Liquidity and Transparency in Bank Risk Management

Lev Ratnovski*
Bank of England and
University of Amsterdam

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Abstract

Liquidity risk is associated with solvency concerns at the refinancing stage. To insure, banks can accumulate liquidity (have a buffer of short-term assets) or adopt transparency (facilitate solvency information transmission). Both are important: a liquidity buffer provides complete insurance against small liquidity shocks, transparency – partial against large ones as well. Banks' private risk management choices can be distorted by leverage. We show that banks can under-invest in both liquidity and transparency due to risk-shifting, and bias towards liquidity as it preserves internal control. While optimal liquidity can be imposed, transparency is not verifiable. The resulting multi-tasking problem complicates the optimal design of liquidity regulation. In particular, reserve requirements can compromise banks' endogenous transparency choices. Consequently, social welfare and financial stability may deteriorate, particularly in financially developed economies where market access plays a larger role. Also, liquidity regulation may in fact address the milder distortion, with initiatives to improve transparency being more important.

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1 Introduction

In performing maturity transformation, banks insure public's liquidity needs, but become exposed to liquidity risk. The concern is that if refinancing frictions prevent a solvent bank from covering a liquidity shortage, it may go bankrupt despite having valuable long-term assets.

Most recent bank liquidity events in developed countries were associated with increased solvency concerns. Some prominent examples are:

- 1991, Citibank and Standard Chartered (Hong Kong): rumors of technical insolvency caused runs in insured and uninsured deposits of both banks;
- 1998, Lehman Brothers (US): rumors of severe losses on emerging markets prompted suspension of credit lines, margin calls, and refusal to trade with the bank;
- 2002, Commerzbank (Germany and UK): rumors of insolvency due to trading losses lead to trimmed credit lines and illiquidity of the bank's CDs.

While, as uncertainty resolves, rumors may turn out to be unsubstantiated, cash withdrawals and restricted access to new funding impose significant strain on a bank's ability to fulfill its liabilities during the crisis. To survive, a bank must be able to support itself with own funds for the duration of liquidity stress, and/or alleviate the markets' concerns over its solvency as soon as possible.

The purpose of this paper is to study the options for bank's liquidity risk management, when liquidity risk is associated with solvency concerns at the refinancing stage. We suggest that there are two distinct ways in which a solvent bank can insure against a failure in a liquidity shock. One is to accumulate *liquidity* – form a precautionary buffer of short-term assets to cover possible outflows internally. Another is to adopt *transparency* – establish a set of mechanisms that facilitate information transmission to the market and help resolve solvency uncertainty. We explore socially optimal and private liquidity risk management choices, study the interaction between liquidity and transparency, and formulate policy and empirical implications.

The intuition of our modelling and main results is as follows. A bank has a long-term positive NPV project that typically yields a high return, but with a small probability can turn out to be of zero value (a solvency problem). At the intermediate date, a bank has to refinance an exogenous random withdrawal. In most states of the world, a bank is known to be highly solvent, and investors are willing to extend new financing in place of withdrawals. However with some probability, the bank can experience a "liquidity shock", when the conditional probability of insolvency becomes high. Increased solvency concerns make investors unwilling to refinance the bank, unless solvency uncertainty is positively resolved.

There are two ways in which a solvent bank can assure continuation in such an event. One is to accumulate liquidity, by allocating some funds to a precautionary buffer of short-term assets. That would allow to cover possible outflows internally. Another is to adopt transparency, that is to establish mechanisms that facilitate solvency information transmission to the public and help resolve solvency uncertainty. If successful, that would allow to refinance by borrowing from the market. Both investments – in liquidity and in transparency – are strategic ex-ante decisions, which should be taken at the initial date, before possible liquidity risks realize.

Liquidity and transparency are costly hedges, with costs stemming from a number of sources. Firstly, a bank operates under a capital constraint, which restricts maximum initial borrowing. Therefore, when a bank invests in a liquidity buffer or spends on establishing transparency, that crowds out profitable long-term investment. Secondly, there are direct costs. For liquidity, we consider those stemming from increased banker's moral hazard (Myers and Rajan, 1998), in particular in liquid but insolvent bankers. For transparency, we associate the costs with the expenses of establishing credible disclosure mechanisms.

Liquidity and transparency have different effects in risk management. A precautionary buffer allows to cover internally all liquidity shortages within its size, providing complete insurance against smaller shocks. However large buffers are prohibitively costly, so liquidity cannot be used cover large shocks. Transparency helps resolve solvency uncertainty and enables refinancing by borrowing from the market. That can cover any liquidity shocks – small or large. Yet, since it relies on ex-post information communication, transparency is effective only with some probability. It therefore provides incomplete insurance, but also against large shocks. We show that banks may therefore optimally combine liquidity and transparency in their liquidity risk management. They can use liquidity to fully insure against small shocks, and transparency – to partially cover large shocks as well.

The main distortion in our model comes from leverage. We show that due to risk-shifting incentives (Jensen and Meckling, 1976), bankers may under-invest in liquidity, or transparency, or both.

This creates scope for policy intervention with the aim of reinstating optimal liquidity risk management. However, while liquidity is verifiable and can be imposed, for example, by reserve requirements, regulatory lever on transparency choices is small. This makes liquidity regulation a multi-tasking problem, and complicates optimal policy design. We show that liquidity requirements can compromise banks' endogenous transparency choices. This is especially likely when transparency is by itself an effective risk management mechanism and market access in important in mitigating liquidity shocks. There is therefore a danger that financial stability and social welfare may deteriorate as a result of ill-designed liquidity requirements.

