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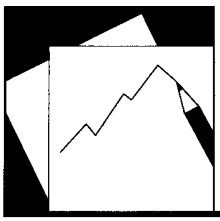

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Is There a Role for Funding in Explaining Recent U.S. Banks' Failures?

Pierluigi Bologna

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Is There a Role for Funding in Explaining Recent U.S. Banks' Failures?

Prepared by Pierluigi Bologna[1]

Authorized for distribution by Ceyla Pazarbasioglu

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Abstract

This paper tests the role of different banks' liquidity funding structures in explaining the banks' failures, which occurred in the United States between 2007 and 2009. The results highlight that funding is indeed a significant factor in explaining banks' probability of default. By confirming the role of funding as the driver of banking crisis, the paper also recognizes that the new liquidity framework proposed by the Basel Committee on Banking Supervision appears to have the features to strenghten banks' liquidity conditions and improve financial stability. Its correct implementation together with closer supervision of banks' liquidity and funding conditions appear, however, the determinant for such improvements to be achieved.

JEL Classification Numbers: G01, G20, G21, G28

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Author's E-Mail Address: pierluigi.bologna@bancaditalia.it

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I. INTRODUCTION

The financial crisis, which shook the global financial system so hard, is still producing its effects on many dimensions of the financial landscape, from the individual banks business strategy to sovereign stability, to the authorities' policy response and regulatory reforms.

One critical dimension experienced by many banks around the world during the crisis has been that of funding liquidity. Very often, banks and nonbank financial institutions discovered themselves in the middle of the crisis unable to refinance their wholesale, short-term funding positions with little or no access to the markets. Some institutions were severely hit by these funding shocks as a consequence of their heavy reliance on wholesale funding. Notable examples are those of some investment banks in the United States, who discovered themselves illiquid almost overnight; the Landesbanken in Germany; and several banks in the United Kingdom, as well as banks in countries like Australia which, despite their sound asset quality, faced major funding challenges because of the their extensive reliance on short-term wholesale funding.[2]

The policy response to these widespread funding weaknesses has come in the form of ample liquidity support measures by all of the most important central banks around the world, who played the role of lenders of last resort. Since then, new regulations aiming at addressing the liquidity shortcomings faced by many banks during the crisis have been proposed or introduced. The new regulatory framework for liquidity risk approved by the Basel Committee on Banking Supervision (2010) is the most notable reform in this direction.[3]

On the basis of this background, the present study investigates the role of the different funding structures at bank-by-bank level to assess if any significant weakness in the funding liquidity profile might have contributed to drive banks toward more vulnerable situations and eventually to default.

In particular, focusing on the defaults of U.S. banks that occurred in recent years the paper explores whether and to what extent different funding profiles might contribute to explain banks' failures. In other words, it aims to identify if any specific funding structure could be considered a possible indicator of banks' fragility and higher default likelihood.

This paper focuses on the United States where the financial crisis has produced a large wave of banks' defaults in the system, which appears not to be over yet while this paper is being written. This large number of defaults is driving a higher level of consolidation in the system, and, possibly, other more profound structural changes. It provides at the same time an interesting set for analysis and research in the sphere of banks' distress. Not only does the

[2] See Viñals et al. (2010) for a discussion of the interbank and repo markets weaknesses involved in the case of Lehman Brothers. Bologna et al. (2011) describe the problems with the German Landesbanken. See Bologna (2010) for a review of Australian banks liquidity conditions.

[3] New regulations for liquidity risk have also been approved and already introduced in some countries like the United Kingdom and New Zealand.

large number of defaults represent a meaningful statistical set, but also the degree and quality of the information available on funding for U.S. banks allows for a more in-depth analysis than would be possible for many other countries.

The contribution of this analysis is original at least in two respects. First, it is one of the very few studies investigating the recent wave of defaults of U.S. banks, with a particular focus on the role of funding. Second, in analyzing banks' deposits, it differentiates between different deposits features, and, particularly, between insured and uninsured deposits.

The paper proceeds as follows. Section II provides a review of the literature on banks' defaults and on the role of depositors in monitoring and disciplining banks' behavior. Section III provides the economic rationale for the empirical analysis presented in the following section. Section IV discusses the scope of the empirical analysis, the data, the econometric modeling, the results, and the robustness of the findings. Section V presents the conclusions.

II. THE LITERATURE

Two strands of literature are of interest for the purpose of this work. One focusing on the analysis of banks' failures and the other looking at the market discipline role of depositors.

A. Defaults Literature

The empirical literature on banks' defaults studies banking crises and the factors predicting failures by applying econometric and statistical techniques to identify the ex-post determinants of the event analyzed, be it a systemic crisis or a financial institution distress. The methodologies more often used range from Logit or Probit regression models, to discriminant analysis, to hazard-function models.[4]

The analysis of the determinants of systemic crises is largely based on the assessment of the role of macroeconomic variables. Among the others, Demirguc-Kunt and Detragiache (1998) look at the determinants of banking crises in a number of countries between 1980 and 1994. They find that crises are more likely in countries with low GDP growth, high real interest rates, high inflation, higher likelihood of balance-of-payment crisis, and explicit deposit insurance. Demirguc-Kunt and Detragiache (2002) confirm the relevance of the latter element as a risk factor for the stability of banks.

Particularly relevant to this work is, however, the literature on forecasting banks' failure, distress, and closure. These analyses are mainly focused on the early identification of institutions in financial difficulties, based on balance-sheet and profit-and-loss information, but also controlling for macroeconomic and other institutional factors. Studies in this area

[4] Works based on hazard models, which assess also the timing of failure, are those by Lane et al. (1986), Whalen (1991), Cole and Gunter (1995), and Gonzales-Hermosillo (1999).

have been developed in the 1970s.[5] Altman (1981) provides a comprehensive review of this early stage literature.

