ABSTRACT

Title of dissertation: ESSAYS ON SYSTEMIC LIQUIDITY RISK

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This dissertation studies two aspects of the implications of liquidity risk-taking by financial institutions on the economy: first, its effects on macroeconomic volatility and the likelihood of financial distress; second, how the exposure to this source of risk is relevant in determining the failure of financial institutions in times of stress. Optimal regulatory responses are derived in the essays on both the macroprudential and the microprudential front.

The first essay develops a welfare theoretic model to study prudential regulation in an emerging market economy that is facing large short-term capital inflows into the banking system. The prospect of a sudden reversal of those flows exposes the economy to liquidity risk. In the model banks finance investments in short-term and long-term assets by borrowing both locally and externally. Government intervention is rationalized with an externality arising from financial frictions. The potential disruption in external financing constitutes the only source of aggregate risk. The analysis shows that inefficient equilibria exist. In those equilibria banks

underinsure against external financing shocks. The underinsurance is the result of excessive external borrowing together with a relative overinvestment in short-term assets. In the proposed setup efficiency is restored by complementing liability-side instruments, such as unremunerated reserve requirements, with asset-side instruments, such as taxes on short-term assets. The theoretical contribution is twofold: First, the framework rationalizes policy action with instruments that attack distortions in the asset side of banks' balance sheet. Second, the analysis points to the systemic exposure to liquidity risk of banks as being the source of concern and the key vulnerability explaining output collapse after an external financing shock. The latter implication is tested by constructing an index that captures such exposure. Extending a methodology recently introduced by Basel III, the index is developed for a sample of 40 emerging markets and developing countries, covering the financial statements of 1,700 banks. It is shown that the index is a robust explanatory variable for unexpected output declines across emerging markets, after the Lehman's bankruptcy.

The second essay studies the determinants of bank failure during the global financial crisis. It exploits a bank-level dataset that covers about 11,000 banks in the U.S. and Europe from 2001 to 2009 to analyze the evolution of bank funding structures in the run up to the global financial crisis and to study the implications for financial stability. Careful measurement of exposure to liquidity risk is achieved by employing a recently introduced metric, the NSFR, by Basel III. The results show that banks with weaker structural liquidity and higher leverage in the pre-crisis period were more likely to fail afterward. The likelihood of bank failure also

increases with bank risk-taking. The main finding of the essay is that, in the cross-section, the smaller domestically-oriented banks were relatively more vulnerable to liquidity risk, while the large cross-border banks were more susceptible to solvency risk due to excessive leverage. The results point to potentially large gains in moving to international banking regulatory standards that are designed to contemplate the heterogeneity of vulnerabilities across different banks.

ESSAYS ON SYSTEMIC LIQUIDITY RISK

by

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Dedication

To my beloved family: Susana, Vicente and Mariana.

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Dape. An special mention for the first three is warranted.

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Chapter 1

Introduction

Financial crises in both industrialized and emerging market economies have highlighted the relevance of understanding how risk taking by financial institutions build-up systemic financial risk. The recent global financial crisis that started in the summer of 2007 is the latest example. A wave of bank failures in the industrialized world, plus prospects of failure of existing banks, were at the core of the collapse in credit that significantly altered the performance of the economy and the well-being of millions. In emerging market economies, thousands of miles from the epicenter of crisis, the crisis spread through real and financial channels, and the collapse in output and the rise in unemployment were far worse than in most of the industrialized economies.

This dissertation presents two essays in which I investigate the relevance for macroeconomic policy of one specific source of risk taken by financial institutions: liquidity risk. The Basel Committee on Banking Supervision defines it as the risk that a bank is unable to fund increases assets or honor its commitments.[1] The first essay studies how the systemic exposure to liquidity risk is the main vulnerability that emerging market economies build to world-level shocks that are transmitted through financial channels. The essay develops a welfare theoretic framework useful to assess the factors that determine the optimality of such exposure and how/when

[1] See BCBS 2008.

to regulate it. The second essay analyzes how the exposure to different source of risks were determinant of the failure of financial institution and focus the analysis on the relevance of liqudity risk for relatively small institutions.

The remainder of this introductory chapter is as follows: the first section overviews the analysis and results exposed in "Systemic Liquidity Risk-Taking in Emerging Markets" (Chapter 2), and the second section summarizes the exposition in "Bank Funding Structure and Risk: Evidence from the Global Financial Crisis" (Chapter 3).

1.1 Systemic Liquidity Risk-Taking in Emerging Markets

This essay studies prudential regulation in an economy where the banking system is receiving large capital inflows that face the prospects of a sudden reversal. This is a situation regularly faced by emerging market economies and there is a large literature documenting stylized facts observed in these episodes.[2] However, relatively little theoretical work has analyzed the reasons why the banking system may be prone to inefficiencies from an ex-ante perspective, the type of risks that might be overdone, and the circumstances in which an intervention is warranted, if at all.

The essay is motivated in two recent set of observations: First, the shock received by emerging market economies after Lehman Brothers' bankruptcy produced a new set of empirical evidence on the large costs associated with a sudden deterioration of international funding conditions when the banking system is vulnerable. A

[2]see Reinhart and Reinhart (2008) and references therein.

number of countries in Eastern Europe, which had their banking systems heavily exposed to liquidity risk, after receiving large capital inflows after their commitment to join the European Union became evident, suffered output collapses of around 20 percent of GDP in the three quarters following Lehman Brothers' bankruptcy. Second, during the second semester of 2009 there was a resumption of large capital inflows to emerging market economies that encourage their policymakers to intervene in multiple ways to contain the inflows. Policy prescriptions were both quantity-based and price-based and include, but are not limited to, limits on growth rate of credit, caps on the loan-to-deposits ratio, unremunerated reserve requirements on local and external liabilities, requirements for extra buffers of liquid assets and taxes on consumption loans. Given the variety of policy responses to attack the same problem it seems a possibility that the literature has not yet identified exactly what is the market failure that needs to be addressed in these episodes.

The essay develops a welfare theoretic framework in which pecuniary externalities and financial market imperfections provide the rationale for government intervention, in the spirit of the literature on systemic risk modeling. A key innovation in the theoretical framework is that banks extend short-term and long-term credit that is financed with local deposits, that are modeled as a stable source of funding, and external financing, which is short-term, and needs to be rolled over. The redemption of external financing is the only source of aggregate risk. My contribution is to show that same externality that is causing the banks to undervalue insurance ex-ante is producing a distortion in the relative amounts of short-term and long-term credit. Contrary to standard intuition that would suggest that banks

need more liquid types of credit to hedge a liquidity problem, I show that banks have incentives to be already overinvested in short-term credit relative to long-term credit. Basically when we observe that banks underinsure against liquidity risk is because they are borrowing and investing excessively. The overinvestment in assets is a result of the overvaluation of their cash flows. The overvaluation is stronger for the assets that produce the most cash flow in those states where the incentives are distorted and the private pricing kernel differs from the social kernel. Thus, the most liquid types of credit, which pay a larger percentage of their cash-flows in states where incentives are distorted, are relatively overdone with respect to more illiquid types of credit.

As a result, any regulatory framework that intends to restore efficiency needs to attack the distortion that arises in the asset side of banks' balance sheet. I set up the Ramsey planner problem and show that a regulatory framework that achieves efficiency involves a tax on short-term credit together with a tax on external borrowing.

In addition to the precise policy recommendation the model has a relevant general implication: it breaks the equivalency that prevails in existing models of systemic risk where inefficient equilibria display at the same time overborrowing of external financing, an inefficient credit boom and excessive exposure to liquidity risk. The framework presented in this essay distinguishes between the first two and the third and points to excessive exposure to liquidity risk as being the market failure to be addressed.

As a positive implication, the systemic exposure to liquidity risk should be

the best indicator of vulnerability against external financing shocks. I construct an index that captures such exposure by extending a methodology recently introduced by Basel III. The index is computed for a total sample of 40 emerging market and developing economies, covering the financial statements of 1,700 banks. I conduct an event analysis around Lehman Brothers' bankruptcy using the index. The baseline empirical framework follows Blanchard et al (2010), where the objective is to explain the cross country variation in unexpected output collapses across emerging market economies, in the three quarters after Lehman Brothers' bankruptcy. The literature that analyzed this episode found three financial aggregates to be the best explanatory variables, namely, the short-term external debt to GDP, the size of the credit boom previous to the collapse, and the loan-to-deposits ratio of the banking system. The index I developed is robust in these framework. More importantly it reduces substantially the explanatory power of other financial aggregates, indicating that their relevance is partially explained by their capacity to capture the exposure to liquidity risk of the banking system.

To summarize, the essay shows both theoretically and empirically that the key vulnerability developed in episodes of large capital inflows into de banking system is the systemic exposure to the liquidity risk. The essay provides a regulatory framework that requires instruments that address the exposure both on the asset and liability side. In addition, it is shown that three financial aggregates that are being the target of policy prescriptions are in fact symptoms of the more general problem: the exposure to liquidity risk.

1.2 Bank Funding Structure and Risk: Evidence from the Global Financial Crisis

This essay is joint work with Francisco Vazquez and constitutes the third chapter of the dissertation. Francisco is a senior economist at the International Monetary Fund. The essay studies the determinants of bank failure across industrialized economies during the global financial crisis. There has been substantial interest on the matter in light of the proposed reforms on international regulatory standards for financial institutions. The main areas being discusses are the regulation of leverage and liquidity. The essay sets up an empirical model with various bank-level and system-level risk indicators that is estimated on a large sample of banks in the developed world.

Different from previous work, the essay measures structural liquidity and leverage in bank balance sheets in a way consistent with the formulations of the Net Stable Funding Ratio (NSFR), and the leverage ratio (EQUITY) proposed in Basel III. More over, it explores for systematic differences in the relationship between structural liquidity, leverage, and subsequent probability of failure across bank types. In particular, it distinguishes between large, internationally-active banks, and (typically smaller) banks that focus on their domestic retail markets.

The results show that banks with weaker structural liquidity and higher leverage in the pre-crisis period were more likely to fail afterward. The likelihood of bank failure also increases with bank risk-taking. Macroeconomic and monetary conditions are also shown to be related with the likelihood of bank failure, providing

a case for the introduction of a macro-prudential approach to banking regulation. The main contribution of the essay is to show that, in the cross-section, the smaller domestically-oriented banks were relatively more vulnerable to liquidity risk, while the large cross-border banks were more susceptible to solvency risk due to excessive leverage. This finding let us understand that a one-size fits all approach to microprudential regulation might have large costs, and that international regulators should focus on the critical vulnerability each type of bank faces.

Chapter 2

Systemic Liquidity Risk-Taking in Emerging Markets

2.1 Overview

After the last three decades of experiences with financial crises, and in particular after the recent crisis, there is a growing concensus that banks are prone to create systemic financial risk. In emerging markets the concerns seem to be particularly relevant in circumstances where the banking system is receiving large capital inflows that are short-term in nature. The perception is that banks do not take the necessary precautions against an abrupt worsening of external financing conditions, making the economy excessively vulnerable from an ex-ante perspective.[1] Recent examples that support this view during the last decade include several economies in Eastern Europe, which enjoyed large banking sector inflows after their commitment to join the EU became evident. Although the inflows into banks helped finance substantial economic growth, the disruption of this source of financing associated with Lehman's brankrutpcy entailed sharpe contractions in output, consumption and employment.

These experiences have led policymakers to be increasingly wary about banks' risk taking in times of inflow bonanzas and to propose various preventive policies to reduce the build-up of vulnerabilities. Current proposals involve both quantity-

[1]For the difficulties arising from capital inflows bonanzas, see Reinhart and Reinhart (2008) and references therein.

based and price-based regulations.[2] Relatively little theoretical work has analyzed the reasons why the banking system may be prone to inefficiencies from an ex ante perspective and under what circumstances an interventation is warranted, if at all. Recent contributions on the study of systemic risk have made progress towards this goal. This literature explains how the presence of frictions in financial contracts, in an environment where individual banks ignore the effects of their actions on prices and returns, can lead to excessive systemic risk.

In this paper I study prudential regulation in a context where banks are receiving large capital inflows and face the prospects of a sudden reversal of flows. I build a framework where banks have the ability to invest in short-term and long-term assets by utilizing both stable and non-stable sources of funding. Like in Lorenzoni (2008), an externality arising from financial frictions provides the rationale for intervention. I analyze constrained efficiency by considering a planner who faces the same constraints faced by private agents. As in the literature, banks underinsure ex-ante. My main contribution is to show that the same mechanism that is producing underinsurance is also distorting the choices between different types of assets. Specifically, because of their hedging properties, there is an overinvestment in short-term assets relative to long-term assets. Based on that result, the model breaks the equivalence prevailing in these class of models between (1) excessive borrowing, (2) an inneficient credit boom, and (3) overexposure to liquidity risk.[3] Indeed, it points to liquidity

[2]Examples of the most discussed policies include: a cap to the growth in bank credit, a cap to the loans-to-deposits ratio, an increase in the amount of liquid assets, a tax on short-term external liabilities, and a tax on short-term loans.

[3]The definition of liquidity risk is taken from Basel Committee in Banking Supervision: "Liquidity is the ability of bank to fund increases in assets and honor its obligations as they come due". I will concentrate on the first part of the definition, implying that liquidity risk should be

risk as the key vulnerability to an external funding shock. I test empirically this implication of the model. For that purpose I develop an index of systemic exposure to the liquidity risk of banks, across emerging markets, and use it to explain the heterogeneity in output collapses, after Lehman's bankruptcy.

The paper develops a three-period model of a small open economy with two agents, banks and households. In the first period, banks invest in short-term assets (seeders) and long-term assets (land) in the domestic economy, using local deposits and external financing. Seeders are liquid, since the return on them is fully received in the second period. Land pays returns both in the second and third period and is illiquid, with the degree of illiquidity being determined endogenously. Seeders and land are required in production in conjunction with households' labor. Local deposits are a stable source of funding, while external financing is contracted short-term and needs to be rolled over. In the second period, the world can be in normal times, in which case the external financing is rolled over, or in crisis times, in which case the external financing is redeemed. This rollover risk is the only source of aggregate risk in the economy. When solving the asset-liability managment problem, banks implictly choose their exposure to liquidity risk (i.e. their capacity to do new lending/investments). When the external financing is redeemed, banks are forced to curtail investment in new seeders, which impairs the productivity of workers and existing land and leads to a sharp output decline. This is the mechanism linking the banking system's exposure to liquidity risk with the collapse of investment, output, and consumption.

understood as the risk of not being able to finance new credit.

In the model I introduce financial market imperfections to provide a rationale for ex-ante prudential regulation. Following Lorenzoni (2008) I model a friction in the financial contract between banks (borrowers) and households (lenders). In particular, banks are subject to a borrowing limit in crisis times.[4] This friction results in a pecuniary externality that can lead banks to underestimate the social value of liquidity ex-ante. This happens becuase banks' decisions in the first period redistribute liquidity between households and banks in the second period. The mechanism works through the returns on factors of production. Every time that a single banks decides to invest more in assets, it is lowering the marginal productivity of these assets, and consequently the amount of liquidity that banks will have in the second period. But at the same time it is increasing the marginal productivity of workers, and consequently the amount of liquidity that households will have in the second period. In an environment without any friction, banks could access households' liquidity when external financing is redeemed, and achieve the level of optimal investments. However, if a friction prevents banks to have full access to households' liquidity, the pecuniary externality derives in inefficiencies. A constrained planner, by internalizing how investment levels affect marginal returns, would choose to invest less in the first period to save more liquidity for banks in the second period. In that way the collapse of invesments in crisis times is less pronounced, and socially optimal.

My main theoretical result is to show that, in those circumstances, the same

[4]Lorenzoni (2008) derives this contraint from a contracting problem in an environment with limited commitment. I am going to use this constraint in reduce form and extend the framework in other dimensions.

pecuniary externality produces a distortion in the choice of different assets. When the marginal returns on assets is lower than the efficient level, it is because banks are investing too much ex ante. Excessive investments result from banks overvaluing the payoffs of the assets. Specifically the overvaluation comes from payoffs in crisis times: when banks do not internalize that decreasing the returns reduce the liquidity available to invest. The natural question is whether some type of asset is overvalued relatively more. The answer is that the assets that produce more cash flow in that scenario will be overvalued more (i.e. the assets that best hedge the liquidity risk introduced by external borrowing).

In inefficient equilibria, there is *overborrowing* of external financing *together* with a *relative overinvestment* in short-term assets with respect to long-term assets. I show that *any* regulatory framework designed to restore efficiency *must* address the asset side of the banks' balance sheet. In particular, the investment in short-term assets needs to be discourage relative to the investment in long-term assets. A system of unremunerated reserve requirements in conjunction with a tax in short-term assets achieves efficiency. In that sense, the model illustrates the idea that, in times of large capital inflows into the banking system, emerging markets rely excessively on short-term credit (typically consumptions credit) rather than long-term credit. The model gives a rationale for the strategy undertaken by the Government of Brazil at the height of the recent capital inflow episode, who introduced a system of unremunerated reserve requirements on short-term external liabilities in conjunction with a tax on consumption loans in April 2011.

The model yields two implications that are tested empirically. First, it high-

lights that the systemic exposure to the liquidity risk of banks is the key vulnerability explaining output collpase after an external financing shock. Second, the model delivers unsually high external short-term debt, high growth of bank credit to GDP, and high loans-to-deposits ratio at the same time that the systemic exposure to liquidity risk is unusually high. Recent literature finds strong support for the first three as indicators of vulnerability to external financing shocks (Berkmen et al, 2009; Blanchard et al, 2010; Lane and Milesi-Ferretti, 2010). The model suggests that their empirical success might be explained, at least partially, by their capacity to capture exposure to liquidity risk, when the latter is not controlled for.[5] My empirical results give support to both implications.

To conduct the empirical test I develop an index of systemic exposure to liquidity risk of a banking system. For this purpose, I extend a methodology recently introduced by international banking regulators (Basel Committee on Banking Supervision - BCBS -, 2009 and 2010) which measures liquidity risk from balance sheet quantities. The index is constructed from microdata (i.e. banks' financial statements) obtained from Bankscope and incorporates three databases on aggregate variables for adjustment purposes. I compute the index for the banking system of 40 emerging markets and developing countries, with a total sample of 1,700 banks. My strategy involves testing the index using an event analysis around Lehman's bankruptcy, which constituted a large external financing shock for emerging markets.[6] I follow the empirical approach from the recent literature that makes use of

[5]It is worth to mention that the test of the Index correspond to one shock: Lehman's Bankruptcy. However, further empirical analysis is required to determine the robustness of the results, including other episodes of exogenous funding shocks.

[6]Lehman's bankruptcy did not only lead to contagion of the crisis through funding channels

the same event to study the vulnerabilities and characteristics that best explain the output collapse across countries. Specifically my framework follows closely Blanchard et al (2010). In section IV, I show that the index is a robust explanatory variable of unexpected output decline accross emerging markets, after Lehman's bankruptcy. Moreover, the index reduces substantially the explanatory power of the other financial indicators of vulnerability.

Many accounts of financial crises in emerging markets have emphasized the role of the banking system in causing or propagating the crisis. Kaminsky and Reinhart (1999) show empirically how problems in the banking system typically preceed currency crises. Chang and Velasco (1998,1999) make the closest argument to the one developed in this paper. The authors argue that the 1997 Asian crisis can be explanied by the large amount of short-term hard-currency liabilities in the banking system relative to the hard-currency it could access in short notice. Based on the ratio of external liabilities to reserves, they suggest that the Asian countries were more vulnerable than their Latin American peers. Edwards and Vegh (2007) present evidence that the banking system propagates external macroeconomic shocks. Although they do not conduct a normative analysis, the authors model an open economy to account for the main empirical regularities.

The theoretical framework relates to the large literature on the role of financial frictions in amplifying and propagating aggregate shocks, including the prominent contributions of Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and

but also through trade and other channels. The empirical framework I follow controls for them. However, many researches have claimed that the funding channels seem the most relevant. See Berkmen et al (2009), Blanchard et al (2010), Lane and Milesi-Ferretti (2010) and Cecchetti et al (2011).

Kiyotaki and Moore (1997). Within that literature, models that study preventive policies from a second-best perspective include Caballero and Krishnamurthy (2001,2003), Allen and Gale (2004), Lorenzoni (2008), Farhi, Golosov and Tsyvinski (2009), Korinek (2009), Jeanne and Korinek (2011) and Mendoza and Bianchi (2011). This paper shows that the same externality that leads descentralized agents to underinsure creates a distortion in the choice of different types of assets.

The paper proceeds as follows. Section II discusses the model. Section III presents the theoretical results and compares current regulatory proposals. Section IV describes the empirical tests and provides support for the model (while appendix A discusses the construction of the index in detail). Section V concludes.

