is provided in Bonfim and Kim (2012) as well as Dinger (2009). Aspachs et al. (2005) also use this ratio, arguing that the ratio of liquid assets to total assets does not capture the maturity mismatch risk specific to banks balance sheet. They propose a more accurate measure, by taking into account the maturity of the liquid assets and short term deposits.

Insert Table 4

A summary statistic with the values registered by the ratio of liquid assets to deposits and short term funding is presented in Table 5.The average over the whole period is 35.50, but there is substantial dispersion between its maxima and minima, 191.85 and 2.11 respectively. The value corresponding to the 75th quantile of its distribution is 45.32. Banks with a liquidity ratio above this value are considered liquidity hoarders at that moment. The number of liquidity hoarding banks varies in time, 2006 and 2007 standing out as having the largest numbers of liquidity hoarding banks.

Insert Table 5

Possible determinants and hypothesis

Among the factors that influence the incentives of banks to start hoarding liquid assets there is a great deal of empirical literature, covering bank level data, aggregate banking sector data, as well as macroeconomic variables. For our sample of EU banks we focus on several hypothesis that could explain the hoarding behavior of banks through different channels: funding, lending, trading and interbank markets.

We start by considering the funding liquidity constraints expressed through the ratio of long term financing in the total assets *(LTFTA)*. This is a very good proxy for the future expected access to funding. The lower the rate, the limited is the reliance on long term financing. A decrease in this rate may enhance the precautionary motive to provision liquidity reserves in order to avoid the risk of limited access long term funding markets. Analyzing the UK banking market between 2007-2010 Kapadia et al (2012) show that stresses banks facing this funding constraint start liquidity hoarding and assets fire sales, their action generating systemic events.

Another constraint that may influence the hoarding behavior is the ratio of net loans to deposits and short term funding *(NLDSTF)*. As a result of long-term lending and short-term borrowing, high values of this indicator reflect problems to meet unexpected withdrawals of depositors or other short term obligations. We expect that the higher the ratio the more motivated the banks to herd in order to reduce future exposure to structural balance sheet risk generated by maturity mismatch. Bonfim and Kim (2012) stressed that this problem become more complicated for banks with low equity ratios that rely on wholesale funding.

The evolution of total derivatives to assets ratio *(DTA)* is another factor that could influence the construction of liquidity buffers. Within our sample the dispersion of this rate is quite large, ranging from 0% to 55% (Table 5), with hoarding liquidity banks being more specialized in this type of activity than the non-hoarding ones.

We continue by considering two control variables for size and capitalization. As a proxy for bank size we use the natural logarithm of total assets *(lnTA)*. Dinger (2009) states that total assets could affect the costs as well as the availability of liquidity. When banks are too big to fail they may hoard liquidity for speculative motives, believing that will be bailed out in case of bankruptcy. Usually they are net borrowers in the interbank market (King, 2008) and engage in similar risk-taking strategies (Bonfim and Kim, 2012). In contrast, Berrospide (2012) found that both large and small banks have incentives to hoard liquidity for precautionary motives. The solvency risk is reflected by the equity to capital ratio *(lnETA)*. We expect that the lower the rate the highest the motivation to constitute liquidity buffers for future recapitalizations or reductions of stable sources of funding.

Empirical findings also suggest that specialization measured as the percentage of net loans in total assets *(NLTA)* is a key determinant of liquidity buffers. Banks specialized in lending present lower liquidity ratios due to the vulnerability of funding structures (Bonfim and Kim, 2012). Considering our sample the hoarding liquidity banks are less specialized in lending in comparison with the non-hoarding liquidity banks (Table 6).

Insert Table 6

Another factor that can condition the hoarding incentives regarding liquidity is the profitability expressed as net interest margin *(NIM)*. A reduction of the profitability as a source of liquidity could motivate banks to provision liquidity buffers for precautionary reasons. Table 6 reveals that hoarding liquidity banks present a lower net interest margin rate in comparison with the hoarding liquidity banks, both before and during crisis.

The choice of the determinants described above is in consensus with the evidence provided by the empirical literature on systemic risk. A detailed view of all variables employed in this study is given in Table 4. The descriptive statistics are reported in Table 5 and the correlation between variables in Table 7.

Insert Table 7

For detecting the presence of unit roots we applied the Fisher-ADF tests[5] with drift, two lags and cross-sectional means removed. Being conducted individually for each panel before combining the p-values to determine de overall test, this type is suitable for unbalanced panels. Its null hypothesis states that all panels contain unit roots, with the alternative that at least one panel is stationary. In table are reported the statistics and p-values for the following Fisher tests: inverse chi-squared, inverse normal, inverse logit and modified inverse chi-squared.

Insert Table 8

The results reflect the rejection of the null hypothesis for almost all series at a 1% significance level. The exception is the total assets, equity to capital ratio and net income to total assets ratio, but they become stationary in the logarithmic series. Further, we use the logarithmic values of these three series in the econometric model. Finally, to mitigate the effect of possibly spurious outliers, the series are winsorized at the 1st and 99th percentiles.

4. Empirical specification

Studies that asses the liquidity choices of banks present a large array of methodologies. Berrospide (2012) uses Ordinary Least Square (OLS) regressions with fixed effects to allow for heterogeneity and the Cox-Proportional Hazard model to account for time-varying hoarding behavior of banks. De Haan and van den End (2013) use Panel VAR, impulse response functions and two way Granger causality tests. In order to control for potential endogeneity problems

[5] Fisher unit root tests based on Augmented Dickey Fuller tests.

several studies use instrumental variables by employing the Generalized Methods of Moments (GMM) methodology (de Haan and van den End, 2013; Aspachs et al., 2005; Bonfim and Kim, 2012). Acharya and Merrouche (2010) use also instrumental variables by running three-stage-least squares regression.

