Targeted Liquidity Requirements as a Commitment Mechanism [preliminary]

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Abstract

In a rational expectations model, with aggregate uncertainty, the optimal liquidity allocation is determined. Bankers are exposed to regional liquidity shocks that can be insured against via inter-bank claims held in the counter-party with a negatively correlated liquidity shock. However, these connections together with the existence of an idiosyncratic liquidity shock expose them to the risk of a failing counter-party. We determine the threshold probability of the idiosyncratic shock for which the absence of a precautionary liquidity buffer is no longer a Nash Equilibrium in the absence of external intervention. However, the existence of a time-inconsistent bail-out policy that leads the regulator to inject liquidity into the failed bank when contagion is at stake eliminates the incentives to this precautionary liquidity investment. Since the amount promised to the depositors is determined exogenously (e.g., by competition with non-banking financial assets or even real assets) and bail-outs generate a cost from the transfer of funds from public to private agents (e.g., inefficiencies introduced by taxes), the absence of a precautionary liquidity buffer increases the bankers' welfare (via the bail-out subsidy) but total welfare is reduced. Finally, we find that imposing targeted liquidity requirements to counter-parties is a credible mechanism to a no bail-out policy when the prime motivation is the avoidance of contagion.

1 Introduction

The US sub-prime crisis and, more recently, the European sovereign debt crisis brought financial contagion to the forefront of the public and academic debate. The seminal contribution of [2] paved the ground to many subsequent developments in economic theory that address this issue by analysing the interconnectedness between financial institutions. These authors have shown that, without aggregate uncertainty, inter-bank connections are able to reproduce the first-best allocation by providing risk-sharing. However, these connections also expose banks to counter-party risk. Financial contagion ensues when an unanticipated idiosyncratic liquidity preference shock drives a bank into bankruptcy, enabling contagion to spread to the remaining regions through inter-bank claims. In this essay, we extend this model to include aggregate uncertainty. We develop a rational expectations model where the idiosyncratic liquidity shock, that is the only source of aggregate uncertainty, is fully accounted by bankers when they decide their portfolio allocation. Although the trade-off that this situation would create has already been discussed by AG[1], the precise portfolio allocation is yet to be determined in the presence of contagion[2]. We find that when bankers fully account for this source

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[1]"The reason for this can readily be seen. The way to prevent contagion is to hold a discrete amount more of the liquid asset to meet the extra liquidity demand in states S_A,...,S_D. However, holding more of the liquid asset means that less of the illiquid asset is held and output is lower at date 2 in states S_1 and S_2. When δ is sufficiently small, this trade-off is not worthwhile. It is better to simply allow the possibility of contagion." [2, pp. 28-29].

[2]The treatment of aggregate uncertainty was treated more recently by these authors in [3], but this framework did not have a focus on financial contagion as is understood in the context of this essay.

of aggregate uncertainty, there is a threshold probability of the idiosyncratic shock for which the absence of a precautionary liquidity buffer is no longer a Nash Equilibrium.

To do so, we base our model in [8] (henceforth DD) and [2] (henceforth AG). In this three date ($t = 0, 1, 2$) setup, consumers are uncertain when they want to consume. At $t = 1$, they learn whether they are impatient, and as such only value consumption at this date, or whether they are patient, and only wish to consume at the final date. To fulfil their consumption needs, they rely on their initial endowment. Bankers emerge as financial intermediaries by providing risk-sharing to consumers. They are able to do so by pooling their own capital with the depositors endowments and investing the funds in productive assets. Unlike in DD and AG, we assume that the deposit contracts are non-contingent, i.e., the banker promises to repay c_t, $t = 1, 2$ to consumers in all states of nature. Once the funds are raised, bankers can choose among three types of assets: liquidity, an illiquid long asset and inter-bank claims. Since the fraction of impatient consumers is restricted to a single region (hence these shock are denoted as regional), inter-bank deposits allow risk-sharing among the bankers against these negatively correlated liquidity shocks.

