Implications of Bank Regulation for Credit Intermediation and Bank Stability: A Dynamic Perspective

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Abstract

Business cycles imply liquidity risks for banks. Within a unified framework with forward-looking banks, this paper explores how these risks influence bank lending over the cycle. The model shows that lending cycles, credit booms and busts, or suppressed and highly fragile bank systems can emerge, depending on the magnitude of liquidity risks. Regulatory stability-enhancing measures have some unpleasant effects on bank lending. When liquidity risks are only moderate and financial stability is barely a threat, imposing countercyclical capital adequacy ratio may amplify pro-cyclicality or result in disintermediation. Adopting a regulatory margin call eliminates failures but stops lending for larger liquidity risks whereas a liquidity ratio might be a way to reduce risk-taking without fully hampering credit intermediation.

Keywords bank lending, banking crisis, credit crunch, pro-cyclicality, bank capital regulation

JEL Classification G01, G21, G28, E32

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1 Introduction

There is a close link between credit cycles and business cycles.[1] This link has become a topical issue in the course of the recent financial crisis.[2] Yet, it is not unique to these most recent experiences. From an economic history perspective, an analysis of nearly 200 recessions in the past 140 years by Jordà *et al.* (2011) identifies a close relationship between the severity of a recession and the extent of a credit boom in the run up to the recession. Furthermore, a larger leverage ratio in the credit boom tends to amplify the extent of the following recession.

Recent research has highlighted the role of bank capital regulation in generating pro-cyclicality of bank lending and thus amplifying real economic volatility.[3] According to this view, a risk-based capital requirement eases constraints for banks in an upswing when risks are supposed to be low, whereas it tightens constraints for banks in a downturn when risks are expected to be larger (see e.g. Kashyap *et al.*, 2008; Goodhart, 2008; Repullo and Suarez, 2008). In response to the recent financial crisis, several proposals thus veer towards a countercyclical capital requirement. In an economic upturn larger capital requirements should dampen excessive lending and provide sufficient capital buffers for potential downturns. Conversely, lower capital requirements in a downturn shall facilitate lending.[4]

The direction of causality between real economic volatility and bank lending is still largely undiscussed in the literature. The aim of this paper is to add to this discussion by exploring how liquidity risks influence bank lending and risk-taking over time. Within a unified dynamic framework with forward-looking banks, we show that depending on the magnitude of liquidity risks in the economy, lending cycles, credit booms that may later bust, or suppressed and highly fragile banking systems may emerge. For moderate liquidity risks bank lending is pro-cyclical. Compared to the efficient loan volume, it is too large in times without liquidity constraints but too small in times of liquidity shortages. For larger liquidity risks, bank lending will increase over time indicating a lending boom that may eventually bust. However, this strong increase

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[1]The link known as the credit channel builds on Bernanke (1983), Bernanke and Gertler (1995), Kiyotaki and Moore (1997) and Bernanke *et al.* (1999). Romer and Romer (1990) and Ramey (1993) analyze the linkage via the bank lending channel.

[2]See for example Iacoviello (2005), Cúrdia and Woodford (2008), Christiano *et al.* (2010) or Meh and Moran (2010) for recent work focusing on the effects of financial frictions on the transmission mechanism of shocks.

[3]One exception is Gersbach and Rochet (2012) who specify moral hazard, banks' high exposure to aggregate shocks or their ease to reallocate capital between different business sectors as factors for pro-cyclical bank lending.

[4]Brunnermeier *et al.* (2009) recommend a countercyclical capital ratio which considers leverage, maturity mismatches, credit and asset prices. Repullo and Suarez (2010) suggest to expand the underlying confidence level in a boom and to reduce it during a bust while the value at risk remains unchanged. Acharya *et al.* (2012) propose a two tier capital requirement with a core capital requirement like Basel II and a special capital account requirement to be invested in treasuries or similar assets. Gersbach and Rochet (2012) suggest a regulatory upper bound on short term debt.

in bank lending is neither excessive nor is it the cause for a potential recession. Rather, it is a result of anticipated liquidity risks. For very high liquidity risks, bank lending remains heavily suppressed and breaks down immediately once a liquidity shortage materializes.

We derive these results from the optimization problem of a bank which takes expected variations in future liquidity conditions into account. We consider a bank that lives for two periods. At the beginning of each period, the banker can raise funds from investors in order to invest in a short-term liquid asset and in loans. Loan earnings depend crucially on the economic conditions at the end of the first period. The economy either is in benign conditions or experiences a downturn. If conditions are benign, loans held on the book are fully repaid immediately so that the banker does not face any financial constraint for granting new profitable loans. If, however, the economy experiences a downturn in the first period, some existing loans will default while others will delay, and new loans will earn only small and risky returns. If the economy recovers in the second period, delayed and new loans will be relatively successful. If the economy fails to recover soon, however, loans will have only small returns or yield even nothing.

