Liquidity risk in banking: is there herding? *

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June 2013

Abstract

Banks individually optimize their liquidity risk management, often neglecting the externalities generated by their choices on the overall risk of the financial system. This is the main argument to support the regulation of liquidity risk. However, there may be incentives, related for instance to the role of the lender of last resort, for banks to optimize their choices not strictly at the individual level, but engaging instead in collective risk taking strategies, which may intensify systemic risk. In this paper we look for evidence of such herding behaviors, with an emphasis on the period preceding the global financial crisis. We find strong and robust evidence of peer effects in banks' liquidity risk management, even after adequately controlling for relevant endogeneity problems associated with the estimation of peer effects. This result suggests that incentives for collective risk taking behaviors may play a role in banks' choices, thus calling for a macroprudential approach to liquidity risk regulation.

JEL Codes: G21, G28.

Keywords: banks, liquidity risk, regulation, herding, peer effects, Basel III, macroprudential policy, systemic risk.

*We thank Paolo Angelini, António Antunes, Sigbjorn Berg, Arnoud Boot, Rosa Borges, Martin Brown, Max Bruche, Jin Cao, Ilan Cooper, Hans Degryse, Falko Fecht, Florian Heider, Thea Kloster, Ana Cristina Leal, Iman van Lelyveld, Antoine Martin, Alberto Pozzolo, Isabel Proença, Lev Ratnovski, Hugo Reis, Nuno Ribeiro, Kasper Roszbach, Martín Saldías, Wolf Wagner, and participants in a seminar in the University of Groningen, in the 2nd MoFiR Workshop on Banking, 6th CEPR Winter Conference on Financial Intermediation, 4th Financial Stability Conference in Tilburg, EBA Research Workshop on Banks' business models after the crisis: incentives, strategies, de-risking, PFN2012, and CREDIT 2011 for insightful comments and suggestions. The analyses, opinions and findings of this paper represent the views of the authors, which are not necessarily those of Banco de Portugal or the Eurosystem.

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1 Introduction

Banks transform liquid liabilities (deposits) into illiquid claims (loans). This basic intermediation role of banks relies on a maturity mismatch between assets and liabilities, making them exposed to bank runs or, more generally, to funding liquidity risk. There is a vast and prominent theoretical literature on this problem. Diamond and Dybvig (1983) provided the pillars for the analysis of banks' liquidity risk and bank runs, while other very relevant contributions include Klein (1971), Calomiris and Kahn (1991), Diamond and Rajan (2000, 2001a and 2001b), Allen and Gale (2004a, 2004b), and, more recently, Wagner (2007a) or Ratnovski (2009). However, there is surprisingly scarce empirical evidence on banks' maturity mismatches and funding liquidity risk.

In this paper, we contribute to fill in this gap by empirically analyzing the way banks manage their liquidity risk. More specifically, we analyze the determinants of banks' liquidity risk management choices, explicitly considering potential strategic interactions among banks. This issue has relevant policy implications, as banks may have incentives to engage in collective risk-taking strategies when there is a strong belief that a (collective) bailout is possible (Farhi and Tirole, 2012). When other banks are taking more risk, a given bank may be encouraged to pursue similar strategies if its managers believe they are likely to be rescued in case of distress. These collective risk-taking strategies may be optimal from an individual perspective, as they should allow banks to increase profitability without increasing the likelihood of bankruptcy, due to the explicit or implicit commitment of the lender of last resort. Hence, these risk-taking strategies may be mutually reinforcing in some circumstances. This collective behavior transforms a traditionally microprudential dimension of banking risk into a macroprudential risk, which may ultimately generate much larger costs to the economy.

The first step in our analysis is to provide detailed empirical evidence on banks' liquidity risk management. We begin by discussing how to measure banks' liquidity risk, as several indicators may be relevant to quantify how exposed to this risk is an institution (Tirole, 2011). Subsequently, using a panel dataset of European and North-American banks for the period 2002-2009, we analyze which factors may be relevant in explaining why some banks adopt a globally prudent behavior in managing the liquidity risk underlying their financial intermediation functions, whereas others engage in more aggressive risk-taking strategies. We find that larger and more profitable banks tend to adopt riskier liquidity strategies, most notably if they have a more traditional intermediation profile. In turn, banks with larger net interest margins and with better cost-efficiency ratios are generally less risky in

their liquidity management. We cannot find empirical evidence of any relationship between capital and liquidity ratios.

Next, in order to search for evidence on collective risk taking behaviors in liquidity risk management, we begin by analyzing the statistical dispersion of several liquidity indicators, as well as of the residuals of the equations used to study the determinants of banks' liquidity choices. Furthermore, we compute a measure of herd behavior, based on Lakonishok et al (1992). Our results suggest that there was some herding in the pre-crisis period, reflected in a global deterioration of liquidity indicators.

Nevertheless, these measures are clearly insufficient to fully identify herding behavior, as many factors may be driving the results. A multivariate setting allows to consider this issue in a more integrated way, through the estimation of the impact of peer effects (other banks' liquidity choices) on the liquidity indicators of each bank, while controlling for other potentially relevant explanatory variables. However, it is important to note that the empirical estimation of these peer effects amongst banks raises some econometric challenges. As discussed by Manski (1993), the identification of endogenous and exogenous effects is undermined by the reflection problem associated with the reverse causality of peer effects. In other words, if we argue that peers' choices may affect the decisions of a specific bank, we cannot rule out that the decisions of that bank will not, in turn, affect the choices made by peers. Our solution to this critical identification problem relies on the use of an instrument, which has to be orthogonal to systematic or herding effects. Specifically, the instrument used for the peer effects is the predicted values of liquidity indicators of peer banks used in the regressions of the determinants of liquidity indicators. Thus, the predicted values depend on the characteristics of the banks in the peer group. These predicted values depend only on observable bank characteristics and should therefore be orthogonal to herding effects. In other words, the predicted value of the liquidity indicators of peer banks should not directly affect the liquidity indicators of bank i at time t, as these predicted values are based solely on observable bank characteristics. By controlling also for time fixed-effects, we are able to orthogonalize all systematic and common shocks to banks. Furthermore, we control for country-year fixed effects. The benchmark peer group is the banks operating in the same country in each year.

After adequately dealing with the peer effect estimation, we obtain strong and consistent evidence of collective risk-taking behaviors in liquidity risk management, under a wide set of specifications. These results have relevant policy implications: liquidity risk is usually regulated from a microprudential perspective, but our results show that a macroprudential approach to the regulation of systemic liquidity risk should be disregarded. Given this, even though the new Basel III package on liquidity risk is a huge step forward in the regulation of

liquidity risk, additional macroprudential policy tools may need to be considered, as the new regulation is still dominantly microprudential. For instance, macroprudential authorities may consider imposing tighter liquidity regulation or limits to certain types of exposures, in order to mitigate contagion and systemic risks, thereby providing the correct incentives to minimize negative externalities.

The contribution of our paper is manyfold. Even though the theoretical literature provides many relevant insights regarding banks' liquidity risk, there is scarce empirical evidence on banks' liquidity risk management. Furthermore, we focus on a period of particular relevance, as there is an extensive discussion regarding excessive risk-taking in the years preceding the global financial crisis. We provide detailed empirical evidence on the determinants of liquidity risk, and, more importantly, we extend the analysis by focusing on strategic interactions and herding behavior. In this respect, we consider not only traditional herding measures, but we also make an effort to provide a correct and rigorous econometric treatment for the endogeneity of peer effects in a multivariate setting. Finally, our results provide important insights for policy makers, most notably in what concerns the macroprudential regulation of systemic liquidity risk.

This paper is organized as follows. We begin by reviewing the expanding literature on bank's funding liquidity risk and its regulation, in Section 2. In Section 3 we discuss several indicators of banks' liquidity risk and characterize the dataset used for the empirical analysis, including an overview of banks' liquidity and funding choices in the run up to the recent global financial crisis. In Section 4 we analyze how banks manage their liquidity risk and in Section 5 we address the most relevant question in our paper: do banks take into account peers' liquidity strategies when making their own choices on liquidity risk management? More importantly, was this relevant to the build-up of global risks in the financial system that eventually led to the Great Recession? In Section 6 we summarize our main findings and discuss their policy implications.

2 Related literature and regulation

Over recent years, banks became increasingly complex institutions, being exposed to an intertwined set of risks. The 2008 financial crisis provided a painful illustration of how severe these risks can be and how they can seriously affect the real economy. However, regardless of how complex banks have become, there is an intrinsic risk that lies deep in their core function: banks are special due to their unique intermediation role. They grant loans to entrepreneurs and consumers, providing them with the necessary liquidity to finance their investment and consumption needs. However, banks use only a limited amount

of their own resources to grant this funding. Capital requirements on risky assets constitute a binding constraint for the minimum amount of own funds needed. Most of the funds used by banks are associated with liabilities to third parties. Traditionally, these liabilities would take the form of deposits. These liquid claims allow consumers to intertemporally optimize their consumption preferences, but leave banks exposed to the risk of bank runs, as shown by Diamond and Dybvig (1983). However, the risk of runs acts as a disciplining device on banks (Diamond and Rajan, 2001b), given that depositors (Calomiris and Kahn, 1991), as well as borrowers (Kim et al, 2005), have incentives to monitor the risks taken by banks.

Through time, banks gained access to a more diversified set of liabilities to fund their lending activities, thus being exposed not only to traditional runs from depositors, but also to the drying up of funds in wholesale markets, as discussed by Huang and Ratnovski (2011) or Borio (2010), amongst many others.

The increased reliance on wholesale funding makes the relationship between funding and market liquidity risk much stronger, as discussed by Brunnermeier and Pedersen (2009), Cai and Thakor (2009), Drehmann and Nikolau (2009), Freixas et al (2011), Krishnamurthy (2010), Milne (2008), Strahan (2008), and Tirole (2011). Funding and market liquidity risk are two distinct concepts: whereas the former can be broadly defined as the risk of losing access to funding (through the form of runs or refinancing risk), the latter can be defined as the ability to sell assets without disrupting their markets prices (see, for instance, Cai and Thakor, 2009, Milne, 2008, or Tirole, 2011). Brunnermeier and Pedersen (2009) and Brunnermeier (2009) show that under certain conditions market and funding liquidity risk may be mutually reinforcing, leading to liquidity spirals, most notably when there are systemic risk concerns. For example, if a bank is not able to rollover some of its debt, it may be forced to sell some of its assets to obtain liquidity. However, the fire sale of assets will depress asset prices and shrink banks' assets, given that they are marked-to-market, thus making access to funding even more constrained (Nikolau, 2009).

Given this, even though banks are the main providers of liquidity to the economy (Berger and Bouwman, 2009; Diamond and Dybvig, 1983), they have to adequately manage the liquidity risk underlying their balance sheet structure, as their maturity transformation function makes them inherently illiquid. To alleviate the maturity gap between assets and liabilities, banks can hold a buffer of liquid assets (Acharya et al, 2011, Allen and Gale, 2004a and 2004b, Farhi et al, 2009, Gale and Yorulmazer, 2011, Rochet and Vives, 2004, Tirole, 2011, and Vives, 2011). However, holding liquid assets is costly, given that they provide lower returns than illiquid assets. Moreover, holding a liquidity buffer may also be inefficient, as it limits banks' ability to provide liquidity to entrepreneurs and consumers. Hence, even though banks have some incentives to hold a fraction of liquid assets (in the

form of cash, short term assets or government bonds, for instance), these buffers will hardly ever be sufficient to fully insure against a bank run or a sudden dry up in wholesale markets.

Against this setting, regulation becomes necessary to mitigate some of these risks. One justification for the need to regulate liquidity risk is related to the fact that banks do not take into account the social optimum when they optimize the relationship between risk and return. However, a bank failure may constitute a huge externality on other banks and, ultimately, on the whole economy. This risk is exacerbated by the fact that liquidity shocks are events with very low probability (though with potentially very high impact), thus making it easy to overlook them during good periods. Allen and Gale (2004a, 2004b) show that liquidity risk regulation is necessary when financial markets are incomplete, though emphasizing that all interventions inevitably create distortions. Furthermore, Rochet (2004) argues that banks take excessive risk if they anticipate that there is a high likelihood of being bailed-out in case of distress. Ex-ante regulation of banks' liquidity may mitigate this behavior. Many other authors share the view that liquidity risk regulation is necessary (Acharya et al, 2011, Brunnermeier et al, 2009, Cao and Illing, 2010, Gale and Yourlmazer, 2011, Holmstrom and Tirole, 1998, and Tirole, 2011, for example).

However, a consensus is far from being reached on the optimal regulatory framework to mitigate liquidity risk, both academically and politically, though a remarkable progress has been achieved during the last few years. Traditionally, reserve requirements on bank deposits were the main tool for liquidity risk management, though they also play an important role in the implementation of monetary policy (Robitaille, 2011). More importantly, deposit insurance is by now broadly recognized as an important tool in preventing depositors' bank runs[1]. Explicit deposit insurance can prevent runs on bank deposits, as shown by Diamond and Dybvig (1983)[2]. However, deposit insurance can only be efficient in minimizing the likelihood of bank runs by depositors. For instance, Bruche and Suarez (2010) show that deposit insurance can cause a freeze in interbank markets, when there are differences in counterparty risk. Indeed, deposit insurance is not sufficient to forestall all liquidity-related risks and may generate moral hazard (Ioannidou and Penas, 2010, Martin, 2006). Given the increased diversification of banks' funding sources (Strahan, 2008), other regulatory mechanisms must be envisaged to ensure the correct alignment of incentives. The dispersion of creditors and the diversification of risks and activities undertaken by banks make this issue even more complex.

[1]During the recent crisis, many governments in advanced economies decided to increase the coverage of their national deposit insurance schemes to avoid panic runs.

[2]However, Demirgüç-Kunt and Detagriache (2002) find that explicit deposit insurance increases the likelihood of banking crises, using data for 61 countries. This empirical result is stronger when bank interest rates are deregulated, the institutional environment is weak and the scheme is run or funded by the government.

Recent and ongoing discussions have suggested the possibility of further increasing capital requirements to also include liquidity risks[3] (Brunnermeier et al, 2009[4]). However, there are several opponents to this view. As argued by Ratnovski (2013), funding liquidity risk is in part related to asymmetric information on banks' solvency. Increasing solvency without reducing the asymmetric information problem would not reduce refinancing risk. Perotti and Suarez (2009) have also put forth a proposal regarding a liquidity insurance mechanism to avoid systemic crises.