Another novel ingredient in our setup is the existence of a deposit insurance scheme. The deposit insurance fund by ensuring that depositors are repaid eliminates bank runs. Deposit insurance has been widely introduced not only to this end, but also to protect a dispersed and uninformed depositor base. The presence of a deposit insurer (such as the FDIC) potentially has implications in the seniority of the claims. Deposit preference laws may be instituted to reduce the costs of these schemes. For example, in the United States of America, in 1993[3], "the Omnibus Budget Reconciliation Act instituted depositor preference for all insured depository institutions" ([11], p. 19). With it, domestic retail depositors, and by extension the FDIC, gained priority over inter-bank claims. When a bank fails, the deposit insurer takes over the failed bank and initiates the debt settlement process. [11] show that by giving a senior status over non-depositor claimants, the deposit insurer has an incentive to intervene in a socially optimal way. Within this line of thought we assume that inter-bank claims are junior to retail deposits.

Liquidity shocks are central to this model. In addition to regional liquidity shocks, each bank may be affected by an idiosyncratic one characterised by an excess demand of liquidity. With probability ϕ the fraction of impatient consumers for a single bank becomes somewhat higher than the average liquidity demand expected ex-ante ($\gamma + \epsilon$). Although, this shock is assumed to be a low probability high impact event, and therefore uninsurable, a banker can choose to invest in liquidity to prevent a default by contagion when the counterparty faces the idiosyncratic shock.

The existence of deposit insurance implies that bank failures are costly to the insurer. Therefore, ex-post the regulator may prefer to keep a bank running if the closure costs outweigh the bail-out costs. This provides an implicit guarantee that eliminates the incentives to a strict preference over the precautionary liquidity investment, i.e., ex-ante the regulator would like to commit not to bail-out a bank but ex-post if contagion is at stake it will prefer to avoid liquate the troubled bank. Since the amount promised to the depositors is determined exogenously (e.g., by competition with non-banking financial assets or even real assets) and bail-outs generate a cost from the transfer of funds from public to private agents (e.g., inefficiencies introduced by taxes), the absence of a precautionary liquidity buffer increases the bankers' welfare (via the bail-out 'insurance') but total welfare is reduced. Note that even if the regulator is able to expropriate completely the shareholders of the bailed out bank, a transfer would still take place via the absence of a precautionary liquidity buffer. The neighbours of the bailed out bank would benefit from the illiquidity of their portfolios in the good states of nature without the downside of a default by contagion. An alternative to liquidity requirements would be the introduction of ex-post tax on surviving banks. However, in the midst of a full blown financial crisis obtaining funds from troubled institutions seems unlikely, leaving the taxpayers to step in and pick-up the bill (at least in the short-term).

[3] For a more complete discussion on the implication of deposits preference law see [4].

Finally, we find that targeted liquidity requirements can then be used to create a 'firewall' by removing default by contagion from the bail-out equation. Consequently, liquidity requirements are an effective commitment mechanism when the bail-out decision depends strictly on the ensue of contagion.

The paper closest to ours is [1], where a time-inconsistent bail-out policy leads banks (specially small ones) to choose correlated portfolios. Ex-ante the regulator would prefer that banks selected a diversified asset structure, but ex-post it finds that a bail-out minimises the costs of intervention. Although we focus on inter-bank loans and not asset correlations as the nature of the linkages, our main difference is to show how targeted liquidity requirements can be used as a commitment mechanism when contagion is the prime motivation to a bail-out.

The rest of the paper is organised as follows. In Section 2, the basic setup is described. In Section 3, the optimal liquidity choice is determined explicitly as a function of the probability of the idiosyncratic shock in the absence of external intervention. In section 4, the case where an implicit guarantee exists and its effects on the strict preference for the precautionary liquidity buffer are studied. Finally, Section 5 concludes.

