A walk down Lombard Street : essays on banking

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Chapter 2

Bank Liquidity Regulation and the Lender of Last Resort

Banks can make suboptimal liquidity choices and gamble for lender of last resort (LOLR) support. Endogenous bailout rents are driven by the need to preserve bankers' incentives under uncertain net worth. In equilibrium, banks can herd in risk management, choosing suboptimal liquidity when they expect others to do so. Optimal liquidity can be restored by quantitative requirements, but such regulation is costly. An LOLR policy incorporating bank capital information can reduce distorting rents and allow for a more efficient solution, but may only be possible in transparent economies.[1]

2.1 Introduction

Banks provide liquidity insurance by offering demandable deposits and underwriting credit lines to firms (Diamond and Dybvig, 1983, Kashyap et al., 2002). In doing so, they become exposed to liquidity risk. The concern is that a bank with positive capital may fail due to a liquidity shortage. To insure, banks maintain precautionary "liquidity buffers" of tradeable short-term assets, which can be converted into cash without loss at a short notice.

[1] Journal of Financial Intermediation, forthcoming. I am grateful for helpful comments to Enrico Perotti (my advisor), George Pennacchi (the Editor), two anonymous referees, Viral Acharya, Arnoud Boot, Erlend Nier, Rafael Repullo, Javier Suarez, Ernst-Ludwig von Thadden, Tanju Yorulmazer, and seminar participants at University of Amsterdam, CEMFI, and Bank of England for helpful comments. The hospitality of University of Mannheim and financial support from the European Corporate Governance Training Network are gratefully acknowledged. All errors are mine.

A bank unable to cover a liquidity shortage fails unless it is bailed out. Its central bank may be averse to providing a bailout in the form of Lender of Last Resort (LOLR) support due to monetary and incentive costs (Rochet and Tirole, 1996). Yet the intervention is unavoidable in a systemic crisis, when the survival of at least some banks is essential for real economic activity[2]. The possibility of LOLR support creates rents for banks. Rents can distort banks' incentives to accumulate sufficient liquidity ex-ante and make them gamble for LOLR support instead.

The purpose of this paper is to analyze the sources of bail out rents and examine the possibilities for policy response. In particular, we ask whether quantitative liquidity requirements are necessary, or whether under some conditions there may be other ways of reinstating optimal bank liquidity.

Liquidity Regulation There are two principal ways in which the regulator can intervene to assure socially optimal bank liquidity. The first, mechanical, is to impose quantitative requirements. However quantitative regulation of liquidity is costly (cf. Glaeser and Shleifer, 2001) because it may be difficult to define precisely the set of appropriate liquid assets.

As an alternative to quantitative regulation, a central bank may attempt to improve the LOLR process in order to reduce bailout rents and eliminate the fundamental distortion. There are two possibilities. The first is to prioritize LOLR support to banks that have made an ex-ante socially optimal choice – were liquid. A credible *ex-ante* commitment to support liquid banks would increase liquidity incentives. However this policy suffers from time inconsistency. Failures of liquid banks occur when their net worth becomes negative, leaving managers no incentives to operate the bank prudently. Therefore, *ex-post*, offering LOLR support to illiquid but potentially positively capitalized banks (with a higher asset value) increases social welfare. Consequently, the policy of conditioning LOLR policy on banks' liquidity is likely unsustainable.

The second possibility is to reduce the *value* of LOLR rents. We show that rents are driven by uncertainty over bank's net worth[3]. If a central bank could use information on bank asset value in setting LOLR repayment terms and charge more to banks with high net worth, that would reduce the distorting rents and bring banks' liquidity choices

[2] Otherwise, severe negative effects may include a payments gridlock or a credit crunch (Freixas et al., 2000, Bernanke and Gertler, 1989).

[3] In this paper, we use the terms "net worth" and "bank capital" interchangeably, referring to the economic value of bank capital. In financial regulation, banks with positive capital are often referred to as "solvent", and those with negative capital – as "insolvent".

close to the social optimum. However such policy is only feasible when a central bank has rather precise information on banks' capitalization, even in times of crisis. Arguably, this is only possible in sufficiently *transparent* financial systems.

We conjecture that regulators in financially developed countries are able to rely less on quantitative liquidity requirements, thanks to the possibility of less distortive LOLR interventions. This is consistent with the observation that liquidity requirements have generally become non-binding in advanced economies, such as the UK or US (Chaplin et al., 2000, Bennett and Peristiani, 2002). In contrast, developing countries, where information on banks' net worth is less readily available, have to (and in practice do) rely on quantitative liquidity regulation (Freedman and Click, 2006).

Modelling In the center of this paper is a model of bank liquidity choices and systemic stability. We consider two banks that face a liquidity risk and choose whether to hold a precautionary buffer against it. Holding liquidity is costly, because a liquidity buffer facilitates managerial moral hazard if a bank becomes insolvent (cf. Myers and Rajan, 1998). Yet in the first best banks decide to be liquid in order to insure long-term charter value.

The distortion we consider is that in a systemic crisis, when both banks fail, the central bank has to bail out one of them to preserve systemic stability. Such intervention is associated with rents, which are driven by the need to preserve bankers' incentives under uncertain net worth. Banks may have assets of high or low value, and can switch to a moral hazard project if the value of bankers' equity stake is too low. If the central bank lacks individual asset value information, it has to set repayment so as to preserve incentives even for a low asset value bank. Generous repayment terms benefit high asset value banks. Banks therefore face a trade-off between a higher probability of preserving charter value (if liquid) and a higher probability of failing and receiving bailout rents (if illiquid). In equilibrium, possible bailout rents may distort incentives to accumulate liquidity ex-ante.

We identify an inter-bank strategic complementarity in liquidity choices, which may lead to self-fulfilling risk management equilibria. A bank has higher incentives to be liquid when it expects another bank to be liquid, because another bank is more likely to weather a possible liquidity shock, reducing the probability of a bailout. A bank has higher incentives to be illiquid when another bank is illiquid, because a systemic liquidity crisis and bailout are more likely. In comparative statics, suboptimal liquidity is more likely when banks have low charter value, or expect severe shocks that reduce the charter value.

Note that banks therefore have incentives to relax risk management in the anticipation of particularly adverse circumstances (such as economic or financial market downturns).

Related literature The paper relates to three strands of literature and policy debate – on suboptimal liquidity, LOLR, and bank herding. It is understood that some liquidity risk may be essential for bank operations (Diamond and Rajan, 2001). However banks' private liquidity choices (investments in cash or easily tradeable assets, Goodfriend and King, 1998) can be compromised by opportunistic incentives (Bhattacharya and Gale, 1987, Allen and Gale, 2004). Empirical evidence demonstrates instances of seemingly lacking bank liquidity. For instance, Gatev et al. (2004) find that not all US banks had sufficient liquidity to be resilient to the 1998 crisis, and Gonzalez-Eiras (2003) shows that Argentinian banks reduced liquidity holdings before the 2001 crisis in the anticipation of LOLR involvement with no apparent fundamental reason. Regulatory concerns are reflected in discussions on whether capital requirements are a sufficient lever for liquidity regulation (Berger and Bouwman, 2006), and the 2006 formation of the Basel Committee's Liquidity working group.