Many authors discuss the importance of holding a liquidity buffer. In a recent paper, Ratnovski (2009) discusses the trade-offs between imposing quantitative requirements on banks' liquidity holdings and improving the incentive scheme in lender of last resort policies. This author argues that quantitative requirements can achieve the optimal liquidity level, but not without imposing costs, whereas a lender of last resort policy that takes into account bank capital information may reduce distortionary rents, thus allowing for a more efficient solution. There are many other contributions in the academic literature pointing to the possibility of imposing minimum holdings of liquid assets (Acharya et al, 2011, Allen and Gale, 2004a and 2004b, Farhi et al, 2009, Gale and Yorulmazer, 2011, Rochet and Vives, 2004, Tirole, 2011, and Vives, 2011). However, Wagner (2007b) shows that, paradoxically, holding more liquid assets may induce more risk-taking by banks. Freixas et al (2011) show that central banks can manage interest rates to induce banks to hold liquid assets, i.e., monetary policy can help to promote financial stability. In turn, Bengui (2010) finds arguments to support a tax on short-term debt, whereas Cao and Illing (2011) show that imposing minimum liquidity standards for banks ex-ante is a crucial requirement for sensible lender of last resort policies. Finally, Diamond and Rajan (2005) and Wagner (2007a) focus on ex-post interventions.

Against this background, the new international regulatory framework will be based on imposing minimum holdings of liquid assets. Globally, liquidity risk regulation was perhaps somewhat overlooked before the global financial crisis, with almost non-existent internationally harmonized rules (Rochet, 2008). However, the role played by funding liquidity during the global financial crisis made clear that a new international regulatory framework was necessary. In December 2010, the Basel Committee disclosed the final version of the international framework for liquidity risk regulation (Basel Committee, 2010), which is an important part of the new Basel III regulatory package. This new regulation provides the necessary incentives for banks to hold adequate liquidity buffers and to avoid over relying on short-term funding. Liquidity risk regulation will be based upon two key indicators: the

[3]In Basel II, capital requirements were set to explicitly cover credit, market and operational risks, but not liquidity risk.

[4]The model in Diamond and Rajan (2001b) implicitly considers this possibility.

Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The LCR will require banks to hold sufficient high-quality liquid assets to withstand a 30-day stressed funding scenario, being a ratio between the value of the stock of high quality liquid assets in stressed conditions and total net cash outflows, calculated according to scenario parameters defined in the regulation. In turn, the NSFR is a longer-term structural ratio designed to address liquidity mismatches and to encourage an increased reliance on medium and long-term funding, thus increasing the average maturity of banks' liabilities. The NSFR is the ratio between the available and the required amount of stable funding, which should be at least 100%. The two indicators are complementary and ensure that banks hold an adequate pool of liquid assets, while simultaneously adopting a reasonable and prudent maturity mismatch.

Still, when regulation fails to preemptively address risks, there is always the lender of last resort. Bagehot (1837) was amongst the first to acknowledge that such mechanism was a central piece in crisis management[5]. Since then, the consensus has been to lend freely, usually at penalty rates, to all solvent but illiquid banks (though it is in practice very hard to draw the line between solvency and liquidity problems). The recent financial crisis demonstrated the importance of the lender of last resort. From August 2007 onwards, the freeze in interbank money markets made lending from central banks worldwide crucial[6]. The failure of Lehman Brothers in September 2008 vividly demonstrated the dramatic consequences of a failure of a systemic financial institution[7]. However, the lender of last resort has an intrinsic moral hazard problem (see, for example, Freixas et al, 2004, Gorton and Huang, 2004, Ratnovski, 2009, Rochet and Tirole, 1996, Rochet and Vives, 2004, Wagner, 2007a). This mechanism has to be credible ex-ante to prevent crises. But if the mechanism is in fact credible, banks will know they will be helped out if they face severe difficulties, thus having perverse incentives to engage in excessive risk-taking behaviors. For instance, Gonzales-Eiras (2004) finds that banks' holding of liquid assets decrease when

[5] "Theory suggests, and experience proves, that in a panic the holders of the ultimate bank reserve (whether one bank or many) should lend to all that bring good securities quickly, freely, and readily. By that policy they allay a panic; by every other policy they intensify it.", Bagehot (1837).

[6] Lending from central banks during the initial stages of the crisis occurred mainly through monetary policy operations and not through emergency liquid assistance (which corresponds to the function of lender of last resort). For further details and analysis of the freeze in interbank markets in 2007 we refer to Acharya and Merrouche (2012), Afonso et al (2011), Allen and Carletti (2008), Angelini et al (2011), Brunnermeier (2009), and Cornett et al (2011).

[7] Two excellent analyzes of the crisis are Acharya and Richardson (2009) and Brunnermeier et al (2009). Both present a set of proposals to rethink the regulation of the financial system globally.

there is a lender of last resort, using a natural experiment in Argentina. This moral hazard problem is further aggravated by systemic behavior[8].

Indeed, when most banks are overtaking risks, each bank manager has clear incentives to herd, instead of leaning against the wind. Ratnovski (2009) argues that, in equilibrium, banks have incentives to herd in risk management, choosing suboptimal liquidity as long as other banks are expected to do the same. These collective risk-taking strategies may be optimal from an individual perspective, as they should allow banks to increase profitability without increasing the likelihood of bankruptcy, due to the explicit or implicit bail out commitment of the lender of last resort. These arguments are discussed in detail by Farhi and Tirole (2012), who argue that when banks simultaneously increase their liquidity risk, through larger maturity mismatches, current and future social costs are being created. Given all these market failures, regulation is needed to ensure that these externalities are considered by banks in their liquidity risk management. Nevertheless, the costs and distortions generated by such regulation also need to be taken into account. Acharya et al (2011) consider the effect of the business cycle on banks' optimal liquidity choices and prove that during upturns banks' choice of liquid assets jointly decreases. In turn, Allen et al (2012) show that when banks make similar portfolio decisions systemic risk increases, as defaults become more correlated. Jain and Gupta (1987) find (weak) evidence on bank herding during a crisis period. Collective risk taking incentives and behaviors are also discussed by Acharya (2009), Acharya and Yorulmazer (2008), Boot (2011), Rajan (2006), Tirole (2011), and Van den End and Tabbae (2012). This emerging evidence on systemic liquidity risk calls for adequate macroprudential instruments that address the sources of such risks, as discussed by Farhi and Tirole (2012), Boot (2011), and Cao and Illing (2010). Nevertheless, most of these conclusions are supported by theoretical results, lacking empirical support. Our paper intends to fill this gap in the literature, by providing empirical evidence of herd behavior in liquidity risk management.

3 How to measure liquidity risk?

The maturity transformation role of banks generates funding liquidity risk (Diamond and Dybvig, 1983). As banks' liabilities usually have shorter maturities than those of banks' assets, banks have to repeatedly refinance their assets. This refinancing risk is larger the wider is the mismatch between assets' and liabilities' average maturities. In the run up to

[8] Citigroup's former CEO, Charles Prince, has been repeatedly quoted by saying before August 2007 that "When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing".

the global financial crisis, many banks were engaging in funding strategies that heavily relied on short-term funding (Brunnermeier, 2009 and CGFS, 2010) thus significantly increasing their exposure to funding liquidity risk. Nevertheless, this risk can be mitigated if banks hold a sufficiently large buffer of highly liquid and good quality assets, which they can easily use when hit by unforeseen funding shocks.

In this section, we briefly review several ways to measure funding liquidity risk, which will later be used in our empirical analysis. As discussed by Tirole (2011), liquidity cannot be measured by relying on a single variable or ratio, given its complexity and the multitude of potential risk sources. This section also includes a brief description of the data used in this paper and an overview of banks' liquidity and funding choices in the years preceding the global financial crisis.

3.1 Liquidity indicators

An analysis of balance sheet structure can provide an important insight on banks' liquidity risk. More specifically, the ratio between credit granted and deposits taken from customers provides a broad structural characterization of banks' main funding risks. Given that customers deposits are a broadly stable funding source (in the absence of bank runs), those banks that finance most or all of their credit with deposits should, *ceteris paribus*, be less exposed to liquidity risk. In contrast, banks that show a large funding gap, i.e., a very high loan-to-deposit ratio, will be more exposed to this risk, as they will need to rely on wholesale funding markets[9]. Against this background, banks in which wholesale market funding as a percentage of assets is higher will be more sensitive to refinancing risk. This latter risk will be higher the shorter is the maturity of market funding. Hence, the analysis of the balance sheet structure based on the above mentioned liquidity indicators (loan-to-deposit ratio, funding gap or market funding as a percentage of assets) does not allow for a complete assessment of liquidity risk, as these indicators are unable to take into account the maturity mismatch between assets and liabilities.

Another important dimension of funding liquidity risk that became a key issue since the summer of 2007 is the reliance on interbank funding. Interbank markets allow markets to close, by allowing banks with short-term liquidity needs to obtain funds from other banks

[9]It is also possible that the mismatch between loans and deposits is financed with more equity, rather than with wholesale funding. If a bank has strong equity ratios and does not rely on wholesale funding, a high loan-to-deposit ratio does not imply strictly higher risk. However, very few banks rely entirely on deposit funding, as most banks approach the interbank market to match short-term mismatches between assets and liabilities and many banks obtain regular funding from debt markets. To control for this interaction between equity and the loan-to-deposit ratio, we control for capital ratios in the multivariate analysis conducted in this paper (see sections 3 and 4).

with temporary excess liquidity. However, after August 2007, unsecured money markets became severely impaired for a long period (Afonso et al, 2011, Cornett et al, 2011, Brunnermeier, 2009, Allen and Carletti, 2008, and Angelini et al, 2011). Wagner (2007a) shows that the interbank markets may be inefficient in providing liquidity when banks are hit by aggregate liquidity shocks. Against this background, the interbank ratio measured, for instance, as the ratio between interbank assets and interbank liabilities, may also be an important input to the assessment of liquidity risk. In fact, if banks structurally rely on funding from interbank markets, which is usually characterized by very short maturities, they may have severe difficulties in rolling over their debt in periods of distress.

Another important dimension of liquidity risk is related to the buffer of liquid assets held by banks. Refinancing risk may be mitigated if banks hold a comfortable buffer of high quality very liquid assets that they can easily dispose of in case of unexpected funding constraints. In this respect, the ratio of liquid assets to short-term funding also provides important insights into banks' liquidity risk. Even though the available data does not allow to compute the Basel III Liquidity Coverage Ratio (LCR), this liquidity indicator may be taken as a close approximation.

All the above mentioned indicators consider only parts of banks' balance sheets. Hence, a more encompassing analysis of the liquidity of assets and liabilities may be desirable. Ideally, a complete liquidity indicator would rely on the overall liquidity mismatch between assets and liabilities. However, the data necessary for such an indicator is not usually publicly available. Nevertheless, some approximation may be feasible. One interesting approach was suggested by Berger and Bouwman (2009). These authors define liquidity creation as:

$$liquidity\_creation = \{1/2 * illiquid\_assets + 0 * semi\_liquid\_assets - 1/2 * liquid\_assets\} + \{1/2 * liquid\_liabilities + 0 * semi\_liquid\_liabilities - 1/2 * illiquid\_liabilities\} - 1/2 * capital$$

The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. More liquidity is created when illiquid assets are transformed into liquid liabilities. Of course, liquidity creation is positively related with funding liquidity risk, given that banks that create more liquidity have less liquid assets to meet short-term funding pressures.

Ultimately, the Net Stable Funding Ratio (NSFR) included in the Basel III package provides the broadest way to characterize the global liquidity profile of a bank. As mentioned before, the NSFR is the ratio between the available and the required amount of stable funding. The higher this ratio is, the more comfortable is the institution's liquidity position. Though the available data does not allow for the accurate computation of this indicator, a gross approximation is possible.

In sum, given the challenges in measuring funding liquidity risk, our empirical analysis will be based on the analysis of five complementary indicators: the credit to deposit ratio, an interbank ratio, a liquidity ratio, a liquidity creation indicator and a net stable funding ratio, all of them defined in detail in Section 3.3. These indicators allow us to capture different dimensions of liquidity risk, including structural balance sheet risks, exposures to short-term funding in interbank markets, the availability of a pool of highly liquid assets to face unexpected shocks, and the magnitude of maturity transformation.

3.2 Data

Given that one of our objectives is to assess the extent to which banks take each others' choices into account when managing liquidity risk, it is relevant to consider a sufficiently heterogeneous group of banks. With that in mind, we collect data from Bankscope for the period between 2002 and 2009, thus covering both crisis and pre-crisis years. We collect data on European and North-American banks, selecting only commercial banks and bank holding companies for which consolidated statements are available in universal format, so as to ensure the comparability of variables across countries. Savings and investment banks were not included in the dataset, as they usually have different liquidity risk profiles and funding strategies. Using these filters, we obtain data for almost 3,500 banks during 8 years, for 45 countries[10]. Excluding banks without information on total assets, we obtain 17,643 bank-year observations.

In Table 1 we summarize the major characteristics of the banks included in the sample. To avoid having results affected by outliers, all variables were winsorised in their 1st and 99th percentiles. We observe that there is a substantial dispersion in bank size, measured by total assets. The average total capital ratio is 14.5% (12.9% for the median bank). There is also substantial dispersion in banks' profitability, measured both by return on assets and by the net interest margin, and in banks' efficiency, measured by the cost-to-income ratio. Loans represent almost two thirds of the assets of the banks included in the sample, even though the table shows that there are banks with very different specializations, as loans range from 5.1% to 90.6% of banks' assets.

[10]These countries are Albania, Andorra, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova Republic, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and United States. In Albania, Bosnia-Herzegovina, Liechtenstein, Moldova Republic, Montenegro and San Marino there are less than 10 observations for the entire sample period. Given this, we exclude these five countries from all cross-country analysis.

Insert Table 1 about here

3.3 An overview of banks' liquidity and funding choices in the run up to the global financial crisis

In Table 2 we summarize the information on liquidity risk for the banks included in the sample. Taking into account our discussion of liquidity indicators in Section 3.1, we focus our analysis of liquidity risk on five different indicators: i) *loans to customer deposits*; ii) the *interbank ratio*, defined as the ratio between interbank assets (loans to other banks) and interbank liabilities (loans from other banks, including central bank funding); iii) the *liquidity ratio*, defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalents) as a percentage of customer deposits and short-term funding; iv) *liquidity creation* as a percentage of total assets, which is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009); and v) a *Net Stable Funding Ratio*, which is an approximation of the indicator proposed by the Basel Committee. The first three variables are computed in a standardized way in the Bankscope database. The remaining two were computed using balance sheet data (details are presented in the Appendix). In Panel A of Table 2 we present summary statistics for these five indicators and in Panel B we depict their evolution during the sample period. In Figures 1 to 10 we present the empirical distributions of these indicators.