2 Basic Setup

In this section we describe a simple stochastic liquidity preference model that allows for inter-bank market connections. There are three dates, $t = 0, 1, 2$. The unique consumption good takes the form of numeraire and can be used both for consumption and investment. The economy is populated by two types of agents: depositors and bankers. Bankers are assumed to be patient and, therefore only wish to consume at the final date. Depositors are assumed to have a stochastic liquidity preference *à la* DD: with probability ω they only want to consume at $t = 1$, these are the so called impatient consumers; while with probability $1 - \omega$ they are patient and, like bankers, only wish to consume at $t = 2$. Since at $t = 0$ consumers only know these probabilities but do not know their own type, the preferences of the individual consumer are given by

$$U(c_1, c_2) = \begin{cases} u(c_1) & with \quad probability \quad \omega \\ u(c_2) & with \quad probability \quad 1 - \omega, \end{cases}$$

where c_t denotes consumption at date $t = 1, 2$. As assumed in DD and AG, the utility function $u(.)$ is twice continuously differentiable, increasing and strictly concave.

In addition to ex-ante liquidity preference, depositors and bankers also differ in their endowments and investment opportunities. Depositors are endowed with 1 unit and bankers are endowed with e (equity) units of the numeraire good at $t = 0$ and nothing in the rest of the dates. Depositors only have access to a storage technology such that each unit of the numeraire invested at t yields 1 unit at $t + 1$. Bankers have access to a richer set of investments opportunities. This broader investment set allows bankers to act as financial intermediaries providing risk sharing to depositors. They offer deposit contracts to raise the needed funds that are pooled with their own equity endowment to finance their portfolio. Unlike DD and AG, we assume that these contracts are not contingent on the states of the world, i.e., banks promise to pay c_t at $t = 1$ or 2, that we assume to be exogenous. Another addition in our setup, with regards to the traditional framework, is the introduction of deposit insurance. The government is assumed to provide a full guarantee of the promised amounts by bankers to depositors. This mandatory insurance mechanism is funded by collecting a premium m at $t = 0$.

Once the funds are raised, bankers choose among three types of assets: liquidity, a long asset and inter-bank claims. Liquidity can be thought of as the risk-free asset and for each unit invested at t yields one unit of the numeraire at $t + 1$. The long asset is illiquid: it pays the full return R at $t = 2$ and r if liquidated before maturity. We take the special case where $r = 0$, the null liquidation value, that is a particular case of the one assumed by AG, translates into the assumption of asset fire sales. In the midst of a full blown financial crisis, the price of illiquid assets may fall dramatically as a consequence of liquidity shortages and/or informational issues.

The economy is divided into two ex-ante identical regions clearly defined. Denoting by ω_i the portion of impatient consumers in region i, we can have a negative liquidity shock if $\omega_i = \omega_H$ or a positive liquidity shock if $\omega_i = \omega_L$, where $0 < \omega_L < \omega_H$. Since these regions are assumed to have negatively correlated liquidity shocks, the average amount of liquidity needs at $t = 1$ is $\gamma = \frac{\omega_H + \omega_L}{2}$. This modelling option is not without its empirical consistency. [6] find that relationships are established between banks with less correlated liquidity shocks. It is conceivable that through a matching process with substantial repeated interaction, banks learn the intrinsic characteristics of their counter-parties. They are, therefore, able to identify ex-ante those that are subject to less correlated liquidity shocks. As in AG, these liquidity shocks materialise in the fraction ω of impatient consumers. By holding deposits in a counter-party that faces negatively correlated liquidity, banks can provide risk-sharing to each other. Therefore, in addition to liquidity and on the long assets, banks can also invest in inter-bank claims.

AG assumed an equal seniority structure, i.e., depositors (or the deposit insurance institution) have the same priority as inter-bank counter-parties in the debt settlement process. Whether this assumption actually holds seems to be an open question[4]. Since we introduce a deposit insurer in the same line of thought of the deposit preference law, we assume that inter-bank claims are junior to retail deposits. This assumption maintains the positive relation between inter-bank exposure and loss given default that we find if claims have equal priority. The difference now is that creditors cannot influence the recovery value of the debt via their inter-bank exposures.