2.2 The Model

Consider a small open economy populated by a continuum of identical households of mass one. The households that live three periods ($t = 0, 1, 2$). Each household owns a bank, also identical. The sum of banks constitute *the banking system*. The economy produces one consumption good, which is tradable and non-storable, and can be borrowed and loaned internationally. The consumption good can be turned into any of two capital goods, seeders (s) and land(l), one for one, althought the opposite is not feasible. There is only one source of aggregate risk, revealed in $t = 1$, where the state of nature (i) can be either normal (n) with probability θ, or crisis (z) with probability $1-\theta$. As will be explained later, the state is only relevant if the economy is borrowing from the external sector, in which case the external financing is rolled over in state n and reedemed in state z.

Households

Households receive an endowment consumption goods, e , in $t = 0$, and consume in $t = 1, 2$. Their preferences are represented by linear utility function:[7]

$$E_0 U = E\left(c_1 + c_2\right) \tag{2.1}$$

where, for simplicity, the intertemporal discount factor has been set to one. They work in $t = 1, 2$ by supplying a fixed amount of labor, h. Each household owns a bank, but its managment is delegated to a banker. Households can deposit their initial endowment with the external sector, for an amount f, or they can enter into a financial contract with the bank. They receive the international gross interest rate $R = 1$ on their deposits with the external sector. The financial contract with the bank, specified at $t = 0$, is state-contingent and takes the form $\{d_0, (d_{1i}, d_{2i})\}$. The contract specifies a loan d_0 in $t = 0$ from the household to the bank (local deposits) and state-contingent payments d_{1i} and d_{2i} from the bank to the household in $t = 1$ and $t = 2$ for state i. The solution to this contract is derived later. The budget constraints for state i, at $t = 1, 2$, are given by

$$c_{1i} = w_1 h + d_{1i} + f_0 - f_{1i} \tag{2.2}$$

$$c_{2i} = w_{2i} h + d_{2i} + f_{1i} \tag{2.3}$$

This setup defines a simple role of households in the economy, allowing us to concentrate in the decision problem of banks.

Banks

[7] To save on notation we omit individual subscripts.

Banks solve an asset-liability management problem in $t = 0, 1$. The objective is to maximize expected intertemporal profits, internalizing households' preferences. Since I am not going to model any friction between banks and their corporate clients, I merge them into a bank that invests in real assets. I explain their optimization problem at each date:

- The $t = 0$ problem: Banks choose their initial funding and investment strategy. The funding consists of local deposits, d_0, and external financing, b_0 (b_0 can be negative, in which case banks are lending to the external sector). External financing is assumed to be short-term and subject to potential redemptions. In $t = 1$ the aggregate uncertaintly is revealed. If the state is n, b_0 is rolled over, and the full amount is repaid in $t = 2$. If the state is z, b_0 is redeemed fully.[8] The cost of external financing is given by R^B and its determination is explained below.

  Banks invest in two asset classes in the economy: short-term assets, s_0, and long-term assets, l_0. I will refer to s_0 as seeders and l_0 as land. Seeders mature in $t = 1$ and their return is given by r_1^S. Land matures in $t = 2$ and produce returns both in $t = 1$, r_1^L, and in $t = 2$, r_{2i}^L. In addition, banks can sell l_0 in $t = 1$ at an endogenously determined price p_{1i}^L. Notice that r_{2i}^L and p_{1i}^L depend on the state. The resulting buget constraint of the representative bank at $t = 0$ is given by

$$l_0 + s_0 = d_0 + b_0 \tag{2.4}$$

[8]The assumption is that redemptions are for the full amount. Assuming that they are a proportion does not change the results.

I assume that banks are the only agents capable of investing in assets in the economy. Households cannot directly invest in assets since they lack the expertise to operate them.

- The $t = 1$ problem: Banks start the period learning whether the external financing, b_0, is redeemed or rolled over. With the proceeds from their investments, $r_1^S s_0 + r_1^L l_0$, and the potential cash-flow from selling land, $p_{1i}^L l_0$, they invest in new seeders, s_{1i}, and in new land, l_{1i}, repay the external financing if recalled and transfer d_{1i} to households. In $t = 1$ the supply of seeders if infinitely elastic and the supply of land is infinitely inelastic. Thus, in $t = 1$, new seeders can be converted one-to-one with consumption goods, but the only way to acquire new land is by paying the market price p_{1i}^L to current owners (ie. other banks). The resulting budget constraint of the representative bank in state i is given by:

$$r_1^L l_0 + r_1^S s_0 + p_{1i}^L (l_0 - l_{1i}) = s_{1i} + d_{1i} + I^i R^B b_0 \tag{2.5}$$

where I^i is an indicator function that satisfies $I^z = 1$ and $I^n = 0$.

In $t = 2$ banks collect the proceeds from their investments in $t = 1$, repay the external financing if rolled over in $t = 1$ and transfer d_{2i} to households. The budget constraint for state i is

$$r_{2i}^L l_{1i} + r_{2i}^S s_{1i} = d_{2i} + (1 - I^i) R^B b_0 \tag{2.6}$$

Financial Contracts

There are two financial contracts to solve, one between banks and the external sector and another between banks and households. When households and banks deposit with the external sector, they receive the international gross interest rate $R = 1$. When banks are borrowing from the external sector, I am going to assume that the claim is the most senior and that the contract is enforceable in international courts at no cost. The result is a riskless claim with a cost of $R^B = R = 1$.

As explained above, the financial contract between households and banks takes the form $\{d_0, (d_{1i}, d_{2i})\}$. I will introduce a friction in this contract to capture that households have limit capacity to inject funds into banks after $t = 0$:[9]

$$d_{1z} \geq -\underline{d} \tag{2.7}$$

Constraint (2.7) captures, in reduced form, the contracting problem modeled in Lorenzoni (2008).[10] In this problem $\underline{d}$ can be understood as the maximum amount of bail-out funds that banks can receive from households in crisis. Households will participate in the contract only if the expected present discounted value of repayments is larger than the initial deposit

$$d_0 \leq \theta \left(d_{1n} + d_{2n}\right) + (1 - \theta) \left(d_{1z} + d_{2z}\right) \tag{2.8}$$

Production Technology, Aggregation and Returns

Production in the economy takes place in $t = 1, 2$ according to the technology:

$$Y_t = A L_{t-1}^{\alpha} S_{t-1}^{\beta} H_t^{1-\alpha-\beta}, \tag{2.9}$$

[9] It can be written symmetrically for any state in $t = 1, 2$ without changing the results, as will be explained later.

[10] In this setup the contracting problem derived from primitives is more complicated because of the presence of multiple assets and liabilities. I use his result to extend the analysis by studying the implications of this friction for the current setup.

where A is a productivity augmenting factor. Aggregate levels of production factors follow $L_t = l_t$, $S_t = s_t$ and $H_t = h_t$. Notice that households' labor is in fixed supply, implying $H_t = h = H$ both in $t = 1, 2$. The market for the factors of production is competitive and their returns follow from (2.9). As explained above, and to simplify the solution of the model, I assume that the aggregate amount of land is determined in $t = 0$ and cannot be adjusted in latter periods, i.e. $L_0 = l_o = L_1 = l_1$. Each bank, however, can trade land with its peers in $t = 1$ at a price p^L_{1i}.

2.2.1 Competitive Equilibrium

The competitive equilibrium consists of two financial contracts $\{d_0, (d_{1i}, d_{2i})\}$ and $\left\{R^B\right\}$, returns and prices $\left\{r^L_1, r^S_1, r^L_{2i}, r^S_{2i}, w_1, w_{2i}, p^L_{1i}\right\}$, portfolio allocations $\{l_0, s_0, b_0, d_0, l_{1i}, s_{1i}\}$,and consumption levels $\{c_{1i}, c_{2i}\}$ that satisfy the equilibrium conditions of banks and households, the participation constraint and all the market clearing conditions. The complete setup of the problem is presented in Appendix C.

Lemma 1 *An optimal contract between the bank and the household will always have* $d_0 = e$ *as an equilibrium*

Lemma 1 says that households know that banks are going to conduct their business taking into accounts households' interests. That is possible because there is no agency problem between them. When the participation contraint does not bind, it is because the local deposits are low relative to the amount of investment opportunities, in which case it is optimal for the banks to borrow from households and for households to lend their endowment fullly. When the participation constraint binds, it is because there are more local deposits relative to the domestic invesment

opportunities. In that case banks will automatically invest the excess local deposits with the external sector in the same way that households would do. Thus $d_0 = e$ is always an equilibrium. Households cannot do better than this contract.

Lemma 2 *There are two types of equilibria. In equibria (A) banks will never hit the contraint (2.7). In equilibria (B) banks will be constrained in state z and unconstrained in the state n. It is nevern an equilibrium for banks to be constrained in both states.*

A proof of the lemma is presented in appendix C. The previous two lemmas are useful for deriving the solution of the problem. A sufficient condition to be in equilibria (B) is that

$$e < \frac{\left(2^{\frac{1-\alpha}{1-\alpha-\beta}} - 2^{\frac{\beta}{1-\alpha-\beta}}\right)(\alpha+\beta)A^{\frac{1}{1-\alpha-\beta}}\alpha^{\frac{\alpha}{1-\alpha-\beta}}\beta^{\frac{\beta}{1-\alpha-\beta}} - \underline{\mathrm{d}}}{R}, \tag{2.10}$$

which is guaranteed to be a positive number since $1-\alpha \geq \beta$. The previous condition means that, when households' endowment is below some threshold, the amount of external financing that will be borrowed, will lead to a binding constraint in $t = 1$. In what follows I assumme that (2.10) holds and analyze the equilibria (B), which is the interesting case. The equilibrium conditions in $t = 1$ define a concept of illiquidity premium in the economy and a price at which land trades:

$$r_{2i}^S = 1 + \lambda \tag{2.11}$$

$$p_{1i}^L = \frac{r_{2i}^L}{(1+\lambda)} \tag{2.12}$$

The quantity λ denotes the multiplier on the financial constraint:

$$s_{1z} \leq r_1^L l_0 + r_1^S s_0 + p_{1z}^L (l_0 - l_{1z}) - b_0 + \underline{\mathrm{d}} \tag{2.13}$$

which is derived from (2.7) and (2.5). Equation (2.11) shows that, in the scenario where the financial constraint is binding because the external financing is reedemed, the return on seeders is above the international gross interest rate. As a result of the shortage of capital, the economy exhibits an illiquidity premium $\lambda = r_{2z}^S - 1 > 0$. When external financing is rolled over, optimal investment decisions imply that the return on seeders is equalized to one. Equation (2.12) defines the price at which land trades in $t = 1$. When the external financing is recalled, the price of land declines both for solvency and liquidity considerations. A binding financial constraint leads to $s_{1z} < s_{1n}$, which implies that $r_{2z}^L < r_{2n}^L$, i.e. the price declines partially for solvency considerations (ie. lower marginal productivity). But liquidity considerations also hit the market price of land in $t = 1$, as captured by the denominator in equation (2.12). Intutively, in an economy where the return on seeders has increased because of lack of financing, the return on land needs increase as well, to prevent arbitrage. That is achieved at a lower price of land. In this model the liquidity constraint will be explaining expected returns on assets, as will be clear below.

At $t = 0$ the equilibrium conditions involve the following euler equations for land and seeders respectively:

$$\theta \left(r_1^L + p_{1n}^L\right) + (1-\theta)(1+\lambda)\left(r_1^L + p_{1z}^L\right) = \theta + (1-\theta)(1+\lambda), \tag{2.14}$$

$$\theta r_1^S + (1-\theta)(1+\lambda) r_1^S = \theta + (1-\theta)(1+\lambda). \tag{2.15}$$

The last equation implies $r_1^S = 1$. The left hand sides of (2.14) and (2.15) capture the marginal benefit of extra land and seeders respecively, while the right

hand sides capture the cost. It is worth noticing that the cash inflows and outflows each asset produces in the scenario where the external financing is recalled, $(1-\theta)$, are valued at $(1+\lambda)$. As a consequence, assets that produce cash outflows larger than inflows in that scenario (i.e. land) will need to compensate with higher return in other scenarios. We can re-write (2.14) and (2.15) as:

$$r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (1-\theta)\lambda r_1^L = 1 + (1-\theta)\lambda, \tag{2.16}$$

$$r_1^S + (1-\theta)\lambda r_1^S = 1 + (1-\theta)\lambda. \tag{2.17}$$

For the purpose of having a bencharmk, below I will state the solution for the type of equilibria (A), where the banks are always unconstrained:

Proposition 3 *In an economy where the financial constraint is not binding , $\lambda = 0$, $r_1^S = r_{2n}^S = r_{2z}^S = 1$ and $r_1^L = r_{2n}^L = p_{1n}^L = r_{2z}^L = p_{1z}^L = \frac{1}{2}$. Then, $S_0 = S_{1n} = S_{1z}$, (remember $L_0 = L_{1n} = L_{1z}$)*

Proof. Since the aggregate amount of land is the same it $t = 1, 2$ and the euler equations require the return on seeders to be one in every state, then the quantity of seeders needs to be equal in every state. The rest follows from the euler equations (2.11), (2.12), (2.14) and (2.15). ■

Naturally, Proposition 3 implies that there is no premium on the returns to assets in a world where the financial constraint does not bind. However, as I show below, in equilibria (B), the investment in land pays a premium. The investment in seeders does not since they provide a perfect hedge from the point of view of the representative bank.

Proposition 4 *In an economy where the financial constraint is binding in state z , $\lambda > 0$, $r_1^S = r_{2n}^S = 1$, $r_{2z}^S = 1 + \lambda$, $1 > r_1^L = r_{2n}^L = p_{1n}^L > \frac{1}{2}$ and $r_1^L > r_{2z}^L > p_{1z}^L > 0$. Moreover, there is an illiquidity premium on land given by $(1-\theta)\lambda(1-r_1^L) > 0$, which implies that $r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L > 1$.*

Proof. In state n, $\lambda = 0$, and $r_1^S = 1$ follows from (2.17) and $r_{2n}^S = 1$ and $r_{2z}^S = 1+\lambda$ from (2.11). For (2.16) to be satisfied $r_1^L < 1$. Since $L_0 = L_1$ and $r_1^S = r_{2n}^S = 1$, the level of $S_0 = S_{1n}$, resulting in $r_1^L = r_{2n}^L$. Then (2.16) also implies that $r_1^L > \frac{1}{2}$ since $r_1^L = r_{2n}^L > r_{2z}^L$. Remembering that the international cost of funds is assumed to be $R = 1$, the illiquidity premium on land also follows from (2.16). ■

2.2.2 Constrained Planner

A social planner facing the same contraints as descentralized agents achieves a different solution compared to the competitive equilibrum. The setup of the problem is described in Appendix C. In period $t = 1$ the planner has the same equilibrium conditions defining the investment in new seeders as in the competitive equilibrium. When external financing is rolled over S_{1n} is defined by the condition $\alpha A S_{1n}^{\alpha-1} L_1^{\beta} H_2^{\gamma} = 1$ (which is analogous to (2.11)). When external financing is recalled, and the financial constraint binds, $S_{1z} = \left[\alpha A S_0^{\alpha-1} L_0^{\beta} H_1^{\gamma}\right] S_0 + \left[\beta A S_0^{\alpha} L_0^{\beta-1} H_1^{\gamma}\right] L_0 - B_0 + \underline{d}$ (which is analogous to (2.13)).

The difference between the planner problem and the competitive equilibrium lies in the definition of S_{1z} : The planner is able to see that the returns on seeders and land in $t = 1$ depend on their aggregate levels. That will have an impact in the

equilibrium conditions at $t = 0$, which are given by

$$r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (\alpha+\beta)(1-\theta)\lambda r_1^L = 1 + (1-\theta)\lambda \tag{2.18}$$

$$r_1^S + (\alpha+\beta)(1-\theta)\lambda r_1^S = 1 + (1-\theta)\lambda \tag{2.19}$$

It is worth to notice that this euler equations differ to ones of the representative bank only in the valuation of cash-flows produced by assets in crisis (i.e. when the constraint binds). It is capture by the terms $(\alpha+\beta)(1-\theta)\lambda r_1^L$ and $(\alpha+\beta)(1-\theta)\lambda r_1^S$, which are lower than $(1-\theta)\lambda r_1^L$ and $(1-\theta)\lambda r_1^S$ since $\alpha+\beta < 1$. The lower valuation is because the planner knows that when returns are driven down, the liquidity available for banks to invest in $t = 1$ becomes lower. In an economy where banks have unlimited access households' liquidity, there is no difference in the valuation of the planner and the representative bank.

Proposition 5 *In a constrained planner solution $r_{2z}^S > r_1^S > 1$, $r_{2z}^S = 1$, the illiquidity premium on land at t=0 is given by $(1-\theta)\lambda(1-(\alpha+\beta)r_1^L) > 0$.*

Proof. Equation (2.19) implies that $r_1^S = \frac{1+(1-\theta)\lambda}{1+(\alpha+\beta)(1-\theta)\lambda} > 1$ since $\alpha+\beta < 1$. Since $(1-\theta) < 1$ and $1 + (\alpha+\beta)(1-\theta)\lambda > 1$, $r_{2z}^S = 1 + \lambda > r_1^S$. In addition, $r_{2n}^S = 1$ follows from the euler equaiton in $t = 1$ (see Appendix C). The illiquidity premium follows from (2.18). ■

2.3 Theoretical Results

The theoretical questions that I address in this section are the following (i) Does the competitive equilibrium achieve an allocation that is socially optimal? and (ii) What are the regulatory frameworks that would produce a socally optimal

allocation in a descentrilzed economy? When addressing (ii), I will introduce a set of policies in the model, which include three policies that gained support after the recent crisis: (a) a cap on the growth of bank credit to the private sector, (b) a cap on the loans-to-deposits ratio of the banking system, and (c) a tax on external financing.

The competitive equlibrium does not produce socially optimal allocations. Banks have a valuation of insurance in $t = 0$ that is less than the social valuation. They fail to internalize the effect of their decisions on the returns of seeders and land in $t = 1$, and borrow and invest more than what is socially desirable. That happens becuase banks are unable to see that when they move returns they reduce the amount of liquidity they have available to invest in the state z. As a result, the investment in new seeders is suboptimal when the external financing is recalled, implying lower marginal product of workers and existing land in $t = 2$.

Proposition 6 *The competitive equilibrium does not produce pareto optimal allocations. Market incompletness results in excessive systemic exposure to liquidity risks in t=0. If the external financing is recalled in t=1 the economy has an inneficiently low level of investment in new seeders, imparing the marginal productivy of other sectors in t=2.*

Proof. Define $\Delta_b^L = r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (1-\theta)\lambda r_1^L$ and $\Delta_b^S = r_1^S + (1-\theta)\lambda r_1^S$ as the competitive equilibrium benefit of investing, in $t = 0$, in an additional land and seeders respectively. In addition, define $\Delta_c^L = 1 + (1-\theta)\lambda$ and $\Delta_c^S = 1 + (1-\theta)\lambda$ as the competitive equilibrium cost of borrowing to invest in the assets. Then the euler equations of the contrained planner in $t = 0$ can be re-written as in (2.20) and

(2.21) (below). The planer has a lower valuation of both assets than descentralized banks. Since the production function of the economy is strictly concave, efficiency is achieved by having a lower level of investment and, consequently, of borrowing.

$$\Delta_b^L - (1-\alpha-\beta)(1-\theta)\lambda r_1^L = \Delta_c^L, \tag{2.20}$$

$$\Delta_b^S - (1-\alpha-\beta)(1-\theta)\lambda r_1^S = \Delta_c^S. \tag{2.21}$$

■

A fundamental new insight of the model is that the planner chooses to reduce the investment in seeders more aggresively than the investment in land. There is nothing inherent in seeders that makes its investment more risky. But in equilibrium without government policies, the externality induces banks to overdo the investment in seeders more than the investment in land. The overvaluation of seeders is stronger because it produces a larger cash flow in state z, exactly the scenario where the representative bank is overvaluaing the cash-flows of assets.

Proposition 7 *In any regulatory framework designed to restore efficiency, the investment in short-term assets (ie. seeders) needs to be disincentivated more than the investment in long-term assets (ie. land).*

Proof. Using Δ_b^L and Δ_b^S as defined in the previous proof, the following relationship follows from (2.16), (2.17), (2.18) and (2.19):

$$\Delta_b^L + (1-\alpha-\beta)(1-\theta)\lambda\left(r_1^S - r_1^L\right) = \Delta_b^S. \tag{2.22}$$

This implies that $\Delta_b^L < \Delta_b^S$ since $r_1^S > r_1^L$ holds at the competitive equilibrium solution, as shown above. The only way to reduce Δ_b^L relative to Δ_b^S is by increasing the ratio $\frac{L_0}{S_0}$. ■

It is worth noticing that, since the welfare function measures expected output, the contrained planner achieves both higher expected output as well as lower volatility of output.