The persistence in the ratio of liquidity assets to deposits and short term funding is taken into account by Dinger (2009) which employs the Dynamic System Generalized Methods of Moments (System GMM) methodology when analyzing the impact of transnational banks activity on the banking system liquidity. Using the same methodology, Delechat et al. (2012) also found persistence features of this rate over time when assessing the determinants of banks' liquidity buffers in Central America.

In our framework we assess the incentives of liquidity hoarding through a dynamic panel specification, using the First Differenced Generalized Method of Moments (FD-GMM) estimator of Arellano and Bond (1991). The regression specification to be estimated has the following form:

$$Lq_{i,t} = \alpha + \beta Lq_{i,t-1} + \mathbf{Risk'}_{i,t}\,\boldsymbol{\gamma} + \mathbf{Ctrl'}_{i,t}\boldsymbol{\theta} + \eta_i + \varepsilon_{i,t} \qquad (1)$$

The subscripts $i=1,\ldots,N$ and $t=1,\ldots,T$ denote the cross-sectional and time dimension, $Lq_{i,t}$ represents the LQ of bank i at time t, $\mathbf{Risk'}_{i,t}$ is a k×1 vector of risk variables (long term funding on total assets ratio, net loans on deposits and short term funding and derivates on total assets), $\boldsymbol{\gamma}$ is a k×1 vector of coefficients, $\mathbf{ctrl'}_{i,t}$ is a q×1 vector of control variables (logharitm of total assets, logharitm natural of equity on total assets, net loans on total assets and net interest margin), $\boldsymbol{\theta}$ is a q×1 vector of coefficients, η_i represent the unobserved bank specific effects and $\varepsilon_{i,t} \sim N(0, \sigma^2)$ is a random disturbance term.

OLS method applied to Eq. (1) may induce several problems. Firstly, it will produce upward biased and inconsistent coefficients estimates in dynamic panel with small T even when the errors are not serially correlated (Baltagi, 2008)[6]. Secondly, the correlation between the lagged dependent variable $Lq_{i,t-1}$ and the fixed effects η_i, generates dynamic panel bias as pointed out by (Nickell, 1981). Thirdly, in case of bidirectional causality between the endogenous and right hand side variables regressors may be correlated with the errors (Mileva, 1997).

By using the FD-GMM estimator proposed by Arellano and Bond (1991) several of the OLS assumptions are relaxed. Both the endogeneity in the lagged independent variable and in the

[6] As T gets large the OLS Fixed Effects estimator becomes consistent, but still biased. Judson and Owen (1999) found that even for T=30 the bias could be around 20% of the coefficients' true value.

right-hand-side variables could be corrected by differentiating the Eq. (1). This way, the bank-specific effects are removed and the following form is obtained:

$$\Delta Lq_{i,t} = \Delta Lq_{i,t-1} + \mathbf{\Delta Risk'_{i,t}}\,\boldsymbol{\gamma} + \mathbf{\Delta Ctrl'_{i,t}}\boldsymbol{\theta} + \Delta\varepsilon_{i,t} \qquad (2)$$

The problem of correlation between the errors $\Delta\varepsilon_{i,t}$ and the independent variable $\Delta Lq_{i,t-1}$ in the differenced Eq. (2) still exists, but could be addressed by instrumenting $\Delta Lq_{i,t-1}$ with lagged values of the dependent variable. Moreover, the consistent estimates can be achieved in the presence of heteroskedasticity and autocorrelation (Roodman, 2006).

In our empirical specification we apply the one-step *FD-GMM* with robust standard error, small sample correction and orthogonal deviations[7]. The robust standard error is consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation. To test for serial correlation the differenced equation we use the Arellano-Bond test which null hypothesis is that of no serial correlation between residuals[8]. As using annual frequency data the time period is short (T=8) and we apply small sample corrections to the covariance matrix[9]. Also, because the panel is unbalanced, in order to maximize the sample size we use orthogonal deviations. Instead of taking the differential between the current and the previous observation, the average of all forward available values is subtracting from the current observation Roodman (2006).

To address the dynamic panel bias problem we instrument the lagged dependent variable with the lags of dependent variable from lags 2 to 5 and the other explanatory variables with their values in the differenced equation. The validity of the instrumental variables set is assessed with the Hansen test[10]. Its null hypothesis is that the instruments are not correlated with the residuals. According to Roodman (2006) the number of instruments should not exceed the number of cross-sections. In this line, the collapse option was applied when using the *xtabond2* command in Stata in order to reduce the number of instruments to the minimum.

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[7] The methodology was implemented in Stata using the the *xtabond2* command of Roodman (2006).

[8] Mileva (2007) pointed out that the second order autocorrelation in first differences is important because it detect autocorrelation in levels.

[9] When using the small option Stata reports z-test statistics and the F test instead of a Wald $\chi 2$ test for the overall fit Roodman (2006).

[10] When using the robust correction for the covariance matrix Stata reports the reports the Hansen j statistic instead of the Sargan test. If the robust option is not used the statistics of Sargan test for the validity of the instruments is reported.

5. Empirical results

As a general empirical strategy we estimate the bank-specific factors that could enhance the incentives of banking institutions to hoard liquidity. Using the 75th quantile of the distribution of liquid assets to deposits and short term funding ratio we distinguish between liquidity hoarding and non-hoarding banks in a time-varying manner. During the 2004-2011 period, 26 European banks from our sample present liquidity hoarding behavior.

The dependent variable is the ratio of liquid assets to deposits and short term funding. We first estimate a baseline equation that consists of risk explanatory variables (long term funding to total assets ratio, net loans to deposits and short term funding ratio and derivatives to total assets ratio) and two control variables for size (logarithm of total assets) and capitalization (logarithm of equity to total assets ratio). In the second model we add the ratio of net loans to total assets as a proxy for specialization and in the third specification we assess the impact of the profitability expressed through the net interest margin. Finally, we test the robustness of our results by considering different specifications. The results of the empirical models are illustrated in Table 9.