The doctrine of the central bank as the Lender of Last Resort responsible for systemic stability was first articulated by Bagehot (1873). The caveats were that the "last resort" funds should be provided only to institutions with positive capital, and at penalty rates. However these restrictions are not easily implemented in practice. Firstly, there is likely to be uncertainty over the net worth of banks affected by liquidity shortages: it is hard or impossible to distinguish pure liquidity events from deeper capitalization crises (Goodhart, 1999). Secondly, contractual imperfections and the need to preserve bankers' incentives (see Acharya and Yorulmazer, 2007A) can render the central bank unable to secure full repayment of the LOLR loan, let alone impose penalties.

In this paper, the LOLR distortion stems from the need to preserve bankers' incentives under uncertain net worth, and has the impact of banks under-investing in liquidity ex-ante. The literature has suggested other plausible LOLR costs, which we see as complementary. Rochet and Tirole (1996) showed that the expectation of LOLR may reduce incentives for peer monitoring among banks. Also, large banks benefit disproportionately from LOLR due to the "too-big-to-fail" guarantee (O'Hara and Shaw, 1990), while smaller banks may get incentives to herd due to a "too-many-to-fail" effect (Acharya and Yorulmazer, 2007A).

While agents' beliefs about a central bank's behavior were long established as an important determinant of financial stability (e.g. Freixas, 1999), the emphasis on beliefs about peer behavior is less conventional (rare exceptions are Mitchell, 1998, and Perotti, 1998). Our herding result is related to similar findings in the other contexts of banking behavior, such as lending standards (Rajan, 1994) or assets choice (Acharya and Yorulmazer, 2007C). Herding in risk management practices, emphasized here, is a topical concern in the current regulatory debate. For example, there are reservations that when banks are allowed discretion in the choice of risk management models, they seem to converge on similar techniques, as driven not by model superiority, but by the search for regulatory arbitrage.

The rest of the paper is structured as follows. Section 2 sets up the model. Section 3 solves for banks' optimal liquidity in the first best. Section 4 analyzes the general case, identifies the source of LOLR rents, and derives equilibrium bank behavior. Section 5 examines possible policy responses. Section 6 discusses the robustness of assumptions and results. Section 7 concludes.

2.2 The Model

Economy Consider a risk-neutral economy with three dates: 0, 1, 2, and no discounting. The economy is populated by multiple small depositors, two banks, and a central bank.

At date 0, banks borrow from small depositors to invest in a long-term project and a liquidity buffer. At date 1, banks may experience a liquidity shock, which can in turn trigger a central bank intervention. Final returns of successful banks are realized at date 2. The detailed sequence of events is shown on Figure 1.

<<FIGURE 1 HERE>>

Depositors Depositors are endowed with wealth, which they can lend to banks against an expected return of 1 (that is, a zero expected rate of return). We denote the corresponding return that the bank has to promise depositors by R. All financing takes the form of straight debt. Since depositors are small, the debt is non-renegotiable. We treat deposits as uninsured; the effects of deposit insurance are discussed in Section 6.

Banks Banks have no initial capital, but enjoy exclusive access to a fixed-size long-term investment technology. The technology is modelled in the spirit of Holmstrom and Tirole

(1998)[4]. It requires initial financing of 1 at date 0, and produces a risky return X_H or X_L at date 2, each with probability 1/2. Return realizations are independent across banks[5]. Bankers learn future return before date 1, but it remains their private information until date 2.

At date 1 a bank may be hit by a "liquidity shock". We consider an asset-side shock, which relates to adverse conditions when the project is in distress and requires additional investment L to materialize. If the bank injects L, it proceeds to realize X_H or X_L (there is no additional return on L). Yet if the bank is unable to inject L, the investment collapses with 0 liquidation value. The probability of a shock is a. We consider the shocks as systemic (occurring to both banks simultaneously; introducing an idiosyncratic component would not alter results) and binary (either no shock, or a shock of fixed magnitude; Section 6 discusses continuous shocks).

Note that this model focuses on asset-side shocks. They can be interpreted as a borrower drawing on a line of credit, or requesting an additional cash injection within some sort of loan restructuring. Asset-side events have been shown to be a significant determinant of bank liquidity needs (Kashyap et al., 2002, Gatev and Strahan, 2006, Pennacchi, 2006). A close setting with demand-side shocks (depositors withdrawing prematurely) is possible when such shocks impact bank's net worth. This can be due to costly emergency refinancing, or commitment problems when depositor financing is substituted by the market (as in Diamond and Rajan, 2001).

A bank can hedge against a possible liquidity shock by becoming *liquid*. To become liquid, a bank has to attract in advance (at date 0) additional financing L and invest it into a precautionary buffer of tradeable short term assets[6]. It can then use this buffer to cover a possible funding need at date 1.

The last technology feature we consider is that at the end of date 1 (after a possible shock) bankers can opportunistically switch to an inferior moral hazard project. Such a project brings them marginal private benefits $\beta < L$, but leaves nothing to depositors.

[4]Banks in this paper are analogous to firms in Holmstrom and Tirole (1998). We have the similar setup with asset-side liquidity shocks, the need to hedge them in advance due to financial market frictions, and ex-post moral hazard that makes banks with negative net worth not viable. As Holmstrom and Tirole, we find that government liquidity provision ex-post may result in private under-investment in liquidity ex-ante.

[5]We assume that individual bank asset returns do not depend on another bank's performance or survival. Perotti and Suarez (2002) show that expected "last-bank standing" rents due to lower competition post crisis can improve ex-ante prudence incentives.

[6]Observe that, since the bank forms a liquidity buffer in advance, it cannot use liquidity holdings to signal asset value (which it learns as private information only at date 1).

This moral hazard risk will be shown to determine both liquidity costs and LOLR rents.

Banks maximize profit, including possible private benefits. For definitiveness, when indifferent, banks prefer to be liquid, and do not switch to moral hazard. Banks' liquidity decisions are observable.

Parameters We set up model parameters to reflect the following properties. Firstly, from the perspective of date 0, the bank's investment has a positive ex-ante net present value (NPV), and banks are always safe (have positive capital) *unless* there is a liquidity shock:

$$X_H > X_L > 1/(1-a) + \beta \tag{2.1}$$

In the right part, $1 - a$ is the minimal probability of bank survival (if it always failed in a liquidity shock), therefore $1/(1-a)$ is the maximum return the bank may need to offer depositors to compensate for the probability of failure. The condition shows that, in the absence of a liquidity shock, even a bank with low asset value X_L has sufficient worth to compensate depositors and not engage in moral hazard: its equity value exceeds β. Note that (2.1) is a sufficient condition for financing at date 0: a bank can always be financed if illiquid. A liquid bank with an additional investment L can also be financed if liquidity increases its profit by reducing risk.