Insert Table 2 about here

As mentioned above, the ratio between loans and customer deposits is a structural indicator of funding liquidity risk. A ratio above 100% means that the bank has to finance part of its loans with wholesale market funding, which may be more expensive and less stable than customer deposits. The difference between loans and customer deposits is usually referred to as the funding gap. During the last decades, banks have moved from a traditional intermediation paradigm in which most loans were funded through deposits (thus implying loan to deposits ratios not far from 100%) to a new framework of bank funding. As access to wholesale markets became more generalized, banks were able to diversify their funding sources. This had implications on the maturity transformation role of banks. Looking at our sample period, we observe a consistent increase in this ratio, from 84.1 per cent in 2002 to 107.9 per cent in 2008. There is a significant dispersion in the ratios recorded by banks in different countries.

Insert Figures 1-2 about here

However, this indicator, in and by itself, is insufficient to globally assess the liquidity position of credit institutions. Several limitations of this indicator can be mentioned. First, it is essentially a structural indicator and thus strategic and cyclical changes may take some time to be reflected in the data. Second, the increased use of securitization operations by banks during the last decade undermines to some extent the analysis of this indicator (when banks securitize loans, these are usually removed from their loan books, thus generating a somewhat misleading decrease in the credit to deposit ratio). Finally, this indicator does not take into account the maturity mismatch between assets and liabilities, which is a key element of liquidity risk analysis.

The interbank ratio allows to assess another dimension of bank's funding liquidity risk, evaluating whether banks are net borrowers or net lenders in interbank markets. As we define this indicator as the ratio between loans to other banks and loans from other banks, a ratio above 100% means that a bank is a net lender in interbank markets, thus signaling a more comfortable liquidity position than otherwise.

During our sample period, this ratio decreased gradually, thus implying a deterioration on the average position of banks in these markets. Comparing the interbank positions at the beginning and end of the sample period, some countries recorded a significant decline, whereas others recorded the opposite evolution. All in all, Figure 4 clearly illustrates that the dispersion in this ratio decreased markedly during the sample period.

The freeze in interbank markets observed since the financial market turmoil started in August 2007 makes the intertemporal analysis of this ratio more challenging. During most of the global financial crisis, the lack of confidence led to severe disruptions in the functioning of interbank markets. Uncollateralized operations almost ceased to exist during significant periods and high haircuts were imposed on collateralized operations. Thus, there is a clear series break in this indicator from August 2007 onwards, which will be analyzed further ahead. Furthermore, it is important to note that end-of-year data for this ratio may sometimes be subject to some window-dressing, thus not fully reflecting the average values shown throughout the year.

Insert Figures 3-4 about here

Again, the interbank ratio allows for the evaluation of only one dimension of liquidity risk. A more encompassing indicator is the ratio of liquid assets to customer and short-term funding. The lower the ratio, the more challenging it may be for banks to honor their short-term financial commitments. This ratio increased up until the financial turmoil in the summer of 2007. Hence, there does not seem to exist evidence of any dilapidation of the buffer of liquid assets or of a relative increase in short-term funding of European and

North-American banks in the run up to the crisis. However, in 2007 and 2008 there was some deterioration in this liquidity ratio, mainly due to the strong growth in customer and short-term funding.

Again, the cross-country dispersion is considerable. For most countries, this ratio shows a remarkable volatility during the sample period, as it easily reflects changes in banks' strategic behavior in terms of liquidity risk management.

Insert Figures 5-6 about here

Liquidity creation increased steadily during the sample period, including during the crisis years. Actually, its highest value was recorded in 2009, thus showing that banks continued to create liquidity even during the global financial crisis. From all the indicators analyzed, this is the one which presents a distribution closer to the normal, though having a fat right tail.

Insert Figures 7-8 about here

Finally, the NSFR showed some deterioration in the run up to the crisis. It is important to stress that this indicator is a rough approximation of the indicator proposed by the Basel Committee. As such, the 100 per cent minimum threshold defined for this ratio for prudential purposes cannot be considered for our indicator. There is a remarkable cross-country heterogeneity in this indicator.

Insert Figures 9-10 about here

All in all, the analysis of these complementary liquidity indicators shows that there is a considerable heterogeneity in liquidity indicators both across countries and over time. Before the crisis, the loan-to-deposit ratio, the interbank ratio and the NSFR showed some deterioration. In turn, the liquidity ratio decreased after the crisis started, with a marked growth of customer deposits and short-term funding (while liquid assets recorded only a mild increase). Hence, even though most banks did not have to sell liquid assets to face short term funding needs, their maturity profile took a pronounced turn for the worse. During this period, many banks were not able to issue medium and long-term debt securities, thus shortening the average maturity of their liabilities. Nevertheless, liquidity creation does not seem to have been affected by these developments. Despite evident balance sheet adjustments, banks worldwide continued to perform their vital intermediation function.

In the next section we will provide some insight on which factors are relevant to explain the heterogeneity in liquidity indicators.

4 How do banks manage liquidity risk?

Even though liquidity risk management is one of the most important decisions in the prudent management of financial institutions, there is scarce empirical evidence on the determinants of liquidity indicators. Using our dataset, we are able to explore which bank characteristics may be relevant in explaining liquidity indicators. In Table 3 we present some results on the five liquidity indicators described in the previous section: i) loans to customer deposits (column 1); ii) the interbank ratio (column 2); iii) the liquidity ratio (column 3); iv) liquidity creation (column 4); and v) net stable funding ratio (column 5). All specifications use robust standard errors and bank fixed-effects, such that:

$$Liqx_{it} = \alpha_0 + \alpha_i + \alpha_{nt} + \beta_1 Capital_{it-1} + \beta_2 Banksize_{it} + \beta_3 Profitability_{it-1} + \beta_4 Cost\_inc_{it-1} +$$

$$+ \beta_5 Lend\_spec_{it-1} + \beta_6 (Liq - x_{it-1}) + i_t + \varepsilon_{it} \quad (1)$$

where $Liqx_{it}$ is the liquidity indicator analyzed, α_0 is a constant, α_i is the bank fixed effect, α_{nt} is the country-year fixed effect, i_t is the year fixed effect and ε_{it} is the estimation residual. As explanatory variables, we use a set of core bank indicators on solvency, size, profitability, efficiency and specialization. $Capital_{it}$ is the total capital ratio calculated according to the rules defined by the Basel Committee. $Banksize_{it}$ is measured by the log of Assets and $profitability_{it}$ includes the return on assets and the net interest margin. $Cost\_inc_{it}$ refers to the cost-to-income ratio, which is a proxy for cost-efficiency, and $lend\_spec_{it}$ measures to what extent a bank is specialized in lending, by considering net loans as a percentage of total assets. Finally, $(Liq - x_{it})$ refers to the other liquidity indicators, i.e., $x_{it} \neq -x_{it}$ (the only exception is the interbank ratio, which is never included as an explanatory variable, given that it would imply a considerable reduction in the sample size). All variables are lagged by one period to mitigate concerns of simultaneity and reverse causality.

Insert Table 3 about here

Across the board, larger banks seem to be generally more risky in what concerns liquidity risk management, showing higher loan-to-deposit ratios, weaker interbank positions, smaller liquidity buffers and less stable funding structures. However, larger banks create less liquidity, as a percentage of total assets, thus being less exposed in this risk dimension.

Even though some relationship between capital and liquidity could be expected (Berger and Bouwman, 2009, Diamond and Rajan, 2000, 2001a), the total capital ratio is not statistically significant in any of the specifications tested.

The impacts of profitability on liquidity risk are rather mixed. On the one hand, banks with larger net interest margins seem to display lower liquidity risk (measured by loan to deposits, liquidity creation and NSFR). On the other hand, banks with higher overall profitability, as measured by return on assets, show more liquidity risk (higher loan to deposit ratios, more liquidity creation, lower liquidity buffers and less stable funding structures). Banks that are profitable in their basic intermediation function seem to have less risky funding structures, while banks that are broadly more profitable (possibly obtaining larger gains from other income sources) tend to be riskier in their liquidity risk management. These are possibly banks that adopt riskier strategies in order to boost profitability, thus being more vulnerable to funding liquidity risk. This result is in line with Demirgüç-Kunt and Huizinga (2010), who show that banks that rely on strategies based on non-interest income and on short-term funding are significantly riskier.

In turn, more efficient banks, with lower cost-to-income ratios, create less liquidity and have larger net stable funding ratios. Finally, one of the most relevant variables in explaining liquidity ratios is bank specialization, measured as net loans as a percentage of total assets: banks that are more specialized in lending to customers have, as would be expected, higher loan to deposit ratios and create more liquidity. These banks also have lower interbank ratios (i.e., they are more likely net borrowers) and display lower liquidity ratios. Hence, even though banks that concentrate most of their assets in lending are usually perceived as having a more traditional, and perhaps more stable, intermediation profile, these are the banks that tend to show worse liquidity ratios (the only exception is the result obtained for the NSFR, which goes in the opposite direction). Hence, even though these banks are usually deemed as globally less prone to risk-taking, they tend to show larger funding gaps and maturity mismatches.

The coefficients on liquidity indicators show that these capture different dimensions of liquidity risk. Indeed, with the exception with the coefficients associated with the NSFR, the signals of these coefficients are contrary to what could be expected ex-ante. This confirms the need to simultaneously assess these different dimensions of liquidity risk.

Finally, it is relevant to note that a large part of the variation in liquidity ratios cannot be attributable to the observed financial ratios analyzed. Indeed, as shown in the table, bank fixed effects account for a very large fraction of the variance. This result is entirely consistent with evidence obtained by Gropp and Heider (2010) regarding the determinants

of banks' capital ratios. These authors find that unobserved time invariant bank fixed effects are ultimately the most important determinant of banks' capital ratios.

In sum, larger and more profitable banks tend to exhibit more liquidity risk, most notably if they have a more traditional intermediation profile, focusing on lending to customers. In turn, banks with larger net interest margins and with better cost-efficiency ratios are generally less risky in their liquidity management. Finally, there does not seem to exist an empirical relationship between capital and liquidity.

5 Are other banks' decisions relevant?

In the previous section we shed some light on the role of different bank characteristics on their observed liquidity strategies. However, it is possible to argue that banks do not optimize their liquidity choices strictly individually, and may take into account other banks' choices. In fact, when banks believe that they may be bailed out in case of severe financial distress (for being too-big, too-systemic or too-interconnected to fail), they may actually have incentives to herd, engaging in similar risk-taking and management strategies. For instance, Goodhart and Schoenmaker (1995) show that banks are more often rescued than liquidated in case of distress. Against this background, when other banks are taking more risk, a specific bank may have the incentives to engage in similar strategies. These collective risk-taking strategies may be optimal from an individual perspective as they should allow banks to increase profitability without increasing the likelihood of bankruptcy, due to the explicit or implicit commitment of the lender of last resort, as theoretically conjectured by Ratnovski (2009).

In this section, we try to find evidence of possible herding behavior of banks in liquidity risk management, especially in the years before the global financial crisis. We begin by analyzing different statistics that may provide some insight on this issue, in section 5.1. However, the identification and measurement of peer effects on individual choices is a challenging econometric problem, as discussed by Manski (1993). In section 5.2 we briefly discuss these identification problems and in section 5.3 we propose an empirical strategy to address these concerns and present our results.

5.1 Some statistics

Figures 1 to 10 show that there is considerable dispersion in liquidity indicators and, in some cases, the distribution of liquidity indicators changed significantly over time. Hence, a further analysis of the concentration of these liquidity indicators over time may provide some

insight about possible trends in banks' collective or systematic behavior. Furthermore, this assessment may be complemented with an analysis of the distribution of the residuals from equation (1). Indeed, the explanatory variables considered are not able to fully capture the heterogeneity in liquidity indicators across banks. Thus, the analysis of what is left unexplained by the available observables may also provide some intuition on herding or collective behavior. The results of this analysis are presented in Table 4.

Insert Table 4 about here

We compute the Gini coefficient over time for all the liquidity indicators, with the exception of the liquidity creation indicator (given that this variable has many negative values). This coefficient is a measure of statistical dispersion and evaluates the inequality in a given distribution, ranging between 0 and 1. A higher Gini coefficient implies more dispersion. Moreover, the standard deviation and the coefficient of variation (which is the standard deviation normalized by the mean of the distribution) of the indicators also allow to analyze how the distribution of liquidity indicators has evolved over time. These dispersion measures may also be used to characterize the residuals, assessing the dispersion in the component of liquidity indicators that is not explained by observable bank characteristics and how it changed during the sample period[11].

Both the Gini coefficient and the coefficient of variation of the loan to deposit ratio suggest that dispersion increased during the sample period, though there was some reversion in 2009, possibly reflecting a widespread deleveraging during the global financial crisis. Furthermore, the coefficient of variation of the residuals in this year was particularly large, suggesting that this ratio was less linked with fundamentals. In what concerns the interbank ratio, there is a steady decrease in concentration, both before and during the crisis. The results obtained for the liquidity ratio point in the same direction, though there was some reversion of this trend in 2008 and 2009. The dispersion of the residuals also increased significantly during the crisis. The coefficient of variation of the liquidity creation indicator decreased markedly, showing an even more pronounced increase of dispersion. Finally, there was also a significant increase of the Gini coefficient of the NSFR in 2006.

All in all, these indicators point to an increase of the dispersion of banks' liquidity indicators, both before and during the global financial crisis. As such, this preliminary statistical analysis does not provide evidence of visible collective risk-taking behaviors.

[11] The Gini coefficient cannot be computed for the residuals, as these take negative values.

5.1.1 A traditional measure of bank herd behavior

A natural extension to the analysis conducted thus far is to estimate measures of herding frequently used in financial markets (see, for example, Graham, 1999, Grinblatt et al, 1995, Scharfstein and Stein, 1990, or Wermers, 1999). To do that, we adapt the often used herding measure proposed by Lakonishok et al (1992) and applied to bank herding by Uchida and Nakagawa (2007) and, more recently, by Van den End and Tabbae (2012). This methodology allows testing the extent to which the liquidity choices of banks collectively deviate from what could be suggested by overall macroeconomic conditions. Implicitly, we are considering a concept of "rational herding", as defined by Devenow and Welch (1996). In other words, we do not consider that banks simply mimic each other's behaviors, but rather that they do so because there are important externalities that affect the optimal decision making process.