Another issue is that, when liquidity is associated with significant private benefits (as in Myers and Rajan, 1998), banks may already have a bias towards liquidity, at the expense of transparency. Liquidity allows them to retain internal control in the stress event and consume private benefits if insolvent. This deepens concerns over reserve requirements, since they may in addition target the "wrong" and milder distortion. Policy initiatives to improve transparency may be equally or more important than regulation oriented on stock liquidity.

The principal links of this paper to the existing literature are as follows. This paper contributes to the literature on liquidity crises. Our modelling of liquidity events differs from the mainstream approach of Holmstrom and Tirole (1998) in several aspects. Firstly, in our model, liquidity needs originate on the liabilities side of the balance sheet and are clearly related to refinancing needs. Secondly, the refinancing problem is driven by asymmetric information, not moral hazard or aggregate liquidity shortages. Such specification relates to the "flight to quality" phenomenon (Bernanke et al., 1996), and has strong empirical foundations.

The concerns about possible suboptimal bank liquidity have received significant attention in the literature. It is understood that, while a degree of liquidity risk may be essential for bank operations (Diamond and Rajan, 2001), their private liquidity and transparency choices can be compromised by opportunistic incentives (see for example Bhattacharya and Gale, 1987). Empirical evidence demonstrates instances of seemingly lacking bank liquidity. In particular, Gatev et al. (2004) finds that not all US banks had sufficient liquidity to be resilient to the 1998 crisis, and Gonzalez-Eiras (2003) shows that Argentinian banks pre-2001 crisis reduced liquidity holdings in the anticipation of LOLR involvement with no other fundamental reason.

There is also an understanding that transparency enables market access and facilitates the management of liquidity shocks. Kashyap and Stein (1990) show that larger banks, and Holod and Peek (2004) – that publicly held banks (both can be seen as proxies for better market access) are less reactive to monetary policy tightening.

There is also strong evidence on the relative shortage of transparency in the banking system. Morgan (1998) finds that bank bonds are more opaque than industrial (basing on the degree of ratings agencies disagreement), and Flannery et al. (2004) suggest that bank stocks are at least as opaque as industrial (basing on trading microstructure properties), while banks' higher refinancing needs require that they actually be *less* opaque.

Our contribution is to emphasize the more complex nature of the interaction between liquidity and transparency. We suggest that liquidity and transparency can have complementary as well as substitute effects. In particular, liquidity is more effective in covering small (or routine) shocks, while transparency enable to deal with large (or exceptional) events.

The literature has yet devoted little attention to the relationship between cash in hand and borrowing capacity. In a recent paper, Acharya et al. (2006) relate the trade-off between increasing cash and withdrawing debt to long-term hedging choices. We offer a different perspective, basing on that the effects of liquidity are certain yet limited, while those of transparency – uncertain but potentially able to address large shocks.

Interactions identified in this model provide avenues for possible empirical research. We predict that more liquid banks will be more resilient to small shocks, while more transparent banks – to large shocks as well. Positive effects of investments in transparency and market access depend on financial market development. Bank's choices of liquidity and transparency depend on the type of shocks they expect (such as routinely small or possibly large), financial development, and bank-specific characteristics (such as size, enabling easier market access).

The rest of the paper proceeds as follow. Section 2 sets up the model. Section 3 solves for the social optimum. Section 4 explores distortions created by leverage and demonstrates that banks may underinvest in liquidity and transparency. Section 5 discusses regulatory intervention and possible effects of reserve requirements on bank's transparency choices. Section 6 extends the basic model and introduces private benefits of liquidity, to demonstrate the presence of a possible bias towards liquidity at the expense of transparency in bank's choices. Section 7 concludes.

2 Setup

2.1 Economy and Agents

Consider a risk-neutral economy with three dates: $0, 1, 2$. The economy is populated by multiple small investors (depositors) and a single bank. Small investors are endowed with money. They have access to a safe storage technology (cash), or can lend to the bank, charging the gross interest rate of 1.

The bank is penniless, but has access to a profitable investment project. For each unit of financing at date 0, the project returns at date 2: typically a high return X

with probability $1 - s$, but 0 with a small probability s (s for a solvency problem). A bank operates under a leverage constraint (representing capital requirements) and cannot borrow more than 1 at date 0.

All financing takes the form of simple debt. Banks maximize date 2 profit.

2.2 Solvency Uncertainty and Liquidity Risk

While the project is long-term, some debt matures earlier and must be refinanced. This represents either the withdrawals of demandable deposits, or the maturity of term funding. While in reality there may be multiple refinancing events through the course of the project, for the analysis we collapse them into a single "intermediate" date 1.

The amount of funds maturing at date 1 is random. With probability 1/2, the liquidity need is low – the bank has to repay some $L < 1$. With additional probability 1/2, the liquidity need is high – the bank has to repay a full 1. If the bank cannot repay, it fails and goes bankrupt with 0 liquidation value.

Because small investors always offer an elastic supply of funds, a bank known to be solvent is able to refinance itself by new borrowing and thus substitute any withdrawals at date 1. However this may be prevented by possible effects of asymmetric information at date 1, namely the increased concerns about a bank's solvency. This is the origin of liquidity risk in this model.