Secondly, as a result of a liquidity shock, the net worth of a bank with low asset value becomes negative:

$$X_L < 1 + L \tag{2.2}$$

Here, X_L is asset value, 1 is the minimal repayment to initial depositors, and L the amount of necessary additional financing. Observe that continuing the project is socially optimal as long as $X_L > L$ (because the cost of initial investment is sunk), but prevented by debt overhang (deposits are non-renegotiable, while bankers need minimal equity value to preserve their incentives). Due to negative net worth, the managers get incentives to engage in moral hazard, making a bank with low asset value not viable after a shock even if it was liquid.

Lastly, banks (including liquid ones) with high asset value X_H, retain positive net worth in a liquidity shock:

$$X_H > (1 + L)/(1-a) + \beta \tag{2.3}$$

The term X_H is the asset value, and $(1 + L)/(1 - a)$ is the maximum possible debt repayment: $(1 + L)$ is the originally borrowed amount for a liquid bank, and $1/(1 - a)$ is the maximum possible interest rate. Banks with high asset value do not have incentives to switch to a moral hazard project, because their equity value exceeds β.

Central Bank An illiquid bank hit by a liquidity shock, as well as a bank that has switched to a moral hazard project, fail at date 1 unless bailed out. We consider the Central Bank as a lender of last resort (LOLR), entrusted with the responsibility for financial stability. We interpret financial stability as a need to assure that at least one bank is present at date 2 – survives a liquidity shock and does not engage in moral hazard. The Central Bank intervenes when a bank is in the process of failing. A bailout, firstly, helps a bank cover a liquidity shortage and, secondly, serves to increase bank's equity value when that is necessary to preserve bankers' incentives[7].

The Central Bank is averse to extending LOLR support. It never bails out a bank if another one is stable. In a systemic crisis, when both banks are failing, it bails out *one* of them *randomly* (we alter the assumption of random intervention in further analysis). The reason is that bailouts are associated with a substantial deadweight cost of public funds (e.g. due to the disincentive effects of taxation). While the bankers obtain a perfect signal of asset value before the refinancing stage, it remains their private knowledge and is not available to the Central Bank (we alter the assumption of private asset value information in further analysis).

Lastly, we assume that when a failing bank receives LOLR support, its depositors still lose their investment. In the sense, bankers are bailed out in order to preserve financial stability, but depositors still bear the costs of failure. Such effects are relatively common in developing countries, which do not have a strong enough fiscal position to fully compensate depositors of failing institutions (cf. Demirguc-Kunt and Detragiache, 2002). Even when depositors are repaid, they often receive money with significant delays or in fixed nominal terms that do not account for inflation or currency depreciation that may have occurred in the meanwhile. This assumption allows us to simplify the exposition by abstracting from a marginal effect of possible bailouts on deposit rates, but it does not influence the qualitative results.

The game tree summarizing strategies and payoffs for liquid and illiquid banks in the case of a liquidity shock, depending on central bank actions, is shown on Figure 2.

[7] In some cases, beyond the scope of this model, the Central Bank may also resolve crises by playing a coordinating role (see Freixas et al, 2000), as was in the LTCM case.

Depositors are repaid when there is no liquidity shock, or when a bank is able to weather a liquidity shock on its own.

<<FIGURE 2 HERE>>

2.3 First Best

We first consider a setting with a single bank and no Central Bank intervention, to study liquidity choices in a world without LOLR distortions. Note that while we consider this a first best benchmark to our setting, it still contains imperfections such as the bankers' moral hazard.

Consider first the payoff to an *illiquid* bank. With probability $1-a$ it avoids a shock and receives average return $(X_H + X_L)/2$. With probability a it is hit by a shock, unable to cover it, and goes bankrupt. Anticipating this, investors require the promised return $R = 1/(1-a)$. The payoff is:

$$\begin{aligned} \Pi_{FB}^{ILL} &= (1-a)\left(\frac{X_H + X_L}{2} - \frac{1}{1-a}\right) \\ &= (1-a)\frac{X_H + X_L}{2} - 1 \end{aligned} \tag{2.4}$$

Before deriving the payoff to a liquid bank, we establish the *endogenous cost of holding liquidity*. Recall that there are no exogenous frictions in liquidity provision in our model, as depositors can elastically supply funds at a required expected return of 1. The liquidity buffer of size L allows a bank with high asset value to cover a possible liquidity shortage, survive a shock, and realize returns. However, the net worth of a bank with low asset value becomes negative in a liquidity shock. Such a bank has two prudent alternatives: either let its long-term assets collapse and distribute the buffer L back to depositors, or use the buffer to cover the liquidity shortage and obtain and pay out X_L at date 2. While both resolutions could be beneficial to depositors, they leave no equity value to the bankers. Therefore, in the spirit of Myers and Rajan (1998), banks that are liquid but have negative capital will exercise moral hazard: use the buffer to cover the liquidity shortage and then switch to a lemon project. In doing so they destroy $L - \beta$ of value. This opportunistic behavior drives the endogenous cost of liquidity: depositors anticipate possible losses on a liquidity buffer, and price them in the nominal interest rate. If the bankers were able to commit to return the liquidity buffer to depositors in the case of negative net worth, holding liquidity on books would have been costless. Therefore, *an endogenous cost of liquidity originates from moral hazard in banks that are liquid but have negative capital.*

Note that a bank's liquidity buffer choice is binary. A smaller buffer $\check{L} < L$ has no benefits (it cannot help a bank with positive capital overcome a liquidity shock), but leads to a loss of value $\check{L} - \beta$ in a bank that is about to fail. A larger buffer $\hat{L} > L$ has no additional benefits compared to a buffer of size L, but a higher cost $\hat{L} - \beta > L - \beta$.

Consider now the payoff to a *liquid* bank. With probability $1 - a$ it avoids a shock and receives average return $(X_H + X_L)/2 + L$ including preserved liquid assets. With probability $a/2$ it is hit by a shock and has assets of high value: it covers the liquidity shortage with buffer L and receives return X_H. With probability $a/2$ it is hit by a shock and has assets of low value: bankers cover the liquidity shortage and then switch to a moral hazard project, retaining private benefits β. The bank fails with probability $a/2$ and investors require the promised return $R = 1/(1-a/2)$ on the borrowed amount $1+L$. The payoff is:

$$\begin{aligned} \Pi_{FB}^{LIQ} &= (1-a)\left(\frac{X_H + X_L}{2} + L - \frac{1+L}{1-a/2}\right) + \frac{a}{2}\left(X_H - \frac{1+L}{1-a/2}\right) + \frac{a}{2}\beta \quad (2.5) \\ &= (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}(X_H - L) - \frac{a}{2}(L - \beta) - 1 \end{aligned}$$

Note that $a/2 \cdot (\beta - L)$ are the costs of liquidity: value $(L - \beta)$ is lost with probability $a/2$ in a bank that is liquid but has negative net worth.