We compute:

$$H_i = |P_i - P_t| - E\,|P_i - P_t|$$

where P_i is the proportion of banks that show an increase in risk for a given liquidity indicator in each country and in each year, computed as $\frac{X_i}{N_i}$. X_i is the number of banks that recorded a deterioration of a liquidity indicator in a country in a given year, and N_i is the total number of banks operating in each country and in each year. For the loan-to-deposit and liquidity creation ratios, X_i refers to the number of banks that showed an increase in these ratios, while for the other three liquidity indicators X_i refers to the number of banks that recorded a decrease in these indicators, i.e., an increase in risk. P_t is the mean of P_i in each year. P_t can be interpreted as an indicator of banks' liquidity choices that reflect overall macroeconomic and financial conditions. The difference between P_i and P_t measures to what extent liquidity indicators in one country and in one year deviate from the overall liquidity indicators in that year, i.e. from common factors. According to the methodology proposed by Lakonishok et al (1992), when banks independently increase or decrease liquidity indicators, P_i and P_t become closer and $|P_i - P_t| \to 0$. However, when several banks collectively deviate and increase or decrease their liquidity indicators, P_i departs from P_t. The second term in the equation is used to normalize the herding measure.

Computing this at the country level is crucial if we consider that the incentives for herding are much stronger amongst national peers. The common belief of bail out is more likely to be shared by banks in the same country. Indeed, the arguments to support that banks take riskier strategies because banks operating in other countries do so are much weaker than when considered at the national level. This will be particularly true if competition between banks exists within markets segmented by national borders.

Table 5 shows our estimates for this herding measure for the five liquidity indicators. The evidence supporting herd behavior based on this indicator is statistically very strong for all the indicators. The only exception is the interbank ratio. This can be explained by the fact that interbank market positions close, i.e., net lending positions of some banks should be offset by net borrowing positions of other banks. For all the other indicators, the results are remarkably strong, thus supporting the hypothesis of collective risk taking before the crisis.

Insert Table 5 about here

Nevertheless, this traditional herding measure has several limitations and cannot be regarded as a full characterization of collective risk taking. This is essentially a static measure and, more importantly, it only considers whether or not there was an increase in risk, without considering its magnitude. Furthermore, this measure does not take into account all other possible determinants of liquidity choices. It is possible that common behaviors are observed because banks are affected by common shocks or because they share common characteristics, rather than by true herding behavior. Hence, only in a multivariate setting, where bank specific characteristics and time effects are explicitly controlled for, it becomes possible to isolate the impact of other banks' choices on each individual bank. In the next subsection we deal with the identification challenges raised by this multivariate analysis.

5.2 The reflection problem and identification strategies

In a multivariate setting, the impact of peers' liquidity indicators on a bank's liquidity decisions could be estimated through the following adapted version of equation 1:

$$Liqx_{it} = \alpha_0 + \alpha_i + \alpha_{nt} + \beta_0 \sum_{j \neq i} \frac{Liqx_{jt}}{N_{it} - 1} + \beta_1 capital_{it-1} + \beta_2 banksize_{it} + \beta_3 profitability_{it-1} +$$

$$+ \beta_4 Cost\_inc_{it-1} + \beta_5 lend\_spec_{it-1} + \beta_6 (Liq - x_{it-1}) + i_t + \varepsilon_{it} \qquad (2)$$

where $\sum_{j \neq i} \frac{Liqx_{jt}}{N_{it}-1}$ represents the average liquidity indicators of peers and all the other variables and parameters are defined as in equation 1. In this setting, the coefficient β_0 captures the extent to which banks' liquidity choices reflect those of the relevant peer group.

However, this estimation entails serious econometric problems: as we argue that peer choices may affect the decisions of a specific bank, we cannot rule out that the decisions of

that bank will not, in turn, affect the choices made by peers. This reverse causality problem in peer effects is usually referred to as the reflection problem. This problem was initially described by Manski (1993), who distinguishes three different dimensions of peer effects: i) exogenous or contextual effects, related to the influence of exogenous peer characteristics; ii) endogenous effects, arising from the influence of peer outcomes (in our case, peers' liquidity choices); and iii) correlated effects, which affect simultaneously all elements of a peer group. Empirically, it is very challenging to disentangle these effects. More specifically, Manski (1993) discusses the difficulties arising from the distinction between effective peer effects (either endogenous or exogenous) from other correlated effects. Furthermore, the identification of endogenous and exogenous effects is undermined by this reflection problem, as the simultaneity in peers' decisions should result in a perfect collinearity between the expected mean outcome of the group and its mean characteristics, as discussed also by Bramoullé et al (2009) and Carrell et al (2009).

This discussion makes clear that the estimation of equation 2 would not allow for the accurate estimation of peer effects. Our solution to this important identification problem relies on the use of an instrument to address this endogeneity problem. Manski (2000) argues that the reflection problem can be solved if there is an instrumental variable that directly affects the outcomes of some, but not all, members of the peer group[12]. As discussed in Brown et al (2008) and Leary and Roberts (2010), such an instrument must be orthogonal to systematic or herding effects. Given this, we use the predicted values of liquidity indicators of peer banks based on the regressions of the determinants of liquidity indicators presented in Table 3. The predicted values depend on the characteristics of the banks in the peer group, excluding bank i. These predicted values depend only on observable bank characteristics and should thus be orthogonal to systematic or herding effects. In other words, the predicted value of the liquidity indicators of peer banks should not directly affect $Liqx_{it}$, the liquidity indicator of bank i at time t, as these predicted values are based solely on observable bank characteristics. As we control also for time effects, we are able to orthogonalize all systematic shocks to banks. In addition, we also control for country-year fixed effects, in order to consider the effect of time-varying country characteristics that may simultaneously affect all banks in a given country. Furthermore, the predicted values of peer banks should be highly correlated with the average of the observed liquidity indicators, our potentially endogenous variable[13].

[12] Other solutions to the reflection problem found in the literature are, for example, having randomly assigned peer groups (Sacerdote, 2001), variations in group sizes (Lee, 2007) or identifying social networks using spatial econometrics techniques (Bramoullé et al, 2009). Given the characteristics of peer groups in our sample, none of these solutions can be applied in our setting.

[13] For a similar solution to the identification of peer effects using instrumental variables, see Leary and Roberts (2010).

Formally, our instrumental variables approach is equivalent to the estimation of

$$Liqx_{it} = \alpha_0 + \alpha_i + \alpha_{nt} + \beta_0 \sum_{j \neq i} \frac{Liqx_{jt}}{N_{it} - 1} + \beta_1 capital_{it-1} + \beta_2 banksize_{it} + \beta_3 profitability_{it-1} +$$

$$+ \beta_4 Cost\_inc_{it-1} + \beta_5 lend\_spec_{it-1} + \beta_6 (Liq - x_{it-1}) + i_t + \varepsilon_{it} \quad (3)$$

where the first step equation is

$$\sum_{j \neq i} \frac{Liqx_{jt}}{N_{it} - 1} = \alpha_0 + \alpha_j + \alpha_{nt} + \gamma_1 \sum_{j \neq i} \frac{Liq\_predx_{jt}}{N_{it} - 1} + \beta_1 capital_{jt-1} + \beta_2 banksize_{jt} + \beta_3 profitability_{jt-1} +$$
$$+ \beta_4 Cost\_inc_{jt-1} + \beta_5 lend\_spec_{jt-1} + \beta_6 (Liq - x_{jt-1}) + i_t + \varepsilon_{it}$$

with $\sum_{j \neq i} \frac{Liq_predx_{jt}}{N_{it}-1}$representing the average predicted values for $Liqx_{it}$ for the peer group in the equation:

$$Liq\_predx_{it} = \alpha_0 + \alpha_i + \alpha_{nt} + \beta_1 Capital_{it-1} + \beta_2 Banksize_{it} + \beta_3 Profitability_{it-1} + \beta_4 Cost\_inc_{it-1} +$$

$$+ \beta_5 Lend\_spec_{it-1} + \beta_6 (Liq - x_{it-1}) + i_t$$

Using this specification, we are able to identify peer effects, after adequately having dealt with the reflection problem. If neglected, this problem could lead to severely biased results.

As before, we define the benchmark peer group as the banks operating in the same country and in the same year. These are the banks that are more likely to engage in collective risk-taking behaviors due to implicit or explicit bailout expectations. Let us suppose that in a given country several banks engage in funding liquidity strategies that are deemed as globally risky (e.g., excessive reliance in short term debt to finance long-term assets, large funding gaps or persistent tapping of interbank markets). If several banks engage in these strategies simultaneously, there is naturally an increase in systemic risk. As discussed by Rochet and Tirole (1996) and Ratnovski (2009), a lender of last resort is not necessarily going to bail out one bank that gets into trouble because of its own idiosyncratic wrong choices (unless this bank is clearly too big or too systemic to fail). However, if several banks are at risk, the lender of last resort needs to take the necessary actions to contain systemic risk. In this case, the likelihood of a bailout should increase, as if one of these banks gets into trouble, very likely other banks will follow very soon, thus becoming

too-many-to-fail (Acharya and Yorulmazer, 2007). Given this incentive structure, a given bank in that country has clearly high incentives to engage in similar risky but profitable strategies. However, the same cannot be said for a bank operating in another country, where there is a different lender of last resort. This reasoning justifies our choice for the reference peer group. Nevertheless, we will later relax this hypothesis and test other possible peer groups.

5.3 Empirical results

In Table 6 we present the results of the instrumental variable approach in the estimation of peer effects in liquidity risk management.

In the first five columns we present, for illustrative purposes, the results of the estimation of equation (2). Hence, in these columns the peer effects are included in the regressions without properly addressing the reflection problem discussed before. When running this simple, yet biased, estimation, we find strong evidence of positive peer or herding effects in individual banks' choices for all liquidity indicators. The riskier are the funding and liquidity strategies of other banks in a given country, the riskier will tend to be the choices of each bank individually. However, as discussed above, these preliminary estimates do not adequately deal with the endogeneity problem underlying the estimation of peer effects.

Insert Table 6 about here

The second group of columns (6-10) displays our main empirical results, when adequately dealing with the serious endogeneity problem created by considering peer effects. When we use the predicted values of peer's liquidity indicators as instruments, we conclude that the results presented in the first columns do not hold for all specifications: peer effects are not statistically significant for the interbank ratio and NFSR. For the other indicators, peer effects continue to be strongly statistically significant and vary between 0.39 (for the loan to deposit ratio) to 0.72 (for the liquidity ratio). The different results obtained when the endogeneity problem is addressed are a strong indication that neglecting endogeneity in peer effects may originate biased and incorrect results.

As discussed before, a good instrument should have an important contribution in explaining the potentially endogenous variable, i.e. the average peers' liquidity choices, but it should not directly affect that the dependent variable. In the previous sub-section we discussed why the latter condition holds in our setting, whereas in the last group of columns of Table 6 we show that the chosen instrument is strongly statistically significant in all the regressions.

To better understand how these peer effects work and to ensure that the results are consistent under a wide set of specifications, we run a battery of robustness tests.

In Table 7 we present some of the most relevant tests conducted. All the estimations were performed without and with instrumental variables, in columns (1)-(5) and (6)-(10), respectively. First step regressions are reported in columns (11)-(15).

Insert Table 7 about here

First, we exclude the crisis period, so as to focus the analysis on possible peer effects in the years before the global financial crisis. The peer effect coefficient for the loan to deposit ratio is not significant in this period, suggesting that collective risk taking behaviors before the crisis were apparent mainly in the liquidity ratio and in liquidity creation. In addition, the results for the NSFR are now marginally significant.

Second and third, we made some adaptations in the definition of variables: first we consider as the dependent variable the change in liquidity indicators (instead of the level), and then we consider all variables in first differences. In both cases, peer effects lack statistical significance after the endogeneity problem is dealt with, except for the loan to deposit ratio. As such, peer effects are observable when the levels of liquidity indicators are considered, but loose significance when first differences are analyzed.

Fourth, we remove from the sample banks with year-on-year asset growth above 50%, as these banks may have been involved in mergers and acquisitions. Still, the results remain consistent, though somewhat stronger.

US banks represent slightly less that one quarter of the sample. In order to ensure that the results are not influenced by this, we exclude all US banks from the sample. The results are globally consistent, though slightly less significant, both economically and statistically.

For robustness purposes, we also run our estimates without using country-year fixed effects and without controlling for liquidity indicators. In both cases the results are robust, becoming slightly stronger in the latter case.

Finally, we consider data only from 2004 onwards, in order to avoid using accounting information that is time inconsistent, given that in many countries common accounting reporting standards (IFRS) were introduced around this time. The results become generally stronger.

5.3.1 Alternative peer group definitions

In Table 8 we explore a different type of robustness analysis, by testing alternative definitions of peer groups. Indeed, the definition of the peer group is a critical issue in the analysis of peer effects (Manski, 2000) and deserves further analysis. Even though we believe that

defining peers as other banks in the same country is the most reasonable assumption, due to the common lender of last resort, this definition may be challenged.

Insert Table 8 about here

First, we consider that it is possible to argue that peer choices should not necessarily affect the decisions of a given bank contemporaneously. To take that into account, we use lagged peer effects instead. The results obtained are very similar.

An additional possibility is to consider that banks focus on peer groups outside borders, implying that the lender of last resort may not be the only motive for excessive risk-taking in liquidity management. For example, large international players may follow similar strategies because they are competing to achieve higher returns on equity, possibly through riskier funding and liquidity strategies. To test this additional hypothesis, we consider as peers all the other banks of the same size quartile, regardless of their country of origin. This hypothesis seems to be implausible, as peer effects are not statistically significant in any of the indicators analyzed. Collective risk taking strategies seem to play a role mainly at the national level, possibly reflecting common lender of last resort incentives previously discussed.

Another possibility is that the lender of last resort may only be willing to support banks that are too big or to systemic to fail, even if several banks are taking risks at the same time. Hence, it is possible that herding incentives are stronger for larger banks. To test this hypothesis, we run our regressions only for the largest banks in the sample, defined as those in the fourth quartile of the total assets distribution in each country. The results are slightly weaker than for the baseline specification. Peer effects are not significant in the liquidity creation indicator for this group of banks, but, in contrast, they become significant in the NSFR.

To further examine the role of peer effects amongst the larger banks, we compare peer effects estimates for banks above the median to those bellow. The statistical significance of peer effects is more robust for the largest banks, though there is also significant evidence of herding among the smaller banks.