Remember that a bank is solvent with probability $1-s$ and insolvent with probability s. Assume that the bankers receive complete information on the bank's solvency before date 1. However the public's information may be noisy. Only with probability $1-(s+q)$ the public receives a correct signal that a bank is solvent and will yield X with certainty. Such banks will be able to obtain refinancing, and such refinancing would be risk-free.

With additional probability, $s + q$, there is a signal that a bank is not in the above category and may be insolvent. This represents a probability q (q for liquidity problem) that a solvent bank is pooled with insolvent banks. The posterior probability of insolvency in such a case, $s/(s + q)$, is higher then the ex-ante probability of insolvency, s. This represents increased solvency concerns – a higher uncertainty over the final payoff, which may prevent external refinancing. We therefore call such event a "liquidity shock".

We impose the following restrictions on parameter values:

1. A bank has a positive NPV, even if it always failed in a liquidity shock.

$$X > \frac{1}{1 - (s + q)}$$

This assures that a bank is always financed at date 0.

2. A bank in a liquidity shock has a negative posterior expected NPV at date 1.

$$X < \frac{s+q}{q}$$

We make two additional assumptions for expositional simplicity – they allow to focus on most relevant effects and cases.

1. The charter value of the bank is sufficiently large, so that public and private risk management choices under leverage are not too divergent.

$$X > 2$$

2. Investments at date 0 are covered by deposit insurance. However, refinancing at date 1 is not covered by it. (One can think that the date 0 investments are deposits, while date 1 refinancing is market-based. This would correspond to the banks' practice of using wholesale funds to actively manage liquidity needs).

These assumption do not affect qualitative properties of the model. Moreover, both higher charter value and deposit insurance reduce leverage – the main distortion of our model. Therefore these simplifications can only weaken our results.

2.3 Liquidity Risk Management

We consider two distinct ways in which a bank can hedge its liquidity risk.

1. **Stock liquidity**. After attracting the maximum 1 unit of initial financing, a bank can invest L of it not in the investment project, but in the short-term asset (cash). This would allow a bank to fully cover small withdrawals at date 1, and therefore insure it against small liquidity shocks that happen with probability 1/2.

2. **Adopt transparency**. After attracting initial financing, a bank can invest T to establish transparency. We think of transparency as a strategic ex-ante investment, such as credible disclosure, that allows a bank to better communicate solvency information to the market. In particular, this may enable the bank to publicly confirm its solvency in the event of liquidity shock. Since it relies on ex-post information transmission, transparency is an imperfect insurance against liquidity risk. We assume that, in the case of a shock, a transparent bank is able to prove its solvency (and thus obtain refinancing) with a given probability t. The effectiveness

of transparency may be determined by factors outside a single bank's control, such as the level of financial market development in a country. Notice that transparency allows to insure against both small and large liquidity shocks.

Both liquidity and transparency have costs. We consider two sources of liquidity costs. Firstly, given maximum date 0 leverage, investing in liquidity crowds out investment in a profitable project. This reduces the return to a successful liquid bank from X to $X(1-L)+L$, a loss of $-(X-1)L$.

Secondly, we assume that when a liquid bank fails (e.g., due to inability to refinance a large liquidity shock or insolvency), the value of its liquidity buffer is lost. It may, for example, be spent in costly bankruptcy proceedings, or appropriated by the bankers and transformed into marginal private benefits (as in Myers and Rajan; we here treat private benefits as insignificant, and examine their effects in more detail in the extension in Section 6). This makes the return to a failing liquid bank 0.

The cost of transparency is the value of associated investment, T, which is, firstly, a direct expense and, secondly, crowds out investment in a profitable project. Transparency reduces return to a successful bank from X to $X(1-T)$, a loss of $-T$.

We focus this analysis on different effects rather than costs of liquidity and transparency (impact of costs would be mirroring), and therefore normalize the costs to be equal:

$$(X-1)L = T = C$$

where C is now a generic cost of hedging, either with liquidity or with transparency.

Notice that should a bank choose to invest in both liquidity and transparency, a return in the successful state would be $X(1-L-T)+L = X-2C$. The costs simply double.

Liquidity and transparency are therefore costly hedges against liquidity risk. The decisions on whether and how to hedge are made by the bankers, and, we assume here, are not contractible. In the presence of leverage, this gives rise to a risk-shifting problem (Jensen and Meckling, 1976) that may lead to insufficient hedging. This basic conflict of interest is the principal distortion of our model.

The time line of the game is as follows.

Date 1. Banks attract deposits. They divide assets between the profitable project, the precautionary liquidity buffer, and the investment in transparency

Date 2. A bank may be hit by a liquidity shock and require refinancing. If the bank unable to cover withdrawals from the precautionary buffer or by borrowing from the market, it is liquidated.

Date 3. Project returns realize; successful banks repay debts and consume profits.

The game tree is shown on Figure 1.

<<Figure 1 goes here>>

3 First Best: Liquidity and Transparency

We first consider socially optimal levels of bank's liquidity and transparency, and show that, when costs of hedging are not too high, it is optimal that the bank combines liquidity and transparency in its risk management. Then, liquidity completely insures a solvent bank against a failure in a small liquidity shock, which the bank will be able to cover from the precautionary buffer. Transparency partially insures a bank against a failure in a large liquidity shock, by possibly enabling market borrowing to refinance .