2.3.1 Plausible Regulatory Frameworks

In this section I derive the equilibrium conditions of descentralized agents in a model where there are five instruments available to the policymaker. Before presenting them it is useful to describe the environment and timeline in which they are introduced. The model can be understood as if in period t=0, before any decision is made, agents learn the total factor productivity level A and the level of the international interest rate R which are kept at a constant level for the life of the economy. The relevance of A and R is in that they determine the set of profitable investment opportunities of the economy. The relative size of that set versus the size of local depotis d_0 will determine the level of borrowing from the external sector. The point can be made using (2.10). Defening its right hand side as e^*, it is easy to compute $\frac{\partial e^*}{\partial A} > 0$ and $\frac{\partial e^*}{\partial R} < 0$. A higher A or a lower R enlarges the set of profitable investment opportunities, and increases the thershold value at which equilibria B take place.

In this context, there is a regulator who can use any of the following instruments right after the level of A and R are learned, and before agents take their decisions:

- proportional tax on seeders: t^S

- proportional tax on land: t^L
- proportional tax on external financing: t^B
- a loans-to-deposits ratio, which introduces the restriction $\frac{l_0+s_0}{d_0} \leq \chi_1 \quad (\Psi_1)$
- a cap on the size of credit to the private sector,[11] represented by $l_0 + s_0 \leq \chi_2 \quad (\Psi_2)$

Appendix C presents the setup of the problem. The $t = 0$ equilibrium conditions are given by

$$r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (1-\theta)\lambda r_1^L = \frac{(1+t^L)}{(1+t^B)}\left[1 + (1-\theta)\lambda\right] + \Psi_1 + \Psi_2, \quad (2.23)$$

$$r_1^S + (1-\theta)\lambda r_1^S = \frac{(1+t^S)}{(1+t^B)}\left[1 + (1-\theta)\lambda\right] + \Psi_1 + \Psi_2, \quad (2.24)$$

which are the implementability conditions that a Ramsey planner would use to solve the optimal policy problem. The main observation to be made is that only t^S and t^L can affect the margin that determines the ratio of assets. The policy variables t^B, χ_1 and χ_2 can only affect the cost of assets in a symmetric way. Using the results of the previous section, the following proposition follows:

Proposition 8 *The regulator must have at least one asset-side instrument to restore efficiency.*

Proof. Taking the ratio of (2.23) and (2.24) shows that the only instruments capable of correcting that intra-asset distortion are t^S and t^L:

$$\frac{r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (1-\theta)\lambda r_1^L}{(1+t^L)} = \frac{r_1^S + (1-\theta)\lambda r_1^S}{(1+t^S)}. \quad (2.25)$$

[11] This is analogous to a cap on the growth of bank credit to the private sector. Althought the model does not have a history, it can be interpreted as a repeated version where, in a second stage, an increase in A or a decrease in R, results in a larger optimal levle of investment to be made. Consequently in a larger amount of borrowing from the external sector.

■

None of the other instruments can achieve efficiency in the absence of an asset-side instrument since the system would be incomplete. In this model, there are multiple regulatory frameworks that achieve efficiency. Since there are two relevant margins to be affected by the planner, a system of two instruments achieves efficiency. One of them needs to be an asset side instrument, as argued above. One system that could restore efficiency involves a tax on external liabilities together with taxes on short-term assets, which is given by

$$t^B = \frac{(1-\alpha-\beta)(1-\theta)\lambda r_1^L}{1+(1-\theta)\lambda+(1-\alpha-\beta)(1-\theta)\lambda r_1^L} \tag{2.26}$$

$$t^S = \frac{(1-\alpha-\beta)(1-\theta)\lambda (r_1^S - r_1^L)}{1+(1-\theta)\lambda+(1-\alpha-\beta)(1-\theta)\lambda r_1^L} \tag{2.27}$$

evaluated at the competitive equilibrium. Another regulatory system that restores efficiency involves taxes on both assets, and is given by:

$$t^L = \frac{(1-\alpha-\beta)(1-\theta)\lambda r_1^L}{1+(1-\theta)\lambda} \tag{2.28}$$

$$t^S = \frac{(1-\alpha-\beta)(1-\theta)\lambda r_1^S}{1+(1-\theta)\lambda} \tag{2.29}$$

also evaluated at the competitive equilibirum solution.

2.3.2 Contrast with Recent Literature

The model is comparable, in terms of results, to recent models in the literature. Specifically, when land is removed from the model, and production only requires seeders and workers, i.e. $\beta = 0$, the model yields results analogous to Lorenzoni (2008). As in that model, at inefficient equilibria the economy would display inefficient levels of external financing, or an inefficient credit boom, or overexposure to liquidity risk, since all of them are equivalent. In the current version of the model with two assets the equivalence is broken, and the model points to the general problem of overexposure to liquidity risk as being the source of concern. The exposure to liquidity risk, in that sense, is analogous to the capacity of the banking system to do new lending when funding shocks hit the economy.

2.4 Empirical Evidence

The model produces two implications that I test empirically. First, it highlights that the systemic exposure to the liquidity risk of banks is the key vulnerability explaining the output collpase after an external financing shock. Second, the model delivers unsually high external short-term debt, high growth of bank credit to GDP, and high loans-to-deposits ratios at the same time the exposure to liquidity risk is also unsually high. Recent literature finds strong support of the first three but the model suggest that their empirical success might be explained by their capacity to capture, at least partially, exposure to the liquidity risk of the banking system, when not properly controlled for. My empirical results give support to these implications

of the model.

The model defines that the exposure to the liquidity risk of banks is the key vulnerability explaining the size of the output collapse. Following definitions from the model, the ratio of output in crisis times to expected output is given by:

$$\lim_{\theta \to 1} \frac{Y_{2z}}{\theta Y_{2n} + (1-\theta) Y_{2z}} = \frac{A S_{1z}^{\alpha} L_{1z}^{\beta} H^{\gamma}}{A S_{1n}^{\alpha} L_{1n}^{\beta} H^{\gamma}} = \frac{S_{1n} - B_0}{S_{1n}} \tag{2.30}$$

The ratio is evaluated at $\lim_{\theta \to 1}$ to produce a clean expression. Such limit is capturing the notion that the probability of an external financing shock is small. The last equality follows from the fact that $S_{1z} \cong S_{1n} - B_0$ given that the repayment to households can be estimated to be small relative to S_{1n} and B_0. Therefore, the capacity of the banking system to do new lending in crisis states, $S_{1n} - B_0$, is the key factor explaining the size of output collapse (i.e. the exposure to liquidity risk). Although in the model B_0 represents external borrowing, when conducting the empirical test it needs to be understood in a broad sense: it represents the amount of liabilities that are redeemed in a liquidity crisis.

By extending a methodoly recently introduced by international banking regulators (BCBS 2009 and 2010), which captures liquidity risks at the bank level, I design an index that captures the exposure at the system level. The index uses both microdata and macrodata. Microdata (ie banks' financial statements) is obtained from the Bankscope database, which is the most comprehensive available source of information on these matters. It accounts for banks with at least 90% of the assets in each country, according to the source. Importantly, it provides an accounting model, the universal bank model, that adjust for differences in accounting standards

across jurisdictions, making the information comparable. A caveat is that it does not present a breakdown of assets and liabilities by currency. For that purpose I also use macrodata on external and total liabilities of the consolidated banking system, to account for the liquidity implications of differences in the currency composition. I obtain this information from two sources: the Quarterly External Debt Statistics database (QEDS), published by the World Bank (WB), and the International Financial Statistics database (IFS), published by the International Monetary Fund (IMF). The index is computed for a *core* sample and an *extended* sample, with a maximum of 40 emerging markets and developing countries, and 1,700 banks. Appendix A explains the construction of the index (FPI) in detail and table B.1, in appendix B, lists the samples.

The empirical excercise consists of testing the power of the FPI in explaining output declines across emerging markets, after the Lehman's bankruptcy. There is a growing recent literature that intends to identify the vulnerabilties and characteristics that best explain that heterogenity. My strategy is to test the FPI in the best performing empirical frameworks identified by the literature. Blanchard et al (2010) find that external short-term debt to GDP is the most significant robust variable in explaining cross country output declines. The authors find that a trade variable, which captures the output declines of the main trade partners, also matters, although the relation is not as tight. In the analysis the authors do not break down the external debt by sector. Lane and Milesi Ferretti (2010) find that the output decline was larger in countries that experienced large pre-crisis net capital inflows and fast credit growth. Berkmen et al (2009) find that the loans-to-deposits ratio of the

banking system and the cumulative growth of bank credit explain a large share of the variation in the forecast revision of output growth. Cecchetti et al (2011) argue that economies featuring low private sector credit to GDP and little dependence on the US for short-term funding were much less vulnerable to the Crisis.[12]

The *core* sample I work with consists of 27 emerging markets, across different regions, and is taken from Blanchard et al (2010).[13] To check the robustness of the results, I construct an *extended* sample, which consists of 40 countries and includes the 27 in the *core* sample and 13 additional countries. The criteria is to include every economy classified as an emerging market or developing country by the following analysts: the 20 countries in FTSE, the 21 countries in MSCI, the 19 countries in the S&P, the 35 countries in Dow Jones, the 22 countries in the EIU and the 11 countries in the Next 11. In addition, I add the countries in the main sample of Berkmen et al (2009). Given that countries overlap in the lists and that the information required for the empirical analysis is not available for some of them, the extended sample comprises 40 countries. Table B.1, in appendix B, lists the countries in both samples.

The empirical specification I adopt follows recent literature and can be written in regression form as

$$y^j = \eta + \delta FPI^j + \sum_{i=1}^{n} \psi_i x_i^j + \epsilon^j \tag{2.31}$$

where η, δ and ψ_i are parameters, y^j is the measure of output growtht for

[12]Berkmen et al (2009), Blanchard et al (2010) and Lane and Milesi Ferretti (2010) use a sample of emerging markets and developing countries. On the other hand, Cecchetti et al (2011) include both developed countries and emerging markets in their sample.

[13]Blanchard et al (2010) have 29 countries. Some data is not publicly available for Taiwan and Venezuela.

country j, FPI^j is the index of systemic exposure to liquidity risk for country j , x_i^j is the control variable i for country j and ϵ^j is an error term. The measure of output decline y^j refers to the unexpected output growth inmediately after Lehman's bankruptcy and is analogous to the one used in Blanchard et al (2010). It is measured as the forecast error for output growth bewteen the end of the third quarter of 2008 (Q3.08) and the end of the second quarter of 2009 (Q2.09). The forecast of output growth rates (i.e. expected) correspond to the ones produced in the April 2008 edition of the World Economic Outlook databased (WEO), published by IMF. Actual output growth rates are taken from IFS. Unexpected output growth is defined as the cumulative difference between the forecast and actual.

The set of controls includes four variables identified by recent literature as the most relevant in explaining cross country output declines after Lehman collapse. The set includes one control that captures trade-related channels and three controls that captured finance-related channels. The trade-related control, unexpected partner growth, is constructed as in Blanchard et al (2010):

$$x_T^j = \left(\frac{ex^j}{gdp^j}\right) \Phi^j \sum_{i \neq j} \frac{ex_i^j}{ex^j} y^i \tag{2.32}$$

where $\frac{ex^j}{gdp^j}$ is the ratio of exports to GDP of country j at the end of 2007, Φ^j is an adjustment factor, ex_i^j represents the exports of country j to country i at the end of 2007, and y^i is the measure of unexpected output growth for country i as defined for the dependent variable. I obtain data on bilateral trade from the Direction of Trade Statistics database (DTS), also published by the IMF, and data on GDP from WEO.[14]

[14]The adjustment factor is required because data on unexpected output growth of trade partners

The finance-related controls include three well-established indicators of vulnerability: (i) the ratio of external short-term debt to GDP, (ii) the growth of bank credit to the private sector, as a fraction of GDP, and (iii) the loans-to-deposits ratio of the banking system. External short-term debt to GDP is defined on a remaining maturity basis and is measured at the end of 2007. I obtain this ratio from WEO. The growth of bank credit to the private sector is measured as the difference between credit to the private sector to GDP at the end of 2007 and at the end of 2003. I obtain this data from the World Development Indicators database (WDI) published by WB. The loans-to-deposits ratio corresponds to total bank credit over resident deposits and is measured at the end of 2007. The data is obtained from IFS. Table B.2, in appendix B, presents the summary statistics for the countries in both samples.

Table 1 presents the results for the *core* sample and table B.3, in appendix B, presents the results for the *extended* sample. There are two points to take from them. First, the first column of both tables shows that a simple regression of the FPI, the trade variable and a constant, achieves an R-squared of 63% in the core sample and 47% in the extended sample. In addition, the FPI is highly significant in both samples. Given the size of both samples this result seems meritful. Although the R-squared is smaller in the extended sample, the coefficient on the FPI is larger (0.33 versus 0.29) and coefficient on the trade variable is smaller (0.74 versus 1.03). In the core the sample, the coefficient of 0.29 means that for an additional point

is not available for all the partners. The variable accounts for partners that represent, at least, 87% of the total trade of the country. Thus, the following adjustment is warranted $\Phi^j = 1/\sum_{i \neq j} \frac{ex_i^j}{ex^j}$

of new credit that the banking system could do in crisis, measured as percentage of GDP, output is forecasted to grow 0.29% in the three quarters after Lehman's bankruptcy (on an annualized basis). Overal, the index seems a robust explanator of unexpected output declines across emerging markets, giving support to the prediction that exposure to liquidity risks of the banking system is a relevant measure of vulnerability of a country to abrupt negative changes in external financing conditions.

In the second place, the explanatory power of the aggregate indicators of vulnerability (i), (ii) and (iii), as specified above, is considerably reduced after controlling for the FPI. In the core sample, the statistical significance of the three of them vanishes completely. This result is evident when comparing column 2 with 5, 3 with 6, and 4 with 7. As an example, the coefficient in external short-term debt is -0.27 in the core sample, when the FPI is not included, and is statistically significant at 1% of confidence. Howerver, its significance dissapears when controlling for the FPI. The coefficient is almot half, and is not statistically significant even at 10% confidence. This behavior is also shared by (ii) growth of bank credit and by (iii) the loans-to-deposits ratio. In the extended sample the change in significance is less dramatic, but still relevant. As an example, the coefficient on external short-term debt changes from -0.26 to -0.13, and changes from being significant at 1% to being significant at 10% confidence. The same is true for (ii) and (iii). Overall these findings suggest that their previous success reflects, at least partially, the ability of (i), (ii) and (iii) to capture the exposure to liquidity risk of the banking system. Section A.2, in appendix A, shows that these indicators are correlated with the FPI

and formulates hypothesis on why that should be the case. Table B.2, in appendix B, presents the results for the *extended* sample.

Table 1. Unexpected Output Growth After Lehman's Bankruptcy in Emerging Markets

(dependent variable: projected minus actual growth from Q3.08 to Q2.09, saar)

Regressor							
Unexpected Partner Growth	1.03***	0.45*	0.95***	0.97***	0.71***	0.97***	0.99***
FPI	0.29***				0.20*	0.21**	0.25**
External Short-Term Debt		-0.27***			-0.13		
Growth of Bank Credit			-0.21***			-0.09	
Loans to Deposits				-0.09***			-0.02
Constant	-6.46***	-2.88	-2.41	4.89	-5.17*	-5.18*	-3.63
N	27	27	27	27	27	27	27
R-sq	0.63	0.60	0.58	0.54	0.66	0.65	0.64

[1]Robust standard errors,*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[2]Forecasetd minus actual GDP growth of trade partners (Q3.08 vs Q2.09, saar), weighted by trade and multiplied by home export share of nominal GDP in 2007.

[3]External short-term debt, on a remaining maturity basis, as a percentage of GDP, end of 2007.

[4]Bank credit to the private sector as a percetage of GDP, end of 2007 minus end of 2003.

[5]Total bank claims over deposits in depositary corporations other than Central Banks.

2.5 Conclusions

The debate on why and how large capital inflows into the banking system should be contained has been with us for some decades. The debate recently shifted towards the area of prudential regulation, which is based on the premise that banks seem prone to create systemic financial risk. In emerging markets, policymakers view with great concern situations where all the banks in the system have a common

source of exposure: an external financing shock. This paper develops a framework that shows that such exposure can be excessive under some circumstances. The undervaluation of insurance by banks leads to distortions in the type of credit they extend. Such distortions need to be addressed to improve economic outcomes. In particular, the model shows that banks tend to choose excessive short-term credit since it hedges better the risks of the external financing. In this sense the model gives support to the perception that, in time of large inflows to the banking system, the economy relies excessively on short-term credit (as consumption credit) rather that on long-term credit to long-term investment projects. Under those circumstances, the policy prescription of the government of Brazil in April 2011 seems sensible.

Both the model and the empirical evidence deliver a clear message: The real concern is the continuous ability of the banking system in extending credit to the economy (i.e. the systemic exposure to liquidity risk of banks). In this framework of thinking, traditional concerns of "overborrowing" or "inefficient booms in credit" seem to be explained, at least partially, by the concerns relevant to systemic exposure to liquidity risk. As I showed in the model, in situations of excessive exposure to liquidity risk, policies design to limiting the amount of external borrowing, or capping the growth in credit, are not sufficient neither necessary to solve the problem. The problem requires not only addressing the size of banks' balance sheet, but its structure. It demands understanding, and taking into account in the formulation of policies, the liquidity characteristics of different types of assets and liabilities. Efforts in this direction are warranted given that the costs of an inefficient regulatory framework are not small in these economies that arguably lack capital investments.

At the same time this paper also provides a warning to policymakers. In an emerging market, where capital is usually imported to finance domestic investment oportunities, some degree of financial fragility is optimal. The model shows that there are equilibria where the benefits of increased investments is worth the liquidity risk. Setting the objective only in terms of reducing volatility, without taking into account the benefits of increased investment, seems inappropriate. On the other hand, the welfare analysis provides a rationale for a (macro)prudential approach. In a framework where banks face constraints to obtain the liquidity they need from other sectors of the economy, banks may underestimate the damage associated with a limited capacity to extend new credit if an aggregate financing shock comes.

The microfoundation of the financial constraint can be obtained from a limited commitment problem bewteen banks and households, as in Lorenzoni (2008). However, the constraint could also be undertood as arising from a central bank that has limited capacity to assist the banking system in times of crisis. This could be due to limited credibility on the institution. The fact that the liabilities of the government (both bonds and bills) are in high supply by the private sector in a liquidity crisis is a key factor distinguing emerging markets from developed countries. This requires an explicit model of the central bank and remains a topic for future research. Once such a framework is developed, it should be possible to evaluate macroprudential policies in conjunction with monetary policy, and even their complementarities with international reserves.

The model presented shows that excessive exposure to liquidity risk is a possibility. However, there are some equilibria where the gains of receiving large capital

inflows compensate the risk. Therefore, the presence and severity of overexposure to liquidity risk becomes an empirical issue. This provides arguments to develop better metrics to monitor this risk. Recent advances include the methodology provided by BCBS. I show that this methodology can be extended to capture exposure at the system level. Although the index I develop performs well in cross-country regressions around Lehman's bankruptcy, further tests are required to understand its validity. Despite the fact that my methodology does not provide a threshold value at which the exposure changes from acceptable to excessive, it allows to identify countries that are highly exposed. As an example, at the end of 2007 the index captured that, had a funding shock taken place, the banking system of Latvia and Estonia would have been not only unable to extend any new credit, but would have also needed to sell loans for a value of 30% and 20% of GDP to honor its liabilities. In the three quarters after Lehman's bankruptcy, their output collapsed around 25% on an annualized basis.

Chapter 3

Bank Funding Structure and Risk: Evidence from the Global Financial Crisis

3.1 Introduction

The global financial crisis raised questions on the adequacy of bank risk management practices and triggered a deep revision of the regulatory and supervisory frameworks governing bank liquidity risk and capital buffers. Regulatory initiatives at the international level included, inter alia, the introduction of liquidity standards for internationally-active banks, binding leverage ratios, and a revision of capital requirements under Basel III (BCBS 2009; and BCBS 2010 a, b). [1] In addition to these micro-prudential measures, academics and policymakers argued for the introduction of a complementary macro-prudential framework to help safeguard financial stability at the systemic level (Hanson, Kashyap and Stein, 2010).