We can now find the bank's first best liquidity choice. A bank prefers to be liquid for

$$\Pi_{FB}^{LIQ} \geq \Pi_{FB}^{ILL}$$

Substituting from (2.5) and (2.4) gives:

$$L \leq L_{FB} = \frac{X_H + \beta}{2}$$

In comparative statics, a bank chooses to be liquid when X_H (a measure of charter value) and β (private benefits of liquidity) are high enough, while L (the size of a possible liquidity shock, which decreases survival value) is low enough. In the following analysis, we will study how a bank's liquidity choice can deviate from the L_{FB} benchmark when the Central Bank provides LOLR support.

2.4 Suboptimal Liquidity

We now return to the general model with two banks and a Central Bank offering LOLR support in the case of a systemic crisis. We first articulate the main distortion of the model: rents associated with a LOLR intervention.

Consider a Central Bank bailing out a failing illiquid bank. Such a bank has an unknown (high or low) asset value. When setting repayment on the LOLR loan, the Central Bank must assure that bankers do not get incentives to switch to a moral hazard project. Therefore, the terms of LOLR support must leave equity value of at least β even for a low asset value bank. Because asset value information is private, the Central Bank cannot discriminate repayment terms against high asset value banks, leaving them with even higher rent $\beta + (X_H - X_L)$. This makes average bailout rents for an illiquid bank $\beta + (X_H - X_L)/2$.[8]

A failing liquid bank has low asset value, so the possible bailout needs to leave the bankers rents β to compensate for what they would receive if switched to moral hazard. Liquid high asset value banks weather a possible liquidity crisis by themselves, and receive no rents at all. Therefore, *endogenous LOLR rents are determined by the need to preserve bankers' incentives under uncertain asset value of illiquid banks. As a result, illiquid banks receive higher average LOLR rents.*

The trade-off The anticipation of rents may distort banks' ex-ante liquidity decisions. Banks make liquidity decisions in the trade-off between preserving charter value (a liquid bank has a higher probability of surviving a shock and realizing long-term returns) and obtaining bail out rents (an illiquid bank has a higher probability of failing and receiving rents, which will also be of higher value due to its uncertain asset value).

The bank's bailout probability, and hence the expected value of rents, depends on the liquidity choice of *another* bank. Consider the consequences of a liquidity shock from the perspective of an illiquid bank. The Central Bank intervenes only if both banks fail. If

[8] While this result hinges on the assumption that LOLR funds are provided under a debt contract, in Section 6 we show that the results are robust to recapitalization when a central bank obtains an equity stake in a bank, and also discuss scope for more complex LOLR contracts.

another bank is liquid, it will survive a liquidity shock by covering it with precautionary buffer if it has high asset value – with probability 1/2. Joint failure occurs only if another bank has low asset value (and chooses to switch to a moral hazard project) – with probability 1/2. The bailout accrues to a given bank randomly, making the ultimate probability of a bank receiving rents 1/4. However if another bank is illiquid as well, it will always fail in a liquidity shock, triggering a systemic crisis. A given bank is bailed out with probability 1/2. Due to a higher probability of obtaining LOLR rents, a bank has higher incentives to be illiquid when it expects the same from another bank.

To see this analytically, consider a bank's payoffs to liquidity and illiquidity under different liquidity choices of another bank.

Consider the payoff to a *liquid* bank. With probability $1-a$ there is no shock and it receives average return $(X_H + X_L)/2 + L$ including preserved liquid assets. With probability $a/2$ it is hit by a shock and has assets of high value: it covers the liquidity shortage and receives X_H. With probability $a/2$ it is hit by a shock and has assets of low value. The bank would switch to moral hazard and receive rents β unless bailed out.

The Central Bank intervenes if another bank also fails. Another bank fails with probability 1/2 if liquid (only when it has low asset value), and always if illiquid. The probability of a bank receiving LOLR support is therefore 1/8 and 1/4, for a liquid and illiquid other bank respectively. Observe that LOLR support does not alter rents obtained by a liquid bank with negative capital – the Central Bank only needs to compensate it for the private benefits of moral hazard β. Nor does LOLR intervention impact the deposit rate – depositors by assumption lose money anyway. In either case, the bank does not repay depositors with a probability $1-a/2$, and the promised return is $R = 1/(1-a/2)$. As a result, the payoff of the liquid bank is independent of LOLR actions and, consequently, from another bank's liquidity. The payoff, identical to (2.5), is:

$$\begin{aligned}
\Pi^{LIQ} &= (1-a)\left(\frac{X_H + X_L}{2} + L - \frac{1+L}{1-a/2}\right) + \frac{a}{2}\left(X_H - \frac{1+L}{1-a/2}\right) + \frac{a}{2}\beta \\
&= (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}(X_H - L) - \frac{a}{2}(L-\beta) - 1 \qquad (2.6)
\end{aligned}$$

Consider now the payoff to an *illiquid* bank. With probability $1-a$ there is no shock and it receives average return $(X_H + X_L)/2$. With probability a there is a shock, and the bank fails. The Central Bank intervenes only if another bank fails as well, which depends on its liquidity choice. If liquid, another bank fails only if it has low asset value

– with probability 1/2, making the bail out probability 1/4. If illiquid, it fails always, doubling the bail out probability to 1/2. This is the source of strategic complementarity: an illiquid bank has higher expected bail out rents when it expects another bank to be illiquid as well.

LOLR support of an illiquid bank leaves a low asset value bank with rents β, but a high asset value bank with $\beta + (X_H - X_L)$, making average rents $\beta + (X_H - X_L)/2$. Investors are not repaid with probability a and require the promised return $R = 1/(1-a)$. The payoffs to an illiquid bank, depending on another bank's liquidity or illiquidity, are:

$$\begin{aligned} \Pi_{LIQ}^{ILL} &= (1-a)\left(\frac{X_H + X_L}{2} - \frac{1}{1-a}\right) + \frac{a}{4}\left(\beta + \frac{X_H - X_L}{2}\right) \\ &= (1-a)\frac{X_H + X_L}{2} + \frac{a}{4}\left(\beta + \frac{X_H - X_L}{2}\right) - 1 \end{aligned} \tag{2.7}$$

$$\begin{aligned} \Pi_{ILL}^{ILL} &= (1-a)\left(\frac{X_H + X_L}{2} - \frac{1}{1-a}\right) + \frac{a}{2}\left(\beta + \frac{X_H - X_L}{2}\right) \\ &= (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}\left(\beta + \frac{X_H - X_L}{2}\right) - 1 \end{aligned} \tag{2.8}$$

We can now derive the bank's optimal liquidity choices. Due to strategic complementarity, they will depend on liquidity choices of another bank.