3.1 Risk Management Options

We first derive the social payoffs depending on the bank's liquidity management choices. They are:

For a strategy "**N**" when a bank is not liquid and not transparent:

$$\Pi_N^S = (1 - s - q) \cdot X - 1$$

Here, $1 - s - q$ is the probability that a bank is not hit by a solvency or liquidity shock, X is the return in that case, and 1 is the initial investment.

For a strategy "**L**" when a bank is liquid but not transparent:

$$\Pi_L^S = (1 - s - q/2) \cdot (X - C) - 1$$

A solvent bank is able to survive a small liquidity shock by covering it from the precautionary buffer (probability $q/2$), but fails in a large liquidity shock that is above the buffer size. The probability of a solvency shock is s, and of a large liquidity shock $q/2$. Therefore the probability of survival is $1 - s - q/2$; the return in that case is $X - C$ (note C is the hedging cost), and the initial investment is 1.

For a strategy "**T**" when a bank is transparent but not liquid:

$$\Pi_T^S = (1 - s - q(1 - t)) \cdot (X - C) - 1$$

A solvent bank is able to survive a liquidity shock (either small or large) when it is successful in communicating solvency information to the market, that is with probability t. The probability of a solvency shock is s, and that of a solvent bank being unable to prove its solvency to the market $q(1-t)$. Therefore the probability of survival is $1-s-q(1-t)$; the return in that case is $X-C$, and the initial investment is 1.

Lastly, for a strategy "**LT**", when a bank is both liquid and transparent:

$$\Pi_{LT}^{S} = (1-s-q(1-t)/2)\cdot(X-2C)-1$$

A solvent bank is able to survive a small liquidity shock always by covering it from a precautionary buffer, and a large liquidity shock with probability t when it is successful in communicating solvency information. The probability of a solvency sock is s, and of a large liquidity shock when a bank is unable to prove its solvency to the market $q/2\cdot(1-t)$. Therefore the probability of survival is $1-s-q(1-t)/2$, the return in that case is $X-2C$ (note double the hedging cost), and the initial investment 1.

3.2 Optimal Risk Management

We use these four payoffs to compare social welfare and derive bank's optimal risk management choices.

We first analyze the choice between liquidity and transparency. Liquidity insures against half of the shocks – small shocks only. Transparency insures against share t of the shocks – only when ex-post information communication is successful. Thus when t is low – liquidity is more effective, and when t is high – transparency is more effective. Indeed, observe that $\Pi_L^S > \Pi_T^S$ (liquidity is optimal) for $t < 1/2$, and $\Pi_T^S > \Pi_L^S$ (transparency is optimal) for $t > 1/2$.

Another dimension is the depth of hedging – whether to hedge at all, adopt a single hedge (liquidity or transparency – whichever is more effective), or have both hedges. Note that the marginal benefit of the second hedge is lower than the marginal benefit of the first hedge. This is because, firstly, the first hedge is already a more effective one (liquidity for $t < 1/2$ and transparency for $t > 1/2$), and, secondly, the first hedge already protects a bank from a range of liquidity shocks. We analyze the optimal depth of hedging as a function of the cost of hedging C. We derive results separately for two cases, corresponding to more effective liquidity or transparency.

Case 1: Liquidity more effective, $\mathbf{t < 1/2}$. It is optimal that a bank:

– Has no hedge, "**N**", for $\Pi_N^S > \Pi_L^S$, corresponding to high costs of hedging:

$$C > \frac{q/2}{1 - s - q/2} \cdot X$$

– Is only liquid, "**L**", for $\Pi_L^S > \Pi_N^S$ and $\Pi_L^S > \Pi_{LT}^S$, corresponding to intermediate costs of hedging:

$$\frac{qt/2}{1 - s - q(1/2 - t)} \cdot X < C < \frac{q/2}{1 - s - q/2} \cdot X$$

– Is both liquid and transparent, "**LT**", for $\Pi_{LT}^S > \Pi_L^S$, corresponding to low costs of hedging:

$$C < \frac{qt/2}{1 - s - q(1/2 - t)} \cdot X$$

Case 2: Transparency more effective, t $>$ 1/2. Analogously, it is optimal that a bank:

– Has no hedge, "**N**", for $\Pi_N^S > \Pi_T^S$, corresponding to:

$$C > \frac{qt}{1 - s - q(1 - t)} \cdot X$$

– Is only transparent, "**T**", for $\Pi_T^S > \Pi_N^S$ and $\Pi_T^S > \Pi_{LT}^S$, corresponding to:

$$\frac{q(1-t)/2}{1 - s} \cdot X < C < \frac{qt}{1 - s - q(1 - t)} \cdot X$$

– Is both liquid and transparent, "**LT**", for $\Pi_{LT}^S > \Pi_T^S$, corresponding to:

$$C < \frac{q(1-t)/2}{1 - s} \cdot X$$

Now observe that for any t, and any q and s, there exists C low enough, such that having both hedges is a socially optimal decision of a bank:

$$C < \min \left\{ \frac{qt/2}{1 - s - q(1/2 - t)} \cdot X ; \frac{q(1-t)/2}{1 - s} \cdot X \right\} \tag{1}$$

From here we can formulate the first main result.