When we consider stricter definitions of large banks, such as banks that are classified among the top 5 in each country, banks belonging to the systemically important financial institutions (SIFIs) list recently disclosed by the Financial Stability Board or banks in the Euribor panel, the results are relatively weaker. This result is not surprising, as these are the banks that have less incentives to engage in collective risk-taking strategies. Indeed, these very large banks are generally too-big-to-fail, benefiting permanently from implicit bail out guarantees. As such, these banks are the ones who face lower incentives to engage

in riskier strategies when other banks are doing so, given that their probability of being bailed out hardly changes.

Given this argumentation, another important dimension to test is whether small banks tend to replicate the behavior of the larger banks. Using different definitions of small and large banks, we obtain evidence of significant peer effects, most notably for the interbank ratio, loan to deposits and liquidity ratio. Interestingly, we obtain negative peer effects in some specifications for liquidity creation and for the NSFR. This means that, in these cases, small banks actually decrease liquidity risk when the largest banks are increasing it.

Finally, given the strong financial integration in the euro area, we also test whether banks operating in euro area countries behave as a peer group. The results are consistent with the baseline specification.

6 Concluding remarks and policy implications

Banks' liquidity risk was at the core of the global financial crisis since its early days. By transforming liquid liabilities (deposits) into illiquid claims (loans), banks are intrinsically exposed to funding liquidity risk, though this risk materializes only occasionally. In this paper we provide empirical insight on how banks manage their liquidity risk and consider explicitly the role of collective risk-taking strategies on herding behavior. Indeed, when other banks are taking more risk, any given bank may have incentives to engage in similar strategies.

By adapting the herding measure proposed by Lakonishok et al (1992) to our setting we find that there was strong herding behavior in the pre-crisis period, reflected in a broad deterioration of liquidity indicators. Herding persisted though the crisis, as banks simultaneously adjusted their business models.

Given the limitations of this herding measure, we extend our analysis to a multivariate setting. However, the empirical estimation of these peer effects amongst banks in such a framework raises some econometric challenges. Based on the arguments put forth by Manski (1993), if we consider that peer choices may affect the decisions of a specific bank, we cannot rule out that the decisions of that bank will not, in turn, affect the choices made by peers (reflection problem). To overcome this critical identification problem we use as an instrumental variable the predicted values of liquidity indicators of peer banks based on the regressions of the determinants of liquidity indicators. These predicted values depend only on observable bank characteristics and should thus be orthogonal to systematic or herding effects. Using this methodology we can find evidence of robust and significant peer effects.

Our results provide an important contribution to this policy debate. These collective risk-taking behaviors call for regulation to adequately align the incentives and minimize negative externalities. The collective behavior of banks transforms a traditionally microprudential dimension of banking risk into a macroprudential risk, which may ultimately generate much larger costs to the economy.

The new Basel III regulatory framework represents a huge step forward in the international regulation of banks. At the microprudential level, new liquidity requirements are going to be gradually imposed, reducing excessive maturity mismatches and ensuring that banks hold enough liquid assets to survive during a short stress period. However, our results suggest that there may be a missing element in the new regulatory framework: the systemic component of liquidity risk. The new liquidity risk regulation will ensure that, at the microprudential level, institutions are less exposed to liquidity risk. Nevertheless, additional macroprudential policy tools may eventually be considered to mitigate the incentives for collective risk-taking strategies. These may include (cyclical or sectoral) tighter liquidity regulation or limits to certain types of exposures or funding sources. Moreover, a well functioning resolution and bail-in framework is critical to mitigate bail out expectations.

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Appendix

	Liquidity creation		NSFR
	Classification	Weights	Weights
Residential Mortgage Loans	SL	0	0.65
Other Mortgage Loans	SL	0	0.65
Other Consumer/ Retail Loans	SL	0	0.85
Corporate & Commercial Loans	I	0.5	0.85
Other Loans	I	0.5	0.85
Less: Reserves for Impaired Loans/ NPLs			-1.00
Net Loans			
Loans and Advances to Banks	SL	0	0.50
Reverse Repos and Cash Collateral			0.00
Trading Securities and at FV through Income			0.50
Derivatives			0.50
Available for Sale Securities			0.50
Held to Maturity Securities			1.00
At-equity Investments in Associates			1.00
Other Securities			1.00
Total Securities	L	-0.5	
Investments in Property	I	0.5	1.00
Insurance Assets	I	0.5	1.00
Other Earning Assets	I	0.5	1.00
Total Earning Assets			
Cash and Due From Banks	L	-0.5	0.00
Foreclosed Real Estate	I	0.5	1.00
Fixed Assets	I	0.5	1.00
Goodwill	I	0.5	1.00
Other Intangibles	I	0.5	1.00
Current Tax Assets	I	0.5	1.00
Deferred Tax Assets	I	0.5	1.00
Discontinued Operations	I	0.5	1.00
Other Assets	I	0.5	1.00
Total Assets			

	Liquidity creation		NSFR
	Classification	Weights	Weights
Customer Deposits - Current	L	0.5	
Customer Deposits - Savings	L	0.5	
Customer Deposits - Term	SL	0	
Total Customer Deposits			0.85
Deposits from Banks	L	0.5	0.00
Repos and Cash Collateral	L	0.5	0.00
Other Deposits and Short-term Borrowings	L	0.5	0.00
Total Deposits, Money Market and Short-term Funding			
Total Long Term Funding	I	-0.5	1.00
Derivatives	L	0.5	0.00
Trading Liabilities	L	0.5	0.00
Total Funding			
Fair Value Portion of Debt	SL	0.0	0.00
Credit impairment reserves	SL	0.0	0.00
Reserves for Pensions and Other	SL	0.0	0.00
Current Tax Liabilities	SL	0.0	0.00
Deferred Tax Liabilities	SL	0.0	0.00
Other Deferred Liabilities	SL	0.0	0.00
Discontinued Operations	SL	0.0	0.00
Insurance Liabilities	SL	0.0	0.00
Other Liabilities	SL	0.0	0.00
Total Liabilities			
Pref. Shares and Hybrid Capital accounted for as Debt	I	-0.5	1.00
Pref. Shares and Hybrid Capital accounted for as Equit	I	-0.5	1.00
Total Equity	I	-0.5	1.00
Total Liabilities and Equity			

Notes: Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. The variable is defined as:

$liquidity\_creation = \{1/2 * illiquid\_assets + 0 * semi\_liquid\_assets - 1/2 * liquid\_assets\} + \{1/2 * liquid\_liabilities + 0 * semi\_liquid\_liabilities - 1/2 * illiquid\_liabilities\} - 1/2 * capital$

Assets and liabilities are classified as liquid, semi-liquid or illiquid based on the criteria used by Berger and Bouwman (2009). The classification for each accounting item is displayed in the table above. Some assumptions were made, as the accounting classification is not identical to the one used in Berger and Bouwman (2009). We consider liquidity creation as a percentage of total assets.

NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding relative to the required stable funding (i.e., assests that need to be funded). The higher this ratio is, the more confotable is the institution's liquidity position. It is defined as:

$NSFR = \frac{available\_stable\_funding}{required\_stable\_funding} * 100$

Each accounting item was given a weight based on the Basel Committee's guidelines. However, it is important to note that this is a rough approximation, as the accounting data available on Banskcope does not allow to accurately classify all the items. The weights chosen are presented in the table above.

Tables and figures

Table 1 - Banks' characteristics

	N	mean	min	p25	p50	p75	max
Total assets	17620	21,200	92	295	659	2,183	772,000
Total capital ratio	10211	14.5	7.3	11.3	12.9	15.6	44.5
Tier 1 ratio	9851	12.6	4.7	9.5	11.2	13.9	41.6
Net interest margin	17561	3.7	0.3	3.0	3.8	4.4	10.4
Return on assets	17596	0.9	-4.9	0.5	1.0	1.3	5.1
Cost to income	17510	67.1	27.4	56.7	65.0	74.2	165.1
Net loans to total assets	17509	63.0	5.1	55.1	66.4	75.2	90.6

Notes: Total assets in millions of USD. The total capital and Tier 1 ratios are calculated according to the regulatory rules defined by the Basel Committee. Net interest margin is defined as net interest income as a percentage of earning assets. Return on assets computed as net income as a percentage of average assets. The cost-to-income ratio is computed as banks operational costs (overheads) as a percentage of income generated before provisions. These variables are included in the Bankscope database. The statistics presented refer to data after outliers were winsorized.

Table 2 - Liquidity indicators - summary statistics

Panel A - Global summary statistics

	N	mean	min	p25	p50	p75	max
Loans to customer deposits	17175	94.5	0.0	73.9	88.1	102.7	365.6
Interbank ratio	3599	143.0	0.0	31.8	71.7	168.1	895.2
Liquidity ratio	17494	16.3	1.2	4.2	7.5	16.7	125.6
Liquidity creation	17620	9.1	-35.7	-4.8	4.8	22.1	69.2
NSFR	17618	115.1	27.8	106.7	121.2	129.9	155.1

Panel B - Liquidity indicators over time (mean)

	2002	2003	2004	2005	2006	2007	2008	2009	Total
Loans to customer deposits	84.1	84.9	89.6	93.0	103.1	106.0	107.9	98.7	94.5
Interbank ratio	195.7	172.2	163.2	152.2	143.8	132.2	122.8	122.1	143.0
Liquidity ratio	14.7	13.4	13.7	15.0	20.6	19.7	18.1	19.1	16.3
Liquidity creation	2.7	2.5	3.8	6.9	13.0	13.7	13.9	24.9	9.1
NSFR	122.2	122.6	119.9	116.9	109.4	108.5	108.2	104.5	115.1

Notes: The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks). The liquidity ratio is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding. The first three variables in this table are included in the Bankscope database. Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). These last two variables are defined in detail in the Appendix. The statistics presented refer to data after outliers were winsorized.

Table 3 - Determinants of liquidity indicators

Dependent variable:	Loan to deposits		Interbank ratio		Liquidity ratio		Liquidity creation		NSFR	
	(1)		(2)		(3)		(4)		(5)	
Total capital ratio $_{t-1}$	0.19		-0.46		0.08		-0.14		0.07	
	1.01		*-0.46*		*1.15*		*-1.56*		*0.85*	
Log Assets $_{t}$	5.09	**	-8.05		-2.50	**	-5.87	***	-2.69	**
	2.09		*-0.46*		*-2.23*		*-4.96*		*-2.46*	
Net interest margin $_{t-1}$	-1.82	**	3.35		-0.05		-1.37	***	2.11	***
	-2.29		*0.78*		*-0.17*		*-3.96*		*5.95*	
Return on assets $_{t-1}$	1.42	*	-1.51		-0.63	**	0.68	*	-1.43	***
	1.73		*-0.25*		*-2.11*		*1.81*		*-3.66*	
Cost-to-income $_{t-1}$	0.02		-0.13		0.00		0.08	***	-0.04	**
	0.43		*-0.54*		*-0.04*		*3.72*		*-2.10*	
Net loans to total assets $_{t-1}$	1.04	***	-2.24	**	-0.20	***	0.29	***	0.11	**
	8.79		*-2.24*		*-5.51*		*6.72*		*2.03*	
Loans to customer deposits $_{t-1}$	-		0.16		0.00		-0.02	**	-0.08	***
	-		*1.31*		*-0.39*		*-2.01*		*-5.77*	
Interbank ratio $_{t-1}$	-		-		-		-		-	
	-		-		-		-		-	
Liquidity ratio $_{t-1}$	0.30	***	0.02		-		0.23	***	0.04	
	3.54		*0.05*		-		*7.90*		*1.36*	
Liquidity creation $_{t-1}$	-0.49	***	1.59	***	0.11	***	-		-0.14	***
	-5.13		*3.21*		*3.63*		-		*-4.22*	
NSFR $_{t-1}$	-0.61	***	1.30	***	0.17	***	-0.15	***	-	
	-7.38		*2.73*		*6.16*		*-5.31*		-	
D2004	1.67	**	0.48		-0.34		-3.74	***	2.10	***
	2.18		*0.03*		*-0.93*		*-10.36*		*5.36*	
D2005	2.27	**	6.28		-0.53		-3.66	***	1.13	**
	2.26		*0.43*		*-1.49*		*-8.58*		*2.55*	
D2006	3.64	***	9.37		0.36		-7.35	***	4.49	***
	4.44		*0.72*		*1.15*		*-21.51*		*11.57*	
D2007	5.56	***	-0.93		-0.02		-9.08	***	4.79	***
	6.58		*-0.08*		*-0.07*		*-23.22*		*12.18*	
D2008	7.50	***	-6.93		-1.38	***	-11.59	***	5.08	***
	10.76		*-0.80*		*-5.37*		*-27.44*		*13.43*	
Constant	348.9	***	445.2		-19.8		-593.2	***	355.24	***
	4.82		*0.66*		*-0.63*		*-15.33*		*9.92*	
Number of observations	7,018		1,885		7,018		7,020		7,020	
Number of banks	1,735		529		1,736		1,738		1,738	
R2 within	0.160		0.059		0.102		0.366		0.160	
R2 between	0.151		0.038		0.303		0.139		0.165	
R2 overall	0.129		0.017		0.276		0.103		0.138	
Frac. of variance due to bank FE	0.965		0.729		0.966		0.998		0.984	

Notes: All regressions include country-year fixed-effects, bank fixed-effects and robust standard errors. t-statistics in italics. The total capital ratio is calculated according to the regulatory rules defined by the Basel Committee. Net interest margin is defined as net interest income as a percentage of earning assets. Return on assets computed as net income as a percentage of average assets. The cost-to-income ratio is computed as banks operational costs (overheads) as a percentage of income generated before provisions. The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks). The liquidity ratio is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding. All these variables are included in the Bankscope database. Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). These last two variables are defined in detail in the Appendix. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 4 - Dispersion in liquidity indicators and residuals