Insert Table 9

Banking risks and liquidity hoarding. The results across all models show a persistent behavior of the liquid assets to deposits and short term funding ratio as the coefficient of the lagged dependent variable is statistically significant. This reflects the fact that banks aim to operate above a prudent level of this ratio. Dinger (2009) also obtained a persistent behavior of this rate for the Central and Eastern European banking system during 1994-2004 and Delechat et al. (2012) obtained the same result for the Central American banking system during 2006-2010.

The long term funding risk expressed through the ratio of long term funding to total assets has a significantly negative influence on the dependent variable (Table 9 Column1). The lower this ratio, the larger are the banks' incentives to hoard liquid assets. A 1% decrease of this ratio will raise the liquid assets to deposits and short term funding ratio by 133.2 %. This reflects liquidity hoarding due to precautionary reasons when the access to long term funding markets is reduced. In the European banking system a number of banks registered a reduction of the long term financing, especially after 2007. Due to increased counterparty risk the long term financing cost jumped during the financial turmoil. Kapadia et al. (2012) found that banks which loss access to long-term financing start hoarding liquidity by shortening wholesale lending maturity.

If confronted with problems to meet unexpected withdrawals of depositors or other short term obligations banks start hoarding liquidity for prudential motives. This hypothesis is confirmed by the statistically significance of the net loans to deposits and short term funding ratio that reflect structural balance sheet risk (Table 9 Column 1). The larger the gap between loans granted and short term resources the larger the incentives of banks to provision liquidity buffers. A 1% increase of this ratio will enhance the liquid assets to deposits and short term funding ratio by 52.31 %.

The percentage of derivates in total assets has a significantly negative influence on the liquid assets to deposits and short term funding ratio (Table 9 Column 1). A reduction of the derivatives to total assets ratio determines banks to hoard more liquidity. A 1% decrease of this ratio will raise the liquid assets on deposits and short term funding ratio by 133.9 %. Through the portfolio of derivatives banks could manage the liquidity and market risk by transforming the duration of their balance sheet items. Market depreciation of asset prices or assets fire sales lowers the values of the derivatives portfolio. Further, the reduction of this ratio could limit the possibility of banks to manage exposure of the loans portfolio to market risk, enhancing them to start hoarding liquidity.

The logarithm of total assets as a proxy for size has a significantly negative influence on the liquid assets to deposits and short term funding ratio (Table 9 Column 1). The lower the size of banks the larger are the incentives of hoarding liquid assets. The result confirms the precautionary motive to provision liquid buffers. The reason behind these incentives is that in the European banking system, usually smaller banks rely on long-term funding (Cardillo and Zaghini, 2012). As the long-term funding dropped during the financial turmoil and the cost of financing increased, smaller banks were the most affected. In anticipation of future liquidity needs they might engage in hoarding operations. For the US banking market, Berrospide (2012) found that both large and small banks have hoard liquidity for precautionary motives.

Another factor that significantly influences the hoarding behavior for the European banking system is the solvency risk. Results indicate that the lower the logarithm of equity on total assets the higher the liquidity buffers (Table 9 Column 1). Thus, there are the less capitalized banks that hold more liquid assets, for precautionary reasons. In addition, Berrospide (2012) found that the impact of capital on the incentives to hoard liquidity is more relevant for smaller banks.

Specialization and liquidity hoarding. In the second specification the net loans to total assets ratio is added (Table 9 Column 2). As expected, bank specialization has a significantly influence on the liquid assets to deposits and short term funding ratio. The lower the ratio, the higher are the incentives of banks to hoard liquid assets. A 1% decrease of this ratio will raise the liquid assets to deposits and short term funding ratio by 137.1 %. The significance and sign of the risk coefficients remain the same as in the first regression specification. Measuring the illiquidity of the assets portfolio this rate also reflects the exposure to credit risk. As a tendency, during vulnerable periods distress banks prefer hoarding liquidity rather than lending to customers, which also seems to be valid for our sample of European banks

Profitability and liquidity hoarding. Expressed in terms of net interest margin, the profitability has a statistically significant influence on the liquid assets to deposits and short term funding ratio (Table 9 Column 3). A 1% decrease of this ratio will raise the liquidity buffer ratio with 11.06 %. Thus, banks with lower profitability rates present larger incentives to hoard liquidity, not the most profitable. Bonfim and Kim (2012) found that profitable banks present lower liquidity buffers, due to the riskier strategies they adopt. Our results are also in the same line with Aspachs et al. (2011) which present a similar result for the impact of net interest margin on liquidity.

To assess the validity of the instruments in the FD-GMM estimations we performed the Hansen test. Its null hypothesis, that the instruments are not correlated with the residuals, is not rejected. Thus, the p-values obtained reflect that the instrument set is orthogonal to the regressors. In addition, by differentiating the initial equation, first order autocorrelation is introduced in the residues. In order to test the validity of the model, we test for autocorrelation of second order or more in the errors. The Arellano and Bond test confirmed the null hypothesis of no serial correlation between residuals.

6. Robustness check

We test the robustness of the empirical results by employing several different strategies. First, we control for other potentially relevant variables. Second, we account for different period spans. Third, we check the validity of results for different endogeneity specifications, using both internal and external instrumental variables.

Robustness with other explanatory variables. We start by replacing the ratio of net loans to deposits and short term funding with the ratio of loans to customer deposits *(LCD)*. We found no significant differences in comparison with the initial regression specifications for following variables: the derivates to total assets ratio, the logarithm of total assets, the net loans to total assets ratio (Table 10, Columns:B1-B5).

An important additional variable when investigating the incentives to hoard liquidity is the return on assets ratio *(lnROA)*. Thus, we replace the net interest margin ratio with the logarithm of net income to total assets ratio. On average, the return on assets ratio is not statistically significant in determining our dependent variable, but the sign and significance of the variables remain unchanged in the present of this ratio (Table 10, Columns: C1-C2).

The interbank ratio of assets to liabilities *(IR)* may provide additional information. A lower value reflects short term funding risk in interbank markets and could provide incentives for banks to hoard liquidity for precautionary motives. A higher value shows a net borrower position in interbank markets and may enhance banks to hoard liquidity for speculative motives when there is a temporary liquidity deficit. Although not statistically significant, the sign of this ratio is as expected and all the other coefficients remain statistically significant in the presence of this control variable (Table 10, Columns: A1-A2).