Proposition 1 *Banks can combine liquidity and transparency in their risk management. There exist parameter values, such that it is optimal that a bank is both liquid*

***and** transparent, combining the two hedging mechanisms in its liquidity risk management.*

This demonstrates that both holding of short-term assets on the balance sheet, and being able to borrow from the market, are important and potentially complementary dimensions of liquidity risk management. They may, and under certain conditions should, be combined, to achieve a socially optimal outcome.

4 Private Choices: Leverage and Suboptimal Liquidity Risk Management

We now turn to bank's private liquidity and transparency choices. They may deviate from the socially optimal ones, because a bank is leveraged. The presence of debt gives bankers risk-shifting incentives, revealing as lower private incentives to hedge. The reason is that the bankers incur the costs of hedging in the form of reduced payoff in the good state, but do not carry the burden of failure in the bad state thanks to limited liability. Those losses are born by debtholders (depositors, or the deposit insurance fund).

We base this analysis on the assumption that liquidity and transparency choices are not contractible (for example, because depositors are small). We return to the question of influencing bank's choices in the policy intervention discussion in the following section.

We assume that the condition (1) holds, so that it is socially optimal that banks are both liquid and transparent. We study how leverage can distort hedging incentives and bias bank's liquidity risk management choices away from the socially optimal ones.

4.1 Private Payoffs

Before deriving private payoffs, consider the bank's leverage. Observe that, at date 0, the bank is financed at 1 nominal interest rate thanks to deposit insurance, so that the original debt is 1. Part of that funding matures at date 1. When the bank covers outflows from the precautionary buffer, this reduces debt remaining to date 2 by the same amount. When the bank finances outflows by market borrowing, new funding is also attracted at 1 nominal interest rate because it is only provided when there is no uncertainty over a bank's solvency. Therefore, the total net debt payments the bank has to make in case of success are always 1.

We can now proceed to private payoffs. While they are similar to the social payoffs, the difference is that the bankers repay initial investment only if the project succeeds.

When the project fails, losses accrue to depositors (and are covered from the deposit insurance fund). The private payoffs are:

For a strategy "**N**" when a bank is not liquid and not transparent:

$$\Pi_N = (1 - s - q) \cdot (X - 1)$$

For a strategy "**L**" when a bank is liquid but not transparent:

$$\Pi_L = (1 - s - q/2) \cdot (X - C - 1)$$

For a strategy "**T**" when a bank is transparent but not liquid:

$$\Pi_T = (1 - s - q(1 - t)) \cdot (X - C - 1)$$

Lastly, for a strategy "**LT**", when a bank is both liquid and transparent:

$$\Pi_{LT} = (1 - s - q(1 - t)/2) \cdot (X - 2C - 1)$$

4.2 Risk Management Choices

Since liquidity and transparency have the same costs, and the bankers have some stake in the effectiveness of the hedge they adopt, the private choice between liquidity and transparency is not influenced by leverage. Liquidity is preferred, $\Pi_L > \Pi_T$, for $t < 1/2$; and transparency is preferred, $\Pi_T > \Pi_L$, for $t > 1/2$.

However, leverage influences the depth of hedging. Since the incentives to hedge are lower, the same depth is chosen only for lower costs of hedging. We distinguish the same two cases, corresponding to more effective liquidity or transparency:

Case 1: Liquidity more effective, $\mathbf{t < 1/2}$. The bank:

– Chooses not to hedge, "**N**", for $\Pi_N > \Pi_L$, corresponding to high costs of hedging:

$$C > \frac{q/2}{1 - s - q/2} \cdot (X - 1)$$

– Chooses to only liquid, "**L**", for $\Pi_L > \Pi_N$ and $\Pi_L > \Pi_{LT}$, corresponding to intermediate costs of hedging:

$$\frac{qt/2}{1 - s - q(1/2 - t)} \cdot (X - 1) < C < \frac{q/2}{1 - s - q/2} \cdot (X - 1)$$

– Chooses to be both liquid and transparent, "**LT**", for $\Pi_{LT} > \Pi_L$, corresponding to low costs of hedging:

$$C < \frac{qt/2}{1 - s - q(1/2 - t)} \cdot (X - 1) \tag{2}$$

Note the difference in these marginal points compared to those in social payoffs. The cost of hedging is now compared not with the social return X but with the private return $X - 1$, and this biases all threshold points towards lower values of C.

Case 2: Transparency more effective, $\mathbf{t > 1/2}$. The bank:

– Chooses not to hedge, "**N**", for $\Pi_N > \Pi_T$, corresponding to:

$$C > \frac{qt}{1 - s - q(1 - t)} \cdot (X - 1)$$

– Chooses to be only transparent, "**T**", for $\Pi_T > \Pi_N$ and $\Pi_T > \Pi_{LT}$, corresponding to:

$$\frac{q(1-t)/2}{1 - s} \cdot (X - 1) < C < \frac{qt}{1 - s - q(1 - t)} \cdot (X - 1) \tag{3}$$

– Chooses to be both liquid and transparent, "**LT**", for $\Pi_{LT} > \Pi_T$, corresponding to:

$$C < \frac{q(1-t)/2}{1 - s} \cdot (X - 1) \tag{4}$$

We can now compare the private decisions with the social optimum. Under the condition that the combination of liquidity and transparency is socially optimal (1) and the assumption that public and private incentives are not too divergent ($X > 2$), we can rule out the extreme cases when banks choose to be neither liquid nor transparent.