	Loans to deposits			Residuals		Interbank ratio			Residuals		Liquidity ratio			Residuals		Liquidity creation			Residuals		NSFR			Residuals	
	Gini coef.	Std. Dev	Coef. of variatio	Std. Dev	Coef. of variatio	Gini coef.	Std. Dev	Coef. of variatio	Std. Dev	Coef. of variatio	Gini coef.	Std. Dev	Coef. of variatio	Std. Dev	Coef. of variatio	Gini coef.	Std. Dev	Coef. of variation	Std. Dev	Coef. of variatio	Gini coef.	Std. Dev	Coef. of variatio	Std. Dev	Coef. of variatio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
2002	0.18	34.4	0.4			0.53	215.4	1.1			0.51	18.8	1.3			-	19.1	7.0			0.08	20.3	0.2		
2003	0.18	35.2	0.4	40.2	-15.8	0.56	197.8	1.1	193.7	-23.9	0.54	18.4	1.4	18.7	-18.6	-	19.1	7.7	22.9	13.0	0.08	20.2	0.2	18.0	-22.5
2004	0.19	39.1	0.4	39.3	-18.9	0.54	185.6	1.1	150.2	-8.2	0.58	20.2	1.5	20.3	-36.8	-	19.2	5.0	21.3	9.7	0.09	21.0	0.2	17.5	-42.9
2005	0.20	41.9	0.5	45.0	17.0	0.58	200.6	1.3	166.1	-15.2	0.58	21.4	1.4	23.2	4.8	-	19.1	2.8	21.4	3.0	0.09	21.9	0.2	18.2	-8.5
2006	0.23	52.9	0.5	39.1	-48.0	0.57	179.2	1.2	137.4	-42.4	0.60	26.9	1.3	22.5	-21.6	-	21.2	1.6	21.5	-14.8	0.12	24.4	0.2	14.8	45.4
2007	0.23	53.1	0.5	39.2	104.0	0.58	173.2	1.3	140.3	60.6	0.61	26.3	1.3	23.2	350.7	-	21.0	1.5	21.8	-23.7	0.12	24.5	0.2	15.6	-2220.0
2008	0.24	56.8	0.5	45.4	39.8	0.61	165.2	1.3	140.8	26.5	0.60	24.3	1.3	20.5	-261.3	-	21.2	1.5	22.2	-27.1	0.12	25.0	0.2	16.0	56.3
2009	0.23	53.1	0.5	39.9	456.0	0.62	172.8	1.4	149.7	17.3	0.55	23.6	1.2	20.1	-58.2	-	18.0	0.7	16.2	-11.5	0.11	22.1	0.2	14.2	18.1
Total	0.21	45.9	0.5	41.1	-	0.58	183.6	1.3	149.0	-	0.58	22.4	1.4	21.5	-	-	20.8	2.3	21.0	-	0.10	23.2	0.2	15.9	-

Notes: The table displays the Gini coefficients of the liquidity indicators (columns 1, 6, 11, 16 and 21), the standard deviations of these indicators (columns 2, 7, 12, 17 and 22) and of the residuals of the regressions on the determinants of these liquidity indicators (columns 4, 9, 14, 19 and 24), as well as the coefficient of variation for the indicators and the residuals (columns 3, 5, 8, 10, 13, 15, 18, 20, 23 and 25). The Gini coefficient was not computed for the liquidity creation, as this variable has many negative values. The residuals refer to the results of the estimations shown in Table 3. The coefficient of variation for the total residuals is impossible to compute as the average of the residuals is zero. The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks). The ratio of liquid assets to customer and short term funding is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding. These variables are included in the Bankscope database. Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). These last two variables are defined in detail in the Appendix.

Table 5 - Measurement of herd behavior (mean)

	Loans to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR
2003	0.124 ***	0.035 **	-0.037 ***	0.130 ***	0.117 **
2004	-0.040 ***	0.009	-0.030 ***	-0.033 ***	-0.034 ***
2005	0.137 ***	0.009	0.133 ***	-0.030 ***	-0.041 ***
2006	0.112 ***	-0.007	-0.028 ***	-0.031 ***	-0.023 ***
2007	-0.012 ***	0.009 *	0.049 ***	0.035 ***	-0.024 ***
2008	0.111 ***	-0.016 ***	0.139 ***	0.057 ***	0.074 ***
2009	0.188 ***	0.032 ***	0.150 ***	0.093 ***	0.070 ***

Notes: Herd behavior measure based on Uchida and Nakagawa (2007) and Lakonishok et al (1992). The herding measure is computed as Hi = |Pi - Pt | - E|Pi - Pt |, where Pi is the proportion of banks that show an increase in risk for a given liquidity indicator in each country and in each year (i.e., increases in the loan to deposit ratio and liquidity creation or decreases in the interbank ratio, liquidity ratio or NSFR) and Pt is the mean of Pi in each year. Liquidity indicators as defined in previous tables.*** significant at 1%; ** significant at 5%; * significant at 10%.

Table 6 - Regressions on peer effects in liquidity strategies

	Interaction with other banks - country year rivals (without IV)					Interaction with other banks (country year rivals) - IV = predicted values of rivals' liquidity ratios					First-step regressions				
	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Peer effects	0.32 ***	0.19 **	0.46 ***	0.81 ***	0.43 ***	0.39 ***	0.81	0.72 ***	0.56 ***	0.36	1.13 ***	0.35 ***	0.86 ***	0.92 ***	0.24 ***
	4.87	*2.33*	*7.96*	*18.62*	*7.54*	*6.64*	*1.09*	*8.88*	*9.02*	*1.08*	*32.47*	*3.24*	*29.16*	*31.28*	*7.21*
Total capital ratio $_{t-1}$	0.19	-0.60	0.03	-0.19 **	0.08	0.18 *	-0.87	0.01	-0.18 ***	0.08	0.12 **	0.57	0.05 ***	0.03	-0.02
	1.01	*-0.61*	*0.46*	*-2.29*	*0.91*	*1.75*	*-0.78*	*0.15*	*-3.63*	*1.51*	*2.20*	*1.36*	*3.07*	*1.15*	*-0.83*
Log Assets $_{t}$	2.76	-6.20	-1.46	-1.73	-2.86 **	2.19 *	-3.24	-0.88 *	-3.02 ***	-2.80 ***	0.51	-4.98	-0.41 **	-2.86 ***	0.87 ***
	1.12	*-0.35*	*-1.23*	*-1.61*	*-2.56*	*1.77*	*-0.23*	*-1.82*	*-4.95*	*-4.77*	*0.79*	*-0.91*	*-2.05*	*-10.22*	*3.47*
Net interest margin $_{t-1}$	-1.42 *	3.17	-0.03	-1.08 ***	1.90 ***	-1.32 ***	2.72	-0.02	-1.17 ***	1.94 ***	-0.53 **	0.60	-0.15 **	-0.29 ***	0.41 ***
	-1.88	*0.74*	*-0.10*	*-3.26*	*5.28*	*-2.92*	*0.71*	*-0.10*	*-5.71*	*7.18*	*-2.26*	*0.38*	*-2.05*	*-2.76*	*4.39*
Return on assets $_{t-1}$	1.39 *	-0.70	-0.62 **	0.56	-1.34 ***	1.36 ***	0.99	-0.62 ***	0.60 ***	-1.36 ***	0.60 **	-4.16 **	-0.16 *	-0.05	-0.19 *
	1.78	*-0.12*	*-2.25*	*1.59*	*-3.46*	*2.69*	*0.18*	*-3.18*	*2.60*	*-5.25*	*2.25*	*-2.07*	*-1.88*	*-0.39*	*-1.85*
Cost-to-income $_{t-1}$	0.02	-0.11	0.00	0.05 ***	-0.04 *	0.02	-0.11	-0.01	0.06 ***	-0.04 ***	0.03 **	-0.12	-0.01	0.02 ***	-0.02 ***
	0.56	*-0.45*	*-0.22*	*2.64*	*-1.81*	*0.90*	*-0.36*	*-0.55*	*4.43*	*-2.80*	*2.28*	*-0.97*	*-1.31*	*2.79*	*-2.93*
Net loans to total assets $_{t-1}$	0.95 ***	-2.15 **	-0.16 ***	0.26 ***	0.12 **	0.93 ***	-1.67 *	-0.13 ***	0.26 ***	0.12 ***	0.11 ***	-0.49	-0.05 ***	0.04 **	-0.01
	8.45	*-2.15*	*-4.46*	*6.34*	*2.18*	*15.20*	*-1.88*	*-5.39*	*9.17*	*3.72*	*3.37*	*-1.62*	*-5.37*	*2.54*	*-0.99*
Loans to customer deposits $_{t-1}$	-	0.15	0.00	0.00	-0.08 ***	-	0.10	0.00	0.00	-0.08 ***	-	0.05	0.00	-0.02 ***	0.00
	-	*1.24*	*-0.30*	*0.43*	*-6.02*	-	*0.74*	*-0.49*	*-0.51*	*-10.95*	-	*1.01*	*1.03*	*-6.33*	*0.63*
Interbank ratio $_{t-1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liquidity ratio $_{t-1}$	0.31 ***	-0.05	-	0.12 ***	0.05 *	0.32 ***	-0.20	-	0.15 ***	0.05 **	-0.02	0.23	-	0.12 ***	-0.04 ***
	3.81	*-0.15*	-	*4.34*	*1.90*	*7.47*	*-0.46*	-	*6.72*	*2.22*	*-1.07*	*1.36*	-	*11.05*	*-4.50*
Liquidity creation $_{t-1}$	-0.40 ***	1.54 ***	0.06 **	-	-0.13 ***	-0.38 ***	1.41 ***	0.03	-	-0.13 ***	-0.09 ***	0.11	0.06 ***	-	-0.04 ***
	-4.31	*3.17*	*1.98*	-	*-3.79*	*-7.78*	*3.29*	*1.49*	-	*-5.92*	*-3.68*	*0.65*	*7.54*	-	*-4.65*
NSFR $_{t-1}$	-0.55 ***	1.26 ***	0.13 ***	-0.12 ***	-	-0.54 ***	1.12 ***	0.11 ***	-0.13 ***	-	-0.11 ***	0.14	0.05 ***	-0.03 ***	-
	-7.11	*2.70*	*5.11*	*-4.53*	-	*-13.66*	*2.68*	*7.05*	*-7.58*	-	*-5.42*	*0.87*	*7.21*	*-3.84*	-
Constant	357.8 ***	288.2	-26.7	69.7	72.8	361.5 ***	-473.7	-30.1	-137.2 **	119.3	-303.9 ***	382.2	39.7 ***	-100.9 ***	587.8 ***
	4.95	*0.41*	*-0.86*	*1.27*	*1.31*	*6.83*	*-0.56*	*-1.48*	*-2.44*	*0.54*	*-10.48*	*1.40*	*4.59*	*-3.84*	*39.78*
Number of observations	7,016	1,882	7,016	7,019	7,019	7,010	1,877	7,010	7,012	7,012	7,010	1,877	7,010	7,012	7,012
Number of banks	1,734	528	1,735	1,737	1,737	1,733	527	1,734	1,736	1,736	1,733	527	1,734	1,736	1,736
R2 within	0.187	0.066	0.141	0.477	0.186	0.186	0.009	0.127	0.467	0.186	0.427	0.135	0.324	0.705	0.484
R2 between	0.155	0.079	0.135	0.329	0.501	0.158	0.003	0.000	0.095	0.524	0.330	0.041	0.573	0.399	0.555
R2 overall	0.132	0.051	0.105	0.331	0.455	0.134	0.013	0.001	0.055	0.471	0.316	0.036	0.466	0.313	0.494

Notes: All regressions include year, country-year and bank fixed-effects. t-statistics in italics. Peers are defined as the j≠i banks operating in the same country and in the same year as bank i. Columns 1-5 show the results obtained when peer liquidity choices are considered directly in the regressions, i.e., not addressing the reflection problem. Columns 6-10 show the results of the instrumental variables regressions (one for each liquidity indicator), where the instruments are the predicted values of peers' liquidity ratios. These predicted values result from the estimation of the regressions in Table 3. Columns 11-15 show the first stage estimation results for these three instrumental variables regressions. The total capital ratio is calculated according to the regulatory rules defined by the Basel Committee. Net interest margin is defined as net interest income as a percentage of earning assets. Return on assets computed as net income as a percentage of average assets. The cost-to-income ratio is computed as banks operational costs (overheads) as a percentage of income generated before provisions.

The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks). The liquidity ratio is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding. All these variables are included in the Bankscope database. Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). These last two variables are defined in detail in the Appendix. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 7 - Regressions on peer effects in liquidity strategies - robustness

	Interaction with other banks - country year rivals (without IV)					Interaction with other banks (country year rivals) - IV = predicted values of rivals' liquidity					First-step regressions				
	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baseline															
Peer effects	0.32 ***	0.19 **	0.46 ***	0.81 ***	0.43 ***	0.39 ***	0.81	0.72 ***	0.56 ***	0.36	1.13 ***	0.35 ***	0.86 ***	0.92 ***	0.24 ***
	4.87	*2.33*	*7.96*	*18.62*	*7.54*	*6.64*	*1.09*	*8.88*	*9.02*	*1.08*	*32.47*	*3.24*	*29.16*	*31.28*	*7.21*
Before the crisis															
Peer effects	0.04	0.06	0.31 ***	0.46 ***	0.12	0.33	1.36	0.76 **	0.35 ***	0.33 *	0.48 ***	-0.15	0.33 **	0.57 ***	-0.63 ***
	0.50	*0.51*	*2.86*	*5.24*	*1.54*	*1.44*	*0.37*	*2.32*	*2.74*	*1.94*	*8.04*	*-0.74*	*2.32*	*16.12*	*-15.89*
Dependent variable: changes in liquidity ratios															
Peer effects	0.22 ***	0.22 ***	0.16 ***	0.70 ***	0.45 ***	0.77 *	-1.10	0.15	4.51	-2.07	0.26 ***	-0.30 *	-0.33 ***	-0.01	-0.08 **
	3.87	*3.21*	*3.23*	*18.05*	*10.18*	*1.90*	*-0.76*	*0.50*	*0.31*	*-1.14*	*4.73*	*-1.74*	*-8.40*	*-0.29*	*-1.98*
All variables as first differences															
Peer effects	0.26 ***	0.14 *	0.22 ***	0.84 ***	0.59 ***	0.79 *	-0.86	-0.05	-1.55	-0.76	0.25 ***	-0.34 *	-0.32 ***	0.01	-0.09 **
	3.65	*1.87*	*3.38*	*18.60*	*9.47*	*1.77*	*-0.68*	*-0.15*	*-0.12*	*-0.57*	*4.45*	*-1.95*	*-8.01*	*0.23*	*-2.17*
Removing banks with asset growth above 50%															
Peer effects	0.32 ***	0.16 *	0.42 ***	0.79 ***	0.39 ***	0.42 ***	0.21	0.64 ***	0.53 ***	0.42 ***	0.87 ***	0.17	0.84 ***	0.70 ***	0.53 ***
	4.50	*1.83*	*6.99*	*17.94*	*7.00*	*6.06*	*0.13*	*7.98*	*7.97*	*2.60*	*27.29*	*1.43*	*29.51*	*27.98*	*14.46*
Excluding US banks															
Peer effects	0.26 ***	0.18 **	0.25 ***	0.24 ***	0.19 ***	0.22 **	0.80	0.42 **	-1.87	0.28 *	1.07 ***	0.29 ***	0.77 ***	0.18 **	0.73 ***
	4.16	*2.15*	*4.24*	*2.92*	*2.94*	*2.22*	*0.92*	*2.43*	*-1.47*	*1.95*	*16.23*	*2.76*	*12.86*	*2.51*	*14.31*
Without country-year fixed effects															
Peer effects	0.32 ***	0.19 **	0.46 ***	0.81 ***	0.43 ***	0.33 **	0.81	0.72 ***	0.43 ***	0.36	0.18 ***	0.35 ***	0.86 ***	0.04 ***	0.24 ***
	4.87	*2.33*	*7.96*	*18.62*	*7.54*	*2.57*	*1.09*	*8.88*	*3.46*	*1.08*	*13.68*	*3.24*	*29.16*	*14.63*	*7.21*
Without liquidity controls															
Peer effects	0.36 ***	0.21 **	0.53 ***	0.81 ***	0.41 ***	0.54 ***	1.33 **	0.83 ***	0.54 ***	0.25	0.89 ***	0.49 ***	0.63 ***	1.02 ***	-0.18 ***
	5.33	*2.47*	*8.51*	*19.91*	*6.90*	*6.37*	*1.97*	*7.17*	*8.58*	*0.44*	*21.72*	*3.83*	*20.48*	*29.89*	*-4.38*
Only after 2004															
Peer effects	0.41 ***	0.24 ***	0.49 ***	0.89 ***	0.53 ***	0.47 ***	1.04 *	0.77 ***	0.58 ***	0.45 **	1.15 ***	0.54 ***	0.84 ***	0.83 ***	0.48 ***
	6.18	*3.85*	*8.04*	*20.90*	*9.01*	*6.51*	*1.80*	*7.11*	*6.41*	*2.31*	*26.73*	*4.37*	*21.83*	*21.72*	*12.38*