Demyanyk and Hasan (2009) provide an updated review of the literature on prediction methods for financial crises and bank failures. Wheelock and Wilson (2000) analyze the bank-specific factors that help to explain banks' defaults in the United States during the period 1984–1993. They find that banks with lower capitalization, lower profitability, and poorer asset quality are more likely to fail than other banks. A proxy for banks' liquidity appears in the model with a sign counter to ex ante expectation. Comparable results are found by Bongini et al. (2001) in analyzing financial institutions' distress during the Asian crisis of the late 1990s.

Cole and Wu (2009) present a comparison between a dynamic hazard model and a Probit model as bank failure early warning system, performing both in-sample and out-of-sample estimation using data on U.S. banks from 1980 to 1992. They found that smaller banks with higher levels of nonperforming loans and relying more on large certificates of deposit for their funding are more likely to fail. Larger banks with higher capital adequacy and profitability, and higher liquidity levels, are relatively safer. They also found that, while both models perform well, a hazard model seems to perform better than a Probit model in forecasting banks' failures. A comparison of the performance of models predicting banks' default is also provided by van der Ploeg (2010), which shows that, using data for U.S. banks between 1987 and 2008, all the models considered (Logit, Probit, hazard, and neural networks) provide adequate and nondivergent performance. Cole and While (2010) analyzed the determinants of the banks' failures that occurred in the United States in 2009 and found that traditional proxies for the CAMEL components do a good job in explaining the failures of banks closed in 2009, just as they did in the banking crisis of 1985–1992.

B. Deposits Literature

Deposits play a pivotal role in banks' funding, as a predominant portion of a commercial bank's assets is usually financed through customer deposits. The literature dealing with deposits and their role for banks is therefore also vast and well developed. Among the others, Diamond and Dybvig (1983) argue that deposits are subject to bank runs and for this reason can be costly for banks because of their asset-liability maturity mismatches. Calomiris and Kahn (1991), Flannery (1994), and Diamond and Rajan (2001) argue, however, that demand deposits have positive effects on banks' governance with a disciplining effect on banks' managers.

When assessing the role of deposit insurance, most literature tends to maintain its distortional effect on depositors' incentives to monitor banks.[6] Some studies argue, however, that, even

[5] Pifer (1970); Sinkey (1975); Altman (1977); Martin (1977); and Sinkey and Pettaway (1980).

[6] Bruche and Suarez (2010) argue that deposit insurance might also affect the functionality of interbank money market. According to their analysis, in the presence of deposit insurance a rise in counterparty risk may in fact cause a freeze of interbank money markets.

when insured, depositors may still continue their monitoring of banks as they might not feel completely protected by the insurance scheme (Flannery, 1998, and Cook and Spellman, 1994).

The usefulness of short-term wholesale funding as a way to supplement traditional retail deposits, particularly during the years preceding the global financial crisis, has been supported by most of the existing literature on the topic, pointing to the positive effects of wholesale funding. Calomiris (1999) finds that wholesale funding allows sophisticated investors to effectively monitor banks, provides market discipline, and lets banks exploit investment opportunities without being constrained by the deposit supply. The recent global financial crisis has however highlighted the limits of an excessive reliance on short-term wholesale funding (Acharya et al., 2008, Huang and Ratnovski, 2009, and Goldsmith-Pinkham and Yorulmazer, 2010). Moreover, Huang and Ratnovski (2010) show that in an environment with a costless but noisy public signal on bank project quality, short-term wholesale financiers might have lower incentives to conduct costly monitoring and instead may withdraw their funds based on negative public signals, triggering inefficient liquidations.

The empirical evidence of the monitoring efforts of customer depositors and their disciplining effect on banks' is not unidirectional. A number of works find that depositors have a disciplining effect on banks, particularly in the United States.[7] Among these, Goldberg and Hudgins (1996 and 2002); Park and Peristiani (1998); Billet et al. (1998); and Berger and Turk-Ariss (2011). Opposite findings are, however, reported by Gilbert and Vaughan (2001), Jordan et al. (1999), and Jagtiani and Lemieux (2001). It is interesting to note that most of the existing literature assesses the role of deposits without being able to distinguish between insured and uninsured ones, while the existing economic theory indicates that different behavior by these two categories of deposits should be expected.

III. THE RATIONALE

A fundamental argument for the need to regulate and supervise banks is to preserve financial stability and, maybe most importantly, to protect depositors, the owners of the large part of the banks' debt (Dewatripont and Tirole, 1994). The need to protect depositors stems from the fact that banks, like many other financial and nonfinancial institutions, are subject to adverse selection and moral hazard. This would require investors and creditors, including depositors, to carry out a close monitoring of the banks. However, not all depositors are skilled enough or willing to exercise an adequate level of monitoring on the banks' conditions and riskiness. Smaller depositors in particular have little or no incentive at the individual level to monitor banks' conditions.

[7] Analysis has however also been conducted on a few European (Poland, Russia, and Switzerland) and Latin American countries (Argentina, Chile, Colombia, and Mexico) as well as for India, Japan, and Jordan (see Berger and Turk-Ariss, 2011 for a review).

If the theory of different monitoring levels by different banks' creditors is correct, with depositors being the ones less willing—and with less incentives—to monitor banks, but rather more willing to rely on banking supervision and deposit insurance to look after them, it should be true that depositors are more stable providers of funding to banks than other credits.

Based on this argument, the first hypothesis assessed in this paper is the following:

> *(i) The higher the reliance of nondeposit funding the higher is, ceteris paribus, banks' vulnerability to default.*

The level of awareness of depositors and their stability should, however, vary amongst different kinds of depositors, also given the different levels of protection enjoyed by them, with only some benefiting from an explicit insurance coverage.