In addition to regional liquidity shocks, bank A can face idiosyncratic liquidity shocks with a positive probability[5]. This shock is characterised by a fraction of impatient consumers that is somewhat higher $(\gamma + \epsilon)$ than expected ex-ante (γ). This shock is assumed to be a high impact low probability event, such that, it is taken to be uninsurable. To say this shock is uninsurable means that the amount of liquidity required to hedge it would make the expected profit in the good states of nature non-positive. It is sufficient for this to be true that the expected profit in the the state where $\omega_i = \omega_L$ to be non-positive, i.e., $\epsilon \geq \frac{[1+e-\omega_H c_1 - (\gamma - \omega_H) c_1 (1-\phi) - m] R - (1-\gamma) c_2}{(1-\phi) R - 1}$. However, ϵ (or more precisely $\gamma + \epsilon$) has the natural upper bound of 1. Since this shock is taken to be a high impact low probability event (e.g., a unexpectedly large fraction of consumers discover at $t = 1$ that they wish to consume immediately), the sufficient condition is studied when $\phi \to 0$: $lim_{\phi \to 0} (\gamma + \epsilon) \leq 1 \Leftrightarrow \gamma (c_1 - 1) < e - m \leq \gamma (c_1 - 1) + (1 - \gamma) \frac{(c_2 - 1)}{R}$.

Table 1: States of the world and associated probabilities

Prob.	State	Banks A	Banks B
$\frac{1}{2}(1-\phi)$	S_A	ω_H	ω_L
$\frac{1}{2}(1-\phi)$	S_B	ω_L	ω_H
ϕ	$\bar{S}$	$\gamma + \epsilon$	γ

The full characterisation of the states of nature is described in table 1 (table 2 of [2] with only two banks).

The uninsured and junior status of inter-bank claims create a wedge between the amount promised to depositors and to inter-bank creditors. Let us denote by $\bar{c}_t^i$ with $t = 1, 2$ and i= A,B the return on the inter-bank deposit at time t offered by bank i. The pricing of this asset can be achieved via risk-neutral pricing based on the liquid asset, i.e., absent of counter-party risk, the return on the inter-bank deposit should be the one offered by the liquid asset since these assets have the same pay-off structure. Since shocks are asymmetric and bank B is never hit by an idiosyncratic shock, $\bar{c}_t^B = 1$. Given that the shock is uninsurable and bank B never goes bankrupt, bank A fails with probability ϕ implying $\bar{c}_t^A = \frac{1}{1-\phi}$.

[4] In the literature, we can find papers where inter-bank claims are assumed to be senior with respect to other non-bank creditors (e.g., [9]), while others assume an equal priority of all creditors (see [2]).

[5] In AG this shock is assumed to occur with 0 probability.

3 Optimal Liquidity Choice

The presence of an idiosyncratic shock with a positive probability requires the revision of the optimal liquidity choice presented in AG, albeit within a markedly different setup. In this section, we aim to determine the portfolio allocation as an explicit function of the parameters of the model.

3.1 Expected Profit Function

In this simple framework, where two banks have negatively correlated liquidity shocks, the inter-bank market structure assumed is a complete one, i.e., banks hold cross-deposits in each other. This architecture not only allows for risk-sharing, but also creates the potential for contagion. It is the dynamics of contagion as a function of the liquidity choice that shapes the form of the expected profit function.

Let us denote by y, x and z the investment in liquidity, the long asset and in inter-bank claims, respectively. Given the disposable funds and the deposit insurance premium, the banker's budget constraint is: $1+e-m = y+x+z$. Since the only purpose of the inter-bank claims is to deal with the regional liquidity shocks, y and z are intrinsically linked. When the bank faces a negative regional liquidity shock it has y units of liquidity and z units of inter-bank claims to deal with it. Since the realisation in this state of nature is a liquidity need of $\omega_H c_1$, then $y+z$ equal to $\omega_H c_1$. A higher amount of liquidity is inefficient and, since these shocks are asymmetric, a lower investment in liquidity would also be inefficient since it would be insufficient to meet the liquidity needs pushing the banker into bankruptcy. Therefore, $z = \left(\omega_H - \frac{y}{c_1}\right) c_1 (1-\phi)$. The investment in the long asset can be determined as the residual value, i.e., $x = 1+e-y\phi-\omega_H c_1 (1-\phi) - m$.