This regulatory response was implicitly based on two premises. First, the view that individual bank decisions regarding the size of their liquidity and capital buffers in the run up to the crisis were not commensurate with their risk-taking-and were therefore suboptimal from the social perspective. Second, the perception that the costs of bank failures spanned beyond the interests of their direct stakeholders due,

[1] On liquidity, the proposals comprise two prudential ratios that entail minimum binding standards: a Liquidity Coverage Ratio (LCR), aimed at promoting banks' resilience to liquidity risk over the short-term (a 30-day period); and a Net Stable Funding Ratio (NSFR), aimed at promoting resilience over a one-year horizon. In addition, a leverage ratio computed as shareholders' capital over total assets was introduced to ensure a hard minimum capital level, regardless of the structure of risk-weights in bank balance sheets.

for example, to supply-side effects in credit markets, or network externalities in the financial sector (Brunnermeier, 2009).

The widespread bank failures in the U.S. and Europe at the peak of the global financial crisis provided casual support to the first premise. Still, empirical work on the connection between bank liquidity and capital buffers and their subsequent probability of failure is incipient. Background studies carried out in the context of Basel III proposals, which are based on aggregate data, concluded that stricter regulations on liquidity and leverage were likely to ameliorate the probability of systemic banking crises (BCBS, 2010b).[2] In turn, studies based on micro data for U.S. banks also support the notion that banks with higher asset liquidity, stronger reliance on retail insured deposits, and larger capital buffers were less vulnerable to failure during the global financial crisis (Berger and Bouwman, 2010; Bologna, 2011). Broadly consistent results are reported in Ratnovski and Huang (2009), based on data for large banks from the OECD.

This paper makes two contributions to previous work. First, it measures structural liquidity and leverage in bank balance sheets in a way consistent with the formulations of the Net Stable Funding Ratio (NSFR), and the leverage ratio (EQUITY) proposed in Basel III. Second, it explores for systematic differences in the relationship between structural liquidity, leverage, and subsequent probability of failure across bank types. In particular, we distinguish between large, internationally-active banks (henceforth Global banks), and (typically smaller) banks that focus on

[2]This work also found evidence of non-linear effects at play, as the estimated marginal benefits of stricter regulations seemed to drop with the size of the liquidity and capital buffers.

their domestic retail markets (henceforth Domestic banks).

This sample partition is suitable from the financial stability perspective. Global banks are systemically important and extremely challenging to resolve, due to the complexity of their business and legal structures, and because their operations span across borders, entailing differences in bank insolvency frameworks and difficult fiscal considerations. Furthermore, the relative role of liquidity and capital buffers for bank financial soundness is likely to differ systematically across these two types of banks. All else equal, Global banks benefit from the imperfect co-movement macroeconomic and monetary conditions across geographic regions (Griffith-Jones, Segoviano, and Spratt, 2002; Garcia-Herrero and Vazquez, 2007) and may exploit their internal capital markets to reshuffle liquidity and capital between business units. In addition, Global banks tend to enjoy a more stable funding base than Domestic banks due to flight to safety, particularly during times of market distress. To the extent that these factors are incorporated in bank risk management decisions, optimal choices on structural liquidity and leverage are likely to differ across these two types of banks.

The paper exploits a bank-level dataset that covers about 11,000 U.S. and European banks during 2001?09. This sample coverage allows us to study bank dynamics leading to, and during, the global financial crisis. As a by-product, we document the evolution of structural liquidity and leverage in the pre-crisis period, and highlight some patterns across bank types to motivate further research. Contrary to expectations, the average structural liquidity in bank balance sheets in the run up to the global financial crisis (as measured by a proxy of the NSFR) was

close to the target values proposed in Basel III recommendations. [3] However, we find a wide dispersion in structural liquidity across banks. A mild (albeit sustained) increase in structural liquidity mismatches in the run up to the crisis was driven by banks located at the lower extreme of the distribution. Pre-crisis leverage was also widely uneven across banks, with the Global banks displaying thinner capital buffers and wider gaps between leverage ratios and Basel capital to risk-weighted assets.

In line with alleged deficiencies in bank risk management practices, we find that banks with weaker structural liquidity and banks with higher leverage ratios in the run up to the crisis were more vulnerable to failure, after controlling for their pre-crisis risk-taking. However, the average effects of stronger structural liquidity and capital buffers on the likelihood of bank failure are not large. On the other hand, there is evidence of substantial threshold effects, and the benefits of stronger buffers appear substantial for the banks located at the lower extremes of the distributions. In addition, we find systematic differences in the relative importance of liquidity and leverage for financial fragility across groups of banks. Global banks were more susceptible to failure on excessive leverage, while Domestic banks were more susceptible to failure on weak structural liquidity (i.e., excessive liquidity transformation) and overreliance on short-term wholesale funding.

In the estimations, we include bank-level controls for pre-crisis risk taking, and for country-specific macroeconomic conditions (i.e., common to all banks incor-

[3] Structural liquidity was measured by the ratio of long-term stable funding sources to structural asset positions.

porated in a given country). The use of controls for pre-crisis risk-taking is critical to this study. To the extent that banks perform active risk management, higher risk-taking would tend to be associated with stronger liquidity and capital buffers, introducing a bias to the results. In fact, we find that banks engaging in more aggressive risk taking in the run-up to the crisis-as measured by the rate of growth of their credit portfolios and by their pre-crisis distance to default-were more likely to fail afterward. Macroeconomic conditions in the pre-crisis period are also found to affect bank probabilities of default, suggesting that banks may have failed to internalize risks stemming from overheated economic activity and exuberant asset prices.

All in all, these results provide support to the proposed regulations on liquidity and capital, as well as to the introduction of a macro-prudential approach to bank regulation. From the financial stability perspective, however, the evidence indicates that regulations on capital-particularly for the larger banking groups-are likely to be more relevant.

The reminder of the paper is as follows. Section II places the paper in the context of the literature. Section III presents the dataset, discusses the criteria for the partition of the sample, and describes some stylized facts on the evolution of liquidity and leverage across groups of banks. Section IV describes the quantitative results of baseline regressions and a parallel set of exercises with alternative partitions of the sample to assess the extent of cross-sectional differences and non-linear effects. Section V presents various robustness checks. Section VI concludes. All the tables and figures referred in this chapter can be found in Appendix C.

3.2 Related Literature and Empirical Hypothesis

The theory of financial intermediation shows that liquidity creation is an essential role of banks and establishes a strong connection between liquidity creation and financial stability (Bryant, 1980; Diamond and Dybvig, 1983). Banks create liquidity on both sides of their balance sheets, by financing long-term projects with relatively liquid liabilities such as transaction deposits and short-term funding. [4] The associated exposure to liquidity risk is an intrinsic characteristic of banks that operates as a discipline device and supports efficiency in financial intermediation (Diamond and Rajan, 2000). In this set up, bank capital (i.e., lower leverage) entails a cost in terms of liquidity creation but provides a buffer against changes in the value of bank assets, increasing bank survival probabilities under distressed market conditions (Diamond and Rajan 2001).

The notion of bank liquidity creation in the literature is closely related with the regulatory concept of structural liquidity mismatches in bank balance sheets. The latter reflects the portion of long-term, illiquid assets (i.e., structural positions) that are financed with short-term funding and non-core deposits. Thus, a bank with larger structural liquidity mismatches would create more liquidity. Bank liquidity creation is also related with the leverage ratio, which measures equity capital relative to total assets. To the extent that (the book value of) equity entails a stable funding component, a bank with a higher leverage ratio would also create more liquidity.

The role of bank liquidity in the global financial crisis has been subject to

[4] Banks can also create liquidity via off-balance sheet operations, for example, by issuing commitments and guarantees (see for example Kayshap, Rajan, and Stein, 2002).

substantial attention. In particular, the reliance of banks on short-term wholesale funding to finance the expansion of their balance sheets in the run-up to the crisis, together with excessive leverage, have been highlighted as key factors in the buildup of systemic risks and the propagation mechanism. [5] Empirical studies show that banking crises in the U.S. have been preceded by periods of abnormal liquidity creation (Berger and Bouwman, 2008, 2009). There is also evidence that banks' reliance on wholesale funding had a negative effect on the performance of their stock prices after the outbreak of the crisis (Raddatz, 2010) and resulted in increased financial fragility, as measured by distance to default and the volatility of bank stock returns (Demirg-Kunt and Huizinga, 2009), or by the likelihood of receiving public assistance (Ratnovski and Huang, 2009). In addition, U.S. banks with more stable funding structures continued to lend relative to other banks during the global financial crisis (Cornett et al., 2010), and were less likely to fail (Bologna, 2011).

A related strand of literature has focused on the role of capital in the capacity of banks to withstand financial crises. The evidence indicates that banks with larger capital cushions fared better during the global financial crisis in terms of stock returns (Demirg-Kunt, Detragiache, and Merrouche, 2010). Related work by Berger and Bouwman (2010) analyzed the survival probabilities of banks in the U.S. during two banking crises and three market-related crises (i.e., those originated by

[5] From the theoretical point of view, however, there are competing views on the effects of bank reliance on wholesale funding on their vulnerability to liquidity risk as well as on market discipline. On the one hand, sophisticated institutional investors may exercise stronger monitoring, enhancing market discipline and offering an alternative to offset unexpected deposit withdrawals (Calomiris, 1999). On the other, in an environment of costless but noisy public signals, short-term wholesale financiers may face lower incentives to monitor, choosing to withdraw in response to negative public signals and triggering inefficient liquidations (Huang and Ratnovski, 2010).

events in the capital markets), and concluded that small banks with higher capital were more likely to survive both types of crises. In contrast, higher capital cushions improved the survival probabilities of medium-size and large banks only during banking crises. Previous studies based on bank-level data also showed that capital ratios had a strong informative content in explaining subsequent bank failure and pointed to the presence of non-linear effects (Estrella, Park, and Peristaki, 2000; Gomez-Gonzalez and Kiefer, 2007).

The combined role of structural liquidity and capital cushions on bank fragility was addressed in the context of Basel III proposals (BCBS, 2010). This work concluded that stronger capital buffers were associated with lower probability of banking crises and also with less severe costs. Evidence on the role of liquidity buffers was somewhat less conclusive possibly due to data limitations, since the analysis was based on aggregate data.

In this paper, we use a bank-level dataset to study the connection between structural liquidity and leverage in bank balance sheets in the run-up to the global financial crisis, and the likelihood of subsequent failure. We also explore for potential differences in the relative importance of liquidity and capital buffers on the likelihood of failure across bank types, distinguishing between large globally-active banks, and domestic retail-oriented institutions. In particular, we try to answer the following questions: (i) are there any connections between structural liquidity and leverage in bank balance sheets during the pre-crisis period and the probability of subsequent failure? (ii) is there evidence of systematic differences across bank types? In answering these questions, we also explore the relationship between bank

risk-taking and macroeconomic and financial factors in the run up to the crisis and the likelihood of subsequent bank failure.

To guide the analysis, we build upon the theories mentioned above, which imply a direct connection between structural liquidity mismatches in bank balance sheets, leverage, and financial fragility. We note, however, that active implementation of risk management and controls by banks may tend to weaken, or even completely dissipate, this connection. In fact, under the hypothesis that bank decisions regarding their risk-taking and the size of the associated liquidity and capital buffers were optimal, we should find a positive relationship between pre-crisis risk-taking and the size of liquidity and capital buffers, but a weak connection whatsoever between the latter and the probability of failure. Following the same reasoning, proper risk-taking and management by banks would tend to weaken the connections between the macroeconomic environment in the run-up to the crisis and the likelihood of subsequent bank failure. These hypotheses are taken to the data in the next sections.

3.3 Data and Target Variables

We obtain bank-level financial statements from the Bankscope database. Using this source has two major advantages. First, the coverage is fairly comprehensive, with sampled banks accounting for about 90 percent of total assets in each country, according to the source. Second, the information at the bank level is presented in standardized formats, after adjusting for differences in accounting and reporting standards across countries. On the other hand, the use of publicly available data has

some limitations, in particular the lack of sufficient granularity in some of the balance sheet accounts. For example, detailed breakdown of loan portfolios by categories, maturity, or currency, is not generally available. Similarly, securities portfolios are not segregated by asset classes, or by maturity. On the other hand, relatively richer information is available on the liabilities' side, as deposits are classified by type, and non-deposit funding is classified in short-term (i.e., residual maturity shorter than one year) versus long-term (i.e., residual maturity longer than one year).

The sample covers about 11,000 banks incorporated in the U.S. and Europe, which were the regions more severely affected by the global financial crisis. Series are yearly, spanning 2001-09. Therefore, we are able to capture the evolution of bank financial conditions in the run up to the crisis (2001-07) as well as throughout the crisis (2008-09). For the purpose of the analysis, we split the sample according to two alternative criteria. First, we distinguish between large internationally active banks versus domestically-oriented banks, and further split the latter in commercial banks, savings banks, and cooperatives. In parallel, we split the sample by target levels of structural liquidity and leverage to explore for potential threshold effects.

Balance sheets and income statements are taken in U.S. dollar terms, using the market rate at the closing dates of the bank-specific accounting exercises. While in many cases Bankscope reports both consolidated and unconsolidated financial statements, we use consolidated figures to the extent possible, to reflect the overall liquidity and leverage positions of individual banking groups. Outliers are identified and removed by filtering-out observations with either liquidity or leverage below the 0.5 percentile and above the 99.5 percentile.

3.3.1 Indicators of Bank Liquidity and Leverage

To measure structural liquidity and leverage, we use two novel international regulatory standards: the Net Stable Funding Ratio, NSFR, and the leverage ratio, measured by dividing equity capital to assets, EQUITY, (BCBS, 2009, 2010). The NSFR reflects the proportion of long-term illiquid assets that are funded with liabilities that are either long-term or deemed to be stable (such as core deposits). In turn, EQUITY reflects the proportion of shareholders' equity to assets and thus provides a measure of bank leverage. All else equal, a higher NSFR and a higher EQUITY imply lower bank liquidity creation.

Specifically, the NSFR is a ratio between the weighted sum of various types of bank liabilities (L_i) and assets (A_j):

$$NSFR = \frac{\sum_i w_i L_i}{\sum_j w_j A_j} \tag{3.1}$$

The weights w are bounded between zero and one, but do not add up to one. They reflect the relative stability of balance sheet components. In the case of assets, larger weights are assigned to less liquid positions. In the case of liabilities, larger weights are assigned to more stable sources of funding. A higher NSFR is therefore associated with lower liquidity risk. The proposed regulations require banks to maintain a NSFR higher than one.

As noted above, the granularity of bank assets and liabilities required to replicate the NSFR is not publicly available. However, we can still approximate the ratio reasonably well using Bankscope data. A stylized bank balance sheet, together with

the weights used in the calculation of the NSFR, is presented in Figure 4. Some departures from the NSFR proposed in Basel III are worth noting. First, we cannot split the loan portfolios according to their type or residual maturity, which under Basel III entail different weights (ranging from 0.50 to 1.00). Following a conservative approach, we assume that the total loan portfolio requires stable funding and use an overall weight of 1.00. For other earning assets, which tend to be more liquid, we use an average weight of 0.35, which is within the range proposed in Basel III. Fixed assets and non-earning assets (except for cash and due from banks) receive a weight of 1.00, also following conservative criteria. On the liabilities side, we split customer deposits by type and other liabilities according to their maturity. The weights assigned reflect the assumption that core retail deposits are more stable than other short-term funding sources. Accordingly, the latter are given a weight of zero. Long-term liabilities and equity are considered to be stable at the one-year horizon.

As for leverage, we use the ratio between shareholder's equity to assets, which is broadly used and in line with Basel III proposals.

Robustness checks are performed using alternative indicators of bank liquidity and leverage. For liquidity, we use the Short Term Funding Ratio (STFR), measured by dividing the liabilities maturing within one-year over total liabilities. For capitalization we use the Basel CAR definition, measured by the ratio of regulatory capital to risk-weighted assets.

3.3.2 Global Banks versus Domestic Banks

As noted before, we classify banks in two categories, namely Global banks and Domestic banks, using information on their size, geographic presence, and ownership. The group of Global banks encompasses internationally-active institutions with consolidated assets surpassing US dollares 10 billion at end-2009. To select only the parent banking groups, we identify banks owing majority stakes in foreign subsidiaries, with no financial institutions listed as their ultimate owners. In turn, the group of Domestic banks encompasses domestically-owned institutions with no majority stakes in subsidiaries abroad. The coverage of the sample is uneven (Table 1). For Domestic banks, it tracks 10,805 institutions during 2001-09, with more than 8 years of time coverage for about 57 percent of the banks in the sub-sample. As for Global banks, the sample covers 91 institutions, with more than 6 years of information for 60 percent of the banks in the sub-sample. Looking closely into the data, there is apparent break in the subsample of European banks in 2005, which is mainly attributable to changes in the accounting information after the adoption of IFRS. We check for potential noise associated with this break by computing the pre-crisis variables according to three alternative criteria: (i) computing their means over the entire available data for each bank; (ii) computing their means over 2004-07; and (iii) using their values as of end-2007. Not surprisingly, since the target variables are stocks, the results obtained under these three criteria are broadly consistent.

3.3.3 Bank Failure

We identify the group of banks that failed during the crisis by using several complementary sources. First, we exploit the information on the ongoing status of each bank contained in BankScope, and single out the banks that changed status from "active" to either: "under receivership", "bankruptcy", "dissolved", "dissolved by merger", or "in liquidation". Second, we track the evolution of the Basel capital (CAR) for each bank and single out the banks with CAR dropping below the 8 percent threshold between 2008?09. Third, we exploit information on Moody's bank financial strength ratings and single out banks downgraded to ratings E+ or E (in distress). These criteria are useful to identify the banks that were allowed to fail and subject to resolution procedures, which were typically the smaller non-systemically important institutions. On the other hand, the failing Global banks were generally assisted by their governments and therefore not properly captured by these criteria. To deal with this issue, we use the information on failing banks from Laeven and Valencia (2010). [6]

3.4 Empirical Approach and Quantitative Results

To gauge the relationship between bank structural liquidity, leverage, and their subsequent probability of failure, we compute a probit model exploiting the cross-sectional distribution of bank-level state variables prior to the crisis. In particular,

[6]The authors provide a summary of the most relevant banks that failed, or were assisted by their home governments during the global financial crisis, starting from end-2007. This captures banks that received direct assistance from the government (equity injections, bond purchases) as opposed to indirect assistance (general asset purchase programs, reductions in discount rates, and other support measures).

we formulate the empirical model:

$$\Pr\left(F_i = 1 \mid x_i\right) = \Phi\left(x_i\beta\right) \tag{3.2}$$

Where F_i is a dummy variable that takes the value of one if bank i failed during the crisis (i.e., between 2008-09) and zero otherwise. The vector Xi contains the two target variables, namely, the NSFR and the EQUITY ratio, both measured prior to the crisis. The vector also contains a set of bank-level controls, aimed at capturing differences in bank risk profiles in the run-up to the crisis. These include: (i) the yearly average of credit growth, CREDIT GROWTH, (ii) the ratio of non-interest income to total income, NON-INTEREST INCOME, and (iii) the distance to default or Z-SCORE, which conveys the number of standard deviations that bank return on assets has to drop to trigger insolvency. The inclusion of non-interest income follows from the conjecture that bank risk profiles increased with their reliance on trading or investment banking activities in the run up to the crisis (Demirguc-Kunt and Huizinga, 2009). The vector also contains two country-specific variables (i.e., common to the banks incorporated in a given country) which are aimed at capturing macroeconomic and monetary conditions in the run-up to the crisis. These are the yearly average rate of GDP growth, GDP GROWTH, and the MONEY MARKET RATES. The use of pre-crisis averages for the explanatory variables ameliorates potential endogeneity problems, which comes at the cost of neglecting dynamics along the time dimension. Thus, the specification is purely cross-sectional and does not include bank-level fixed effects.

As noted before, under the premise that banks manage their liquidity and capitalization in a sound way, one should expect to find a positive correlation between their ex-ante risk taking and their capital and liquidity ratios, and a weak connection whatsoever between these and their probabilities of failure. Evidence on the contrary would indicate that banks failed to properly account for their risk taking in the run-up to the crisis, providing some ground for a more intrusive prudential framework regarding capital and liquidity buffers. Following a similar argument, macroeconomic conditions should not play a systematic role in the probabilities of failure of well-managed banks. Evidence on the contrary would imply a link between macroeconomic conditions and systemic financial stability (since the former are common to all banks incorporated in a given country), providing ground for a complementary macro-prudential approach to banking regulation.

3.4.1 Stylized Facts

Summary statistics of the variables are presented in Table 2, splitting the sample across Global and Domestic banks. The magnitude of the difference in size between these two groups of banks is striking. The average balance sheet of the Domestic banks was US dollars 0.7 billion at end-2009, compared with US dollars 527.1 billion for Global banks, and the institution in the 99 percentile of the distribution had a balance sheet of US dollars 2.9 trillion at end-2009. The massive size of these banks makes them extremely challenging to resolve, and their interconnectedness and financial complexity compounds with the breath of their operations, which span across borders.