Hence, depositors with lower protection can be expected to behave somewhat differently from the more protected ones, particularly when the conditions of a bank start to deteriorate. Under these circumstances, the insured depositors would remain stable, as they perceive no risk associated with maintaining their funds within the bank, while the less-secure ones would run off more easily. If this is true, then the composition of customer deposits would also matter for banks' stability and therefore:

> *(ii) The higher the share of less-stable deposits, the higher is the banks' default probability, all other things being equal.*

More formally, hypotheses *(i)* and *(ii)* can be represented as follows:

$$Pd_{i,t} = f(y_{j,i,t-k}, deposits_{\ i,t-k}) \text{ with } \frac{\delta\, Pd_{\ i,t}}{\delta\,(\ deposits_{i,t-k})} < 0$$

and

$$Pd_{i,t} = g\left(y_{j,i,t-k}, less\ stable\ deposits_{i,t-k}\right) \text{ with } \frac{\delta\, Pd_{\ i,t}}{\delta\,(less\ stable\ deposits_{i,t-k})} > 0$$

where $Pd_{i,t}$ is the probability of default of bank *i* at time *t*, $deposits_{i,t-k}$ is the level of customers deposits of bank *i* at time *t-k*, $less\ stable\ deposits_{i,t-k}$ is the share of less-stable deposits out of the total customer deposits of bank *i* at time *t-k*, and $y_{j,i,t-k}$ is the control variable *j* for bank *i* at time *t-k*.

IV. EMPIRICAL ANALYSIS

A. Scope of the Analysis

The empirical analysis aims at testing the two hypotheses described in the previous section in the context of the U.S. banking system. In particular, with funding fragility having been shown to be one of the most relevant fragility factors in the recent financial crisis (and in several large financial institutions' distress), this work proposes a formal assessment of the role played by funding in the defaults of commercial banks that occurred in the United States between 2007 and 2009.

In assessing the role of funding, a statistical model controlling for variables which, according to the literature, have systematically shown to explain banks' defaults is being used. These variables reflect both bank-specific conditions as well as macroeconomic and structural conditions.

Hypothesis *(i)* in particular is tested by looking at the composition of funding between customer deposits and other sources. If hypothesis *(i)* is correct, then the probability of a bank's default should increase with lower use of customer deposits funding.

Once the role of deposits is assessed vis-à-vis other funding sources, the analysis moves to test hypothesis *(ii)*. It investigates whether any specific form of customer deposits considered ex ante to be potentially more volatile than others has been in fact a significant driver of banks' defaults.

In particular, leveraging on the granularity of the information available for U.S. banks on deposits' composition at bank-by-bank level, the paper tests whether deposits above the level of coverage provided by the deposit insurance scheme are a meaningful indicator of the riskiness of a bank. It tests also for the demand vs. time nature of these deposits.

It then moves to test the role of brokered deposits. Brokered deposits have been a source of significant risk during the Savings and Loan (S&L) crisis in the 1980s, growing in a significant way ahead of the crisis, particularly within those institutions that were then sold or liquidated by the authorities (Barth et al., 1990). High probability of use of brokered deposits in the 1980s has been associated with low capital ratios and risky asset quality (Moore, 1991). As a consequence, U.S. authorities introduced regulations to limit the use of broker deposits.[8] Investigating whether brokered deposits have had a role as a source of risk for banks also in the most recent crisis allows assessing the effectiveness of the policy response put in place at the time by the U.S. authorities.

[8] Limits were introduced by the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA) and the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA). For further details see Davison (2000).

By testing the role of deposits as a driver of banks' failure, and, hence, as an indicator of banks' riskiness, this analysis also allows to draw some observations as to the market discipline and monitoring efforts by different kinds of depositors in the most recent crisis.

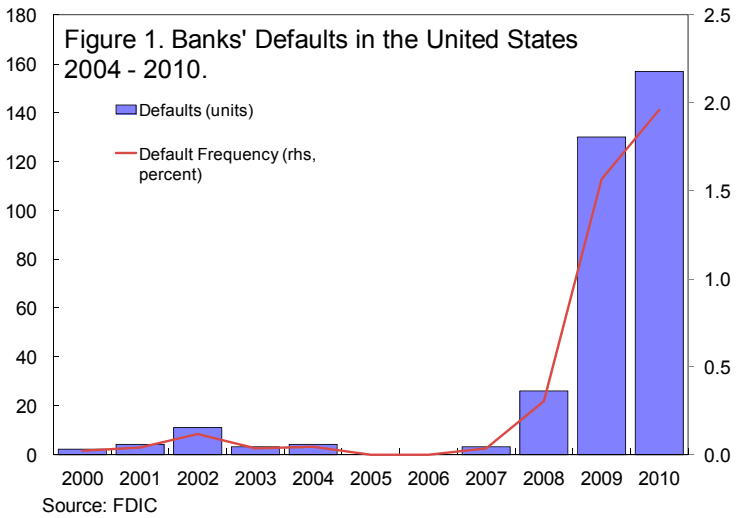
B. Data and Definitions

For the purpose of the analysis, it is necessary to define what a bank is and when a bank's default occurs. In this regard it is here defined that:

- A bank is a regulated depository institution licensed in the United States and subject to the oversight within the country of one or more regulatory authorities and with its customer deposits insured by the Federal Deposit Insurance Corporation (FDIC). Other nondepository financial institutions such as investment banks, insurance companies, and brokers and hedge funds are not therefore included in the analysis.

- A bank is in default when it is considered "failed" by the Federal Deposit Insurance Corporation (FDIC) and listed as such on its website.[9] Under these circumstances, the liquidation of the bank, or its restructuring through purchase and assumption or similar transactions, usually occurs.

On the basis of the above definitions, 168 banks failed in the United States between 2007 and 2009. The number of failures registered dramatically increased in 2008 and then 2009, with defaults occurring well beyond the peak of the global financial crisis in 2007/2008, and continuing in significant number also in 2010 and 2011. Before 2007 very few or no defaults occurred for a number of years.