When a liquidity shock hits a bank, the banker must use the available liquidity to repay his/her creditors. If that is not sufficient, then the banker can liquidate his/her holdings in the other bank to face the additional liquidity needs. Since early liquidation does not generate liquidity, after the idiosyncratic shock, banker A may not able to meet his/her obligations leading to a fundamental default. As in AG, there are no netting agreements, i.e., inter-bank claims are not settled in advance to the bankruptcy proceedings. Therefore, the counter-party of the failed bank must meet his/her debits without a guarantee that his/her credits are also met. To avoid a default by contagion, banker B must hold not only sufficient liquidity to repay the retail but also the inter-bank depositors. The expected profit can then be described as the return realised in the survival states in addition to the excess liquidity.

Extending the baseline scenario of AG, where the authors' conjecture pointed towards optimal liquidity choice to be γc_1 for a sufficiently small probability of the idiosyncratic shock, we search the threshold for this parameter that validates AG's conjecture in our particular setting. Since only bank A faces the idiosyncratic shock and, therefore, both liquidity and inter-bank deposits held in B are assets with equal characteristics, only B can deviate. To do so, we start by characterising the expected profit function of bank B when the counter-party chooses $y_A = \gamma c_1$. When the counter-party holds a small amount of liquidity a default by contagion may ensue. Given our simplifying assumption of a null liquidation value, this type of default can only be avoided if, in addition to the average retail deposit demand, the banker holds a precautionary amount of liquidity correspondent to the wholesale deposit. Since $y_A = \gamma c_1$, it implies that $z_A \bar{c}_1^A = (\omega_H - \gamma) c_1$, therefore, a default by contagion is avoided as long as $y_B \geq \omega_H c_1$. Since $\epsilon > (\omega_H - \gamma) c_1$, the banker B has two options: i) $y_B = \gamma c_1$ and be exposed to a default by contagion; or ii) remaining solvent in all states of nature. Synthetically, these outcomes can be described by the expected profit function given by equation (1)[6]:

$$E\left[\pi_B (y_i, z_i) | y_j = \gamma c_1\right] = \begin{cases} (1-\phi)\left[(1+e-\gamma c_1 \phi - \omega_H c_1 (1-\phi) - m) R - (1-\gamma) c_2\right] & if \quad y_B = \gamma c_1 \\ \\ \left[(1+e-\omega_H c_1 - m) R - (1-\gamma) c_2\right] - \phi (\omega_H - \gamma) c_1 & if \quad y_B = \omega_H c_1 \end{cases} . \tag{1}$$

[6]Full derivation in appendix.

3.2 Equilibrium

Since the idiosyncratic shock is uninsurable and it only affects banker A, the only deviation to the $(\gamma c_1, \gamma c_1)$ strategy that is not strictly dominated is the creation of a precautionary liquidity buffer by banker B. This buffer allows B to face a contagion shock following the bankruptcy of A.

An additional investment in liquidity entails a trade-off, though. A more liquid portfolio is less profitable, but is also safer. Therefore, there is a critical probability for the idiosyncratic shock such that the marginal benefit of liquidity equals the marginal cost. Proposition 1 presents this threshold.

Proposition 1 *If the probability of the idiosyncratic shock, ϕ is lower that the threshold $\tilde{\phi}$, then $(\gamma c_1, \gamma c_1)$ is a Nash Equilibrium, where $\tilde{\phi} = \frac{(\omega_H - \gamma) c_1 (R+1) - (1+e-\omega_H c_1 - m) R + (1-\gamma) c_2}{(\omega_H - \gamma) c_1 R}$.*

Proof.

$$\begin{array}{c} (1-\phi)\left[(1+e-\gamma c_1 \phi - \omega_H c_1 (1-\phi) - m) R - (1-\gamma) c_2\right] \geq \\ \left\{[1+e-\omega_H c_1 \phi - \omega_H c_1 (1-\phi) - m] R - (1-\gamma) c_2\right\} - \phi (\omega_H - \gamma) c_1 \end{array} \Leftrightarrow$$

$\phi \leq \frac{(\omega_H - \gamma) c_1 (R+1) - (1+e-\omega_H c_1 - m) R + (1-\gamma) c_2}{(\omega_H - \gamma) c_1 R}$.□

Therefore, without external intervention, $\tilde{\phi}$ is the threshold probability that implies a strict preference of B for the precautionary liquidity investment. In the next section, the case where an implicit guarantee exists and its effects on the strict preference for the precautionary liquidity buffer are studied.