A bank will choose to be liquid in response to a liquid other bank for:

$$\begin{aligned} \Pi^{LIQ} &\geq \Pi_{LIQ}^{ILL} \\ L &\leq L_{HIGH} = \frac{3X_H + X_L + 2\beta}{8} \end{aligned}$$

A bank will choose to be liquid in response to an illiquid other bank only for:

$$\begin{aligned} \Pi^{LIQ} &\geq \Pi_{ILL}^{ILL} \\ L &\leq L_{LOW} = \frac{X_H + X_L}{4} \end{aligned}$$

It is easy to verify that $L_{LOW} < L_{HIGH}$. For $L \leq L_{LOW}$, a bank will always choose to be liquid. For $L > L_{HIGH}$, a bank will always choose to be illiquid. In the intermediate range $L_{LOW} < L \leq L_{HIGH}$ there is a strategic complementarity: a bank will choose to be liquid when expects another bank to liquid, but illiquid when expects the other bank to be illiquid. This can be interpreted either as inter-bank herding in liquidity risk management choices, or as the impact of a self-fulfilling "climate" of prudence in the banking system.

It is also easy to verify that $L_{HIGH} < L_{FB}$. This means that banks choose liquidity for a narrower range of parameter values than socially optimal: never for $L_{HIGH} < L \leq L_{FB}$ and only in some equilibria for $L_{LOW} < L \leq L_{HIGH}$. We can now state the main result of this section.

Proposition 1 *Banks' equilibrium liquidity choices are characterized by two thresholds $L_{LOW} < L_{HIGH}$, such that:*

1. *For $L \leq L_{LOW}$, banks choose to be liquid, in a unique equilibrium in dominating strategies;*
2. *For $L_{LOW} < L \leq L_{HIGH}$, the game has multiple Nash equilibria, with a bank choosing to be liquid when it expects another bank to be liquid, and illiquid when it expects another bank to be illiquid. There also exists an equilibrium in mixed strategies;*
3. *For $L > L_{HIGH}$, banks choose to be illiquid, in a unique equilibrium in dominating strategies.*

Banks' choices can be socially suboptimal: there exist parameter values where banks choose illiquidity, while liquidity is the first best.

The equilibrium threshold values of L and corresponding banks' strategies are depicted on Figure 3.

<<FIGURE 3 HERE>>

In comparative statics, threshold values L_{LOW} and L_{HIGH} depend positively on the proxies of bank charter value X_H and X_L and private benefits β: a bank is more likely to be illiquid when its charter value is low or the expected shock severe. This can be related to the times of recession or the end of expansion with downside expectations, and indicate conditions when regulators should be particularly concerned about suboptimal liquidity risk management.

2.5 Policy Response

The previous section identified that bank liquidity choices can be socially suboptimal due to distortions associated with a possible LOLR intervention. There are a number of measures that authorities can undertake to try and correct banks' liquidity choices.

The direct mechanical solution is to impose quantitative liquidity requirements. However quantitative regulation of liquidity is costly (cf. Glaeser and Shleifer, 2001), because it is difficult to define precisely the set of appropriate liquid assets. For example, assets unconditionally eligible for central bank repo operations have guaranteed liquidity, but are typically restricted to select government bonds and therefore particularly expensive to hold[9]. Banks could ideally use cheaper (but still sufficiently liquid) assets, such as high-grade corporate bonds. Yet their liquidity may change over time, being especially unpredictable in times of crises. Since it is difficult or impossible to define in advance which assets will be liquid in relevant future contingencies (and can be allowed in the prudential buffer), these non-central bank eligible assets are unsuitable for effective quantitative liquidity requirements. Put differently, when asset liquidity changes unpredictably over time, it may be observable ex post, but cannot be well contracted upon ex-ante.

There are two additional concerns which also determine the costs of liquidity requirements. Firstly, due to changing assets' liquidity, quantitative liquidity requirements often become outdated with time, especially when there is no institutional flexibility to change them frequently. Secondly, within broader risk management agenda, banks may over-rely on mandatory ratios and avoid evaluating liquidity needs by themselves, softening internal risk management frameworks. Due to all these limitations, regulators prefer to rely on less distortive mechanisms of restoring optimal liquidity when possible.

As an alternative, the authorities may attempt to redesign LOLR procedures to make them targeted and informed (as opposed to random and uninformed in the basic model). There are two sources of information that may be used in LOLR decisions: banks' liquidity and banks' capitalization (net worth); the latter – only if such information is available to the Central Bank). We will now analyze the possibility of conditioning LOLR on that information.

[9] Central banks typically maintain conservative collateral lists, in order to avoid credit risks that could compromise their balance sheets. Eurosystem central banks accept some lower quality assets (such as MBS), yet only with high haircuts, which makes liquidity generated by them costly as well. The discount window of the Federal Reserve System also employs haircuts, as well as penalty rates.

2.5.1 LOLR and Liquidity

The first option is to redirect LOLR rents by offering priority support to liquid banks. If a liquid bank is more likely to be bailed out, that would reduce expected rents accruing to an illiquid bank.

Consider the case when, if faced with two failing banks, of which one is liquid and another illiquid, the Central Bank bails out a liquid bank. Such policy would remove any bailout rents from the payoff to an illiquid bank when another bank is liquid, making it

$$\tilde{\Pi}_{LIQ}^{ILL} = (1-a)\frac{X_H + X_L}{2} - 1 \tag{2.9}$$

and changing the L_{HIGH} threshold to

$$\begin{aligned} \Pi^{LIQ} &\geq \tilde{\Pi}_{LIQ}^{ILL} \\ L &\leq \tilde{L}_{HIGH} = \frac{X_H + \beta}{2} = L_{FB} \end{aligned}$$

Therefore, credible conditioning of LOLR support on ex-ante liquidity can reduce distortions and improve incentives, allowing multiple equilibria in the range $L_{HIGH} < L < L_{FB}$, where banks used to unambiguously choose illiquidity under a random bail out.

The problem however is that such policy is time inconsistent. Ex-post, failing liquid banks have low asset value with certainty, while failing illiquid banks can have high asset value with probability 1/2. Saving an illiquid bank with potentially high asset value instead of a liquid one with low asset value increases ex-post social welfare. If a Central Bank was conditioning on liquidity, but unable to commit to an ex-ante optimal policy, it would end up offering priority support to illiquid banks instead. That would increase (rather than decrease) the payoff to an illiquid bank when a peer is liquid:

$$\tilde{\Pi}_{LIQ}^{ILL} = (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}\left(\beta + \frac{X_H - X_L}{2}\right) - 1 \tag{2.10}$$

and reduce L_{HIGH} to

$$\begin{aligned} \Pi^{LIQ} &\geq \tilde{\Pi}_{LIQ}^{ILL} \\ L &\leq \tilde{L}_{HIGH} = \frac{3X_H + X_L + 2\beta}{8} = L_{LOW} \end{aligned}$$

This is a distortion further from social optimum: in the range $L_{LOW} \leq L < L_{HIGH}$ banks would always choose illiquidity, instead of multiple equilibria under a random bailout. When liquidity-conditional bailout is likely to be unsustainable, it is inferior to the random one.