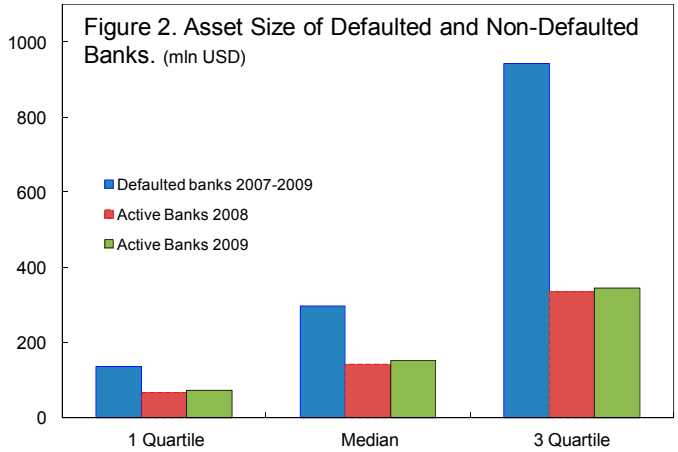
[9] Failed banks are listed by the FDIC on its website at http://www.fdic.gov/bank/individual/failed/banklist.html.

The 168 banks' failures between 2007 and 2009 are distributed on relatively larger banks when compared with the universe of active banks in 2008 and 2009. All quartiles of the distribution of the defaulted banks are higher than those of the entire population of active banks. The statistics for the defaulted banks, referred to the year before default, are reported in Table 1 and Figure 2.

Table 1. U.S. Banks Failures 2007-2009: Descriptive Statistics (USD mn)

	Assets	*Deposits*
Mean	4,008	2,538
Median	297	254
Max	325,809	186,655
Min	14	14
Skewness	11	11
Kurtosis	138	133

Source: FDIC, SNL and Author's calculations.



Source: FDIC and Author's Calculations.

For the purpose of the statistical analysis, a bank is considered defaulted in a given year *t* based on the information released by the FDIC, provided that a balance sheet referred to the previous year *t-1* is available. On a few occasions, when defaults occurred at the beginning of the calendar year *t* and the defaulting banks had not yet released their balance sheet information for the period *t-1*, defaults have been conventionally assigned to the previous calendar year *t-1* so that a balance sheet existed one year before the default (i.e., at *t-2*).[10]

A paired sample of defaults and nondefaults has then been selected for each given year from 2007 to 2009. Nondefaulted banks have been selected from the entire universe of active banks in order to match the asset size of the nondefaulted banks with that of the defaulted banks. After this procedure, the average asset size of the two paired subsamples should not be, by construction, significantly different from each other. This null hypothesis is tested and accepted, with a t-test for paired samples (Table 2).

[10] Data on banks' balance sheets, both for failed and active banks, has been provided by SNL Financial.

Table 2. Paired Samples T-Test: Defaults and Non-defaults 1/

Sample	Average Asset Size at t-1 (USD mn)
Defaults	4,008
Non-defaults	4,847
One-tail t-test probability	16.15
Two-tails t-test probability	32.29

Source: Author's Estimates.

1/ Non-sgnificance of the test statistic means that the null hypotesis of the two samples having the average is accepted.

The estimation sample includes therefore 336 banks, of which 168 failed over the period 2007–2009 and 168 were still in a going-concern situation at the end of the observation period (end-2009).

Using a matched sample is intuitively attractive compared to the use of the entire population, for which the estimates are affected by changes in the population characteristics and composition from one period to the next. By using a paired sample, the impact of these changes is avoided, reducing the volatility of the estimates. A low-default frequency potential problem is also addressed. However, the common sample has a reduced sample size and the sampling error can be partially offset by the reduced volatility on the matched sample estimates. More importantly, the sampling procedure does not ensure the sample to be representative of the population. This limitation can however be overcome by recalibrating the estimated model to the actual population, if need be, for it to be used for forecasting purposes. Anyhow, this is not the immediate scope of this work, for which the use of a paired sample appears desirable.

C. The Model

To analyze the role of funding in explaining banks' defaults, a Logit model is used. Logit regression models are very frequently applied in the field of credit risk to estimate probabilities of default for their attractive feature of being able to deal with dichotomous response variables, taking 0–1 values.[11]

In this work, as in large part of the literature of credit and default risk, the binary dependent variable $S_{i,t}$ is a variable representing the status of bank i at time t. When $S_{i,t}$=1 a bank is in default and when $S_{i,t}$=0 a bank is in a going concern situation.

As a first step in the model identification process, a base model of the likelihood of banks' default is estimated. The model is based on a set of explanatory variables, which are

[11] See Gujarati (1995) and Greene (2011) for a detailed description of the properties of Logit models.

intuitively related to the solvency conditions of a bank and which have consistently been shown to be significant predictors of banks' default likelihood in the existing literature.

A combination of bank-specific balance sheets and profit-and-loss variables as well as macro-economic variables has been selected, so that a satisfactory explanatory power is achieved while keeping the model efficient and limiting the number variables used. The selection of the set of explanatory variables is based on both a statistical and a graphical analysis, always verifying the economic meaningfulness of each variable in order to include only those variables that would be acceptable not just from a statistical but also from an economic standpoint ex ante, and would show the expected sign ex post.[12]

Hence, only variables statistically significant and with the correct signs have been selected in an iterative approach aimed at maximizing the log likelihood function of the model. The final specification has been identified through a two-step procedure: first the univariate predictive power of each variable has been assessed, and then the optimal multivariate specification has been identified. The variables chosen represent banks' profitability, asset quality, capital adequacy, and the interest rates prevailing in the market.

To address the nonexistence of the explanatory variables for defaulted banks at time *t*, only lagged variables (with 1 to 4 lags) have been used in the process of model selection. The choice of using only lagged explanatory variables limits also the extent of any endogeneity issue in the model.

As a result, the following multivariate Logit model has been identified and estimated:

$$S_{i,t} = \beta_1 + \beta_2 NPL_{i,t-1} + \beta_3 RBC_{i,t-1} + \beta_4 ROAE_{i,t-1} + \beta_5 PLR_{t-2} + \mu_i \qquad (1)$$

with $S_{i,t}$ being the status of each bank *i* at time *t*, $NPL_{i,t-1}$, $RBC_{i,t-1}$, $ROAE_{i,t-1}$ being respectively the nonperforming loans ratio, the risk-based capital ratio, and the return on equity for bank *i* at time *t-1* and PLR_{t-2} being the level of the prime rate on short-term loans at time *t-2* (Table 3).