Insert Table 10

Robustness for different period specifications. As an additional robustness check we test for different time specifications. First, we introduce two year dummy variables for 2008 and 2009. All the significant variables from the equations keep the expected sign (Table 11, Columns: A1-A3). Second, we restrict the sample to the crisis years, estimating the regressions for the period between 2007 and 2011. With the exception of the size variable, all other coefficients remain statistically significant during the financial crisis period (Table 11, Columns: B1-B3).

Insert Table 11

Robustness for different endogeneity specifications. As the FD-GMM specification is sensitive to the set of instrumental variables we consider different endogeneity specifications, using both an internal and an external set of instrumental variables. First we treat as endogenous variables the long term funding to the total assets ratio and the logarithm of total assets (Table 12, Columns: A1-A3). Second, we add to the previous specification two market indices as external instrumental variables: the volatility of governmental bonds prices calculated within a year *(GovB)* and the spread between the 3 month interbank offered rate and overnight interbank offered rate calculated as volatility within a year *(SpreadIR)*. See Table 12, Columns: B1-B3. Third, with the exception of the dependent variables we treat all variables as exogenous and use a set of external instrumental variables that consists of the governmental bonds spread *(GovSpread)* and the volatility of governmental bonds prices within a year (Table 13, Columns: A1-A3). Forth, we modify the previous specification using as external instrumental variables the governmental bonds spread and the interest rate spread (Table 13, Columns: B1-B3). The result obtained does not change our main findings as reported in the results section of this paper. Almost all the variable used in regressions maintain the significance and the expected sign, with the exception of few variables that lost the statistical significance.

Insert Table 12

Insert Table 13

Summarizing the robustness tests employed in this study we can conclude that the results are valid to different type of specifications regarding other control variables, a different time period and a various sets of instrumental variables. Hansen p-values confirm the validity of the instrumental variables sets and the the null hypothesis of no serial correlation between residuals is confirmed by the Arellano and Bond test.

7. Conclusions

This paper provides empirical evidence on the main incentives of liquidity hoarding behavior within a unique sample of European banks which assets represent around 80% of the European banking system total assets over the period 2004-2011. The dependent variables is the ratio of liquid assets to deposits and short term funding ratio.

Among the possible determinants provided by the theoretical and empirical literature we consider bank specific risk variables, specialization and profitability. The incentives of liquidity hoarding are assessed through a dynamic panel specification, using the First Differenced-GMM estimator of Arellano and Bond (1991). The methodology accounts for persistency of the dependent variable, endogeneity, heteroskedasticity and autocorrelation, producing unbiased and consistent estimates in unbalanced panels with “large N, small T”. The results across all models reveal a persistent behavior of the dependent variable, which is in line with Dinger (2009) and Delechat et al. (2012).

Despite the number of papers that analyze the liquidity hoarding behavior of banks, there is scarce evidence of empirical measures that distinguish between hoarder and non-hoarder financial institutions. In addition to Berrospide (2012), we propose a time varying approach to distinguish between liquidity hoarding and non-hoarding banks. We define the liquidity hoarding banks to be the financial institutions for which the liquid assets to deposits and short term funding ratio exceeds a certain threshold. The proposed threshold is the value corresponding to the 75^{th} quantile of the distribution of liquid assets to deposits and short term funding ratio. On the one hand, this measure allows for a time-varying liquidity hoarding behavior of banks. On the other hand, the ratio of liquid assets to deposits and short term funding ratio accounts for both the availability of liquid buffers as well as the risk of short term funding liquidity shocks. These features are of great importance especially during stress periods.

The bank specific data used in our analysis reveals the precautionary motives of European banks to hoard liquid assets. We demonstrate that funding and liquidity constraints significantly influence the liquidity hoarding behavior, due to concerns regarding future access to long term financing markets and unexpected withdrawals of depositors. A reduction of the derivatives portfolio, through which banks could actively manage the liquidity and market risk, determines the decrease of the liquidity buffers. Specialization is another important factor, as a reduction in the lending activity enhances banks to provision liquid reserves. Also, a decrease in the profitability ratio enhances hoarding behavior. Moreover, smaller and less capitalized banks present more incentives to hoard liquid assets in respect to funding liquidity shocks.

The empirical results are valid to different type of specifications. Their robustness was checked by employing different strategies: controlling for other potentially relevant variables, accounting for different period spans and allowing for different endogeneity specifications.

In terms of policy implications, we want to stress that the analysis of liquidity hoarding behavior in the banking system is of great importance both for the individual risk management of banks as well as for the financial supervisory authorities in designing an efficient macroprudential supervision framework.