Proposition 2 *The policy of conditioning LOLR support on prudent liquidity risk management is time inconsistent. Ex-ante it is optimal to bail out liquid banks; ex-post – illiquid banks since they may have positive net worth. If banks anticipate ex-post policy, they never choose liquidity for* $L > L_{LOW}$*.*

2.5.2 LOLR and Capitalization

Another option is to try and reduce the value of LOLR rents. Remember that their principal component stemmed from uncertain capital (asset value) of illiquid banks. The Central Bank could not distinguish between pure liquidity shortages (in banks with high asset value) from deeper capitalization problems (in banks with low asset value). If the Central Bank had such information, it could demand higher repayment from high asset value banks, reducing the expected value of bail out rents.

We call conditions where bank asset value information is readily available *transparency*. We do not distinguish between the availability of information to the central bank or to the markets. The reason is that there will unlikely be any divergence in the case of an unexpected significant shock. There is little evidence that central banks have superior information on an individual bank's conditions (except for short periods after extensive regulatory assessments, see Berger et al., 2000, Flannery, 1997). Nor is there a reason to believe that a well-functioning central bank is unable to collect information available to market participants.

Assume that the Central Bank has information on banks' net worth. When faced with two failing banks, one with positive capital and another with negative capital, it can bail out the one with positive capital (high asset value) and charge it an appropriate repayment that leaves bankers only minimal incentive compatible rents β. When faced with two negatively capitalized banks, liquid and illiquid, the Central Bank can now also credibly commit to bail out the liquid bank, because there is no asset value difference between the two.

Consider the probability of a bailout of an illiquid bank when a peer bank is liquid. With probability $1/2$ another bank has negative capital and there is a joint failure. With further probability 1/2 the illiquid bank has positive capital and is bailed out; otherwise both banks have negative capital and a liquid bank is bailed out. Another parameter that changes is the value of bailout rents. Because the Central Bank is able to charge a higher repayment to a high asset value bank, removing excess component $(X_H - X_L)$, the expected value of rents for an illiquid bank decreases from $\beta + (X_H - X_L)/2$ to β. The new payoffs are:

$$\hat{\Pi}_{LIQ}^{ILL} = (1-a)\frac{X_H + X_L}{2} + \frac{a}{4}\beta - 1 \tag{2.11}$$

$$\hat{\Pi}_{ILL}^{ILL} = (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}\beta - 1 \tag{2.12}$$

The threshold points are:

$$\begin{aligned} \hat{\Pi}^{LIQ} &\geq \hat{\Pi}_{LIQ}^{ILL} \\ L &\leq \hat{L}_{HIGH} = \frac{X_H + \beta/2}{2} \end{aligned}$$

and

$$\begin{aligned} \Pi^{LIQ} &\geq \Pi_{ILL}^{ILL} \\ L &\leq \hat{L}_{LOW} = \frac{X_H}{2} \end{aligned}$$

Both $\hat{L}_{LOW}$ and $\hat{L}_{HIGH}$ are within $\beta/2$ of L_{FB}: the solution approaches the social optimum, and the divergence between the socially optimal and private banks' liquidity choices is possible only on a small interval of length $\beta/2$. The size of possible private benefits β that determine the length of that interval can be related to the bankers' ability to create and retain moral hazard benefits, as driven in particular by financial development (legal environment, supervision, enforcement, etc.).

Proposition 3 *When bank capital information is available and private benefits of moral hazard are low, a capital-based LOLR policy can bring banks' liquidity choices close to the social optimum. Under a capital-based LOLR policy, banks always choose liquidity for* $L \leq L_{FB} - \beta/2$.

Observe that both the availability of capital (asset value) information and low private benefits of moral hazard are likely to be found in more advanced financial systems. They may be lacking in developing countries, making capital-based LOLR policies less feasible there.

2.6 Discussion

This paper showed that expected ex-post LOLR action can affect banks' ex-ante liquidity choices, and analyzed how the authorities can respond to such a distortion. The modelling relied on a number of mildly restrictive simplifying assumptions. In this section, we recall those modelling features and analyze their robustness to possible generalizations.

Bailouts The model posits that the Central Bank will always have to intervene in a systemic crisis: to preserve systemic stability, at least some banks will have to be bailed out. Therefore, importantly, any claim that no assistance will be offered to banks in a systemic crisis is not credible.

We also assume that the Central Bank would never bail out a bank when another one is stable, and bail out only a single bank in a systemic crisis when both fail. For this we offer an intuitive explanation through the costs of extra taxation, which if sufficiently high and convex, would prevent any unnecessary bailouts. This effect is likely to be amplified by unnecessary bailouts reducing banks' incentives to hold liquidity, making systemic crises and consequent LOLR interventions more frequent in the first place.

Indeed, in the extreme when the Central Bank always bails out all failing banks, the payoff to an illiquid bank increases from (2.7) and (2.8) to:

$$\Pi^{ILL} = (1-a)\frac{X_H + X_L}{2} + a\left(\beta + \frac{X_H - X_L}{2}\right) - 1 \tag{2.13}$$

It is clear that $\Pi^{ILL} > \Pi^{ILL}_{ILL}$, so under blanket bail-outs banks would have lower incentives to be liquid. Banks would choose to hold buffers only for $\Pi^{LIQ} \geq \Pi^{ILL}$ or $L \leq (X_L - \beta)/2 < L_{LOW}$, which is a very limited range of parameter values.

Equity financing The model focused on debt as initial financing vehicle. Debt is, indeed, the major source of finance used by banks, perhaps as it alleviates the costly state verification problem (Townsend, 1979), strengthens monitoring mechanisms (Calomiris and Kahn, 1991), and helps commit to a degree of prudence (Diamond and Rajan, 2001). Nevertheless, banks do use *some* equity financing. In particular, the lower bound on equity – capital requirements – is one of the cornerstones of contemporary banking regulation.

We can introduce some initial equity financing into the model without affecting the results, because the underlying conflict of interest is not between bankers and depositors, but between bankers and the LOLR. Yet, it is essential for our exposition (and factual) that banks are not default-free and can become under-capitalized and fail as a result of *some* adverse shocks. This limits the amount of equity that can be tractably considered[10]. Indeed, in the extreme, when the bank is fully equity financed, it cannot have negative net worth by definition.

To verify this formally, consider a bank endowed with A units of initial capital. However $A < 1$, so that additional external financing of at least $1 - A$ is always necessary, and

$$X_L < 1 - A - L \tag{2.14}$$

so that a low asset value bank has negative capital following a liquidity shock.

Under these conditions, the introduction of equity financing into the set-up does not affect the bank's decisions (in particular, the decision to switch to the moral hazard project when its future asset value is low). Nor does it therefore affect the costs of liquidity. Consequently, the reduction of leverage affects the payoffs (4-8) in the same way: the volume of deposits to be repaid falls by A (the last term -1 transforms into $-(1 - A)$). The threshold points L_{FB}, L_{LOW} and L_{HIGH} do not change.