The specification of the model described in equation (1) has been then amended to test for the hypothesis *(i)* and *(ii)* previously mentioned and, hence, assess whether funding can be considered a meaningful indicator of banks' risk conditions. In particular, variables representing the banks funding conditions have been introduced.

The first augmented model aims in particular at testing hypothesis *(i)* by using the loan-to-deposit ratio, $LTD_{i,t}$, as explanatory variable, as specified by equation (2). This ratio provides

[12] The graphical analysis consists of representing each variable on a scatter plot to see if there is an apparent separation of the values between the different statuses of default and nondefault. This is, however, not reported for parsimony.

a measure of the funding mix chosen by a bank to finance its loan portfolio. The higher the LTD ratio the less the bank is using customer deposits to finance its loan portfolio.

$$S_{i,t} = \beta_1 + \beta_2 NPL_{i.t-1} + \beta_3 RBC_{i,t-1} + \beta_4 ROAE_{i,t-1} + \beta_5 PLR_{i,t-2} + \beta_6 LTD_{i,t-3} + \mu_i \quad (2)$$

If hypothesis *(i)* is correct, then a higher loan-to-deposit ratio should be positively related to banks' riskiness and probability of default. It implies in fact that a larger share of banks' assets is financed with forms of funding intrinsically more volatile than deposits.

Once the role of the composition of funding between deposits and nondeposits has been considered, an investigation of the role of different forms of deposits $D_{i,k,t}$ (with k being the different subset of deposits) is carried out to test hypothesis *(ii)*. The alternative model specifications look at those deposits which, ex ante, can be considered to be potentially more volatile.

In particular, deposits that can be considered ex ante potentially less stable are those exceeding the level of coverage provided by the FDIC.[13] Brokered deposits are also assessed for the role they played in the S&L crisis. The time and nontime nature of deposits has been analyzed as well. The variables used in the model are therefore the following:

- Brokered Deposits to Total Deposits
- Deposits Larger than $100,000 (or $250,000) to Total Deposits
- Time Deposits Larger than $100,000 to Total Deposits
- Nontime Deposits Larger than $100,000 to Total Deposits
- Nontime Deposits to Total Deposits

The equation including the deposits variables listed above is hence the following.

$$S_{i,t} = \beta_1 + \beta_2 NPL_{i,t-1} + \beta_3 RBC_{i,t-1} + \beta_4 ROAE_{i,t-1} + \beta_5 PLR_{i,t-2} + \beta_6 LTD_{i,t-3} + D_{i,k,t-j} + \mu_i \quad (3)$$

D. Results

The basic results confirm the findings of the literature on banks' defaults, which show a clear evidence of the relationship between probability of default and capital adequacy, profitability, and asset quality. These variables are all very significant in explaining banks' defaults in the United States between 2007 and 2009 (Table 4).

[13] The threshold used is $100,000 in line with the maximum coverage provided by the FDIC before the crisis. The limit has been, however, temporarily increased to $250,000 as of October 3, 2008. On May 20, 2009, the temporary measure was extended to the end of 2013. On July 21, 2010, the approval of the Dodd-Frank Wall Street Reform and Consumer Protection Act permanently raised the maximum coverage to $250,000 (FDIC, 2010a). On November 9, 2010, the FDIC issued a Final Rule implementing section 343 of the Dodd-Frank Wall Street Reform and Consumer Protection Act that provides for unlimited insurance coverage of noninterest-bearing transaction accounts (FDIC 2010b).

Looking at the role of funding, the results also clearly indicate that funding played a key role in determining banks' default risk. A weaker deposit base negatively affects the likelihood of bank's failure. In particular, both level and composition of the deposit funding appear to matter.

It is found that both the extent to which a bank is funding its asset through deposits (rather than other forms of funding) and the intrinsic stability of such deposit base play a key role in explaining banks' default. Both these dimensions are relevant for the sample analyzed, after controlling for bank-specific variables (profitability, capitalization, asset quality, and size) and macro-economic variables.

In particular, a higher level of loan-to-deposit ratio or, in other words, a heavier reliance of banks on forms of funding alternatives to deposits, significantly increases banks' default probability.[14] Defaults are more likely not only immediately after a higher level of the loan-to-deposit ratio is observed but also two to three years after such an increase. This implies therefore the need for banks to achieve a balanced funding position in a structural and stable manner, since temporary improvements of the funding profile (as temporary weakening) are not likely to affect banks' stability in a significant way (Table 5).

Not all deposits are, however, the same in contributing to banks' funding stability. Although results are subject to some uncertainties, they seem to clearly suggest that different types of deposits have different effects on banks' default likelihood, with the reliance on more volatile sources of deposits appearing to be a significant risk factor.

Deposits above the level of coverage provided by the deposits insurance scheme contribute, however, to explain banks' defaults in a peculiar way. While there is no apparent effect of the stock of deposits above the level of deposit insurance, there is still some indication that higher reliance on deposits above the level of coverage might imply a higher default probability. In particular, those deposits above the level of coverage and with time-nature appear to be correlated to the default risk (Table 6). This finding might indicate that when a bank's conditions tend to deteriorate, the bank's managers increase their preference for large time-deposits; possibly knowing that these, because of their time feature, would inherently be more stable than large demand deposits if the conditions of the bank worsen.

Hardly anything can be said, however, for the entire stock of deposits above the level of coverage which, in this analysis, is nonsignificant in explaining banks' default. There is in fact no clear evidence of the more stringent banks' monitoring by uninsured depositors that one would expect ex ante. However, the variable representing the large demand deposits, although nonsignificant, shows a negative sign, suggesting some consistency with the hypothesis of more active monitoring by large demand depositors.

[14] Merrouche and Nier (2010) provide empirical evidence of the possible reasons behind the build-up of financial imbalances (as measured by the loan-to-deposit ratio) in OECD countries ahead of the global financial crisis.