Some additional differences between Global and Domestic banks are worth noting. In the pre-crisis period, Global banks displayed thinner capital cushions than Domestic banks, and weaker indicators of structural liquidity. The structure of Global bank liabilities was also more heavily reliant on non-deposit funding, and tilted to the short-term. The statistics also uncover a wide difference between EQUITY and the Basel CAR, which is mainly attributable to the effect of risk-weighs in the Basel formula. Furthermore, the gap between these two measures is larger for Global banks suggesting a negative relationship between bank size and average risk-weights. For example, Global banks in the first percentile have an EQUITY ratio of only 1.4 percent compared to a Basel CAR of 9.2 percent, which is 6.6 times higher. In turn, Domestic banks have an EQUITY ratio of 2.5 and a Basel CAR of 10.1 percent, which is 4.0 times higher. Other risk indicators, such as the Z-score and credit growth are broadly similar across bank types.

To explore the relationship between the target variables in the pre-crisis period, pair-wise correlations are presented in Table 3. As before, we split the sample between Global banks (lower triangle) and Domestic banks (upper triangle) to gauge the extent of potential cross-sectional differences. Not surprisingly, various measures of liquidity tend to be closely related for both types of banks. For example, stronger structural liquidity is associated with lower reliance on short-term funding (and with money market funding) and positively correlated with deposit funding. Also, the two measures of bank capital seem to convey similar information, despite gaps stemming from risk weights. It is worth noting that the correlation between bank capital and credit growth is positive and statistically significant in both subsamples. This is

consistent with the idea that bank governance and risk management mechanisms were at play (i.e., a more aggressive credit expansion was associated with stronger capital cushions). On the other hand, some differences between the two bank types are apparent. In the case of Global banks, higher structural liquidity seems to be associated with more moderate credit growth and a larger distance to default. In the case of Domestic banks, the relationship between these variables is not significant. All in all, these correlations suggest that the expansion of bank balance sheets in the pre-crisis period was associated with riskier liquidity profiles, particularly for Global banks, but do not suggest an immediate connection with potential shortages in capital buffers. The next section explores the link between bank probability of failure with their pre-crisis levels of liquidity and capital in a more rigorous way.

To gauge the time evolution of structural liquidity and leverage across bank types, Figure 1 plots the respective medians together with the 10th and 90th percentiles. Interestingly, the average NSFR before the crisis is relatively stable and close to one. However, there is a wide dispersion across banks, with those located at the lower extreme of the distribution displaying extremely weak structural liquidity. A similar picture emerges for EQUITY capital. While the average bank displayed relatively comfortable equity to asset ratios, those located at the low end of the distribution were extremely leveraged.

A complementary diagram of the evolution of structural liquidity during the sampled period is presented in Figure 2, splitting the sample by bank types and across Failed and Non-Failed banks. The plots reveal interesting cross-sectional patterns. As expected, the failed banks had lower structural liquidity and higher

leverage than the non-failed banks. Furthermore, the NSFR follows a declining trend in the pre-crisis period, which reverts from 2007 for the Domestic banks, and from 2008 for the Global banks. In the latter group, there is a sudden drop at the peak of the crisis, followed by an equally sharp increase that reflects the hoarding of liquidity for precautionary purposes. Regarding EQUITY, Domestic banks display more comfortable cushions than Global banks and an upward trend in the pre-crisis period. After the eruption of the crisis, equity collapses in the group of failed Domestic banks, but increases in the group of failed Global banks, reflecting capital injections and public support due to their systemic importance.

Before turning to the regression analysis, we compare the distributions of pre-crisis structural liquidity and leverage across Failed and Non-Failed banks, further distinguishing between bank types (Figure 3). To facilitate the reading, we exclude banks with NSFR above 1.5 and banks with EQUITY above 20 percent. All the distributions have positive skewness and excess kurtosis, with normality tests rejecting the null in all cases. Comparing across subsamples, the most striking result is the evidence of substantially lower EQUITY in the case of Failed Global banks, with the mean close to 4 percent. The distributions of NSFR for Failed banks are also displaced to the left, but the differences tend to be lower. In fact, tests of differences of means (not shown) suggest that insufficient EQUITY was associated with failure in the case of Global banks while insufficient structural liquidity was a problem associated with the Domestic banks. In the next section we develop a empirical model to formally test these conjectures.

3.4.2 Baseline Regressions

The results of baseline probit regressions, properly transformed around the mean of the explanatory variables to show the change in the probability of failure associated with a change in the explanatory variables, support the notion that banks with higher NSFR and EQUITY in the years before the crisis were less susceptible to fail during the turmoil (Table 4). The coefficients associated to the two target variables are negative and statistically significant at the one percent level in all cases and the results are robust to the inclusion of the control variables. At the same time, the evidence indicates that banks with higher risk taking in the pre-crisis period were more likely to fail afterward. In particular, credit growth is positively associated with the probability of failure, while the Z-score (i.e., distance to default) operates in the opposite direction. On the other hand, the ratio of non-interest income to total income is not statistically significant. The latter result contrasts with Demirguc-Kunt and Huizinga (2010), which is likely due to differences in the construction of the variable. [7] Interestingly, the macroeconomic variables (which are common to all banks incorporated in a given country) are also highly significant and operate in the expected direction. Banks incorporated in countries with higher pre-crisis economic growth and with easier monetary conditions were more likely to fail during the crisis. This is consistent with the notion that banks failed to fully internalize risks stemming from their external environment. This may provide justification for the

[7] This paper measures NON-INTEREST INCOME by taking the absolute value of non-interest income to total income, to account for the fact that trading income may take negative values. Therefore, a bank with either large non-interest gains or losses relative to total income is assumed to be riskier.

implementation of macro-prudential regulations as a complement to the traditional micro-prudential approach. At the same time, it is also worth noting that the pseudo R-square of the regression tends to be low, with the model explaining less than five percent of the variation in bank probability of failure.

To assess the economic significance of the results, we take the regression coefficients presented in column (6) and compute the estimated change in the probability of failure resulting from a 0.5 standard deviation change in the explanatory variables. The results (Table 5) indicate that a 10.4 percentage point increase in the NSFR, from 0.99 to 1.09, would cause a drop 0.46 percentage point drop in the probability of failure of the average bank, all else equal. Similarly, a 3.1 percentage point increase in EQUITY, from 10.7 percent to 13.8 percent would cause a drop of 0.64 percentage point drop in bank probability of failure. Thus, the quantitative importance of these effects appears to be small, which is consistent with the results obtained in quantitative impact studies (BCBS, 2010). A caveat of this interpretation is the potential presence of either non-linear or threshold effects operating more severely for banks in the extremes of the distribution. This possibility is assessed in the next section.

Turning back to the results, the probability of failure seems to be relatively more influenced by bank risk profiles, particularly as reflected in the pre-crisis Z-score, and by bank's operating environments. Notably, banks incorporated in countries with a pre-crisis GDP growth 0.5 percentage points higher than the average were 2.2 percentage points more likely to fail, while tighter monetary conditions operated in the opposite direction. This is consistent with the presence of unsus-

tainable economic activity and/or potential asset bubbles in the pre-crisis period.

3.4.3 Are There Threshold Effects at Play?

To gauge the extent of threshold effects, we split the sample according to pre-crisis values of NSFR and EQUITY with the help of dummy variables. [8] In particular, we indentify banks with a NSFR below one and banks with EQUITY below seven. These values are relevant references from the regulatory perspective. We then re-estimate the regressions over each subsample and their combinations. As before, the estimated coefficients are transformed to convey the marginal impact of each explanatory variable on the probabilities of bank failure (Table 6). Overall, the results are consistent with the idea that liquidity and capital play a complementary role in financial stability and that threshold effects are at play. In the leftmost three columns, which are computed over the subsamples of banks with weak structural liquidity, the coefficients associated with EQUITY are two and four times higher than those obtained in the matching baseline regressions. Furthermore, the relationship between structural liquidity and the probability of failure reverses sign and becomes statistically insignificant for the subsample of banks with low liquidity and capital, indicating that capital shortages were critical for the failing banks in this subsample.

Going back to results, the rightmost three columns display a partition of the sample by levels of EQUITY. Not surprisingly, the strongest marginal benefits of capital cushions originate from the subsample of banks operating below the seven

[8] We also computed a set of regressions including squared values of the NSFR and EQUITY to allow for non-linear effects, but the results were not statistically significant.

percent threshold, as shown in column (4). The explanatory variables also account for a more significant proportion of the probability of failure in the subsamples of banks with lower capital ratios, as indicated by the pseudo R-squared at the bottom. As for the subsample of banks operating with intermediate EQUITY levels, both structural liquidity and capital seem to contribute to their capacity to withstand the crisis. The target coefficients are two and three times larger than those obtained in the baseline regression. Conversely, the coefficients are not statistically significant for the subsample of banks with EQUITY above twelve percent, as shown in column (6), which is also consistent with the existence of threshold effects.

These results, together with those obtained in the previous section indicate that the stability benefits of tighter regulations on liquidity and capital are moderate for the average bank, but substantially more relevant for the institutions located at the lower extreme of the distribution. Furthermore, the results suggest that, from the financial stability perspective, regulations on capital are likely to play a more critical role than regulations on liquidity. This poses a question on the extent of potential differences in the target parameters across Global and Domestic banks, as the former were typically more leveraged than Domestic banks in the run up to the crisis. The next section explores for this possibility.

3.4.4 Are There Differences Across Bank Types?

To assess the extent of differences across bank types, we compute separate regressions for Global and Domestic banks, and further split the latter by categories, distinguishing between commercial banks, savings banks, and cooperatives. The

results (Table 7) provide strong evidence that capital shortages played a more important role in the failure of Global banks, while liquidity was the key factor in the subsample of Domestic banks. It is worth noting the magnitude of the coefficient associated with EQUITY for the subsample of Global banks, which is almost 25 times larger than that obtained in the baseline regression. Using this value, a one percent increase in Global bank capital in the pre-crisis period would cause a material 4.8 percent drop in their probability of failure. This highlights the importance of ensuring adequate capital buffers in the systemically-important institutions. In turn, the coefficient associated with credit growth is also substantially larger for the sub-sample of Global banks, suggesting that those engaged on a more aggressive expansion in the pre-crisis period were more likely to fail. Conversely, country-specific macroeconomic conditions do not play a systematic role in the subsample of Global banks. This is likely due to diversification effects stemming from their international operations. In fact, as their operations span many countries, changes in macroeconomic conditions in their home countries do not have a strong impact on the likelihood of failure of the entire group.

In the subgroup of Domestic banks, cross-sectional differences are less stark, as indicated by the results presented in columns (3) to (5). Capital shortages appear to be relatively more important in the segment of savings banks, while commercial banks appear to be more vulnerable to problems associated to weak structural liquidity. In the segment of credit cooperatives, those more heavily engaged in non-traditional activities, proxied by the ratio of non-interest to total income, were more likely to fail during the crisis.

3.5 Robustness Checks

To gauge the robustness of the results, we estimate a complete set of parallel regressions using two alternative measures of bank liquidity and capital. As for liquidity, we use the Short Term Funding Ratio, STFR, computed by dividing liabilities with less than one year residual maturity to total liabilities. For capital, we use the Basel Tier 1 capital ratio, CAR, defined as the ratio of Tier 1 regulatory capital to risk-weighted assets. As mentioned before, this measure of capital is larger than the one used in the baseline regressions due to the application of risk weights on bank assets.

In addition, we explore with three variations in the definition bank failure. In particular, we decompose the bank failure dummy according to its components as follows: (i) banks that ceased their active status during the crisis or that were reclassified to risk categories E and E+ by Moody's; (ii) banks with regulatory CAR ratios dropping below 8 percent between 2008-09; and (iii) banks included in the failed list of compiled by Laeven and Valencia (2009).

The full set of results, omitted for brevity, is broadly consistent with those discussed previously. Summary regressions replicating the baseline specification with combinations of the alternative measures of liquidity and capital are presented in Table 8. The coefficients associated with the STFR are positive, indicating that bank reliance on short-term funding before the crisis was associated with increased financial fragility. The set of regressions that use variations in the definition of bank failure, presented in Table 9, are also broadly consistent with the baseline results.

3.6 Concluding Remarks

Overall, the findings of this paper provide broad support to Basel III initiatives on structural liquidity and leverage, and show the complementary nature of these two areas. Banks with weaker structural liquidity and higher leverage before the global financial crisis were more vulnerable to subsequent failure. The results are driven by banks in the lower extremes of the distributions, suggesting the presence of threshold effects. In fact, the marginal stability gains associated with stronger liquidity and capital cushions do not appear to be large for the average bank, but seem substantial for the weaker institutions.

At the same time, there is evidence of systematic differences across bank types. The smaller banks were more susceptible to failure on liquidity problems, while the large cross-border banking groups typically failed on insufficient capital buffers. This difference is crucial from the financial stability perspective, and implies that regulatory and supervisory emphasis should be placed on ensuring that the capital buffers of the systemically important banks are commensurate with their risk-taking.

The evidence also indicates that bank risk-taking in the run-up to the crisis was associated with increased financial vulnerability, suggesting that bank decisions regarding the associated liquidity and capital buffers were not commensurate with the underlying risks, resulting in excessive hazard to their business continuity. Country-specific macroeconomic conditions also played a role in the likelihood of subsequent bank failure, implying that banks failed to properly internalize the associated risks in their individual decision-making processes. Thus, while more intrusive

regulations entail efficiency costs, the results point to associated gains in terms of financial stability that have to be pondered. This also supports the introduction of a macro-prudential framework as a complement to traditional, micro-prudential approach. In this regard, further work is needed to deepen the understanding of the role of the macroeconomic environment on financial stability.

Appendix A

An Index of Systemic Exposure to Liquidity Risk

In a first step I explain how to construct the index of systemic exposure to liquidity risk of a banking system (hereafter, FPI). In a second step I explain why the FPI is a better indicator of liquidity risk than traditional macro-financial measures and compare and constrast them. For the contruction of the FPI I used bank-level data and macro data. Bank-level information, specifically the financial statements, is obtained from the Bankscope database. Using this source has two major advantages: (i) the coverage is fairly comprehensive with sampled banks accounting for about 90 percent of total assets in each country, according to the source, and (ii) the information at the bank level is presented in standardized formats, after adjusting for differences in accounting and reporting standards across countries. The major limitation of the data is the lack of breakdown by currency of assets and liabilities. We address the problem with aggregate data. For that and other concerns I use macroeconomic data coming from the following sources: Quarterly Externl Debt Statistics (QEDS), International Financial Statistics (IFS), World Economic Outlook (WEO) and Bank of International Settlements - Locational Banking Statistics (BIS).

A.1 The FPI

The construction of the FPI is explained in four steps: (1) selection of the institutions to be included and the level of consolidation of their balance sheet, (2) the computation of a bank-level vulnerability measure, *cash shortages*, (3) the aggregation of the previous measure and the mapping of aggregate liquidity shortages into aggregate lending problems, and (4) the normalization of the previous measure.

- **Step 1:** I define the banking system in a broad way. In addition to depositary institutions[1] I include other institutions that perform similar functions. Following Bankscope classification I include: Commercial Banks, Cooperative Banks, Real Estate & Mortgage Banks, Saving Banks, Finance Companies (Credit Card, Factoring and Leasing), Investment Banks, Micro-Financing Institutions, Specialized Governmental Credit Institutions and Other Non-Banking Credit Institutions.

  Bank holding companies are not included in the analysis when information of the actual bank belonging to the holding company is available. The reason being that the balance sheet of holding companies usually has risk characteristics that are influenced by other non-banking subsidiaries of the holding company.

  I use, when possible, the unconsolidated balance sheet of the bank. Consolidated balance sheets often present a problem when subsidiaries of the bank include insurance companies, changing dramatically the amount of securities

[1] Institutions that have access to the central bank.

and ergo the exposure to liquidity risk. However a bank facing liquidity problems does not have full access to those securities. More over, when using consolidated balance sheets the potential of double counting of balance sheets are high if bank subsiaries of the institutions have not all being properly identified.

- **Step 2:** The FPI uses as a building block the methodology and weights defined by BCBS (2009) for the purpose of computing the net stable funding ratio (NSFR). Table A.1 presents the weights in a simplified version of a financial statement, following the "universal model" in Bankscope. I use those weights[2] to compute a monetary measure of vulnerability: the potential shortage of cash an instution could face if a liquidity shock realizes. The cash shortage for bank i in country j is given by:

$$cs^{i,j} = \sum_{k} \left(1 - W_{L_k}\right) L_k^{i,j} - \sum_{h} \left(1 - W_{A_h}\right) A_h^{i,j} \tag{A.1}$$

where W_{L_k} and W_{A_h} refer to the weight assigned by BCBS (2009) to the liability k and to the asset h respectively, as described in Table A.1.

[2]Few weights have been slightly adjusted following IMF(2011).

Table A.1. Stylized Balance Sheet and the Net Stable Funding Ratio

ASSETS	RSF	**LIABILITIES AND EQUITY**	ASF
1. Total Earning Assets		1. Interest-bearing Liabilities	
1.a. Net Loans		1.a. Total Deposits, Money Market and Short-term Funding	
1.a.i. Gross Loans		1.a.i. Total Customer Deposits	
Residential Mortgage Loans	1.00	Customer Deposits - Current	0.85
Other Mortgage Loans	1.00	Customer Deposits - Savings	0.70
Other Consumer/ Retail Loans	0.70	Customer Deposits - Term	0.70
Corporate & Commercial Loans	0.85	1.a.ii. Deposits from Banks	0.00
Other Loans	1.00	1.a.iii. Repos and Cash Collateral	0.00
1.a.i. (Reserve for impared loans)	-1.00	1.a.iv. Other Deposits and Short-term Borrowings	0.00
1.b. Other Earning Assets		1.b. Total Long Term Funding	
1.b.i. Loans and Advances to Banks	0.00	1.b.ii. Senior Debt Maturing after 1 Year	0.75
1.b.ii. Total Securities		1.b.iii. Subordinated Borrowing	1.00
Reverse Repos and Cash Collateral	0.00	1.b.iv. Other Funding	0.75
Trading Securities and at FV through Income	0.15	1.c. Derivatives (NETTED IN ASSET SIDE)	
Derivatives (NETTED IN ASSET SIDE)	0.90	1.d. Trading Liabilities	0.00
Available for Sale Securities	0.15	2. Non-interest Bearing Liabilities	
Held to Maturity Securities	1.00	Fair Value Portion of Debt	0.00
At-equity Investments in Associates	1.00	Credit impairment reserves	0.00
Other Securities	1.00	Reserves for Pensions and Other	0.00
1.b.iii. Investment in Property	1.00	Current Tax Liabilities	0.00
1.b.iv. Insurance Assets	1.00	Deferred Tax Liabilities	0.00
1.b.v. Other Earning Assets	1.00	Other Deferred Liabilities	0.00
2. Non Earning Assets		Discontinued Operations	0.00
Cash and Due From Banks	0.00	Insurance Liabilities	0.00
Foreclosed Real Estate	1.00	Other Liabilities	0.00
Fixed Assets	1.00	3. Hybrid Capital	
Goodwill	1.00	Pref. Shares and Hybrid Capital accounted for as Debt	1.00
Other Intangibles	1.00	Pref. Shares and Hybrid Capital accounted for as Equity	1.00
Current Tax Assets	1.00	4. Total Equity	
Deferred Tax Assets	1.00	Common Equity	1.00
Discontinued Operations	1.00	Non-controlling Interest	1.00
Other Assets	1.00	Securities Revaluation Reserves	1.00
		Foreign Exchange Revaluation Reserves	1.00
		Fixed Asset Revaluations	1.00

- The methodology described in BCBS (2009) does not provide a way to properly account for the implications of the currency specification of assets and liabilities on liquidity risk. In addition, Bankscope does not provide a breakdown by currency of assets and liabilities. As a consequence I design a methodology to make the adjustment that relies on aggregate data. The adjusted cash shortages of bank i in country j are given by

$$acs^{i,j} = cs^{i,j} + (1 - W_{L_{bd}})\,\phi \left(\frac{b_S^j}{b_T^j}\right) \sum_k L_k^{i,j} + (1 - W_{L_{sd}})\,\phi \left(\frac{b_L^j}{b_T^j}\right) \sum_k L_k^{i,j} \quad \text{(A.2)}$$

where b_S^j, b_L^j and b_T^j represent the amount of external short-term, external long-term and total external debt that the banking system in country j has; $W_{L_{bd}}$ and $W_{L_{sd}}$ are the weights on "bank deposits" and "senior debt" of liabilities, and ϕ is a penalization factor that is calibrated to capture a tipical depreciation rate on an aggregate liquidity episode.[3] The data for b_S^j, b_L^j and b_T^j was taken from QEDS when avaiable. IFS was the second source and BIS the third source in case the information was not available in the first two.[4].