Notes: Peers are defined as the $j \neq i$ banks operating in the same country and in the same year as bank i. t-statistics in italics. Each line shows the coefficients for these peer effects for different robustness tests. The pre-crisis period refers to the years 2002-2006. In the third group of regressions, the dependent variable was first-differenced, whereas in the fourth group this procedure was applied to all the variables. Columns 1-5 show the results obtained when peer liquidity choices are considered directly in the regressions, i.e., not addressing the reflection problem. Columns 6-10 show the results of the instrumental variables regressions, where the instruments are the predicted values of peers' liquidity ratios. These predicted values result from the estimation of the regressions in Table 3. Columns 11-15 show the first stage estimation results for these instrumental variables regressions.

All the regressions use the same control variables as those reported in Table 6. All regressions include year, country-year and bank fixed-effects, unless otherwise stated. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 8 - Regressions on peer effects in liquidity strategies - robustness on peer group definition

	Interaction with other banks - country year rivals (without IV)					Interaction with other banks (country year rivals) IV = predicted values of rivals' liquidity ratios					First-step regressions				
	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR	Loan to deposits	Interbank ratio	Liquidity ratio	Liquidity creation	NSFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baseline															
Peer effects	0.32 ***	0.19 **	0.46 ***	0.81 ***	0.43 ***	0.39 ***	0.81	0.72 ***	0.56 ***	0.36	1.13 ***	0.35 ***	0.86 ***	0.92 ***	0.24 ***
	4.87	*2.33*	*7.96*	*18.62*	*7.54*	*6.64*	*1.09*	*8.88*	*9.02*	*1.08*	*32.47*	*3.24*	*29.16*	*31.28*	*7.21*
Lagged peers															
Peer effects	0.13 **	-0.09	0.32 ***	0.38 ***	0.03	0.38 ***	0.19	0.75 ***	0.74 ***	0.79	1.19 ***	0.34 **	0.64 ***	0.63 ***	0.09 ***
	2.47	*-1.20*	*5.18*	*5.83*	*0.65*	*5.78*	*0.23*	*5.76*	*6.00*	*0.67*	*28.06*	*2.47*	*5.76*	*29.18*	*2.63*
Peers as other banks (in other countries) in the same quartile															
Peer effects	0.11	-0.09	-0.04	0.82 ***	0.21 ***	0.08	2.01	0.22	0.30	-0.11	0.10 ***	-0.11 ***	-0.14 ***	0.02 ***	0.06 ***
	1.04	*-0.36*	*-0.45*	*9.50*	*3.59*	*0.43*	*1.56*	*1.02*	*1.22*	*-0.39*	*31.52*	*-6.27*	*-29.37*	*19.71*	*13.12*
Large banks (4th quartile in each country)															
Peer effects	0.22 ***	0.07	0.30 ***	0.40 ***	0.27 ***	0.36 ***	-0.05	0.39 ***	0.10	0.35 ***	1.49 ***	0.97 ***	1.51 ***	0.53 ***	1.40 ***
	3.37	*1.16*	*3.82*	*5.97*	*4.40*	*7.15*	*-0.27*	*5.05*	*0.33*	*5.05*	*29.00*	*7.08*	*23.10*	*6.03*	*27.97*
Only larger banks (3rd and 4th quartiles)															
Peer effects	0.26 ***	0.11	0.42 ***	0.63 ***	0.39 ***	0.34 ***	0.63 **	0.59 ***	0.59 ***	0.33 **	1.45 ***	0.88 ***	1.37 ***	1.24 ***	0.71 ***
	3.39	*1.24*	*7.46*	*10.45*	*7.38*	*6.49*	*2.26*	*8.46*	*6.64*	*2.46*	*35.78*	*6.54*	*29.27*	*21.26*	*16.48*
Only smaller banks (1st and 2nd quartiles)															
Peer effects	0.21 ***	0.10	0.21 ***	0.75 ***	0.34 ***	0.24 ***	1.50 *	0.51 ***	0.98 **	0.16	1.53 ***	0.25 ***	0.85 ***	0.14 ***	0.93 ***
	3.89	*1.07*	*3.71*	*12.19*	*4.14*	*3.71*	*1.69*	*3.74*	*1.98*	*1.50*	*21.67*	*2.82*	*13.95*	*3.41*	*18.05*
Only larger banks (top 5 in each country)															
Peer effects	0.04	0.07	0.21 **	0.15 *	0.17 **	0.31 **	-0.27	-0.09	-0.04	0.26	1.03 ***	0.46 *	0.84 ***	0.65 ***	0.70 ***
	0.75	*0.94*	*2.39*	*1.78*	*2.27*	*2.57*	*-0.40*	*-0.45*	*-0.12*	*1.27*	*9.13*	*1.82*	*5.76*	*3.93*	*6.80*
Only larger banks (banks classified as SIFIs)															
Peer effects	-0.69 ***	-0.20	0.70 ***	-0.03	0.21	-0.70 ***	0.16	0.71 **	-0.27	0.48	0.83 ***	1.63 ***	2.03 ***	0.75 ***	1.07 ***
	-2.98	*-1.35*	*3.38*	*-0.14*	*1.11*	*-2.61*	*0.63*	*2.21*	*-0.52*	*1.27*	*4.67*	*4.57*	*3.88*	*2.80*	*4.30*
Only larger banks (banks that belong to the Euribor panel)															
Peer effects	0.10	-0.16	-0.02	0.46 **	0.17 *	0.05	-0.19	0.13	-0.37	0.38 *	1.12 ***	0.91 ***	0.46 **	0.49	0.81 ***
	0.68	*-1.31*	*-0.08*	*2.55*	*1.70*	*0.26*	*-0.52*	*0.19*	*-0.38*	*1.87*	*6.21*	*3.27*	*2.27*	*1.41*	*6.73*
Small banks following large banks (4th quartile)															
Peer effects	0.26 ***	0.21 **	0.26 ***	0.59 ***	-0.01	0.27 ***	0.11	0.60 ***	-0.41 **	-0.15 **	1.47 ***	0.77 ***	1.56 ***	0.79 ***	1.28 ***
	5.01	*2.10*	*4.44*	*7.41*	*-0.24*	*6.07*	*0.48*	*11.18*	*-2.35*	*-2.15*	*39.39*	*8.41*	*30.80*	*13.97*	*33.65*
Small banks following large banks (top 5)															
Peer effects	0.22 ***	0.09	0.17 ***	-0.84 ***	-0.30 ***	0.16 ***	0.00	0.67 ***	-1.38 ***	-0.27 ***	1.16 ***	0.55 ***	0.94 ***	0.48 ***	1.64 ***
	3.86	*1.28*	*4.47*	*-9.66*	*-7.13*	*3.59*	*0.00*	*10.40*	*-4.33*	*-5.71*	*46.14*	*3.94*	*23.56*	*10.94*	*44.99*
Small banks following large banks (SIFI list)															
Peer effects	0.10 *	0.16	0.32 ***	-0.47 ***	0.00	0.25 ***	0.71 **	1.02 ***	-1.84 ***	0.33 ***	0.97 ***	0.98 ***	0.77 ***	0.77 ***	1.36 ***
	1.95	*1.17*	*3.29*	*-5.82*	*-0.01*	*4.57*	*2.46*	*12.33*	*-14.06*	*3.42*	*40.88*	*9.27*	*27.66*	*31.15*	*33.97*
Small banks following large banks (Euribor panel)															
Peer effects	0.17 **	0.91 ***	0.31 ***	-0.21 ***	-0.03	0.26 ***	2.12 ***	1.03 ***	-0.86 ***	-0.30 ***	0.74 ***	0.76 ***	0.53 ***	1.18 ***	0.94 ***
	2.04	*2.89*	*3.36*	*-3.41*	*-0.51*	*4.37*	*3.58*	*14.41*	*-9.77*	*-4.92*	*58.86*	*10.55*	*50.14*	*38.85*	*60.01*
Euro area as one peer group															
Peer effects	0.37 ***	0.22 **	0.57 ***	0.85 ***	0.47 ***	0.30 ***	0.23	0.68 ***	1.29 ***	4.00	0.90 ***	0.26 **	1.03 ***	0.18 ***	0.02
	5.22	*2.25*	*8.77*	*18.87*	*7.49*	*4.61*	*0.22*	*9.96*	*10.47*	*0.68*	*30.62*	*2.40*	*40.44*	*15.39*	*0.74*

Notes: t-statistics in italics. Each line shows the coefficients for these peer effects for different robustness tests. Bank quartiles were defined based on banks' total assets. Top 5 referes to the banks classified as being in the top 5 by assets in each country in Bankscope. The list of SIFIs (systemically important financial institutions) is the one disclosed by the Financial Stability Board in 2011. Columns 1-5 show the results obtained when peer liquidity choices are considered directly in the regressions, i.e., not addressing the reflection problem. Columns 6-10 show the results of the instrumental variables regressions, where the instruments are the predicted values of peers' liquidity ratios. These predicted values result from the estimation of the regressions in Table 3. Columns 11-15 show the first stage estimation results for these instrumental variables regressions. All the regressions use the same control variables as those reported in Table 6. All regressions include year, country-year and bank fixed-effects. *** significant at 1%; ** significant at 5%; * significant at 10%.

Figure 1

Empirical distribution of the ratio between loans and customers deposits

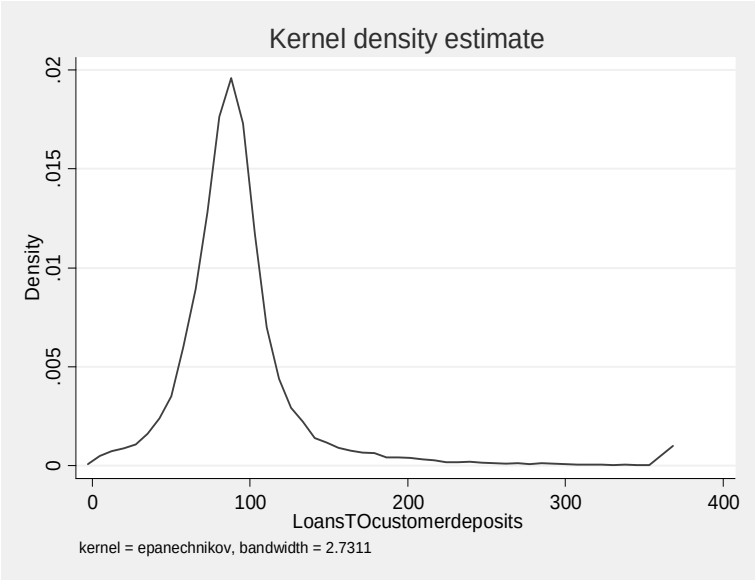


Figure 2

Empirical distribution of the ratio between loans and customers deposits - by year

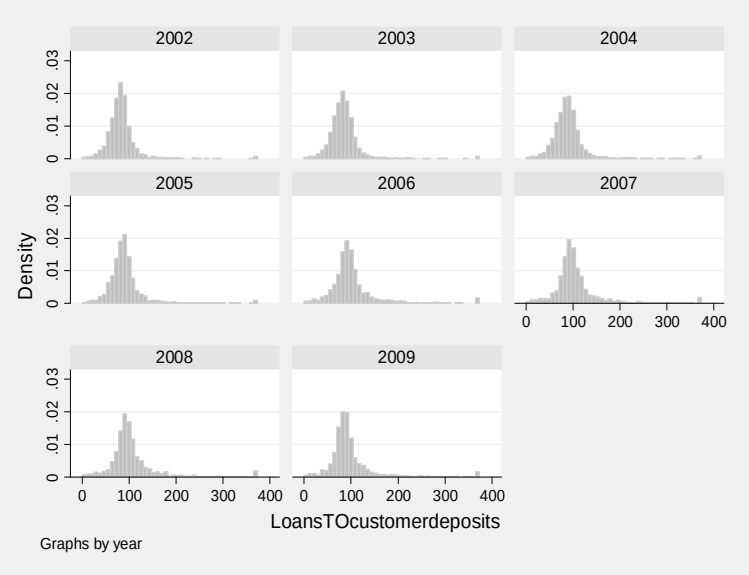
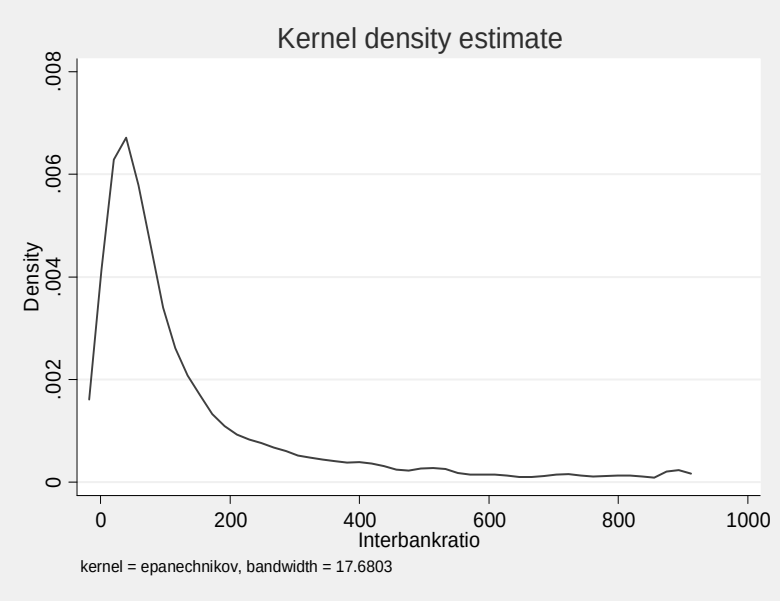