Lemma 1 *When a combination of liquidity and transparency is socially optimal, and private and public incentives not too divergent, bank would choose to have at least some liquidity risk hedge (liquidity, or transparency, or both)*

Proof. For $t < 1/2$ we have to show that

$$\frac{q/2}{1 - s - q/2} \cdot (X - 1) > \frac{qt/2}{1 - s - q(1/2 - t)} \cdot X$$

This follows from that, in the numerator, $X - 1 > tX$ since $X > 2$ and $t < 1/2$; and in the denominator, $1 - s - q/2 < 1 - s - q(1/2 - t)$.

For $t > 1/2$ we have to show that

$$\frac{qt}{1-s-q(1-t)} \cdot (X-1) > \frac{q(1-t)/2}{1-s} \cdot X$$

This follows from that, in the nominator, $X - 1 < (1-t)X$ since $X > 2$ and $(1-t) > 1/2$; and in the denominator, $1 - s - q(1-t) < 1 - s$. ■

Lemma 1 restricts bank's strategies to the choice between a single hedge or a combination of two hedges. When the cost of hedging is very low, such that conditions (2) or (4) are satisfied, the bankers will choose to be both liquid and transparent, in line with the social optimum. However, when the cost of hedging is not as low, and the bank may choose to have a single hedge, despite the fact that a combination of liquidity and transparency is socially optimal. In particular, for any t, and any q and s, there exists C such that:

For $t < 1/2$, a bank chooses to be only liquid while it is socially optimal that it is both liquid and transparent:

$$\frac{qt/2}{1-s-q(1/2-t)} \cdot (X-1) < C < \frac{qt/2}{1-s-q(1/2-t)} \cdot X$$

For $t > 1/2$, a bank chooses to be only transparent while it is socially optimal that it is both liquid and transparent:

$$\frac{q(1-t)/2}{1-s} \cdot (X-1) < C < \frac{q(1-t)/2}{1-s} \cdot X$$

The scope for divergence is determined in particular by X – returns in the good state (related to the charter value) that reduce effective leverage. We can now formulate the following main result:

Proposition 2 *A bank may under-invest in liquidity and transparency due to risk-shifting incentives associated with leverage. There exist parameter values, such that a bank chooses only liquidity or only transparency, while a combination of liquidity and transparency is socially optimal.*

5 Public Intervention: Reserve Requirements and Transparency

In the previous section we have established that banks' private liquidity risk management choices can be suboptimal due to leverage. Banks may under-invest in liquidity or transparency. This creates scope for regulatory intervention. It is relatively easy to influence bank's liquidity, because the holdings of short-term assets on the balance sheet are normally verifiable. The authorities concerned with insufficient liquidity can implement reserve requirements, intended to align bank's liquidity choices with their socially optimal level.

The regulatory lever on transparency is weaker. Mandatory disclosure may be ineffective in promoting transparency when it is difficult to precisely define relevant and quantifiable parameters. Disclosure without proper private incentives can also be perfunctory on "creative" – overall, not credible. A suggestion by Calomiris (1999) to mandate the issue of short-term subordinated debt so as to make banks financial position more depended on the market's assessment and thus improve market discipline is intriguing, but has not yet been fully tested in practice.

This implementation issue may explain why in addressing liquidity risk, financial regulation typically puts emphasis prudential liquidity buffers rather than on the enhanced ability to refinance by borrowing from the market[1]. However, when transparency is an important component of risk management, the optimal design of liquidity regulation becomes a multi-tasking problem. The concern is how liquidity requirements may affect bank's endogenous transparency choices. To address this, we consider a case when a bank chooses suboptimal liquidity and study the consequences of introducing reserve requirements.

5.1 Effect of Reserve Requirements

Consider a setting where it is socially optimal that banks are both liquid and transparent, however, following their private incentives, banks under-invest in liquidity. Note that, by Lemma 1, banks must still have some liquidity risk hedge, and therefore are transparent. The fact that banks choose transparency over liquidity implies that transparency is more effective: $t > 1/2$. From (1) and (3), the range of relevant costs of hedging, such that $\Pi_{LT}^S > \Pi_T^S$ but $\Pi_{LT} < \Pi_T$ is:

$$\frac{q(1-t)/2}{1-s} \cdot (X-1) < C < \frac{q(1-t)/2}{1-s} \cdot X$$

Suppose that the authorities respond to suboptimal liquidity by imposing reserve requirements. They aim to restore socially optimal liquidity risk management, that combines liquidity and transparency. We can now show that this result will not always be achieved. In particular, there is a danger that, in response to liquidity requirements, banks may stop investing in transparency.

[1] Glaeser and Shleifer (2001) analyze the trade-off between a preferred versus easier-to-enforce mode of regulation.

The decision regarding transparency depends on the effectiveness of the second hedge. The intuition is that when t is high, and transparency very effective, the bank is more likely to choose it as a second hedge on top of mandated liquidity. From (2) and (3), the range of costs of hedging C such that banks chose to be transparent only, $\Pi_{LT} < \Pi_T$, and are willing to retain transparency after the introduction of liquidity requirements, $\Pi_{LT} > \Pi_L$, is:

$$\frac{q(1-t)/2}{1-s} \cdot (X-1) < C < \frac{qt/2}{1-s-q(1/2-t)} \cdot (X-1)$$

Note that this is not empty, because $q(1-t)/2 < qt/2$ and $1-s > 1-s-q(1/2-t)$.