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Annexes

Table 1. Sample of banks

Country of origin	Number of banks	Banking institution
Austria	3	Erste Group Bank AG, Raiffeisen Bank International AG, Oesterreichische Volksbanken AG
Belgium	2	Dexia, KBC Bank NV
France	3	BNP Paribas, Crédit Agricole S.A., Société Générale,
Germany	9	Deutsche Bank AG, Commerzbank AG, DZ Bank AG-Deutsche Zentral-Genossenschaftsbank, Bayerische Landesbank, Norddeutsche Landesbank Girozentrale NORD/LB, Portigon AG, HSH Nordbank AG, Landesbank Berlin Holding AG-LBB Holding AG, DekaBank Deutsche Girozentrale, WGZ-Bank AG Westdeutsche Genossenschafts-Zentralbank
Netherlands	5	ING Bank NV, Rabobank Nederland-Rabobank Group, Rabobank Nederland-Rabobank Group, RBS Holdings NV, SNS Bank N.V.
Slovenia	2	NLB dd-Nova Ljubljanska Banka d.d., Nova Kreditna Banka Maribor d.d.
Greece	5	Eurobank Ergasias SA, National Bank of Greece SA, Alpha Bank AE, Agricultural Bank of Greece, TT Hellenic Postbank S.A
Italy	2	Banco Popolare, Unione di Banche Italiane Scpa-UBI Banca
Portugal	5	Caixa Geral de Depositos, Banco Comercial Português, SA-Millennium bcp, Espirito Santo Financial Group S.A., Banco BPI SA
Spain	16	Banco Santander SA, Banco Bilbao Vizcaya Argentaria SA, Banco Popular Espanol SA, Banco de Sabadell SA, Caixa de Aforros de Vigo, Ourense e Pontevedra-Caixanova, Bankinter SA, Caja de Ahorros y Monte de Piedad de Zaragoza-Aragon y Rioja-Ibercaja, Unicaja - Montes de Piedad y Caja de Ahorros de Ronda, Cadiz, Almeria-Malaga Y Antequera,, Banco Pastor S, Bilbao Bizkaia Kutxa, BBK, Caja de Ahorros y Monte de Piedad de Gipuzkoa y San Sebastian-Kutxa, Banco Grupo Cajatres SA-Caja 3, Banca March SA, Caja de Ahorros de Vitoria y Alava-Caja Vital, Caja de Ahorros y Monte de Piedad de Ontinyent - Caixa Ontinyent, Caja de Ahorros del Mediterraneo CAM
Denmark	4	Danske Bank A/S, Jyske Bank A/S (Group), Sydbank A/S, Nykredit Realkredit A/S
Finland	1	OP-Pohjola Group
Irland	6	Allied Irish Banks plc, Bank of Ireland-Governor and Company of the Bank of Ireland, Permanent TSB Plc, Intesa Sanpaolo, UniCredit SpA, Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena
Norway	1	DNB Bank ASA
Sweden	4	Nordea Bank AB (publ), Skandinaviska Enskilda Banken AB, Svenska Handelsbanken, Swedbank AB

United Kindom	4	Royal Bank of Scotland Group Plc (The), HSBC Holdings Plc, Barclays Plc, Lloyds Banking Group Plc
Cyprus	2	Cyprus Popular Bank Public Co Ltd, Bank of Cyprus Public Company Limited-Bank of Cyprus Group

Table 2. Liquidity hoarding banks

Country of origin	Number of banks	Banking institution
Austria	1	Oesterreichische Volksbanken AG
France	3	BNP Paribas, Crédit Agricole S.A., Société Générale,
Germany	9	Deutsche Bank AG, Commerzbank AG, DZ Bank AG-Deutsche Zentral-Genossenschaftsbank, Bayerische Landesbank, Norddeutsche Landesbank Girozentrale NORD/LB, Portigon AG, HSH Nordbank AG, Landesbank Berlin Holding AG-LBB Holding AG, DekaBank Deutsche Girozentrale, WGZ-Bank AG Westdeutsche Genossenschafts-Zentralbank
Netherlands	1	RBS Holdings NV
Denmark	3	Danske Bank A/S, Jyske Bank A/S (Group), Nykredit Realkredit A/S
Irland	3	Permanent TSB Plc, Intesa Sanpaolo, UniCredit SpA, Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena
Sweden	2	Svenska Handelsbanken, Swedbank AB
United Kindom	4	Royal Bank of Scotland Group Plc (The), HSBC Holdings Plc, Barclays Plc, Lloyds Banking Group Plc

Table 3. The number of liquidity hoarding banks during 2004-2011

Year	Number LH banks
2004	11
2005	16
2006	22
2007	21
2008	15
2009	18
2010	16
2011	18

Source: authors’ calculations

Table 4. Description of variables

Variable	Description	Frequency	Source
Y	Liquid assets / deposits and short term funding	Annually	Bankscope
IR	Interbank ratio	Annually	Bankscope
LCD	Loans/ customer deposits	Annually	Bankscope
NLTA	Net loans / total assets	Annually	Bankscope
NLDSTF	Net loans / deposits and short term funding	Annually	Bankscope
lnTA	Logarithm of total assets	Annually	Bankscope
DTA	Derivatives/ total assets	Annually	Bankscope
lnETA	Ln((equity/total assetsy$_{t)}$)	Annually	Bankscope
NIM	Net interest margin	Annually	Bankscope
lnNIROA	Ln (net income/ average total assets% (roa) y_t)	Annually	Bankscope
SpreadGOV	The spread between the governmental bonds of Euro Area with 5 years maturity and the governmental bonds of Euro Area with 1 years maturity calculated as volatility within a year	Annually	Authors' calculation based on data from Datastream
GovB	The volatility of governmental bonds calculated within a year	Annually	Authors' calculation based on data from Datastream
SpreadIR	The spread between the 3 month interbank offered rate and overnight interbank offered rate calculated as volatility within a year	Annually	Authors' calculation based on data from Datastream
DLQ_Q75	Dummy of liquidity hoarding banks using the 75th quantile of the liquid assets to deposits and short term funding as threshold. Dummy variable takes the value of 1 for the hoarder banks, and 0 otherwise.	Annually	Authors' calculation based on data from Bankscope

Table 5. Descriptive statistic

Statistics	Y	LTFTA	NLDSTF	DTA	lnTA	lnETA	NLTA	NIM	IR	LCD	lnNIROA
N	542	542	542	504	542	539	542	539	528	525	418
Mean	35.509	0.36969	1.0428	0.0500	468.567	-2.9767	0.5711	1.7027	100.658	152.383	-0.7931
Sd	30.798	0.1703	0.7785	0.0706	677.53	0.5346	0.1780	0.8651	115.267	55.8874	0.9498
P25	14.782	0.256	0.737	0.008	44.9888	-3.3524	0.477	1.008	44.1845	119.91	-1.2039
P50	27.5545	0.372	0.9735	0.0205	131.174	-2.9374	0.6125	1.675	65.138	143.38	-0.6733
P75	45.324	0.482	1.165	0.064	624.844	-2.6450	0.692	2.26	113.387	174.98	-0.1392
Min	2.115	0.005	0.006	0.001	0.7632	-4.7103	0.003	0.177	5.901	7.63	-4.6051
Max	191.858	0.871	10.469	0.556	3543.97	-1.2801	0.888	4.586	941.03	468.8	2.2235