- **Step 3:** In this step we map the previous measures into a lending problem and we aggregate the results. Lets define $rnl^{i,j}$ as the amount of loans that need to be refinanced to keep the size of the loan portfolio, which is computed

[3] ϕ was calibrated at 0.4. Sensitivity analysis shows that the results are robust to in a range of 0.1-0.7.

[4] Both QEDS and IFS include, in principle, all the external liabilities of the banks (others than central bank) and should coincide. On the other hand BIS includes the external liabilities with BIS reporting banks. In addition, QEDS shows a breakdown into short-term and long-term liabilities. A comparison of the three sources can be found in Federico (2011).

as:

$$rnl^{i,j} = \omega \sum_{k \in loans} A_k^{i,j} \tag{A.3}$$

where $\sum_{k \in loans} A_k^{i,j}$ captures the loan portfolio (ie, the accounts in the asset side that represents loans to customers, as opposed to securities, deposits in the central bank or cash in vaults) and ω is a parementer that measures the typical rifinancing fraction of the loan portfolio.[5] Then $cnl^{i,j} = rnl^{i,j} - acs^{i,j}$ is the covered new lending of bank i in a scenario of aggregate liquidity stress.

Heterogeneity in bank positions can situate a bank in one of the following three scenarios: (a) $acs^{i,j} < 0$, in which case $rnl^{i,j}$ is fully refinanced and the surplus cash, -$acs^{i,j}$, finances other banks in the system that are less liquid or captures market share (the procedure is explained below); (b) $0 < acs^{i,j} < rnl^{i,j}$, in which case $cnl^{i,j}$ is rolled over; and (c) $acs^{i,j} > rnl^{i,j}$, in which case the bank cannot roll over any loans and is potentially facing default if not financed by other banks in the system. The aggregate covered new lending of country j follows from aggregating each case:

$$CNL^j = \sum_i I_{(a)}^{i,j} rnl^{i,j} + \sum_i I_{(b)}^{i,j} cnl^{i,j} + \sum_i I_{(c)}^{i,j} cnl^{i,j} - \varphi \sum_i I_{(a)}^{i,j} acs^{i,j} \tag{A.4}$$

where $I_{(a)}^{i,j}$, $I_{(b)}^{i,j}$ and $I_{(c)}^{i,j}$are indicator functions. $I_{(a)}^{i,j} = 1$ when the bank i in country j belongs to group (a) (that is, when $acs^{i,j} < 0$). $I_{(b)}^{i,j} = 1$ and $I_{(c)}^{i,j} = 1$ when bank i in country j belongs to group (b) and (c) respectively. The parameter φ captures the sharing of extra liquidity of banks in group (a) with

[5] ω has been set at $\frac{2}{7}$. I have conducted a sensitivity analysis and results are robusts. The tests were conducted in the range of reasonable values defined by $\frac{1}{3}$ and $\frac{1}{5}$.

banks in other groups.

- **Step 4:** I normalize CNL^j, which is a monetary measure, by the GDP of country j. Normalizing by GDP has the feature of partially controlling for the relevance of credit, and of exposures, for the production process of the economy.[6] I tested other normalizations as total loans in the economy, given by $\sum_i \sum_{k \in loans} A_k^{i,j}$ for country j, and the amount of loans requiring refinancing in a given year, given by $\sum_i rnl^{i,j}$ for country j. Although both have the desire feature that measure more directly the size of the exposure relative to the banking system, they fail to account how the banking system is relevant for the production process of the economy, leading, perhaps, to a high index of exposure for a country with tiny banking system. So the FPI for country j is given by:

$$FPI^j = \frac{CNL^j}{GDP^j} \tag{A.5}$$

Table A.2 describes the sample of banks used in the analysis.

[6] In addition, normalizing by GDP has the feature of controlling for the size of the resources of the economy relative to the exposure in the case the banking system could be assisted.

Table A.2. Sample of Banks in Emerging Markets

Country	# of Banks	Loans	OEA	NEA	STF	LTF	NIBL	Capital
Argentina	82	41.4%	48.3%	10.3%	82.2%	3.1%	2.5%	12.3%
Belarus	21	65.5%	20.5%	14.0%	84.9%	2.6%	1.2%	11.3%
Bolivia	13	55.7%	35.2%	9.1%	85.9%	1.0%	3.0%	10.2%
Brazil	124	35.6%	50.4%	13.0%	60.2%	11.2%	18.1%	9.9%
Bulgaria	27	62.6%	21.5%	15.9%	78.4%	9.5%	1.1%	11.0%
Chile	25	71.1%	16.9%	12.0%	73.2%	12.6%	4.8%	9.4%
China	130	49.3%	46.4%	4.2%	86.9%	4.0%	3.8%	5.4%
Colombia	26	62.4%	25.2%	12.3%	77.9%	4.6%	5.0%	12.5%
Costa Rica	63	64.7%	20.7%	14.6%	83.2%	0.0%	4.0%	12.8%
Croatia	36	59.2%	26.5%	14.3%	68.1%	16.3%	2.1%	13.5%
Czech Rep.	38	48.8%	43.8%	7.0%	74.9%	14.1%	4.3%	6.5%
Egypt	30	37.5%	52.5%	10.0%	87.2%	2.4%	4.3%	6.1%
Estonia	7	78.7%	11.4%	9.9%	81.5%	6.4%	3.7%	8.4%
Georgia	11	61.4%	13.9%	24.8%	54.9%	22.7%	3.0%	19.3%
Hungary	33	58.7%	33.4%	7.3%	72.4%	14.2%	3.4%	9.6%
India	85	59.0%	30.9%	10.1%	83.9%	4.6%	5.3%	6.3%
Indonesia	52	48.6%	36.4%	15.0%	79.6%	4.8%	4.7%	11.0%
Israel	10	65.4%	28.9%	5.5%	83.1%	4.8%	5.4%	6.7%
Jordan	14	48.2%	41.5%	10.2%	77.9%	2.0%	3.5%	16.6%
Korea	36	66.6%	24.9%	8.0%	62.7%	21.6%	6.2%	8.9%

The definitions follow from the balance sheet specified in table A.1. Assets are summarized in columns three to five, which refer to net loans - Loans (1.a.), other earning assets - OEA (1.b), and non-earning assets -NEA (2). Liabilities are summarized in columns six to nine, which refer to short-term funding - STF (1.a +1.d), long-term funding - LTF (1.b), non-interest liaibilities - NIBL (2), and hybrid capital and total equity - Capital (3+4). Financial statements were obtained from Bankscope. All variables are measured at the end of 2007.

Table A.2. Sample of Banks in Emerging Markets (*continue*)

Country	# of Banks	Loans	OEA	NEA	STF	LTF	NIBL	Capital
Latvia	21	67.0%	27.0%	6.0%	87.8%	2.4%	1.2%	8.5%
Lithuania	12	71.2%	20.2%	8.4%	85.0%	5.5%	1.5%	7.8%
Malaysia	53	51.6%	23.3%	24.9%	81.4%	5.8%	4.4%	8.4%
Mauritius	17	53.3%	24.5%	22.2%	83.7%	4.6%	3.3%	8.5%
Mexico	54	60.4%	23.2%	15.6%	58.8%	14.4%	11.8%	14.3%
Moldova	14	61.6%	18.7%	19.6%	74.0%	5.9%	1.6%	18.4%
Morocco	15	50.1%	35.8%	14.2%	86.1%	1.3%	4.4%	8.3%
Peru	22	50.9%	31.1%	18.0%	80.9%	3.5%	5.6%	10.0%
Philippines	38	39.3%	45.7%	14.7%	77.4%	3.7%	7.5%	11.4%
Poland	51	60.2%	32.5%	6.8%	84.1%	2.5%	2.7%	10.6%
Romania	31	58.5%	16.1%	25.3%	82.4%	4.8%	3.4%	9.3%
Russia	227	61.5%	28.4%	10.1%	49.3%	29.2%	7.8%	13.7%
Serbia	34	51.6%	16.2%	32.2%	70.9%	4.4%	4.0%	20.7%
Singapore	22	46.1%	40.7%	11.1%	77.1%	8.0%	3.4%	10.5%
Slovak Rep.	19	49.8%	39.5%	10.1%	81.0%	7.0%	3.1%	8.8%
Slovenia	22	67.1%	28.1%	4.7%	80.8%	8.9%	2.2%	8.1%
South Africa	37	73.4%	19.9%	5.4%	78.9%	11.1%	2.5%	6.4%
Thailand	34	67.7%	23.9%	8.3%	82.9%	3.4%	3.7%	9.9%
Turkey	56	52.3%	39.1%	8.5%	71.2%	10.0%	6.1%	12.6%
Ukraine	47	73.0%	12.1%	15.0%	77.0%	10.3%	2.1%	10.7%

The definitions follow from the balance sheet specified in table A.1. Assets are summarized in columns three to five, which refer to net loans - Loans (1.a.), other earning assets - OEA (1.b), and non-earning assets -NEA (2). Liabilities are summarized in columns six to nine, which refer to short-term funding - STF (1.a +1.d), long-term funding - LTF (1.b), non-interest liaibilities - NIBL (2), and hybrid capital and total equity - Capital (3+4). Financial statements were obtained from Bankscope. All variables are measured at the end of 2007.

Table A.3. Exposure to Liquidity Risk

Country	RSF	ASF	CS	FPI	Country	RSF	ASF	CS	FPI
Argentina	60.2%	51.4%	8.7%	-1.0%	Latvia	66.3%	50.3%	16.0%	-28.7%
Belarus	66.1%	61.8%	4.3%	4.0%	Lithuania	71.4%	52.4%	19.0%	-9.1%
Bolivia	89.0%	64.3%	24.7%	-3.3%	Malaysia	60.2%	61.8%	-1.6%	28.5%
Brazil	55.6%	41.9%	13.7%	-4.1%	Mauritius	69.6%	67.4%	2.2%	-2.0%
Bulgaria	58.3%	69.0%	-10.7%	19.4%	Mexico	67.3%	63.2%	4.1%	3.5%
Chile	74.2%	65.0%	9.1%	12.7%	Moldova	70.4%	70.0%	0.3%	7.9%
China	68.0%	66.3%	1.7%	28.7%	Morocco	62.4%	61.6%	0.7%	13.7%
Colombia	71.1%	62.1%	9.0%	5.2%	Peru	70.0%	60.9%	9.1%	0.6%
Costa Rica	86.8%	64.4%	22.3%	-3.7%	Philippines	59.9%	67.4%	-7.5%	11.1%
Croatia	58.0%	69.3%	-11.3%	21.3%	Poland	66.4%	65.2%	1.3%	7.3%
Czech Rep.	65.8%	68.9%	-3.1%	10.0%	Romania	54.1%	51.0%	3.1%	2.2%
Egypt	55.4%	64.2%	-8.8%	18.3%	Russia	70.4%	48.5%	22.0%	-4.6%
Estonia	80.3%	53.8%	26.5%	-21.3%	Serbia	56.1%	68.6%	-12.5%	12.4%
Georgia	71.7%	74.6%	-2.8%	7.1%	Singapore	55.2%	64.0%	-8.9%	26.0%
Hungary	72.1%	53.2%	18.6%	-9.0%	Slovak Rep.	66.4%	63.3%	3.1%	5.0%
India	86.2%	64.6%	21.6%	-2.0%	Slovenia	71.5%	55.6%	15.9%	-3.4%
Indonesia	63.9%	71.2%	-7.3%	9.0%	South Africa	74.7%	61.7%	13.0%	8.6%
Israel	64.6%	58.8%	5.7%	15.5%	Thailand	78.3%	65.2%	13.2%	12.2%
Jordan	59.9%	66.3%	-6.5%	20.3%	Turkey	64.7%	63.4%	1.3%	8.6%
Korea	61.9%	55.9%	6.0%	16.3%	Ukraine	71.0%	57.6%	13.3%	1.2%

RSF refers to required stable funding and is computed as specifiied in table A.1. ASF refers to available stable funding and is computed as specifiied in table A.1. CS referes to cash shortages and is computed as RSF minus ASF. The FPI is the index that capture systemic liquidity risk exposure, which is computed as defined in this appendix. All variables are measured at the end of 2007.

A.2 Comparison With Traditional Measures

After reapeted crisis in emerging markets, the literature has identified some macrofinancial aggregates that are relevant in capturing the vulnerability of such economies to aggregate liquidity shocks. Three of them stand as the most robust: (i) external short-term debt to GDP, (ii) growth of bank credit to the private sector over GDP, and (iii) the loans to deposits ratio of the banking system. Berkmen et al (2009) and Blanchard et al (2010) find that they are the most robust financial variables to explain cross country output collapse, inmediately after Lehman Brothers' bankruptcy. Their findings are replicated and discussed in detail in Appendix B.

I argue that the three macrofinancial aggregaes capture, in some degree, the exposure to liquidity risk of the banking system. Table A.3 presents the correlations between these aggregates and the FPI, but first I hypothesize potential links between them :

- External short-term debt to GDP: When the banking system is the sector borrowing short-term to external creditors it is increasing its vulnerability due to a double liquidity mismatch problem. On one hand the maturity mismatch. On the other hand there is a currency mismatch, even if the loans are specified in the funding currency, always that the bank customer has business risk specified in non-tradable goods. There are other channels throught which high short-term debt, even when hold by other sectors of the economy, can capture liquidity risks at banks. For example, banks could extend guarantees and contingent credit lines to corporate that can withdraw heavily in times of

drying up of external financing.

- Growth of bank credit to the private sector to GDP: In emerging markets it is typically the case that the local deposit base does not match the aggresive expansion in aggregate credit, and banks rely increasingly in wholesale interbank funding to finance the gap, becoming vulnerable to liquidity shocks.

- Loans to deposits is perhaps the one with the most obvious relationship. Domestic loans that are not financed with local deposits are either financed with wholesale short-term funding, long-term debt or equity. The gap is financed, into a large extent, by the first option and only to a lesser degree with the other two options, exposing the bank to liquidity risks. A bank might well have less leverage with a high loan to deposit ratio but it is almost certainly more exposed to liquidity risks. In that sense, our interpretation differs from Berkmen et al (2009).

Table A.4. Pairwise Correlations

Correlations	FPI	External Short-Term Debt	Growth of Bank Credit	Loans to Deposits
FPI	1			
External Short-Term Debt	-0.50	1		
Growth of Bank Credit	-0.57	0.65	1	
Loans to Deposits	-0.65	0.57	0.64	1

External Short-Term Debt is measured over GDP a the end of 2007. Growth of Bank Credit refers to credit to the private sector and is measures as the ratio of bank credit to GDP at the end of 2007 minus the ratio at the end of 2003. Loans to Deposits is measured at the end of 2007.

A.3 Other Tables and Figures

Table A.5. Core and Extended Samples

Country	Core	Extended	Country	Core	Extended
Argentina	✓	✓	Latvia	✓	✓
Belarus		✓	Lithuania	✓	✓
Bolivia		✓	Malaysia	✓	✓
Brazil	✓	✓	Mauritius		✓
Bulgaria		✓	Mexico	✓	✓
Chile	✓	✓	Moldova		✓
China	✓	✓	Morocco		✓
Colombia	✓	✓	Peru	✓	✓
Costa Rica		✓	Philippines	✓	✓
Croatia	✓	✓	Poland	✓	✓
Czech Rep.	✓	✓	Romania		✓
Egypt		✓	Russia	✓	✓
Estonia	✓	✓	Serbia	✓	✓
Georgia		✓	Singapore		✓
Hungary	✓	✓	Slovak Rep.	✓	✓
India	✓	✓	Slovenia	✓	✓
Indonesia	✓	✓	South Africa	✓	✓
Israel	✓	✓	Thailand	✓	✓
Jordan		✓	Turkey	✓	✓
Korea	✓	✓	Ukraine		✓

Table A.6. Selected Macro Aggregates for Sample Countries

Country	UOG	UPG	ESTD	LD	CG	Credit	NPL
Argentina	-8.9%	-2.6%	13.0%	111.0%	3.7%	14.5%	0.3%
Belarus	-7.5%	-11.3%	18.5%	127.8%	13.1%	24.8%	2.5%
Bolivia	-4.1%	-5.1%	10.6%	92.1%	-10.9%	37.0%	-0.8%
Brazil	-9.7%	-1.3%	5.7%	155.8%	19.2%	47.9%	1.1%
Bulgaria	-7.0%	-8.3%	48.7%	98.9%	36.3%	62.8%	3.9%
Chile	-9.2%	-4.5%	14.0%	94.7%	9.9%	88.3%	2.0%
China	-1.0%	-3.9%	7.4%	94.7%	-19.7%	107.5%	-0.8%
Colombia	-4.0%	-1.4%	4.9%	122.8%	9.4%	30.4%	0.1%
Costa Rica	-8.5%	-4.0%	16.1%	110.0%	13.1%	44.4%	0.5%
Croatia	-10.9%	-5.4%	20.7%	113.2%	16.5%	62.3%	2.9%
Czech Rep.	-12.0%	-10.0%	25.3%	91.5%	16.2%	47.9%	1.8%
Egypt	-3.9%	-2.3%	2.9%	101.1%	-8.4%	45.5%	-1.4%
Estonia	-24.1%	-12.3%	49.3%	172.1%	43.3%	93.9%	3.3%
Georgia	-12.5%	-4.8%	9.7%	187.4%	19.6%	28.3%	2.2%
Hungary	-12.6%	-10.4%	27.8%	156.1%	19.1%	61.4%	3.7%
India	3.9%	-2.1%	4.4%	101.0%	12.8%	44.8%	
Indonesia	-3.2%	-3.4%	13.7%	109.3%	2.5%	25.5%	0.1%
Israel	-3.5%	-3.8%	21.4%	83.9%	3.0%	88.5%	
Jordan	-2.3%	-2.9%	14.4%	94.4%	17.5%	88.3%	2.5%
Korea	-6.6%	-4.2%	15.3%	128.4%	9.3%	99.6%	0.1%

UOG refers to unexpected output growth, UPG to unexpected partner growth, ESTD to the external short-term debt to GDP ratio, LD to the loans to deposits ratio, CG to the growth of bank credit to the private sector, Credit to the amount of bank credit to the private sector over GDP, and NPL to the change in non-performing loans over assets. UOG, UPG, ESTD, LD and Credit are measured at the end of 2007. CG corresponds to the growth between 2003 and 2007 and is normalized by GDP. NPL refers to the change between 2008 and 2009.

Table A.6. Selected Macro Aggregates for Sample Countries (*continue*)

Country	UOG	UPG	ESTD	LD	CG	Credit	NPL
Latvia	-26.3%	-8.0%	78.7%	244.7%	48.4%	88.7%	12.8%
Lithuania	-24.2%	-9.6%	45.1%	163.5%	37.2%	60.0%	14.7%
Malaysia	-10.3%	-11.9%	10.9%	91.8%	-13.7%	105.3%	-1.1%
Mauritius	-4.7%	-5.4%	2.3%	107.9%	4.5%	77.7%	
Mexico	-14.3%	-1.9%	5.1%	148.5%	6.0%	22.0%	-0.1%
Moldova	2.0%	-5.3%	33.6%	103.8%	16.5%	36.9%	11.1%
Morocco	0.1%	-3.0%	2.4%	104.0%	16.0%	58.4%	-0.5%
Peru	-11.5%	-2.5%	9.7%	68.6%	0.5%	21.0%	0.5%
Philippines	-7.3%	-4.8%	9.7%	87.7%	-5.0%	29.9%	-0.4%
Poland	-3.8%	-5.5%	21.4%	113.0%	11.4%	39.4%	3.1%
Romania	-17.9%	-3.3%	24.9%	114.1%	21.3%	35.1%	8.8%
Russia	-18.9%	-3.9%	16.6%	79.6%	17.6%	38.7%	5.9%
Serbia	-10.1%	-4.3%	13.4%	88.5%	15.7%	34.9%	4.2%
Singapore	-6.7%	-17.0%	13.6%	65.3%	-22.4%	87.4%	0.6%
Slovak Rep.	-17.6%	-10.3%	24.0%	105.0%	10.5%	42.4%	2.8%
Slovenia	-16.1%	-8.6%	33.3%	158.1%	38.1%	79.5%	0.5%
South Africa	-7.4%	-3.0%	11.7%	107.6%	43.0%	161.9%	2.0%
Thailand	-12.2%	-7.7%	14.1%	106.0%	12.7%	113.2%	-0.4%
Turkey	-8.4%	-2.7%	12.9%	120.3%	14.9%	29.5%	1.8%
Ukraine	-21.2%	-7.2%	27.0%	154.6%	33.6%	58.2%	22.8%

UOG refers to unexpected output growth, UPG to unexpected partner growth, ESTD to the external short-term debt to GDP ratio, LD to the loans to deposits ratio, CG to the growth of bank credit to the private sector, Credit to the amount of bank credit to the private sector over GDP, and NPL to the change in non-performing loans over assets. UOG, UPG, ESTD, LD and Credit are measured at the end of 2007. CG corresponds to the growth between 2003 and 2007 and is normalized by GDP. NPL refers to the change between 2008 and 2009.