Brokered deposits, despite the regulatory limitations introduced after the S&L crisis, are still a significant variable in explaining banks' defaults**.** Higher levels of brokered deposits are in fact significantly associated with higher default probabilities. Such a relation appears to be stable and persistent, provided that the significance of this variable is observed from one to three periods before default. Hence, it can be argued that the more persistently problematic institutions tend to rely more than sound institutions on such a form of funding without being able to achieve any improvement of their funding conditions, but rather further increase their default risk. The effectiveness of the regulations introduced after the S&L crisis appears questionable.

Overall, banks' management actions seem to signal banks' weak conditions better than depositors' monitoring efforts. With the variables approximating the latter not being significant, the variables more likely to reflect banks' managerial actions, such as time-deposits and brokered deposits, show a much clearer relationship with the banks' probability of default.

In either case it is however evident that the banks' funding choices do affect banks' probability of default and clearly indicate banks' deteriorating conditions well ahead of the actual failure.

Table 3. Definition of Variables Used in the Main Model

Variable Name	Definition
Bank Status	Default/Non-Default 1/
Non Performing Loans	Non Performing Loans to Total Gross Loans
Capital Adequacy	Risk-based Captial Ratio
Profitability	Return on Average Equity
PL rate	Average Prime Rate on Short-Term Loans to Business
LTD	Loans-to-Deposits Ratio
Brokered Deposits	Brokered Deposits to Total Deposits
Large Time Deposits	Time Deposits above $ 100.000 to Total Deposits
Large Non-Time Deposits	Non time-Deposits above $ 100.000 to Total Deposits
All Large Deposits	Deposits above $ 100.000 to Total Deposits
All Non-Time Deposits	Non-Time Deposits to Total Deposits

1/ A bank si considered to be in default when formally intervened by the US authorities and included in the list of failed banks by the FDIC.

Table 4. Basic Determinants of Banks' Defaults 1/

Constant	194.433 (48.433)
Non Performing Loans $_{t-1}$	35.731 (7.362)***
Capital Adequacy $_{t-1}$	-45.519 (9.757)***
Profitability $_{t-1}$	-4.080 (1.037)***
Lending Rate $_{t-2}$	-2366.439 (595.871)***
Size $_{t-1}$	-0.088 (0.116)
McFadden R-squared	0.664
Log likelihood	-78.16

Source: Author's Estimates.

1/ Dependent variable is banks' status (default/non-default).

*** Shows significance at 1 percent.

Table 5. Introducing Funding. The Impact of the Loan-to-Deposit Ratio on Banks' Defaults 1/

	I	II	III
Constant	189.310 (49.213)	178.794 (51.950)	168.167 (52.834)
Non Performing Loans $_{t-1}$	37.579 (7.642)***	40.007 (8.234)***	36.761 (7.791)***
Capital Adequacy $_{t-1}$	-43.598 (9.700)***	-53.629 (10.358)***	-59.143 (11.627)***
Profitability $_{t-1}$	-4.146 (1.040)***	-4.618 (1.078)***	-4.390 (1.070)***
Lending Rate $_{t-2}$	-2320.588 (605.533)***	-2204.617 (639.710)***	-2052.078 (649.757)***
Size $_{t-1}$	-0.141 (0.126)	-0.177 (0.129)	-0.168 (0.128)
LTD $_{t-1}$	1.944 (1.307)		
LTD $_{t-2}$		4.701 (1.103)***	
LTD $_{t-3}$			3.696 (0.956)***
McFadden R-squared	0.669	0.709	0.709
Log likelihood	-77.00	-67.69	-67.17

Source: Author's Estimates.

1/ Dependent variable is banks' status (default/non-default).

*** Shows significance at 1 percent.

Table 6. Banks' Defaults. Does Deposit Composition Matter? Looking at Size, Contractual Maturity (Demand vs Time), and Brokered 1/

	I	II	III	IV	V	VI	VII	VIII	IX
Constant	195.427 (50.358)	182.051 (49.817)	185.400 (50.159)	167.756 (50.325)	149.028 (53.645)	148.922 (52.834)	193.524 (48.326)	187.291 (49.197)	194.068 (48.460)
Non Performing Loans $_{t-1}$	35.563 (7.630)***	34.476 (7.567)***	35.202 (7.484)***	37.464 (7.813)***	33.301 (7.792)***	29.03 (7.702)***	36.426 (7.519)***	35.086 (7.396)***	35.726 (7.357)***
Capital Adequacy $_{t-1}$	-39.705 (9.673)***	-40.574 (9.595)***	-39.984 (9.686)***	-43.678 (9.843)***	-45.257 (10.805)***	-43.704 (12.141)***	-45.835 (9.837)***	-44.477 (9.699)***	-45.717 (9.912)***
Profitability $_{t-1}$	-4.122 (1.040)***	-4.209 (1.053)***	-4.085 (1.051)***	-4.044 (1.034)***	-4.054 (1.031)***	-3.579 (1.201)***	-4.081 (1.045)***	-4.071 (1.023)***	-4.086 (1.038)***
Lending Rate $_{t-2}$	-2394.988 (620.412)***	-2222.935 (613.178)***	-2263.046 (617.108)***	-2059.617 (619.162)***	-1803.660 (660.756)***	-1797.489 (652.023)***	-2357.988 (594.765)***	-2280.533 (605.0989)***	-2362.963 (595.816)***
Size $_{t-1}$	-0.084 (0.120)	-0.100 (0.119)	-0.103 (0.118)	-0.036 (0.123)	-0.142 (0.136)	-0.187 (0.146)	-0.099 (0.117)	-0.050 (0.122)	-0.083 (0.123)
Brokered Deposits $_{t-1}$	4.335 (1.527)***								
Brokered Deposits $_{t-2}$		5.413 (2.084)***							
Brokered Deposits $_{t-3}$			3.644 (2.032)*						
Large Time-Deposits $_{t-1}$				5.099 (2.088)**					
Large Time-Deposits $_{t-2}$					4.415 (2.127)**				
Large Time-Deposits $_{t-3}$						4.705 (1.927)**			
All Large Deposits $_{t-1}$							0.876 (1.304)		
Large Non-Time Deposits $_{t-1}$								-1.640 (1.388)	
All Non-Time Deposits $_{t-1}$									0.457 (3.556)
McFadden R-squared	0.684	0.682	0.672	0.678	0.676	0.663	0.665	0.668	0.664
Log likelihood	-73.61	-74.03	-75.63	-74.71	-73.47	-66.59	-77.93	-77.43	-78.15

Source: Author's estimates.