Table 6. Liquidity hoarding (LH) and non-hoarding (non-LH) banks' characteristics

	All banks		LH banks		non-LH banks	
	2004-2008	2009-2011	2004-2008	2009-2011	2004-2008	2009-2011
Y	38.42666	31.20591	81.20713	68.98446	23.14792	19.44253
LTFTA	0.377217	0.358612	0.321094	0.266039	0.397261	0.387437
NLDSTF	1.06983	1.00311	1.160824	0.929231	1.037332	1.026114
DTA	0.043701	0.059048	0.083872	0.125765	0.029194	0.037648
TA	434.691	518.5323	899.4599	1079.665	268.7021	343.8085
ETA	.059161	.0578584	.0360941	.0359038	-2.82271	.0673992
NLTA	0.568709	0.574808	0.380435	0.37975	0.63595	0.635545
NIM	1.749508	1.63395	0.934833	0.959423	2.038253	1.845247
IR	112.9272	83.2112	96.56063	93.41512	118.9115	80.0148
LCD	151.2468	154.0606	143.987	146.7065	153.7394	156.2713
NIROA	.7384328	-.0498165	.3770588	.1013462	-0.32263	.8613

Table 7. Correlation

	Y	LTFTA	NLDSTF	DTA	lnTA	lnETA	NLTA	NIM	IR	LCD	lnNIROA
Y	1										
LTFTA	-0.4081	1									
NLDSTF	-0.4672	0.1043	1								
DTA	0.4332	-0.3682	-0.3434	1							
lnTA	0.5037	-0.2704	-0.2201	0.5861	1						
lnETA	-0.5555	0.4291	0.2574	-0.4209	-0.4952	1					
NLTA	-0.8091	0.3481	0.7643	-0.5735	-0.5087	0.5508	1				
NIM	-0.498	0.4029	0.1435	-0.3984	-0.4079	0.6023	0.5078	1			
IR	0.0699	0.0819	-0.1017	-0.0957	-0.1956	0.1625	-0.0288	0.11	1		
LCD	-0.1281	-0.1966	0.6576	-0.1213	0.0671	-0.1508	0.3365	-0.2268	-0.2038	1	
lnNIROA	-0.2492	0.2143	0.1015	-0.2104	-0.1859	0.5088	0.2565	0.4086	0.1082	-0.1259	1

Table 8. Fisher-ADF unit root tests

	Inv. chi-squared	Inv.N	Inv.L	M.Inv chi-squared
Y	119.5072	-3.1085	-3.0989	2.9288
	[0.0044]	[0.0009]	[0.0011]	[0.0017]
LTFTA	152.0959	-5.0895	-5.0926	5.4736
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NLDSTF	136.2320	-4.1106	-3.9796	4.2348
	[0.0002]	[0.0000]	[0.0000]	[0.0000]
DTA	112.3661	-4.3158	-4.1613	3.8044
	[0.0006]	[0.0000]	[0.0000]	[0.0000]
TA	166.7985	-6.7932	-6.4401	6.6216
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
lnTA	115.8499	-3.2205	-3.0348	2.6432
	[0.0082]	[0.0006]	[0.0014]	[0.0041]
ETA	99.2781	-2.0815	-1.9530	1.3492
	[0.0941]	[0.0187]	[0.0261]	[0.0886]
lnETA	106.7897	-3.0022	-2.7540	2.3050
	[0.0169]	[0.0013]	[0.0032]	[0.01106
NLTA	132.4441	-3.9669	-3.7085	3.9390
	[0.0004]	[0.0000]	[0.0001]	[0.0000]
NIM	115.2501	-3.6887	-3.5199	2.9824
	[0.0039]	[0.0001]	[0.0003]	[0.0014]
IR	153.4498	-5.6559	-5.6103	6.7875
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
LCD	139.5700	-5.4193	-5.1522	5.1562
	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Note:

Fisher-ADF tests[11] with drift, two lags and cross-sectional means removed. Its null hypothesis states that all panels contain unit roots, with the alternative that at least one panel is stationary. In table are reported the statistics and p-values for the following Fisher tests: inverse chi-squared, inverse normal, inverse logit and modified inverse chi-squared.

[11] Fisher unit root tests based on Augmented Dickey Fuller tests.

Table 7. Baseline regressions results for liquidity hoardeing banks

Variables	(1)	(2)	(3)
L.Y	0.507***	0.336**	0.205*
	(0.138)	(0.150)	(0.119)
LTFTA	-133.2*	-134.3*	-163.9**
	(66.94)	(70.35)	(63.54)
NLDSTF	52.31***	66.71***	70.83***
	(11.64)	(19.50)	(20.39)
DTA	-122.9***	-126.2***	-133.9***
	(34.23)	(30.44)	(27.30)
lnTA	-31.03*	-30.46	-32.80*
	(16.57)	(17.94)	(19.16)
lnETA	-28.50***	-23.19*	-23.25*
	(9.963)	(13.17)	(13.00)
NLTA		-137.1*	-135.7*
		(67.22)	(71.48)
NIM			-11.06***
			(3.971)
Observations	92	92	92
No. of bank	26	26	26
No. of instruments [a]	9	10	11
AR2 Test	0.250	0.166	-0.296
AR2 Test (p-value) [b]	0.802	0.869	0.767
Hansen Test	5.101	5.221	6.135
Hansen Test (p-value) [c]	0.165	0.156	0.105

Note:

Standard errors in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%.

Dependent variable: y measured by liquid assets on deposits and short term funding ratio.

Method used is *First difference GMM* of Arellano and Bond (1991) with robust standard error, consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation, with small sample correction and orthogonal deviations.

[a] The number of instruments was reduced to the minimum by applying the *collapse* option when using the *xtabond2* command in Stata.