4 Optimal Bail-out Policy

When a default occurs, the deposit insurance institution takes over the failed bank and repays creditors according to the settlement priority order. However, since the failed bank holds illiquid assets that do not have value if liquidated prematurely, deposit insurance involves costs for the insurer. Therefore, if the ex-post costs of bailing out the bank are inferior to those (direct and indirect[7]) implied by a bankruptcy, the regulator may choose to keep the failed institution running. When this occurs, the policy maker injects the funds needed to repay both the insured and uninsured bank creditors.

Suppose that bank A becomes insolvent and that although the bail-out costs (ϵc_1) are larger than these direct costs (denoted by $\underline{b}\left(y_A, \bar{c}_1^B\right) = (\gamma + \epsilon) c_1 + (1 - \gamma - \epsilon) c_2 - 2m - y_A - z_A \bar{c}_1^B$ that repay the failed institution's insured deposits), the sum of the direct with the indirect costs (denoted by $\bar{b}(y_A, y_B) = 2\gamma c_1 + \epsilon c_1 + 2(1-\gamma) c_2 - \epsilon c_2 - 2m - y_A - y_B$ that additionally repay B's insured deposits as a consequence of the default by contagion)[8] outweighs the bail-out costs. Since we are focusing on the $(\gamma c_1, \gamma c_1)$ strategy, when $\epsilon c_1 \in \left]\underline{b}(\gamma c_1, 1), \bar{b}(\gamma c_1, \gamma c_1)\right[$, the best response of the insurer is to bail-out the failed institution. In its turn, the counter-party may anticipate the regulator's optimal policy and may choose not to create a precautionary liquidity reserve to face the shock propagated by the inter-bank linkages. This result is summarised in Proposition 2.

Proposition 2 *A bail-out policy that provides A with an implicit guarantee never induces B to strictly prefer the precautionary liquidity reserve.*

[7] While deposit insurance costs (i.e., direct costs) may be substantial, indirect costs such as disruptions in the payment system or contagion effects to the real/ remaining financial sector may overcome the direct ones.

[8] Note that since inter-bank claims are not real assets but just uninsured cross deposits, the deposit insurer can not use them to face the insurance costs.

Proof.

With the implicit guarantee of a bail-out, from B's point of view, A's debts will always be repayed. Therefore, the payoff structure of the inter-bank claim matches the one of liquidity. As such, liquidity and inter-bank deposits become indifferent assets in all states of the world. □

Since without counter-party risk inter-bank claims and liquidity become indifferent assets, a counter-party that anticipates a bail-out does not strictly prefers to create a precautionary investment in liquidity regardless of probability of the idiosyncratic shock. Unlike in the case, studied in the previous section, where a bail-out was ruled out, there is not a threshold value for the probability of the idiosyncratic shock such that $(\gamma c_1, \gamma c_1)$ is no longer a Nash Equilibrium.

Therefore, ex-ante the regulator would like to motivate the counter-party to invest in liquidity to prevent a bail-out[9]. However, a non-commitment strategy is not credible since ex-post the costs of a failure outweigh the bail-out costs. This creates a time-inconsistency in the bail-out policy (as has already been shown by [1] and [10])[10]. Imposing targeted liquidity requirements to counter-parties resolves this time-inconsistency in those cases where the indirect effects are the ones that are relevant for the optimal bail-out policy. Consequently, the existence of a liquidity 'firewall' can be a credible commitment mechanism to a no bail-out policy, i.e., targeted liquidity requirements can be used to remove default by contagion from the bail-out equation.