If some equity within A was external (not belonging to the bankers), that would not change the qualitative results either. In fact, compared to inside equity, external equity makes bankers more likely to switch to suboptimal projects, because they claim only a share of monetary profit, but retain full private benefits. A higher bailout grant would be necessary to keep them from switching to a moral hazard project. If the stake of insiders was i and that of outsiders $1 - i$, the bailout must leave the bank profits of at least β/i to keep insiders from switching to an inferior project. This relative ineffectiveness of external equity in disciplining banks may be related to the fact that banks indeed often have relatively concentrated ownership (see Caprio et al., 2005).

[10] Banking regulation recognizes that the extent to which banks can rely on equity financing, and the degree of safety that it provides, are limited. Indeed, capital requirements are only one of the three pillars of the Basel II accord (the other two being supervisory review and market discipline).

Recapitalization We also focused on debt in the LOLR mechanism. Based on this, we derived the bailout rents: if a low asset value bank needed rents β, the high asset value bank charged the same debt repayment ended up with rents $\beta + (X_H - X_L)$. An alternative LOLR arrangement could be recapitalization, when, in return for the bailout, the central bank obtains an equity stake the bank.

Our model is robust to the possibility of recapitalization. Assume that, instead of debt, the Central Bank retains an equity stake in the saved illiquid bank. The bankers' remaining equity stake α must leave the low asset value bank rents of at least β: $\alpha\,(X_L - D) > \beta$ where D is some nominal repayment to depositors. The same equity stake α would leave a high asset value bank with excess rents $\alpha\,(X_H - D) = \beta + \alpha(X_H - X_L)$, comparable to those in the case of debt refinancing.

In some circumstances, more complex contracts may be used. In particular, a constrained optimal contract, under which a high asset value bank repays $X_H - X_L$ more than a low asset value bank, would reduce rents to an incentive-compatible minimum of β and result in an equilibrium equivalent to that of Proposition 3. Regulators may also have other powers, such as to replace bank managers. For example, in the case of the largest US bank failure Continental Illinois, the government (FDIC) injected new capital in return for hiring new management and obtaining junior preferred stock convertible into common stock, as well as (non-convertible) adjustable rate rate preferred stock in the restructured bank.

All these regulatory powers and capabilities strengthen banks' ex-ante incentives to be prudent. However, the scope for such arrangements (even that of simple equity recapitalization) may be constrained in countries with less advanced financial system or less developed regulatory practices and crisis resolution capabilities. There, central banks may have limited experience and may be reluctant to get involved in managing commercial banks, as well as be less able to implement complex financial solutions under the time pressures involved in financial crisis management.

Refinancing This model did not consider the possibility of external refinancing in a liquidity shock. The breakdown of access to wholesale money markets, that in normal times can provide necessary liquidity at a short notice, is indeed a distinguishing feature of most recent bank liquidity crises in industrial economies (Citibank and Standard Chartered in Hong Kong in 1991, Lehman Brothers in 1998, and Commerzbank in 2002). There may be a number of reasons involved: aggregate liquidity shocks (Holmstrom and Tirole, 1998), some type of flight to quality (Bernanke et al., 1996), or strategic counterparty behavior

(Brunnermeier and Pedersen, 2005). These frictions can prevent refinancing even when the bank's capitalization is publicly known (as in Section 5.2).

Another fundamental constraint on external refinancing, which may be most naturally introduced into our setting, is asymmetric information on a bank's capital. In the event of a liquidity shock, the probability of under-capitalization rises, and financiers would only be prepared to lend at high interest rates. In our model, the probability of negative capital in a liquidity shock is 1/2 and the corresponding promised loan return $R_{refin} = 2$. Unless X_H is very high, such a loan return may be prohibitive and lead to negative net worth even for a bank with a high asset value:

$$X_H < 1 + 2L + \beta$$

Here 1 is the minimal repayment to initial depositors (for $R = 1$) and $2L$ the repayment on the refinancing loan (for $R_{refin} = 2$). Note that, in contrast to ex-post refinancing, by attracting a liquidity buffer ex-ante, the bank effectively spreads its cost between good and bad states (Acharya et al., 2007).

Observe also that when a failing bank is liquid, this contains a negative signal on its capitalization and the possibility of refinancing. Therefore if for any reason the bank's ex-ante liquidity position was not fully observable, that would make it more difficult for outsiders to distinguish between illiquidity and low capital. Interest rates would increase as a result, making refinancing even more problematic.

Deposit insurance Deposit insurance reduces interest rates that the bank must pay depositors, however its overall effects on the cost of funds depends on deposit insurance premia. If deposit insurance was fairly priced such that an ex-post premium of $R - 1$ was paid to the insurer whenever the bank had positive net worth, no change in the previous analysis would occur. If premia were set unfairly, various additional distortions could occur. How these distortions affect liquidity decisions depends on a particular structure of subsidies. Yet we have verified that even under a fully publicly funded deposit insurance, banks could still choose to be illiquid and gamble for a bailout when associated rents exceed the benefit of preserving long term charter value[11].

[11] Consider a simple quantitative example. Assume $X_H = 2$, $X_L = 1.2$, $\beta = .2$, $L = .6$. Then $L_{FB} = 1.1$, so in the first best the bank should be liquid. Assume that the other bank is illiquid, so that a bailout happens with probability 1/2 in joint failure. The bank's payoff to being liquid is

$$a(\frac{2 + 1.2}{2} - 1) + a/2(2 - .6 - 1) + a/2 \cdot .2 = .6a + .3a = .9a$$

Another alternative is an ex-post funded deposit insurance, where surviving banks are taxed to repay depositors and possibly even boost the equity value of failing counterparts. Such equalizing taxation has indeed sometimes been used in practice, for example during the Japanese banking crisis (Hoshi, 2002). Yet such arrangements carry the risks of increased moral hazard ex-ante (banks have less incentives to survive a crisis) and undermining financial stability ex-post (risks are transferred to stable banks). Moreover, ex-post deposit insurance may be not functional in a wide systemic crisis, when no banks can be feasibly taxed.

Continuous liquidity shocks The model considered binary liquidity events – either no shock, or a shock of fixed magnitude. This can be extended to account for liquidity shocks of varying sizes. The main intuition would persist: banks would hedge against smaller shocks and leave the larger shocks that deplete charter value unhedged. The depth of hedging depends negatively on the probability of a bailout.