Table A.7. Unexpected Output Growth After Lehman's Bankruptcy in Emerging Markets (*extende sample*)

(dependent variable: projected minus actual growth from Q3.08 to Q2.09, saar)

Regressor							
Unexpected Partner Growth	0.74***	0.26*	0.71***	0.65***	0.48**	0.71***	0.68***
FPI	0.33***				0.24***	0.22**	0.21**
External Short-Term Debt		-0.26***			-0.13*		
Growth of Bank Credit			-0.23***			-0.13**	
Loans to Deposits				-0.11***			-0.06*
Constant	-7.33***	-3.28*	-2.49	7.00**	-5.80***	-5.09**	-0.39
N	40	40	40	40	40	40	40
R-sq	0.47	0.51	0.5	0.54	0.51	0.53	0.52

[1]Robust standard errors,*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[2]Forecasetd minus actual GDP growth of trade partners (Q3.08 vs Q2.09, saar), weighted by trade and multiplied by home export share of nominal GDP in 2007.

[3]External short-term debt, on a remaining maturity basis, as a percentage of GDP, end of 2007.

[4]Bank credit to the private sector as a percetage of GDP, end of 2007 minus end of 2003.

[5]Total bank claims over deposits in depositary corporations other than Central Banks.

Appendix B

Derivation of the Model in Chapter 2

A full maximazation is a possible approach to solve the model. However, its simple structure allows us to solve it using dynamic programming tecniques. In this appendix I use the second approach to work the solution.

B.1 Descentrilized Equilibrium

I use standard dynamic programming techniques to solve the competitive equilibrium problem. I start with the $t = 1$ optimization problem and solve recursively:[1]

$$V_1^i(l_0, s_0, b_{0,} d_0, L_0, S_0) = Max_{n_1, s_1} \quad d_{1i} + V_2^i(l_{1i}, s_{1i}, b_{0,} L_{1i}, S_{1i})$$

subject to

$$r_1^L l_0 + r_1^S s_0 + p_{1i}^L(l_0 - l_{1i}) = s_{1i} + d_{1i} + I^i b_0 \tag{B.1}$$

$$d_{1z} \geq -\underline{\mathrm{d}} \quad (\lambda) \tag{B.2}$$

$$V_2^j = r_{2i}^L l_{1i} + r_{2i}^S s_{1i} - (1 - I^i) b_0 \tag{B.3}$$

where $i = n, z$ and I^i is an indicator function equal to one when external financing is recalled in $t = 1$ and equal to zero when it is rolled over. The euler equations for s_{1i} and l_{1i} are :

$$r_{2i}^s = 1 + \lambda \tag{B.4}$$

[1] We work in a model with no default of banks to households' deposits. Thus, implicit in the optimization we satisfy the restriction $n_1 + n_2 > d_0$ on the realized values.

$$r_{2i}^L = p_{1i}^L(1+\lambda) \tag{B.5}$$

When the external financing is recalled and the financial constraint binds, $s_{1z} = r_1^L l_0 + r_1^S s_0 + p_{1z}^L(l_0 - l_{1z}) - b_0 + \underline{d}$. When solving the $t = 0$ problem the representative bank knows that the level of s_{1z} follows the contraint and takes it into account. The $t = 0$ problem can be written as:

$$\begin{aligned} V_0(d_0) \;=\; & Max_{s_0,l_0,b_0} \;\; \theta\left\{r_1^L l_0 + r_1^S s_0 + p_{1n}^L(l_0 - l_{1n}) - s_{1n} + r_{2n}^L l_{1n} + r_{2n}^S s_{1n} - b_0\right\} \\ & +(1-\theta)\left\{p_{1z}^L(l_0 - l_1) + r_{2z}^S\left(r_1^L l_0 + r_1^S s_0 - b_0\right) + r_{2z}^L l_{1z}\right\} \end{aligned} \tag{B.6}$$

subject to

$$l_0 + s_0 = d_0 + b_0 \qquad (\mu) \tag{B.7}$$

with the resulting euler equations given by

$$\theta\left(r_1^L + p_{1n}^L\right) + (1-\theta)(1+\lambda)\left(r_1^L + p_{1z}^L\right) = \theta + (1-\theta)(1+\lambda) \tag{B.8}$$

$$\theta r_1^S + (1-\theta)(1+\lambda) r_1^S = \theta + (1-\theta)(1+\lambda) \tag{B.9}$$

B.2 Constrained Planner

In t=1 the constrained planner has the same euler equations than in the competitive equilibrium. However the planner recognizes that the returns of the assets are derived from the marginal productivities:

$$S_{1n} = \left(\alpha A L_0^{\beta}\right)^{\frac{1}{1-\alpha}} \tag{B.10}$$

$$S_{1z} = \left[\alpha A S_0^{\alpha-1} L_0^{\beta}\right] S_0 + \left[\beta A S_0^{\alpha} L_0^{\beta-1}\right] L_0 - B_0 + \underline{d} \tag{B.11}$$

Notice that in this economy, where households have linear preferences in consumption and own the banks, the problem of a contrained planner in $t = 0$ is to maximize expected production. The value function in $t = 0$ is given by:

$$V_0(D_0) = Max_{L_0,S_0,B_0}\ Y_1 + \theta Y_{2n} + (1-\theta)Y_{2z} - B_0 - \theta S_{1n} - (1-\theta)S_{1z} \quad \text{(B.12)}$$

subject to

$$L_0 + S_0 = D_0 + B_0 \quad \text{(B.13)}$$

where $S_{1n} = \left(\alpha A L_0^{\beta}\right)^{\frac{1}{1-\alpha}}$, $S_{1z} = (\alpha+\beta)AS_0^{\alpha}L_0^{\beta}H^{1-\alpha-\beta} - B_0 + \underline{d}$, $Y_1 = AS_0^{\alpha}L_0^{\beta}H^{1-\alpha-\beta}$, $Y_{2n} = AS_{1n}^{\alpha}L_0^{\beta}$ and $Y_2 = AS_{1z}^{\alpha}L_0^{\beta}H^{1-\alpha-\beta}$. The euler equations for L_0 and S_0 are given respectively by:

$$r_1^L + \theta r_{2n}^L + (1-\theta)r_{2z}^L + (\alpha+\beta)(1-\theta)\lambda r_1^L = 1 + (1-\theta)\lambda$$

$$r_1^S + (\alpha+\beta)(1-\theta)\lambda r_1^S = 1 + (1-\theta)\lambda \quad \text{(B.14)}$$

B.3 Descentrilized Equilibrium with Policies

I derive the euler equations of the descentralized equilibrium at $t = 0$ with policy instruments in the problem. Specifically I introduce five policy instruments:

- proportional tax on seeders: t^S
- proportional tax on land: t^L
- proportional tax on external financing: t^B
- a loans to deposits ratio, which introduces the restriction $\frac{l_0+s_0}{d_0} \leq \chi_1 \quad (\Psi_1)$

- a cap on the size of credit to the private sector,[2] represented by $l_0 + s_0 \leq \chi_2 \quad (\Psi_2)$

The $t = 0$ problem can be written as:

$$\begin{aligned} V_0(d_0) &= Max_{s_0,l_0,b_0} \ \theta \left\{ r_1^L l_0 + r_1^S s_0 + p_{1n}^L (l_0 - l_{1n}) - s_{1n} + r_{2n}^L l_{1n} + r_{2n}^S s_1 - b_0 \right\} \\ &\quad + (1-\theta) \left\{ p_{1z}^L (l_0 - l_{1z}) + r_{2z}^S \left(r_1^L l_0 + r_1^S s_0 - b_0 \right) + r_{2z}^L l_{1z} \right\} \end{aligned} \tag{B.15}$$

subject to

$$(1 + t^L) l_0 + (1 + t^S) s_0 = d_0 + (1 - t^B) b_0 \qquad (\mu) \tag{B.16}$$

$$\frac{l_0 + s_0}{d_0} \leq \chi_1 \quad (\Psi_1) \tag{B.17}$$

$$l_0 + s_0 \leq \chi_2 \quad (\Psi_2) \tag{B.18}$$

with the euler equations given by

$$r_1^L + \theta r_{2n}^L + (1-\theta) r_{2z}^L + (1-\theta)\lambda r_1^L = \frac{(1+t^L)}{(1+t^B)} \left[1 + (1-\theta)\lambda \right] + \Psi_1 + \Psi_2 \tag{B.19}$$

$$r_1^S + (1-\theta)\lambda r_1^S = \frac{(1+t^S)}{(1+t^B)} \left[1 + (1-\theta)\lambda \right] + \Psi_1 + \Psi_2 \tag{B.20}$$

B.4 Proofs

Proof to Lemma 2: It is trivial to show that the contraint will never bind in the equilibria where banks are unconstrained in both normal and crisis states. In that equilibria $r_1^S = r_{2n}^S = r_{2z}^S = 1$ and $r_1^L = r_{2n}^L = r_{2z}^L = \frac{1}{2}$ follow from the

[2]This is analogous to a cap on the growth of bank credit to the private sector. Althought the model doesnt have a history, we can think on a repeated version where, in a second stage, the parameter productivity augmenting parameter increases, increasing the optimal amount of credit/investment to be made.

equilibrium conditions and the fact that the aggregate amount of land is constant. The previous implies $s_0 = s_{1n} = s_{1z}$, and the participations constraint is equivalent to

$$\begin{aligned} d_0 \;\leq\; & \theta(r_1^L l_0 + r_1^L s_0 - s_{1n} + r_{2n}^L l_0 + r_{2n}^L s_0 - l_0 - s_0 + d_0) \\ & +(1-\theta)\left(r_{1z}^L l_0 + r_{1z}^L s_0 - s_{1z} - l_0 - s_0 + d_0 + r_{2z}^L l_0 + r_{2z}^L s_0\right) \end{aligned} \tag{B.21}$$

where the constraint $l_0 + s_0 = b_0 + d_0$ was replaced. The previous reduces to $d_0 \leq d_0$, which is always true. In the equilibria where the transfer constraint binds in the crisis state, it is true that $r_1^S = r_{2n}^S = 1$, what implies $s_0 = s_{1n}$ since the aggregate amount of land is constant. Lets assume for a momment that k is =1, that is, there is no transfer from households to banks in the crisis state at date 1. Then, the participation constraint is given by:

$$d_0 \leq \theta(r_1^L l_0 + r_{2n}^L l_0 - l_0 + d_0) + (1-\theta)\left(r_{2z}^L l_0 + r_{2z}^L\left(r_1^L l_0 - l_0 + d_0\right)\right) \tag{B.22}$$

where the budgen constraint $s_{1z} = r_1^L l_0 - l_0 + d_0$ was replaced. Re-writing the previous condition

$$d_0 \leq l_0(\theta r_1^L + \theta r_{2n}^L + (1-\theta)r_{2z}^L + (1-\theta)r_{2z}^L r_1^L - \theta - (1-\theta)r_{2z}^L) + (\theta + (1-\theta)r_{2z}^L)d_0 \tag{B.23}$$

where the first parenthesis is equal to zero by equilibrium condition (2.14). Then it follows

$$d_0 \leq d_0(\theta + (1-\theta)r_{2z}^L) \tag{B.24}$$

$$0 \leq \lambda \tag{B.25}$$

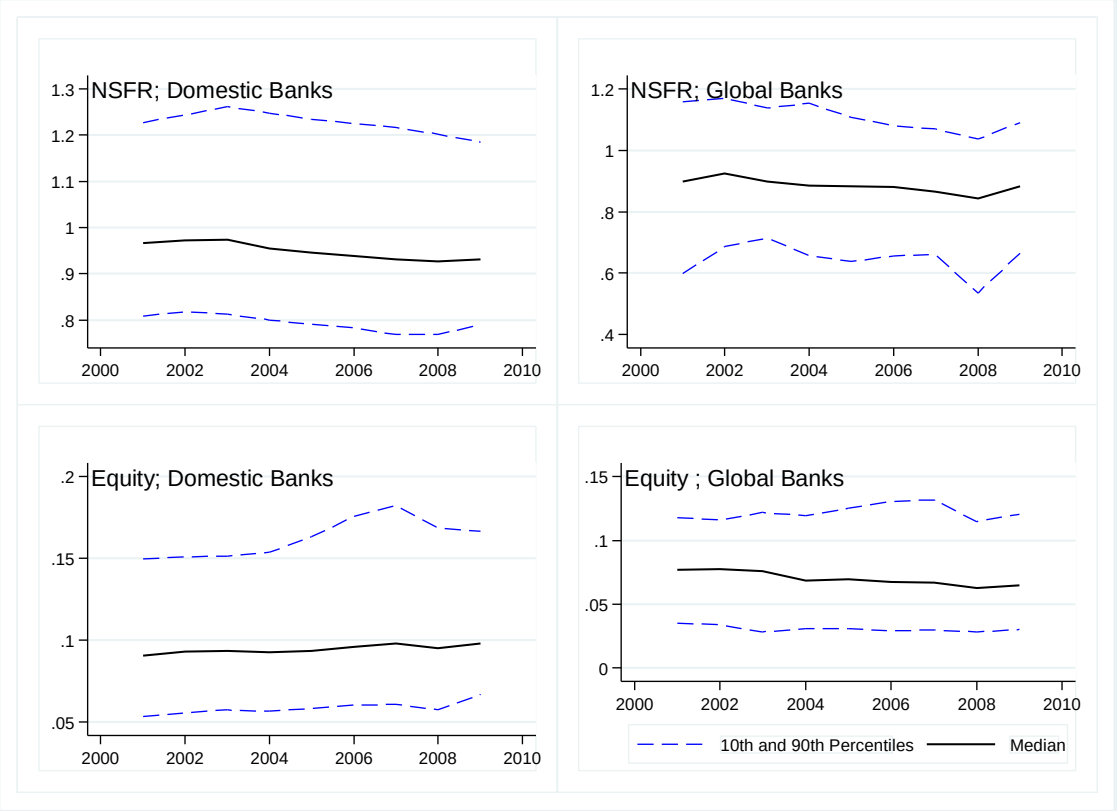
which always hold with inequality when the constraint binds. The reason is that the will be a liquidity premium in such equilibria. When the assumption $\kappa = 1$

is relaxed, the participation constraint will still be holding since, the amount of cash injected by the houshods $(1-\kappa)w_1 h$ will be invested in seeders with return $r^S_{2z} > 1$.

Appendix C

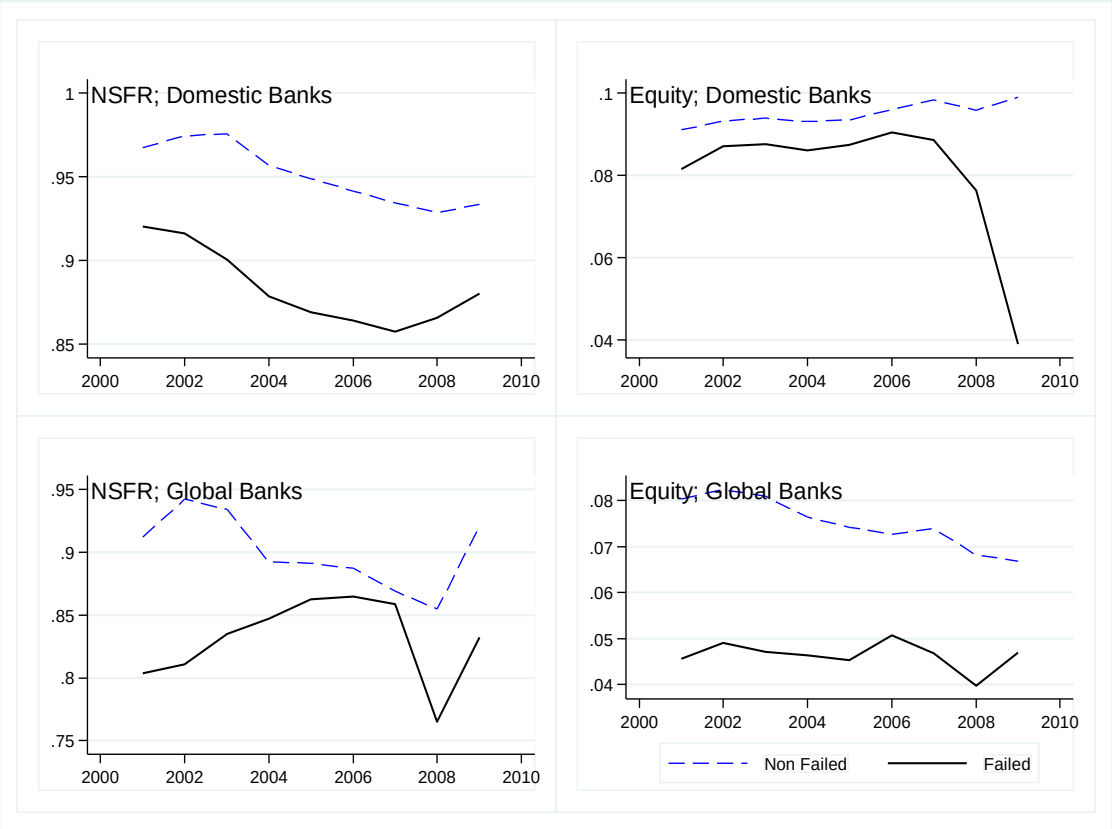
Tables and Figures from Chapter 3

Figure C.1: Evolution of Structural Liquidity and Leverage across Bank Types, 2001-09



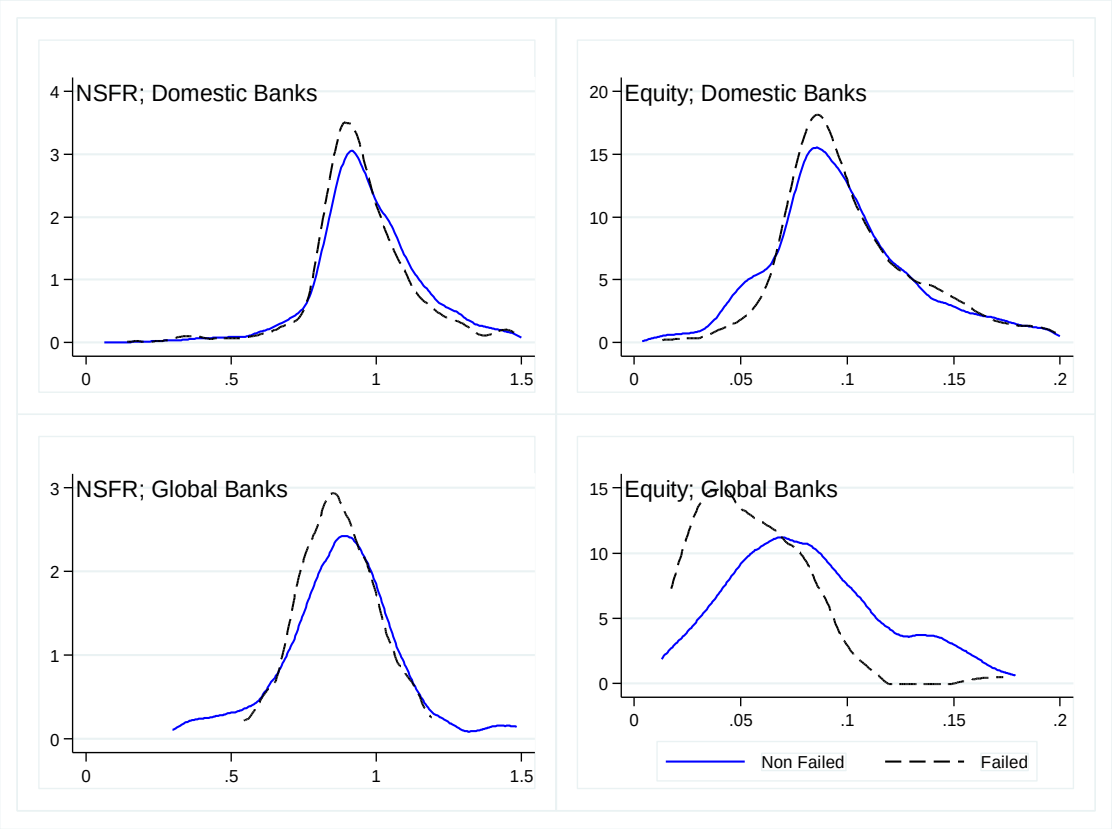
This figure presents the evolution of the structural liquidity and leverage for the subsamples of Domestic and for Global banks during 2001-09. The solid lines correspond to the median and the dotted lines to the 10th and 90th percentiles of the distributions.