However, when t is close to $1/2$, transparency is relatively less effective, and the bank may choose to remain with mandated liquidity only. This would happen when $\Pi_{LT} < \Pi_L$ even though $\Pi^S_{LT} > \Pi^S_L$. From (1) and (2), for any q and s there exist values of t larger but close enough to $1/2$, and values of C such that:

$$\frac{qt/2}{1-s-q(1/2-t)} \cdot (X-1) < C < \frac{q(1-t)/2}{1-s} \cdot X \tag{5}$$

Note that, indeed, for t close to, but still above, $1/2$, the two fractions in (5) become nearly identical, while $X-1 < X$. Then the region defined by (5), in response to reserve requirements, a bank would stop investing in transparency and remain with mandated liquidity only.

Proposition 3 *Liquidity requirements may compromise bank's endogenous transparency choices.*

Such a shift from transparency to liquidity would be detrimental for welfare. Remember that the reason for why a bank chose to forego liquidity in the first place (and remained only with transparency) was that liquidity was relatively less efficient as a method of hedging against liquidity risk. Since $t > 1/2$, the probability of liquidity crises increases from $q(1-t)$ to $q/2$, by $q(t-1/2)$. This represents lower financial stability and higher welfare losses from the bankruptcies of solvent banks.

Note lastly that transparency is likely to be effective, $t > 1/2$, in countries with relatively more developed financial markets, where banks can better rely on external refinancing in the case of a liquidity shock. It is in those countries that improperly designed liquidity requirements may have an unwanted adverse effect. Transparency is likely to be less effective, $t < 1/2$, in countries with developing financial systems. (There, reliance on liquidity, predicted by our model, well corresponds to the evidence of typically highly liquid banks, and higher and more binding reserve requirements.) This suggests that, internationally, there may be heterogeneity in optimal liquidity-transparency outcomes, and divergent benefits and costs of liquidity regulation. Financial markets development may be a significant determinant influencing the relative importance of prudential buffers versus market access in managing liquidity risks. This may need to be borne in mind in the possible process of international convergence of liquidity regulation.

6 Liquidity Bias

In this section we extend the basic model to study the private benefits of liquidity. Myers and Rajan (1998) showed that, while offering protection against liquidity shocks, the holdings of short-term assets may also enable managers (bankers) to extract private benefits from controlling them. The reason is that it is relatively easy to direct liquid funds in privately beneficial ways, and relatively difficult to do that with encumbered long-term assets. Liquid funds can be can be invested pet projects, spent on perks, or just tunneled away.

So far in the model, leverage has only affected the privately chosen depth of hedging, but did not distort socially optimal choice between liquidity and transparency. Here we show that, under private benefits of liquidity that choice can also become distorted. Banks may choose liquidity where transparency would have been preferred from a social welfare standpoint.

It seems natural to associate the misuse of liquidity with the situation on non-viable banks, for example where a bank is liquid but insolvent, or has suffered a liquidity shock beyond the size of its precautionary buffer and cannot cover it externally by borrowing. In these cases, a bank fails, and the value of banker's equity is 0. We assume that, in response, they are able to transform the remaining liquidity (by tunneling or otherwise) into private benefits β.

6.1 Payoffs with private benefits

The presence of private benefits alters the social and private payoffs. Respective payoffs for a strategy "**L**" are:

$$\begin{aligned}\Pi^S_{L,\beta} &= (1-s-q/2)\cdot(X-C)-1+\beta(s+q/2)\\ \Pi_{L,\beta} &= (1-s-q/2)\cdot(X-C-1)+\beta(s+q/2)\end{aligned}$$

Payoffs for a strategy "**LT**" are:

$$\begin{aligned}
\Pi^S_{LT,\beta} &= (1-s-q(1-t)/2)\cdot(X-2C)-1+\beta(s+q(1-t)/2)\\
\Pi_{LT,\beta} &= (1-s-q(1-t)/2)\cdot(X-2C-1)+\beta(s+q(1-t)/2)
\end{aligned}$$

The last terms accounts for private benefits β that bankers receive when a liquid bank fails.

Observe that private benefits introduce divergence in the social and private choices between liquidity and transparency. Transparency is welfare preferred over liquidity, $\Pi^S_T > \Pi^S_{L,\beta}$, for

$$t > 1/2 + \beta\frac{(s+q/2)}{q(X-C)} \tag{6}$$

Yet, bankers privately choose transparency over liquidity, $\Pi_T > \Pi_{L,\beta}$, only for:

$$t > 1/2 + \beta\frac{(s+q/2)}{q(X-C-1)} \tag{7}$$

Observe that

$$1/2 + \beta\frac{(s+q/2)}{q(X-C)} < 1/2 + \beta\frac{(s+q/2)}{q(X-C-1)}$$

so that bankers privately choose transparency only for a narrower range of higher values of t, and in particular may choose liquidity while it is socially optimal to be transparent for:

$$1/2 + \beta(s+q/2)/q(X-C) < t < 1/2 + \beta(s+q/2)/q(X-C-1) \tag{8}$$

6.2 Double distortion

Consider now a situation where, for social welfare, transparency is preferred to liquidity, $\Pi^S_T > \Pi^S_{L,\beta}$ (6), and both hedges are preferred to transparency only, $\Pi^S_{LT,\beta} > \Pi^S_T$:

$$C < \frac{q(1-t)/2}{1-s}\cdot X + \beta\frac{s+q(1-t)/2}{1-s}$$

Consider in addition that, privately, liquidity is preferred to transparency (7), and transparency only (and therefore liquidity only) is preferred to both hedges, $\Pi_{LT,\beta} > \Pi_T$:

$$C > \frac{q(1-t)/2}{1-s}\cdot (X-1) + \beta\frac{s+q(1-t)/2}{1-s}$$

Then, for parameter values given by (8) and

$$\frac{q(1-t)/2}{1-s} \cdot (X-1) + \beta \frac{s+q(1-t)/2}{1-s} < C < \frac{q(1-t)/2}{1-s} \cdot X + \beta \frac{s+q(1-t)/2}{1-s}$$

banks operate under two distortions to socially optimal liquidity risk management. They, firstly, choose a single hedge instead of both hedges, due to leverage. Secondly, for this single hedge, they choose liquidity instead of transparency, due to the associated private benefits of control. We can now formulate the last result.

Proposition 4 *When liquidity is associated with private benefits of control, in addition to suboptimal depth of liquidity risk hedging, banks may choose a suboptimal type of hedging – use prudential liquidity buffers instead of investing in transparency.*

The fact that banks may have an intrinsic bias towards liquidity, at the expense of transparency, further cautions on over-reliance on liquidity requirements. There may be a need for more attention to transparency in policy actions aimed at alleviating excessive liquidity risk taking.

7 Conclusion

This paper studied the roles of liquidity and transparency in bank's liquidity risk management. We showed that investing in both is important, yet bank's private choices may be distorted by leverage. Policy response is complicated by the fact that transparency is not verifiable, making the design of optimal reserve requirements a multi-tasking problem. In particular, there is a danger that reserve requirements compromise bank's endogenous transparency incentives. Initiatives to improve transparency may have prime importance in the regulatory efforts to control and mitigate liquidity risks.

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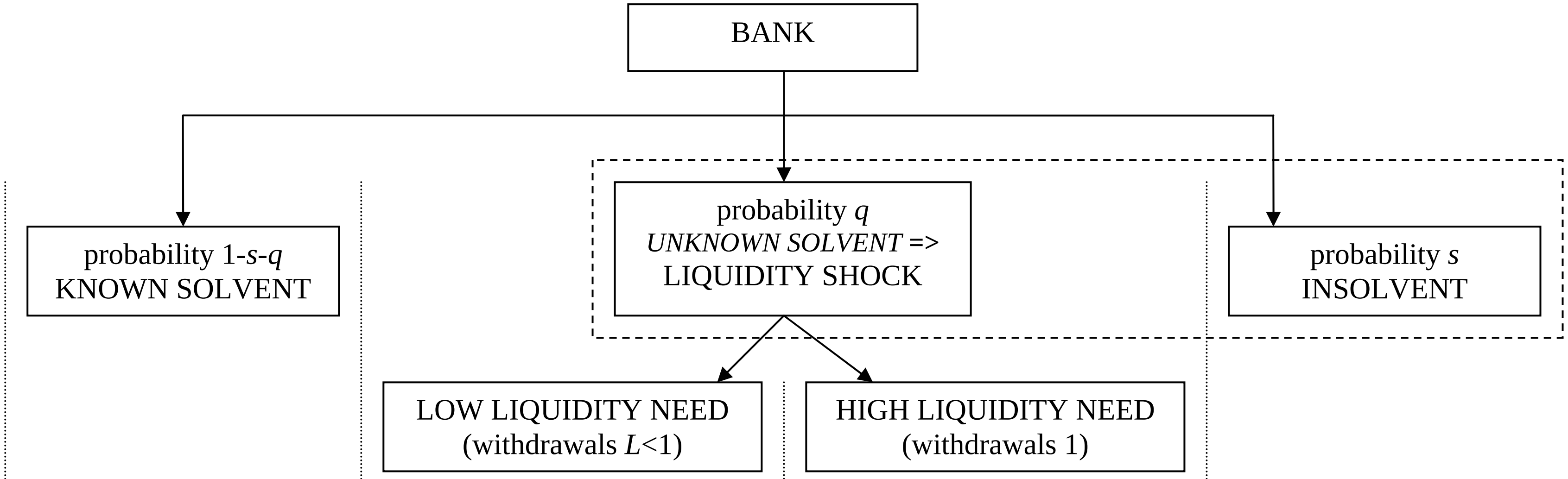
Figure 1: Game tree



NO HEDGE	Survives, returns *X*	Fails, returns *0*	Fails, returns *0*	Fails, returns *0*
LIQUID	Survives, returns *X-C*	Survives, returns *X-C*	Fails, returns *0*	Fails, returns *0*
TRANSPARENT	Survives, returns *X-C*	Survives w/p *t*, returns *X-C* Fails w/p *1-t*, returns *0*	Survives w/p *t*, returns *X-C* Fails w/p *1-t*, returns *0*	Fails, returns *0*
BOTH	Survives, returns *X-2C*	Survives, returns *X-2C*	Survives w/p *t*, returns *X-2C* Fails w/p *1-t*, returns *0*	Fails, returns *0*