To see this formally, consider the following extension. Assume that liquidity shocks occur with probability a and are uniformly distributed on $[L_1; L_2]$. As in the main model, assume that X_L banks have negative capital as a result of any liquidity shock, while X_H banks remain positively capitalized in any liquidity shock:

$$\begin{aligned} X_L &< 1 + L_1 \\ X_H &> (1 + L_2)/(1 - a) + \beta \end{aligned}$$

Consider a single bank that is bailed out with an exogenous probability p, and observe its payoff from having a liquidity buffer $L : L_1 \leq L \leq L_2$. In the case of a liquidity shock, with probability $\frac{1}{2}\frac{L-L_1}{L_2-L_1}$ the bank is positively capitalized and liquid. It invests additional funds as required (average liquidity shock in that interval $\frac{L_1+L}{2}$) and obtains return X_H. With probability $\frac{1}{2}\frac{L-L_1}{L_2-L_1}$ the bank is liquid but has negative capital. It covers the liquidity shock and switches to the inferior project, destroying long-term value but obtaining private benefits β (the part of the liquidity buffer not used to cover the shock is returned to depositors). With probability $\frac{1}{2}\frac{L-L_1}{L_2-L_1}$ the bank is illiquid. It receives 0 return if liquidated (an insufficiently liquid bank fails immediately and the liquidity buffer is

The bank's payoff to being illiquid is

$$a(\frac{2 + 1.2}{2} - 1) + a/2(.2 + \frac{2 - 1}{2}) = .6a + .35a = .95a$$

Therefore, the bank would choose to be illiquid.

transferred to depositors), β if bailed out but has a low asset value, and $\beta + (X_H - X_L)$ if it has a high asset value.

This makes the overall payoff for a bank with liquidity buffer L

$$\begin{aligned}\Pi &= (1-a)\frac{X_H + X_L}{2} + \frac{a}{2}\frac{L - L_1}{L_2 - L_1}\left(X_H - \frac{L + L_1}{2}\right) - \frac{a}{2}\frac{L - L_1}{L_2 - L_1}\left(\frac{L + L_1}{2} - \beta\right) \\ &+ \frac{a}{2}p\frac{L_2 - L}{L_2 - L_1}\left(\beta + \frac{X_H - X_L}{2}\right) - 1\end{aligned} \quad (2.15)$$

The payoff is maximized for

$$L^* = \frac{X_H + \beta}{2} - p\frac{\beta + (X_H - X_L)/2}{2}$$

Observe that in the first best with no LOLR intervention, $p = 0$: $L^* = L_{FB}$. A higher probability of bailout p distorts the bank's choice of liquidity buffer below that of the social optimum.

2.7 Conclusions

This paper demonstrated that banks may make suboptimal liquidity choices due to distortions associated with a LOLR intervention that is unavoidable in a systemic crisis. Endogenous bailout rents are driven by the need to preserve bankers' incentives under uncertain net worth. Banks may herd and are more likely to choose suboptimal liquidity when they expect other banks in the system to do so. We showed that a LOLR policy based on bank's capital information can reduce the distortion, but such information may be available only for more transparent economies. Other jurisdictions, such as developing countries, may need to rely on costly quantitative liquidity regulation. This may explain observed global divergence in approaches to liquidity regulation: liquidity requirements become increasingly marginal in advanced economies, but are substantially relied upon in the developing world.

Figure 1.

<u>The time line</u>

Date 0

* Banks make liquidity decisions

* Banks attract initial financing (1 unit to invest in a long-term project; liquid banks also L units for a buffer)

Date 1

* Bankers receive a perfect signal of their date 2 asset value

* Banks may be hit by a shock, and can use a precautionary buffer to cover resulting liquidity shortage

* Banks that covered the shortage can switch to a moral hazard project

* Banks that did not cover the shortage or switched to moral hazard start failing

* If both banks are failing, the Central Bank bails out one of them randomly. This reverses imminent failure and can restore bankers' incentives

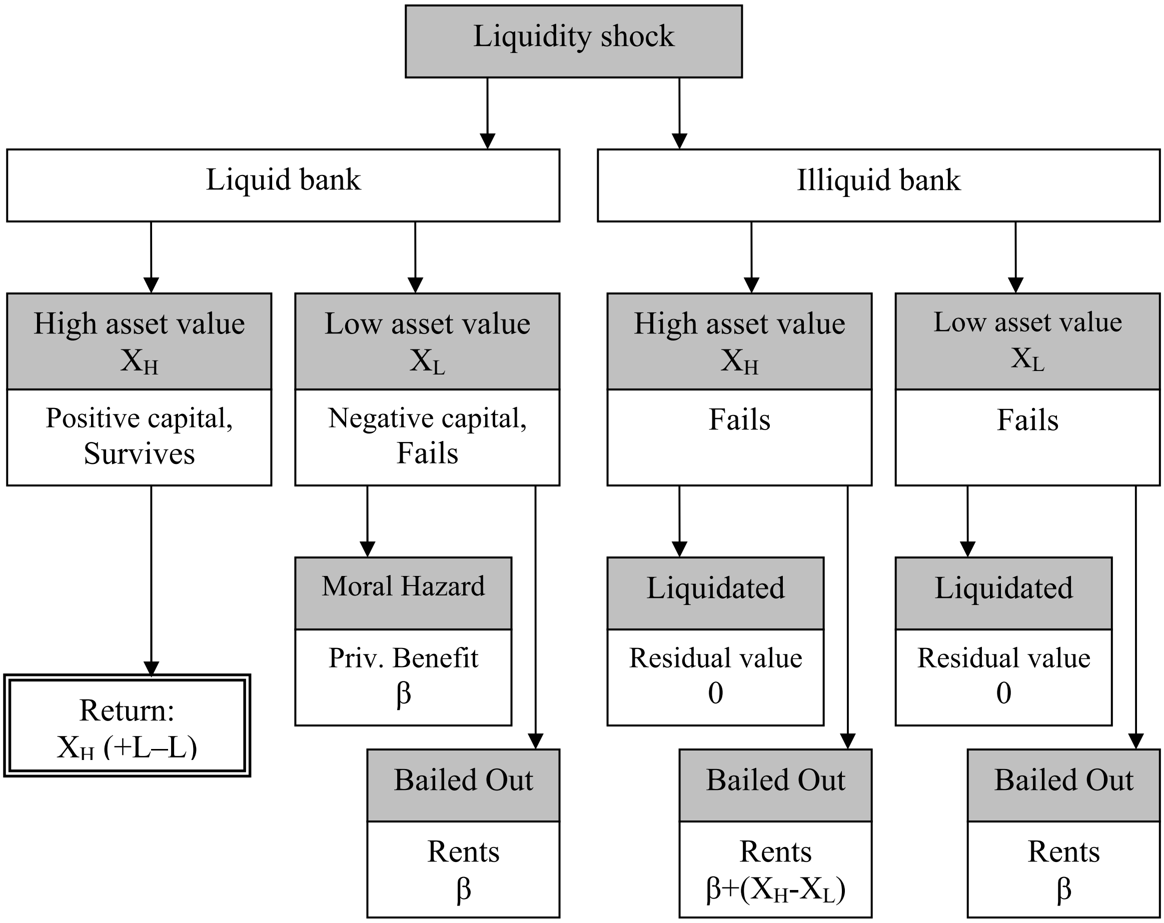
* Banks that did not refinance fail with 0 liquidation value. Banks that switched to moral hazard fail with bankers obtaining private benefits β

Date 2

* Surviving banks realize returns X_H or X_L, repay depositors and the Central Bank, and consume profit

Figure 2.

The game tree



Note: Bail out happens when another bank fails as well.
It accrues to a given bank randomly with probability ½

Figure 3.

Threshold values of banks' liquidity choices