Figure C.2: Evolution of Structural Liquidity and Leverage across Failed and Non-Failed Banks, 2001-09



This figure presents the evolution of the median structural liquidity and leverage for the subsamples of Domestic and Global banks, further splitting each group in failed versus Non-Failed institutions.

Figure C.3: Distributions of Pre-Crisis Liquidity and Leverage across Failed and Non-Failed Banks



This figure plots the pre-crisis density functions of structural liquidity and leverage for the subsamples of Domestic and Global banks, further splitting each group in Failed and Non-Failed institutions.

Figure C.4: Stylized Balance Sheet and Weights to Compute the NSFR

ASSETS	Wi	LIABILITIES + EQUITY	Wi
1 Total Earning Assets		**1** Deposits & Short term funding	
1.A Loans	100%	**1.A** Customer Deposits	
1.A.1 Total Customer Loans		**1.A.1** Customer Deposits - Current	85%
Mortgages		**1.A.2** Customer Deposits - Savings	70%
Other Mortgage Loans		**1.A.3** Customer Deposits - Term	70%
Other Consumer/ Retail Loans		**1.B** Deposits from Banks	0%
Corporate & Commercial Loans		**1.C** Other Deposits and Short-term Borrowings	0%
Other Loans			
1.A.2 Reserves for Impaired Loans/NPLs		**2** Other interest bearing liabilities	
1.B Other Earning Assets	35%	**2.A** Derivatives	0%
1.B.1 Loans and Advances to Banks		**2.B** Trading Liabilities	0%
1.B.2 Derivatives		**2.C** Long term funding	100%
1.B.3 Other Securities		**2.C.1** Total Long Term Funding	100%
Trading securities		Senior Debt	
Investment securities		Subordinated Borrowing	
1.B.4 Remaining earning assets		Other Funding	
2 Fixed Assets	100%	**2.C.2** Pref. Shares and Hybrid Capital	100%
3 Non-Earning Assets		**3** Other (Non-Interest bearing)	100%
3.A Cash and due from banks	0%	**4** Loan Loss Reserves	100%
3.B Godwill	100%	**5** Other Reserves	100%
3.C Other Intangibles	100%		
3.D Other Assets	100%	**6** Equity	100%

This table presents a stylized bank balance sheet, together with the weights assigned to different assets and liabilities for the computation of the net stable funding ratio.

Table C.1. Sample Coverage by Bank Types

	Domestic Banks			Global Banks		
	Non-Failed	Failed	Total	Non-Failed	Failed	Total
Austria	142	0	142	4	3	7
Belarus	2	0	2	0	0	0
Belgium	8	0	8	0	2	2
Bosnia-Herzegovina	3	0	3	0	0	0
Bulgaria	1	0	1	0	0	0
Croatia	5	0	5	0	0	0
Cyprus	3	0	3	2	0	2
Denmark	56	0	56	2	1	3
Finland	0	0	0	1	0	1
France	40	36	76	1	4	5
Germany	1274	6	1280	5	4	9
Greece	2	0	2	0	4	4
Hungary	3	0	3	1	0	1
Iceland	8	0	8	0	0	0
Ireland	1	0	1	1	0	1
Italy	27	0	27	2	3	5
Latvia	0	2	2	0	0	0
Lithuania	1	0	1	0	0	0
Luxembourg	3	0	3	0	0	0
Macedonia (FYR)	2	0	2	0	0	0

Table C.1. Sample Coverage by Bank Types (*continued*)

	Domestic Banks			Global Banks		
	Non-Failed	Failed	Total	Non-Failed	Failed	Total
Malta	1	0	1	0	0	0
Moldova Rep. Of	3	1	4	0	0	0
Montenegro	2	0	2	0	0	0
Netherlands	2	0	2	3	3	6
Norway	43	1	44	0	0	0
Poland	3	0	3	0	0	0
Portugal	0	0	0	2	0	2
Romania	2	0	2	0	0	0
Russian Federation	60	17	77	1	1	2
Serbia	6	0	6	0	0	0
Slovenia	3	0	3	0	0	0
Spain	28	1	29	2	0	2
Sweden	60	13	73	3	0	3
Switzerland	241	6	247	2	1	3
Turkey	3	0	3	1	0	1
Ukraine	7	6	13	0	0	0
United Kingdom	6	0	6	3	5	8
U.S.	7950	715	8665	19	5	24
Total	10,001	804	10,805	55	36	91

Table C.2. Summary Statistics of Selected Variables, 2001-07

	Mean	St. Dev.	Perc. 1	Perc. 99	Obs.
Domestic Banks					
NSFR	0.987	0.190	0.599	1.615	10704
STFR	0.059	0.100	0.000	0.480	10704
Money Market Funding to Total Liabilities	0.030	0.056	0.000	0.242	10106
Customer Deposits to Total Liabilities	0.894	0.124	0.429	1.000	10704
Equity Capital to Assets	0.101	0.044	0.025	0.251	10704
CAR Ratio	0.175	0.088	0.101	0.522	9260
Sharpe Ratio	0.050	0.048	-0.006	0.232	10704
Z-score	0.467	0.433	0.042	2.077	10704
Non-Interest Income to Assets	0.009	0.009	0.001	0.049	10704
Credit Growth	0.111	0.130	-0.084	0.661	10704
memo: Total Assets 2009 (Bln. USD)	0.7	2.9	0.0	11.3	
Global Banks					
NSFR	0.895	0.214	0.545	2.352	91
STFR	0.252	0.157	0.013	0.681	91
Money Market Funding to Total Liabilities	0.123	0.109	0.001	0.566	89
Customer Deposits to Total Liabilities	0.499	0.218	0.002	0.921	91
Equity Capital to Assets	0.063	0.035	0.014	0.205	91
CAR Ratio	0.132	0.075	0.092	0.766	83
Sharpe Ratio	0.067	0.118	-0.001	1.035	91
Z-score	0.441	0.712	0.039	5.910	91
Non-Interest Income to Assets	0.018	0.020	0.001	0.127	91
Credit Growth	0.198	0.145	-0.023	0.788	91
memo: Total Assets 2009 (Bln. USD)	527.1	707.6	23.1	2964.3	

This table presents summary statistics of selected variables during 2001-07 (the period preceding the global financial crisis). The statistics are computed over two subsamples: Global banks and Domestic banks.

Table C.3. Pair-wise Correlations between Selected Variables, by Bank Types, 2001-07

	NSFR	STFR	Money Market Funding	Deposit Funding	Equity to Assets	CAR	Credit Growth	Z-score	Other Income to Assets
NSFR		-0.6030*	-0.3288*	0.2816*	0.025	0.5899*	0.057	-0.046	0.1052*
STFR	*-0.4480**		0.5504*	-0.6671*	-0.064	-0.066	-0.022	0.088	-0.063
Money Market Funding	*-0.3463**	*0.8658**		-0.3513*	-0.2146*	-0.013	-0.1071*	-0.086	0.054
Deposit Funding	*0.3785**	*-0.8472**	*-0.7452**		0.2430*	-0.1193*	0.016	-0.088	0.1936*
Equity to Assets	*0.3362**	*0.1429**	*0.2449**	*-0.0774**		0.1469*	0.2237*	0.079	0.3864*
CAR	*0.6090**	*-0.0636**	*-0.0667**	*0.1183**	*0.8173**		0.073	0.2353*	0.046
Credit Growth	*0.0140**	*0.0497**	*0.0729**	*-0.0405**	*0.0619**	*0.1186**		-0.036	0.029
Z-score	*0.0722**	*0.0102**	*0.0110**	*-0.0150**	*0.1290**	*0.1738**	*-0.1130**		-0.698
Other Income to Assets	*-0.0868**	*0.3805**	*0.4476**	*-0.3704**	*0.1950**	*-0.0631**	*0.0098**	*-0.0957**	

This table presents pair-wise correlations of selected variables during 2001?07. Starred correlations are statistically different from zero at the one percent level. Correlations in the lower triangle are for the subsample of Global banks; correlations in the upper triangle are for the subsample of Domestic banks.

Table C.4. Baseline Probit Regressions for the Entire Sample

	[1]	[2]	[3]	[4]	[5]	[6]
	All Sample	All Sample	All Sample	All Sample	All Sample	All Sample
NSFR	-0.0690***		-0.0585***	-0.0461***	-0.0421***	-0.0431***
	[0.015]		[0.015]	[0.015]	[0.015]	[0.015]
Equity		-0.2341***	-0.1452**	-0.2512***	-0.2008***	-0.1993***
		[0.068]	[0.069]	[0.073]	[0.072]	[0.073]
Credit Growth				0.0590***	0.0491***	0.0487***
				[0.015]	[0.014]	[0.014]
Z-Score					-0.0471***	-0.0477***
					[0.011]	[0.011]
Non-Interest Income						-0.253
						[0.302]
GDP Growth 2001-07	4.1008***	4.4759***	4.3866***	4.2473***	3.9885***	4.0479***
	[0.336]	[0.361]	[0.356]	[0.357]	[0.363]	[0.366]
Monetary Conditions 2001-07	-0.9138***	-0.8543***	-0.8646***	-0.9469***	-1.0286***	-0.9738***
	[0.281]	[0.264]	[0.266]	[0.280]	[0.341]	[0.334]
Observations	10,896	10,896	10,896	10,896	10,896	10,896
Pseudo R2	0.0243	0.0225	0.0252	0.0322	0.0398	0.0399

This table presents the results of bank-level probit regressions with robust standard errors [in brackets]. The dependent variable equals one for banks failing during the global financial crisis (2008?09) and zero otherwise. The regression coefficients have been transformed to convey the change in the probability of failure associated with a marginal change in the explanatory variables from their pre-crisis mean values. The two target variables are the net stable funding ratio (NSFR), and equity to assets (Equity). The explanatory variables include a set of bank-level controls aimed at capturing bank risk profiles during the pre-crisis period: the average yearly credit growth, the distance to default (z-score), and the absolute value of non-interest income to total income. The explanatory variables also include two macro-level controls, which are common to all banks incorporated in a given country: the average GDP growth in the pre-crisis period, and the money market rates. All the explanatory variables are measured by the average of the respective series during the pre-crisis period (2001?07). Similar results were obtained by averaging the explanatory variables over 2004?07 to check for an apparent break associated with the introduction of International Financial Reporting Standards in 2005, and using their values as of end-2007. Starred coefficients indicate statistical significance at one percent (***); five percent (**), and ten percent (*).

Table C.5. Estimates of the Marginal Impact on the Probabilities of Default

Variable	[1] Regression Coefficients	[2] Mean of Variable	[3] Change in Variable	[4] Change in Pr. Failure (Percentage points) 1/
NSFR	-0.043	0.986	0.104	-0.45
Equity Capital to Assets	-0.199	0.107	0.031	-0.63
Credit Growth	0.049	0.130	0.081	0.39
Z-Score	-0.047	0.469	0.230	-1.08
Non-Interest Income to Assets	-0.253	0.010	0.006	-0.16
GDP Growth 2001-07	4.048	0.026	0.005	2.16
Monetary Conditions 2001-07	-0.973	0.031	0.007	-0.67

1/ Associated with a 0.5 standard deviation change in the corresponding variable.

This table presents the estimated impact of a change in the pre-crisis values of the explanatory variables on the likelihood of subsequent bank failure. The coefficients presented in column [1] are taken from the last regression in Table 5. For each explanatory variable, the pre-crisis mean is presented in column [2], and a 0.5 standard deviation is displayed column [3]. The estimate defects, measured in percentage point changes in the probability of bank failure, are presented in column [4].

Table C.6. Probit Regressions by Sub-Samples of Liquidity and Leverage

	[1]	[2]	[3]	[4]	[5]	[6]
	NSFR < 1	NSFR<1 and Equity below 7 Percent	NSFR<1 and Equity between 7 and 12 Percent	Average Equity below 7 Percent	Average Equity between 7 and 12 Percent	Average Equity above 12 Percent
NSFR	0.009	0.0704	-0.1091*	-0.0218	-0.0858***	-0.0018
	[0.036]	[0.046]	[0.057]	[0.018]	[0.025]	[0.023]
Equity	-0.3490***	-1.1667***	-0.5937*	-1.0045**	-0.6343**	-0.1475
	[0.112]	[0.447]	[0.353]	[0.404]	[0.262]	[0.105]
Credit Growth	0.1301***	0.0885	0.2897***	0.0881*	0.1902***	0.0180*
	[0.023]	[0.056]	[0.037]	[0.048]	[0.025]	[0.010]
Z-Score	-0.0543***	0.0017	-0.0544***	0.0029	-0.0542***	-0.0657***
	[0.017]	[0.012]	[0.020]	[0.009]	[0.016]	[0.018]
Non-Interest Income	-0.2159	-0.4481	0.1243	-0.3947	0.094	-0.5872
	[0.412]	[0.838]	[0.516]	[0.598]	[0.407]	[0.447]
GDP Growth 2001-07	4.0177***	4.7385***	2.9141***	4.5008***	3.1336***	3.5580***
	[0.479]	[0.679]	[0.959]	[0.585]	[0.755]	[0.715]
Monetary Conditions 2001-07	-0.8515**	2.1617***	-3.0919***	2.1699***	-3.2266***	-0.8456
	[0.378]	[0.800]	[1.002]	[0.809]	[0.960]	[0.542]
Observations	6,744	1,421	4,391	1,798	6,637	2,461
Pseudo R2	0.0478	0.146	0.0489	0.128	0.0424	0.0492

This table presents the results of bank-level probit regressions with robust standard errors [in brackets]. The dependent variable equals one for banks failing during the global financial crisis (2008?09) and zero otherwise. The regression coefficients have been transformed to convey the change in the probability of failure associated with a marginal change in the explanatory variables from their pre-crisis mean values. All the regressions conform to the same specification, applied to alternative sample partitions according to target levels of liquidity and capital. The regressions presented in leftmost three columns correspond to the subsample of banks with a pre-crisis NSFR below one and complementary intervals of EQUITY specified in the headings. The regressions presented in the rightmost three columns correspond to sample partitions by intervals of EQUITY. Starred coefficients indicate statistical significance at one percent (***); five percent (**), and ten percent (*).

Table C.7. Probit Regressions by Bank Types

	[1]	[2]	[3]	[4]	[5]
	Global Banks	Domestic Banks	Domestic Commercial Banks	Domestic Savings Banks	Domestic Cooperatives
NSFR	-0.3565	-0.0370**	-0.0619***	0.0520**	-0.0322*
	[0.232]	[0.015]	[0.020]	[0.024]	[0.017]
Equity	-5.9592***	-0.1024	-0.0714	-0.4274***	-0.1476
	[2.236]	[0.065]	[0.081]	[0.142]	[0.135]
Credit Growth	1.6543***	0.0392***	0.0372***	0.0707**	0.0761**
	[0.447]	[0.012]	[0.013]	[0.034]	[0.034]
Z-Score	0.0261	-0.0545***	-0.0777***	-0.0454***	0.0064**
	[0.063]	[0.010]	[0.013]	[0.016]	[0.003]
Non-Interest Income	-2.8068	-0.3172	-0.403	-0.1616	1.8486***
	[3.066]	[0.309]	[0.370]	[0.455]	[0.585]
GDP Growth 2001-07	0.208	4.1505***	2.9101***	5.7008***	1.5062***
	[6.940]	[0.360]	[0.590]	[0.778]	[0.507]
Monetary Conditions 2001-07	-1.1448	-1.1965***	-0.7675*	-0.7383*	2.8008
	[1.512]	[0.449]	[0.440]	[0.383]	[2.688]
Observations	91	10,805	8,243	1,550	1,012
Pseudo R2	0.200	0.043	0.033	0.099	0.161

This table presents the results of bank-level probit regressions with robust standard errors [in brackets]. The dependent variable equals one for banks failing during the global financial crisis (2008?09) and zero otherwise. The regression coefficients have been transformed to convey the change in the probability of failure associated with a marginal change in the explanatory variables from their pre-crisis mean values. All the regressions conform to the same specification, applied to alternative sample partitions according to bank types. The regression in column [1] corresponds to the subsample of Global banks. The regression in column [2] corresponds to the subsample of Domestic banks. Those in columns [3] to [5] further split the subsample of Domestic banks by the types specified in the headings. Starred coefficients indicate statistical significance at one percent (***); five percent (**), and ten percent (*).

Table C.8. Robustness Checks by Alternative Definitions of Liquidity and Capital

	[1] NSFR Equity	[2] NSFR CAR	[3] STFR Equity	[4] STFR CAR
Liquidity Measure	-0.0431***	-0.0409*	0.0449*	0.1523***
	[0.015]	[0.022]	[0.025]	[0.037]
Capital Measure	-0.1993***	-0.1453**	-0.2487***	-0.1840***
	[0.073]	[0.061]	[0.070]	[0.055]
Credit Growth	0.0487***	0.0501***	0.0495***	0.0486***
	[0.014]	[0.016]	[0.014]	[0.016]
Z-Score	-0.0477***	-0.0626***	-0.0495***	-0.0641***
	[0.011]	[0.015]	[0.011]	[0.014]
Non-Interest Income	-0.253	-0.1859	-0.3128	-0.4828
	[0.302]	[0.346]	[0.315]	[0.375]
GDP Growth 2001-07	4.0479***	3.6582***	4.1631***	3.9135***
	[0.366]	[0.567]	[0.374]	[0.582]
Monetary Conditions 2001-07	-0.9738***	-2.0121***	-1.0647***	-2.8030***
	[0.334]	[0.728]	[0.366]	[0.945]
Observations	10,896	9,441	10,896	9,441
Pseudo R2	0.0399	0.0352	0.039	0.0379

This table presents robustness checks for alternative measures of structural liquidity and capital. As for structural liquidity, we use the net stable funding ratio (NSFR) and the short-term funding ratio (STFR) as defined in the text. As for capital, we use shareholders equity to total assets (EQUITY) and the regulatory capital ratio (CAR). The corresponding combinations of these measures are indicated in the headings. The regression coefficients have been transformed to convey the change in the probability of failure associated with a marginal change in the explanatory variables from their pre-crisis mean values. Starred coefficients indicate statistical significance at one percent (***); five percent (**), and ten percent (*).

Table C.9. Robustness Checks by Sub-Components of Bank Failure

	[1]	[2]	[3]	[4]
	Baseline	Baseline ex-CAR	Laeven-Valencia	CAR
NSFR	-0.0431***	-0.0186	-0.0282***	-0.0313***
	[0.015]	[0.015]	[0.005]	[0.007]
Equity	-0.1993***	-0.1720**	-0.1465***	-0.0527*
	[0.073]	[0.072]	[0.035]	[0.029]
Credit Growth	0.0487***	0.0327***	0.0182***	0.0119***
	[0.014]	[0.011]	[0.004]	[0.004]
Z-Score	-0.0477***	-0.0348***	-0.0016	-0.0238***
	[0.011]	[0.011]	[0.003]	[0.004]
Non-Interest Income	-0.253	-0.3357	0.1739**	-0.0446
	[0.302]	[0.293]	[0.075]	[0.119]
GDP Growth 2001-07	4.0479***	3.9072***	0.2065*	0.7779***
	[0.366]	[0.360]	[0.107]	[0.114]
Monetary Conditions 2001-07	-0.9738***	-0.7906***	0.0261	-0.4991***
	[0.334]	[0.287]	[0.029]	[0.114]
Observations	10,896	9,713	10,896	10,896
Pseudo R2	0.0399	0.033	0.091	0.0814

This table presents robustness checks for alternative definitions of bank failure. The regression in column [1] is the baseline specification, which identifies a failing bank by combining four criteria: (i) a change in the Bankscope status from "active" to either: "under receivership", "bankruptcy", "dissolved", "dissolved by merger", or "in liquidation" at any point during 2008?09; (ii) a drop in regulatory CAR below the 8 percent threshold between 2008?09; (iii) a downgrade in Moody's bank financial strength ratings to E+ or E (in distress); (iv) a bank identified as failed in Laeven and Valencia (2010). The regression presented in column [2] excludes criterion (ii); the regression presented in column [3] corresponds to criterion (iv) only; and the regression in column [4] corresponds to criterion (ii) only. The regression coefficients have been transformed to convey the change in the probability of failure associated with a marginal change in the explanatory variables from their pre-crisis mean values. Starred coefficients indicate statistical significance at one percent (***); five percent (**), and ten percent (*).

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