Instruments. Arrelano-Bond type: the lags from 2 to 5 of the dependent variable. *Standard instruments*: the level of all other regressors.

[b] The *Hansen test* reports the validity of the instrumental variables test. The null hypothesis is that the instruments are not correlated with the residuals.

[c] For the *Arellano-Bond test* the null hypothesis is that of no serial correlation between residuals.

Table 8. Robustness with other explanatory variables

Variables	(A1)	(A2)	(B1)	(B2)	(B3)	(B4)	(B5)	(C1)	(C2)
L.Y	0.745***	0.507***	0.633***	0.435***	0.254	0.165	0.454***	0.578**	0.588**
	(0.158)	(0.134)	(0.148)	(0.138)	(0.153)	(0.150)	(0.136)	(0.277)	(0.276)
LTFTA	-105.4	-129.2*	-67.05	-97.56	-71.73	-90.80	-98.98	-102.2	20.69
	(67.39)	(65.72)	(47.99)	(65.30)	(75.17)	(79.28)	(63.70)	(75.06)	(77.80)
NLDSTF	53.66***	58.37***						63.92***	
	(16.65)	(14.89)						(20.25)	
DTA	-122.8***	-128.5***	-77.62***	-81.00***	-66.71**	-70.06**	-77.26***	-134.6***	-86.94**
	(42.78)	(36.81)	(21.87)	(20.52)	(26.27)	(26.93)	(18.66)	(47.89)	(33.51)
lnTA	-23.41	-33.01*	-36.95*	-41.39**	-46.43*	-47.93*	-37.12*	-33.73	-35.22*
	(17.54)	(18.87)	(19.62)	(19.31)	(24.19)	(24.64)	(20.20)	(21.07)	(19.26)
lnTA		-27.35***		-24.90***	-15.53	-16.15	-25.63**	-13.14	-0.885
		(9.444)		(8.526)	(9.855)	(9.508)	(9.931)	(12.43)	(9.682)
IR		-0.0414					0.0552		
		(0.0407)					(0.0452)		
LCD			0.200**	0.163***	0.282***	0.276***	0.176***		0.411***
			(0.0778)	(0.0531)	(0.0530)	(0.0498)	(0.0510)		(0.0917)
NLTA					-155.4***	-153.0***		-113.5	-187.2**
					(45.90)	(45.56)		(79.96)	(81.16)
NIM						-5.745			
						(3.733)			
lnNIROA								-0.673	2.284
								(2.139)	(2.889)
Observations	92	91	91	91	91	91	90	74	73
No. of bank	26	26	25	25	25	25	25	26	25
No. of instruments [a]	8	10	8	9	10	11	10	11	11
AR2 Test	-1.056	0.347	-0.968	0.509	0.677	0.726	0.217	0.116	0.190
AR2 Test (p-value) [b]	0.291	0.729	0.333	0.610	0.498	0.468	0.828	0.907	0.849
Hansen Test	3.773	5.366	4.650	5.691	5.818	5.446	6.094	2.397	4.567
Hansen Test (p-value) [c]	0.287	0.147	0.199	0.128	0.121	0.142	0.107	0.494	0.206

Note:

Standard errors in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%.

Dependent variable: y measured by liquid assets on deposits and short term funding ratio.

Method used is *First difference GMM* of Arellano and Bond (1991) with robust standard error, consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation, with small sample correction and orthogonal deviations.

[a] The number of instruments was reduced to the minimum by applying the *collapse* option when using the *xtabond2* command in Stata.

Instruments. Arrelano-Bond type: the lags from 2 to 5 of the dependent variable. *Standard instruments*: the level of all other regressors.

[b] The *Hansen test* reports the validity of the instrumental variables test. The null hypothesis is that the instruments are not correlated with the residuals.

[c] For the *Arellano-Bond test* the null hypothesis is that of no serial correlation between residuals.

Table 9. Robustness for different period specifications

Variables	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
L.Y	0.538***	0.304**	0.245**	0.551***	0.363*	0.230
	(0.135)	(0.110)	(0.101)	(0.160)	(0.178)	(0.141)
LTFTA	-124.8**	-116.2**	-115.3**	-127.3*	-131.4*	-160.8**
	(58.08)	(48.70)	(47.97)	(70.36)	(70.74)	(62.90)
NLDSTF	99.30***	121.7***	124.2***	52.62***	66.41***	70.48***
	(11.64)	(15.54)	(15.03)	(12.01)	(19.51)	(20.38)
DTA	-157.5***	-164.5***	-166.7***	-122.9***	-126.1***	-133.6***
	(27.19)	(24.36)	(24.14)	(34.17)	(30.37)	(27.42)
lnTA	3.837	1.140	-2.835	-29.88	-29.91	-32.31
	(9.350)	(16.06)	(17.84)	(17.59)	(18.41)	(19.26)
lnETA	-26.93**	-18.76	-18.82	-27.81***	-23.02*	-23.12*
	(12.32)	(14.84)	(14.92)	(9.647)	(12.98)	(12.86)
NLTA		-206.4***	-207.3***		-132.9*	-132.5*
		(66.08)	(67.31)		(72.08)	(74.03)
NIM			-7.564*			-10.72**
			(3.864)			(4.188)
Observations	67	67	67	92	92	92
Number of bank	23	23	23	26	26	26
No. of instruments [a]	9	10	11	11	12	13
AR2 Test	-0.280	-0.270	-0.418	0.239	0.183	-0.251
AR2 Test (p-value) [b]	0.780	0.788	0.676	0.811	0.855	0.802
Hansen Test	4.505	5.092	4.746	6.410	5.927	6.305
Hansen Test (p-value) [c]	0.212	0.165	0.191	0.268	0.313	0.278

Note:

Standard errors in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%.

Dependent variable: y measured by liquid assets on deposits and short term funding ratio.

Method used is *First difference GMM* of Arellano and Bond (1991) with robust standard error, consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation, with small sample correction and orthogonal deviations.