Since the amount promised to the depositors is determined exogenously (e.g., by competition with non-banking financial assets or even real assets) and bail-outs generate a cost from the transfer of funds from public to private agents (e.g., inefficiencies introduced by taxes), the absence of a precautionary liquidity buffer increases the bankers' welfare (via the bail-out subsidy) but total welfare is reduced. Note that even if the regulator is able to expropriate completely the shareholders of the bailed out bank[11], a transfer would still take place via the absence of a precautionary liquidity buffer. The neighbours of the bailed out bank would benefit from the illiquidity of their portfolios in the good states of nature without the downside of a default by contagion. An alternative to liquidity requirements would be the introduction of ex-post tax on surviving banks. However, in the midst of a full blown financial crisis obtaining funds from troubled institutions seems unlikely, leaving the taxpayers to step in and pick-up the bill (at least in the short-term)[12].

5 Conclusion

In a rational expectations model, with aggregate uncertainty, the optimal liquidity allocation is determined. Bankers are exposed to regional liquidity shocks that can be insured against via inter-bank claims held in the counter-party with a negatively correlated liquidity shock. However, these connections together with the existence of an idiosyncratic liquidity shock expose them to the risk of a failing counter-party. We find that when bankers fully account for this source of aggregate uncertainty and there is not a source of external intervention, there is a threshold probability of the idiosyncratic shock for which the absence of a precautionary liquidity buffer is no longer a Nash Equilibrium. However, when bankruptcy costs outweigh bail-out costs, the regulator may find ex-post optimal to keep a failed institution running. This provides the system with an implicit government guarantee that eliminates the incentives for a strict preference over the precautionary liquidity buffer. Since the amount promised to the depositors is determined exogenously (e.g., by competition with non-banking financial assets or even real assets) and bail-outs generate a cost from the transfer of funds from public to private agents (e.g., inefficiencies introduced by taxes), the absence of a precautionary liquidity buffer increases the bankers' welfare (via the bail-out subsidy) but total welfare is reduced. Even if the regulator is able to expropriate completely the shareholders of the bailed out bank,

[9] [5] provide empirical evidence that the regulator is more prone to show forbearance when the financial system is more fragile.

[10] As argued by these authors the immediacy of raising funds creates an added cost, here we abstract from this cost since both bail-out and deposit insurance activities generate it.

[11] [1] provides a justification based on risk-shifting of why the regulator may need to guarantee a minimum return on the period after the bail-out.

[12] This argument is also defended by [7] and [12] with respect to the Dodd-Frank Act.

a transfer would still take place via the absence of a precautionary liquidity buffer. The neighbours of the bailed out bank would benefit from the illiquidity of their portfolios in the good states of nature without the downside of a default by contagion. An alternative to liquidity requirements would be the introduction of ex-post tax on surviving banks. However, in the midst of a full blown financial crisis obtaining funds from troubled institutions seems unlikely, leaving the taxpayers to step in and pick-up the bill (at least in the short-term). To conclude, we find that targeted liquidity requirements can be used to create a 'firewall' by removing default by contagion from the bail-out equation.

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Appendix

When $y_j = \gamma c_1$ and:

- $y_i = \gamma c_1$ there are both types of default, no excess of liquidity occurs and since the choice is symmetric inter-bank claims cancel out in the regional shock states. Therefore, the expected profit corresponds to the difference between the return on the long asset and the amount owed to late retail depositors in the regional shock states, i.e.,
  $(1-2\phi)\left[\left(1+e-\gamma c_1\frac{\bar{c}_1-1}{\bar{c}_1}-\omega_H\frac{c_1}{\bar{c}_1}-m\right)R-(1-\gamma)\,c_2\right].$

- $y_i = \omega_H c_1$ and $z_i = 0$ the default by contagion is avoided but the fundamental default still occurs. There is an excess of liquidity in the regional shocks states and there is a deficit with regards to inter-bank claims in these states since the higher is the choice of liquidity the lower is the investment in inter-bank deposits. Consequently, the expected profit function is given by the return on the long asset in every state with the exception of the one characterised by the idiosyncratic shock $\{(1-\phi)[(1+e-\omega_H c_1 - m)R - (1-\gamma)c_2]\}$ plus the excess liquidity in the regional shock states $\{(1-2\phi)(\omega_H - \gamma)c_1\}$ plus the net inter-bank balance $\{-(\omega_H - \gamma)c_1\}$.