1/ Dependent variable is banks' status (default/non-default).

*, **, *** Show significance at 10, 5 and 1 percent respectively.

E. Robustness

The Logit model presented above has been tested for robustness to the use of an alternative set of explanatory variables. First, a number of macroeconomic variables have been tested in alternative specifications of the model by replacing the lending rate previously used (the average prime rate on short-term loans to business) with the GDP growth rate, the unemployment rate, the consumer price index, and an alternative measure of lending rate (the conventional mortgage rate) (Table 7).

Unemployment rate and the alternative lending rate show to be significant and their introduction confirms the general findings of the main model specification already presented. GDP growth rate and CPI are also significant, but the former variable presents a sign that is not consistent with the economic rationale, while the interpretation of the latter is not immediate due to the unclear ex ante relationship between CPI and banks' default probability. Even in these cases, however, the funding variables remain highly significant, confirming the robustness of the estimates (Table 8).

Robustness of the results concerning the sensitivity of the banks' default probability to their funding conditions is confirmed also when using a different set of bank-specific variables to represent capital adequacy, profitability, and asset quality. In practice, the tangible common equity ratio, net income before taxes to total asset, and loss reserves to total asset are now used instead of the risk-based capital ratio, the return on average equity, and the nonperforming loans ratio (Table 7). The results show that in all cases there is no loss of significance of the funding variables (Table 9).

This is confirmed also when jointly substituting the banks' specific variables and the macroeconomic variable by replacing the lending rate with the rate of unemployment. In this last specification of the alternative model, all but one (asset size) control variables have been replaced from the original model and still all three significant funding variables confirm, if not improve, their level of significance (Table 9). The difference here is that with this alternatively specified set of banks' specific variables the bank's asset size, previously never significant, becomes now a somewhat significant variable in explaining banks default probability.

Results are also robust to the use of alternative specifications of the banks' funding mix. While in the main model the LTD ratio has been used as the best performing proxy for funding composition, alternative variables could have also been used to measure bank funding mix. To the robustness of results to this choice, the asset-to-deposits ratio, a commonly used alternative to the LTD ratio, has also been tested. Results show that it is as significant as the LTD ratio in explaining banking crisis (Table 10).

Table 7. Definition of Bank-Specific and Macroeconomic Variables Used in the Alternative Modes

Variable Name	Definition
Asset Quality	Reserves to Total Assets Ratio
Capital Adequacy	Tangible Common Equity Ratio
Profitability	Net Income Before Tax to Total Asset Ratio
Lending Rate	Contract Rate on 30Y fixed Rate Conventional Home Mortgage Commitments
GDP	GDP Growth Rate, Real Percentage Change
Inflation Rate	CPI-U Non Seasonally Adjusted
Unemplyment Rate	Unemployment Rate Seasonally Adjusted

Source: SNL Financials, BLS, BEA, Federal Reserve.

Table 8. Banks' Defaults and Funding Relevance. Testing for Robustness to Alternative Macroeconomic Variables 1/

	I a	II a	III a	I b	II b	III b	I c	II c	III c	I d	II d	III d
Constant	25.803	28.927	25.305	-13.904	-14.720	-13.342	0.677	1.650	1.122	0.773	1.803	1.220
	(7.259)	(6.964)	(7.009)	(4.122)	(3.956)	(3.929)	(1.951)	(1.885)	(1.991)	(1.949)	(1.897)	(1.999)
Non Performing Loans $_{t-1}$	39.770	35.580	37.683	39.996	36.090	38.081	39.972	35.964	38.011	39.221	34.775	36.920
	(8.104)***	(7.512)***	(7.760)***	(8.056)***	(7.554)***	(7.742)***	(8.117)***	(7.570)***	(7.800)***	(8.027)***	(7.376)***	(7.634)***
Capital Adequacy $_{t-1}$	-50.537	-36.519	-39.978	-49.939	-36.068	-39.936	-50.480	-36.598	-40.135	-50.319	-36.031	-39.459
	(9.915)***	(9.078)***	(9.199)***	(9.825)***	(9.204)***	(9.288)***	(9.906)***	(9.143)***	(9.261)***	(9.878)***	(8.956)***	(9.069)***
Profitability $_{t-1}$	-4.284	-3.812	-3.701	-4.261	-3.854	-3.745	-4.309	-3.869	-3.746	-4.192	-3.682	-3.595
	(1.037)***	(0.997)***	(0.990)***	(1.032)***	(1.005)***	(0.996)***	(1.040)***	(1.005)***	(0.996)***	(1.027)***	(0.979)***	(0.979)***
Size $_{t-1}$	-0.177	-0.067	-0.026	-0.185	-0.089	-0.045		-0.079	-0.037	-0.159	-0.044	-0.006
	(0.124)	(0.114)	(0.115)	(0.123)	(0.114)	(0.116)		(0.114)	(0.115)	(0.123)	(0.114)	(0.115)
Alternative lending rate $_{t-3}$	-385.297	-418.459	-371.129									
	(102.646)***	(99.060)***	(98.573)***									
Unemployment Rate $_{t-3}$				343.454	387.485	342.466						
				(92.324)***	(88.420)***	(87.927)***						
GDP Growth Rate $_{t-1}$							120.945^	133.871 ^	118.285 ^			
							(31.917)***	(30.963)***	(30.643)***			
CPI $_{t-1}$										52.035 ^	54.823 ^	48.758 ^
										(14.332)***	(13.639)***	(13.719)***
LTD $_{t-2}$	4.618			4.580			4.585			4.696		
	(1.061)***			(1.049)***			(1.057)***			(1.066)***		
Brokered Deposits $_{t-1}$		4.275			4.483			4.352			4.171	
		(1.496)***			(1.510)***			(1.505)***			(1.481)***	
Large Time-Deposits $_{t-1}$			4.767			4.957			4.782			4.815
			(2.006)**			(1.975)**			(1.998)**			(2.010)**
McFadden R-squared	0.694	0.665	0.658	0.692	0.659	0.659	0.695	0.667	0.660	0.692	0.660	0.654
Log likelihood	-71.21	-78.01	-79.38	-71.64	-79.15	-79.16	-71.11	-77.59	-79.05	-71.81	-79.15	-80.31

Source: Author's estimates.