[a] The number of instruments was reduced to the minimum by applying the *collapse* option when using the *xtabond2* command in Stata.

Instruments. Arrelano-Bond type: the lags from 2 to 5 of the dependent variable. *Standard instruments*: the level of all other regressors.

[b] The *Hansen test* reports the validity of the instrumental variables test. The null hypothesis is that the instruments are not correlated with the residuals.

[c] For the *Arellano-Bond test* the null hypothesis is that of no serial correlation between residuals.

Table 10.Robustness with internal and external instrumental variables

Variables	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
L.Y	0.490***	0.348**	0.245*	0.521***	0.339**	0.250*
	(0.157)	(0.146)	(0.127)	(0.155)	(0.146)	(0.131)
LTFTA	-451.8**	-321.1*	-362.9**	-343.9**	-226.5	-233.5*
	(211.2)	(161.7)	(153.2)	(156.2)	(137.9)	(124.4)
NLDSTF	56.91***	65.47***	69.77***	55.73***	66.11***	69.96***
	(13.01)	(17.94)	(18.27)	(11.87)	(18.30)	(18.27)
DTA	-136.5***	-130.6***	-141.2***	-134.7***	-128.1***	-135.9***
	(39.25)	(32.95)	(27.81)	(36.13)	(32.94)	(28.33)
lnTA	-126.7**	-91.79*	-94.91*	-89.20*	-61.17	-55.87
	(61.17)	(47.41)	(46.59)	(50.24)	(42.03)	(35.01)
lnETA	-28.88**	-25.20*	-25.01*	-28.23**	-24.21*	-23.77*
	(12.25)	(13.36)	(13.43)	(10.87)	(13.33)	(13.15)
NLTA		-102.9	-91.70		-120.7	-115.4
		(78.23)	(84.65)		(76.02)	(79.79)
NIM			-12.84**			-11.29**
			(5.220)			(4.576)
Observations	92	92	92	92	92	92
Number of bank	26	26	26	26	26	26
No. of instruments [a]	15	16	17	17	18	19
AR2 Test	0.518	0.393	0.143	0.306	0.247	-0.108
AR2 Test (p-value) [b]	0.605	0.694	0.886	0.760	0.805	0.914
Hansen Test	12.59	13.51	12.75	16.53	16.97	15.65
Hansen Test (p-value) [c]	0.182	0.141	0.174	0.123	0.109	0.155

Note:

Standard errors in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%.

Dependent variable: y measured by liquid assets on deposits and short term funding ratio.

Method used is *First difference GMM* of Arellano and Bond (1991) with robust standard error, consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation, with small sample correction and orthogonal deviations.

[a] The number of instruments was reduced to the minimum by applying the *collapse* option when using the *xtabond2* command in Stata.

Instruments. Arrelano-Bond type: one lag of the dependent variable, LTFTA and lnTA. *Standard instruments*: the level of all other regressors. In columns B1-B3 we introduce as external instrumental variables GovB and SpreadIR.

[b] The *Hansen test* reports the validity of the instrumental variables test. The null hypothesis is that the instruments are not correlated with the residuals.

[c] For the *Arellano-Bond test* the null hypothesis is that of no serial correlation between residuals.

Table 11. Robustness with external instrumental variables

Variables	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
L.Y	0.498***	0.343*	0.244	0.504***	0.338**	0.206*
	(0.165)	(0.177)	(0.164)	(0.137)	(0.149)	(0.117)
LTFTA	-134.3*	-133.6*	-158.9**	-138.0**	-137.4*	-168.6**
	(68.82)	(67.82)	(58.29)	(67.09)	(71.02)	(63.29)
NLDSTF	52.25***	66.64***	70.27***	53.07***	66.78***	71.00***
	(11.62)	(19.09)	(19.33)	(11.64)	(19.31)	(20.13)
DTA	-122.9***	-126.1***	-133.5***	-123.9***	-126.7***	-134.8***
	(34.21)	(30.48)	(27.60)	(34.01)	(30.42)	(27.01)
lnTA	-31.26*	-30.32*	-32.02*	-31.30*	-30.67*	-33.11*
	(16.84)	(17.65)	(18.40)	(16.61)	(17.91)	(19.13)
lnETA	-28.63***	-23.15*	-23.05*	-28.75***	-23.51*	-23.68*
	(10.13)	(13.34)	(13.12)	(9.965)	(13.20)	(13.00)
NLTA		-136.1**	-130.6*		-133.3*	-130.5*
		(63.50)	(66.64)		(68.08)	(72.46)
NIM			-10.52**			-11.28***
			(4.328)			(3.992)
Observations	92	92	92	91	91	91
Number of bank	26	26	26	26	26	26
No. of instruments [a]	11	12	13	11	12	13
AR2 Test	0.253	0.169	-0.232	0.236	0.150	-0.317
AR2 Test (p-value) [b]	0.800	0.866	0.817	0.814	0.881	0.751
Hansen Test	6.072	6.712	7.729	5.126	5.222	6.142
Hansen Test (p-value) [c]	0.299	0.243	0.172	0.163	0.156	0.105

Note:

Standard errors in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%.

Dependent variable: y measured by liquid assets on deposits and short term funding ratio.

Method used is *First difference GMM* of Arellano and Bond (1991) with robust standard error, consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation, with small sample correction and orthogonal deviations.

[a] The number of instruments was reduced to the minimum by applying the *collapse* option when using the *xtabond2* command in Stata.

Instruments. Arrelano-Bond type: one lag of the dependent variable. *Standard instruments*: the level of all other regressors. In columns A1-A3 we introduce as external instrumental variables GovB and SpreadIR. In columns B1-B3 we introduce as external instrumental variables SpreadGov and SpreadIR.

[b] The *Hansen test* reports the validity of the instrumental variables test. The null hypothesis is that the instruments are not correlated with the residuals.

[c] For the *Arellano-Bond test* the null hypothesis is that of no serial correlation between residuals.