Figure 3

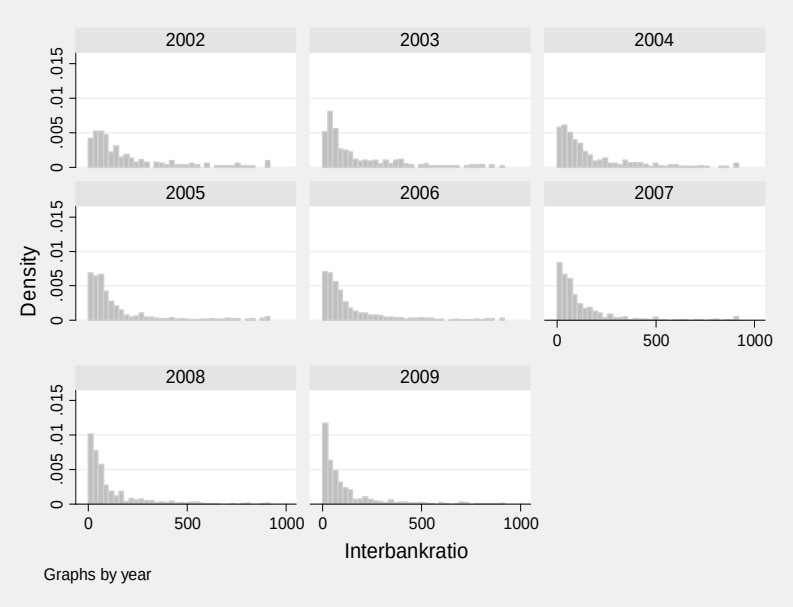
Empirical distribution of the interbank ratio



Note: The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks).

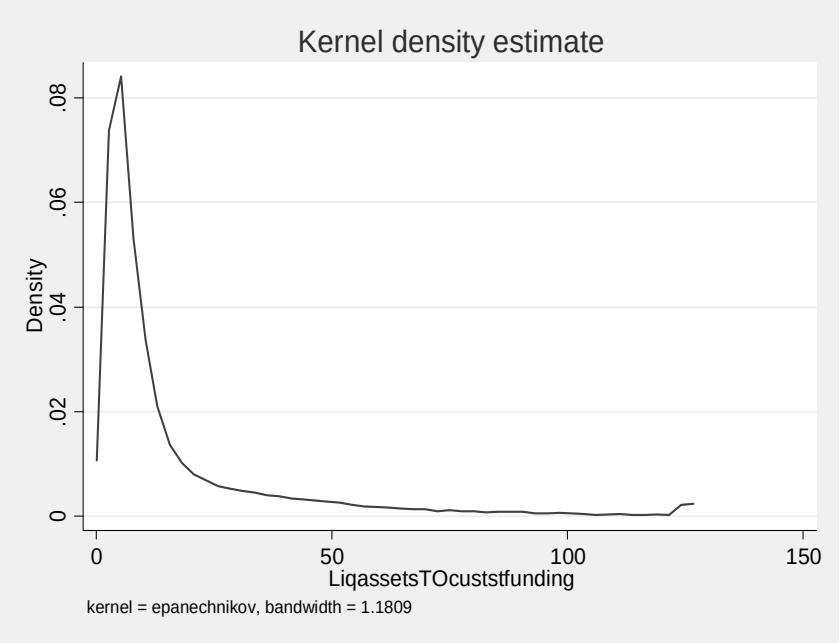
Figure 4

Empirical distribution of the interbank ratio - by year



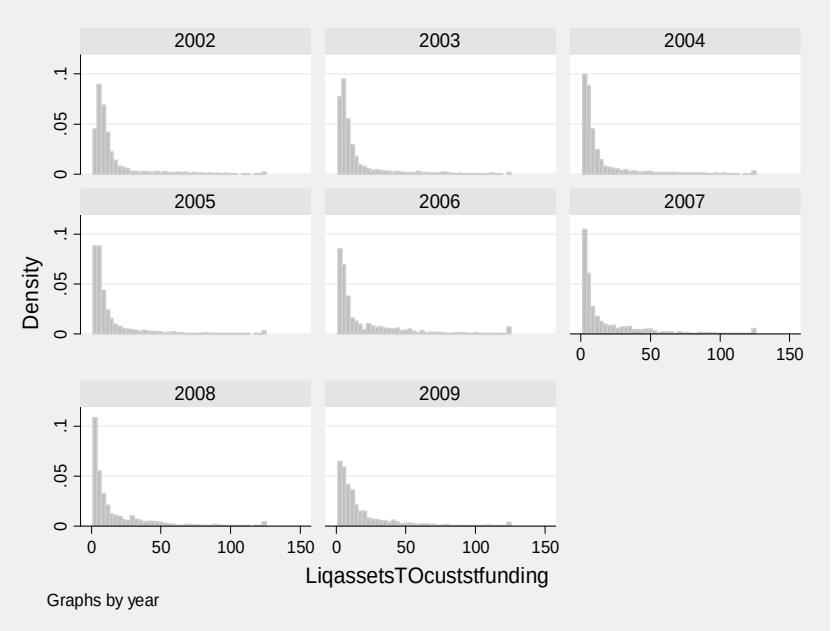
Note: The interbank ratio is defined as interbank assets as a percentage of interbank liabilities (loans to other banks as a percentage of loans from other banks).

Figure 5
Empirical distribution of the liquidity ratio



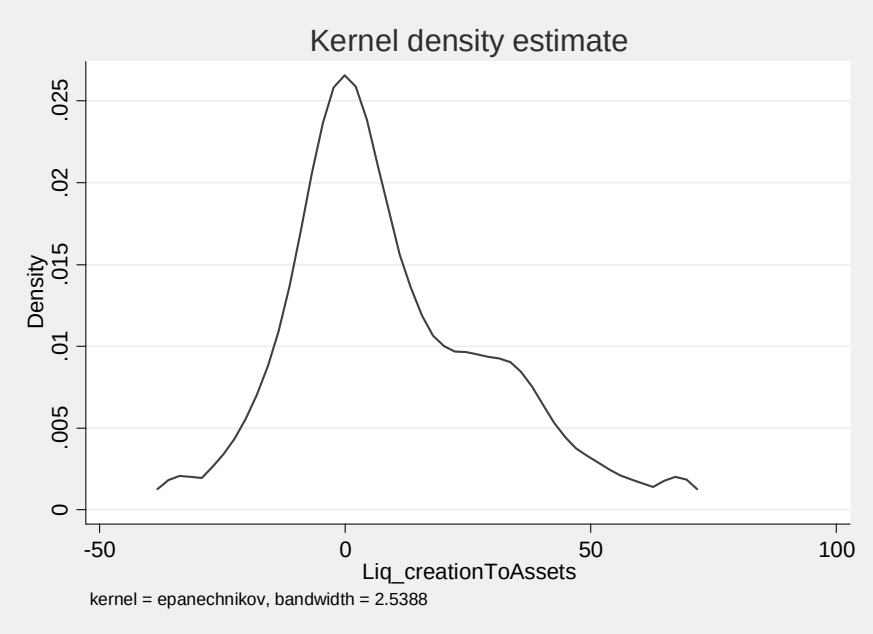
Note: The liquidity ratio is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding.

Figure 6
Empirical distribution of the liquidity ratio - by year



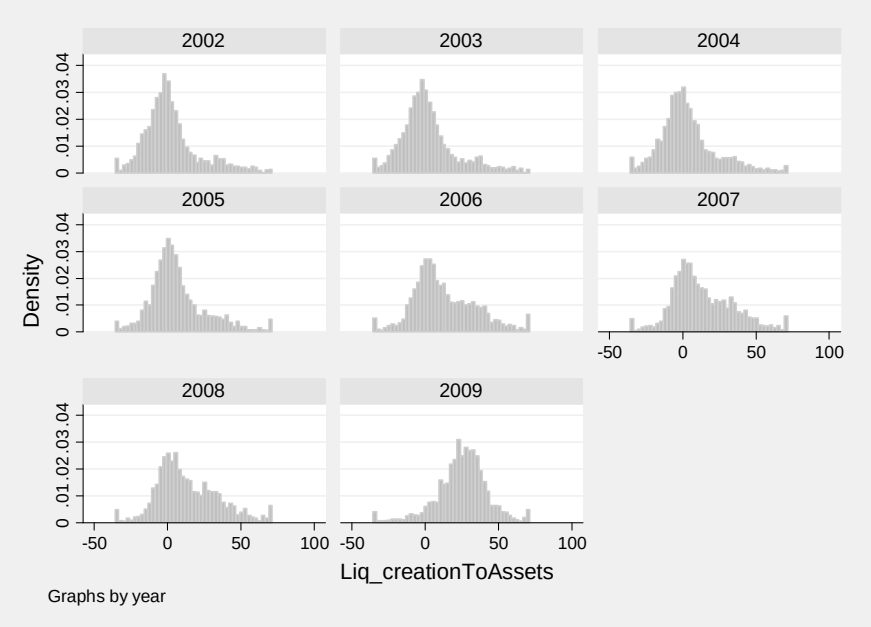
Notes: The liquidity ratio is defined as liquid assets (deposits and loans to banks with less than 3 months residual maturity, quoted/listed government bonds realizable within 3 months, cash and equivalent), as a percentage of customer deposits and short term funding.

Figure 7
Empirical distribution of the liquidity creation ratio



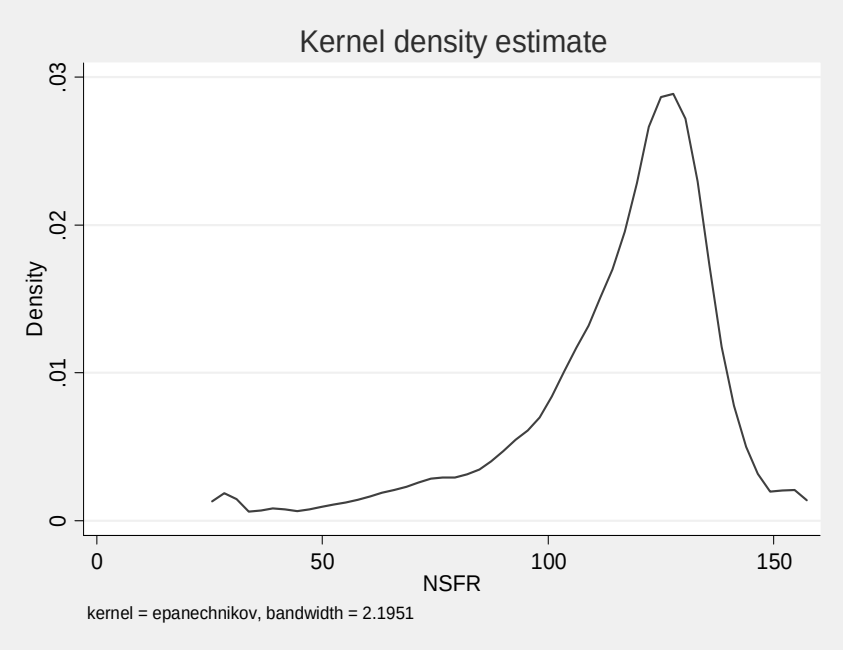
Note: Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. Please see Appendix for further details.

Figure 8
Empirical distribution of the liquidity creation ratio - by year



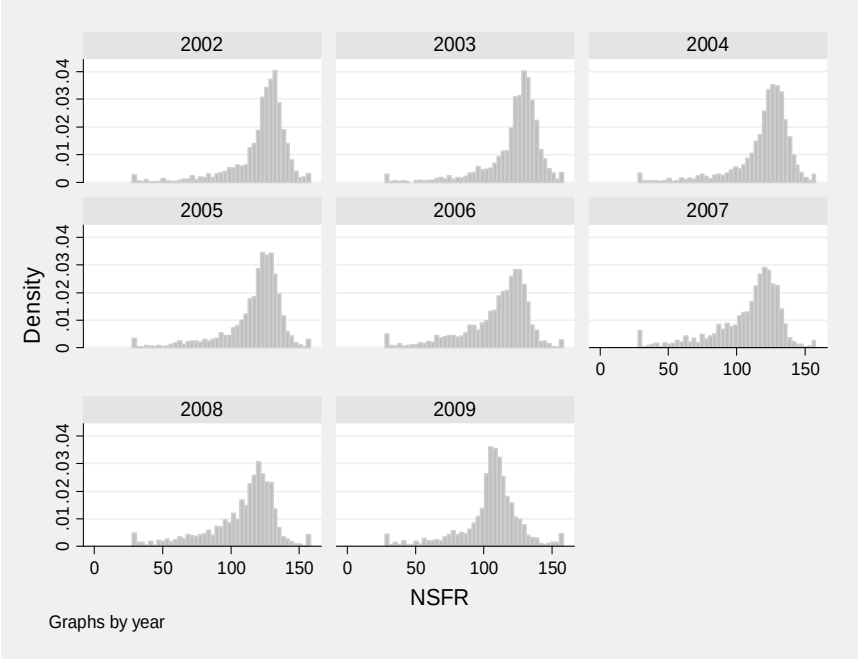
Note: Liquidity creation is a proxy of the liquidity indicator proposed by Berger and Bouwman (2009). The higher this variable is, the more liquidity a bank is creating, i.e., the larger is its maturity transformation role. Please see Appendix for further details.

Figure 9
Empirical distribution of the NSFR



Note: NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). Please see Appendix for further details.

Figure 10
Empirical distribution of the NSFR - by year



Note: NSFR is an approximation of the Net Stable Funding Ratio defined in Basel III, which considers the available stable funding as a percentage of the required stable funding (i.e., assests that need to be funded). Please see Appendix for further details.