1/ Dependent variable is banks' status (default/non-default).

*, **, *** Show significance at 10, 5 and 1 percent respectively.

^ Indicates that the sign is either not the expected one or its interpretation is not univocal.

Table 9. Banks' Defaults and Funding Relevance. Testing for Robustness to Alternative Bank Specific Variables 1/

	I a	II a	III a	I b	II b	III b
Constant	240.970	260.263	234.210	-12.487	-13.227	-12.656
	(55.013)	(57.914)	(55.357)	(4.276)	(4.325)	(4.161)
Alternative Asset Quality Ratio $_{t-1}$	-1.147	-1.038	-1.201	-1.233	-1.183	-1.339
	(0.376)***	(0.385)***	(0.383)***	(0.370)***	(0.399)***	(0.391)***
Alternative Capital Adequacy Ratio $_{t-1}$	-72.493	-63.215	-66.283	-70.635	-60.386	-64.505
	(12.116)***	(11.287)***	(11.415)***	(11.944)***	(11.032)***	(11.203)***
Alternative Profitability $_{t-1}$	-44.558	-43.112	-40.968	-43.451	-41.482	-39.801
	(8.752)***	(8.457)***	(8.301)***	(8.617)***	(8.311)***	(8.197)***
Size $_{t-1}$	-0.386	-0.299	-0.228	-0.382	-0.295	-0.223
	(0.134)***	(0.127)**	(0.125)*	(0.131)***	(0.125)**	(0.122)*
Lending rate $_{t-3}$	-2913.715	-3136.585	-2827.246			
	(674.711)***	(710.410)***	(678.386)***			
Unemployment Rate $_{t-3}$				427.962	474.537	435.971
				(101.286)***	(103.617)***	(99.986)***
LTD $_{t-2}$	4.092			4.580		
	(1.103)***			(1.049)***		
Brokered Deposits $_{t-1}$		5.385			5.322	
		(1.566)***			(1.543)***	
Large Time-Deposits $_{t-1}$			6.155			6.243
			(2.006)***			(2.223)***
McFadden R-squared	0.633	0.623	0.608	0.623	0.613	0.600
Log likelihood	-82.35	-84.57	-87.66	-84.49	-86.84	-89.53

Source: Author's estimates.

1/ Dependent variable is banks' status (default/non-default).

*, **, *** Show significance at 10, 5 and 1 percent respectively.

Table 10. Testing for Robustness of Results to an Alternative Measure of Funding Mix 1/

Constant	192.690 (50.625)
Non Performing Loans $_{t-1}$	39.776 (7.938)***
Capital Adequacy $_{t-1}$	-51.334 (9.978)***
Profitability $_{t-1}$	-3.979 (1.073)***
Lending Rate $_{t-2}$	-2384.009 (623.345)***
Size $_{t-1}$	-0.211 (0.128)
Alternative Measure of Funding Mix $_{t-2}$	4.089 (1.227)***
McFadden R-squared	0.690
Log likelihood	-72.31

Source: Author's Estimates.

1/ Dependent variable is banks' status (default/non-default).

*** Shows significance at 1 percent.

V. CONCLUSIONS

The experience of the latest financial crisis has shown how critical liquidity conditions can be in affecting banks' operations under stress and its likelihood of survival. Particularly, for medium and large banks, critical liquidity conditions can spill over to other parts of the financial system, with negative consequences on its stability. The evidence of this paper confirms that funding liquidity conditions significantly affect banks' risk profile and, ultimately, their default likelihood.

The empirical evidence for the U.S. banks provides therefore a clear support for more careful regulation and supervision of banks' liquidity conditions by the supervisory and regulatory authorities. While this paper focuses on U.S. banks only, the policy recommendation of tighter regulation and supervision of banks' liquidity conditions can arguably be extended to a large number of countries.

The evidence of the relationship between banks' funding profiles and their risk of default can be related to the new regulatory framework for liquidity risk adopted by the Basel Committee on Banking Supervision (2010). While the main purpose of the paper is neither to assess the new framework nor to discuss the optimal design of liquidity regulation, it is however possible to note that the new rules appear to have the potential and the features to help reduce the likelihood of banks' liquidity weaknesses.[15] In particular, by differentiating the treatment for the more stable and the less-stable deposits in the context of both the Liquidity Coverage Ratio and the Net Stable Funding Ratio, the regulatory framework correctly recognizes the different impacts that different deposits can have on banks' stability. It will nonetheless be of great importance the implementation of the new measures, where supervisory authorities will be called upon to identify those deposits that are more likely to have a destabilizing effect on banks.

It will be also important that the new regulation be applied extensively within and across banking systems. The findings of this analysis suggest in fact that it is advisable not to limit the application of the new liquidity regulations to internationally active banks only, but rather to extend their application also to medium- and small-sized institutions, whose survival can be as well critically affected by a weak liquidity and funding profile.

The U.S. authorities might wish also to reconsider the existing regulation on the use of brokered deposits, which does not appear to have been effective enough in reducing the abuse of brokered deposits, given that their use remains a critical factor in explaining defaults of U.S. banks.

Finally, while introducing prudential regulation on liquidity appears important, it is also essential that this comes together with reinforced supervisory focus on this specific risk area, which was almost completely neglected by supervisory authorities worldwide ahead of the crisis.

[15] Perotti and Suarez (2011) analyze the design of liquidity regulation and suggest that an optimal policy should involve both price and quantity rules.

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