In this setting, liquidity risks refer to expected volatility of the funding liquidity available to the bank. This volatility results from a combination of the risks associated with loan earnings and the limited ability of the banker to fully pledge them to bank shareholders. As regards the former, loans granted in the first period can be collected either early or late, and if they are late, their returns are still risky. To concentrate on the effects of risk we take the expected value of loans at the time when they are originated as constant and compare situations that differ only according to a mean preserving spread. A higher mean preserving spread than implies larger liquidity risks when the banker cannot always fully pledge loan earnings to investors. This limitation stems from a friction in financial contracting borrowed from Diamond and Rajan (2000, 2001). While the banker's skills are needed to collect the full value of the loan, he can commit himself to use these skills on behalf of investors only if he refinances the bank with demandable deposits. The downside of deposits is that a bank run occurs in bad times when the banker collects less than what he owes to depositors. Having issued bank equity capital allows the banker to share his loan losses with shareholders without facing a run in bad times. The downside of equity is that the banker can divert some of his loan earnings as personal rents in good times. The higher the rents the banker can extract, the less he can pledge to investors and the the tighter is thus the financial constraint that he faces.

In this setting, the banker originates the efficient loan volume in all states only if he expects negligible liquidity risks. If the economy is in a downturn, there will be a debt overhang which, however, does not

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pose a problem for the bank. New loans can hardly be refinanced by borrowing against their own future earnings when the banker issues sufficient new equity to keep the bank stable throughout the cycle. In principle, he therefore either relies on additional sources of liquidity or has to refinance loans by issuing mainly deposits and putting the future stability of the bank at risk. However, with negligible liquidity risks, legacy loans are still rather valuable in a downturn. Their own funding liquidity is thus high enough not only to roll over their own refinancing but also to co-finance new risky loans. This co-financing eventually allows the banker to grant new loans in an unconstrained manner without threatening the future stability of the bank.

For modest liquidity risks, the value of first-period loans in the bad state differs significantly from the good state. As the banker cannot write state-contingent contracts, he will face a liquidity problem in the bad state. The debt overhang will be strong compared to the funding liquidity of legacy loans so that only little will remain to co-finance new loans. The banker then expects to face a financial constraint on new loans. A forward looking banker wishes to make provisions in good times for the case the economy will experience a liquidity shortage later on. In order to mitigate the expected losses associated with a constraint on new loans, he will grant loans in the first period that cannot be justified by their NPV only to increase the available funding liquidity in future bad times. Hence, lending will be procyclical.

For larger liquidity risks, the banker will expect rather strong liquidity problems for the economy running in a downturn. He is not only heavily restricted or even unable to co-finance new loans by borrowing against legacy loans. The banker is even unable to roll over already existing deposits without weakening the resilience of the capital structure in the downturn. By issuing mostly new deposits in a downturn, the banker is more credible not to extract rents but also adopts a more fragile capital structure. Doing so mitigates the associated liquidity problems at the expense of financial fragility as the bank will fail if the economy does not recover soon. In that case, loans granted at the beginning cannot always be collected and their expected value is thus lower. In anticipation thereof, the banker will underinvest in loans. Later on, bank lending will recover irrespective of the state, although the bank will become fragile should the bad state materialize. Accordingly, there is a strong secular trend in credit growth with the banking sector collapsing should the recovery be too slow or too weak. Hence, anticipating a potential future failure makes banks initially rather cautious in terms of both capital structure and lending and later on more aggressive once the economic conditions worsen. Anticipating deep recessions is thus causal for credit booms that later bust.

Finally, for very high liquidity risks, the bank will be unable to survive a downturn at all. From an ex ante point of view, the expected loan earnings will be rather small already in the first period. Hence, bank lending in the first period is very low.

Against this background we explore the impact of different new proposals to regulate banks with respect to their implications for financial stability and bank lending. We analyze the effects of counter-cyclical capital adequacy regulation and of the margin call proposed by Hart and Zingales (2011). We find that they differ mainly with respect to their impact on credit allocation. Hart and Zingales (2011) propose that a bank is forced to issue additional equity when the market's assessment of the institution's probability of default is too high. They consider the price for credit default swaps (CDS) as an appropriate indicator, which must not exceed a predefined threshold. If the bank cannot hold the CDS price below this threshold, the regulator will take over the bank. In our context, the banker would loose control over his assets when he opted for a fragile capital structure. Hence, whenever possible, the banker will rather underinvest in new loans but to put the existence of the bank at risk. This has mainly three effects. First, a banker who cannot survive an economic downturn without weakening the resilience of the bank has to close the bank in the downturn. Second, a banker who would run the bank in a safe manner even without the regulation does not change his behavior at all. Finally, in all other cases the margin call will increase financial stability but promotes a pro-cyclical lending pattern.

As regards strongly counter-cyclical capital adequacy ratios, their effects mainly arise due to implied deviations from the capital structure which the banker would have chosen voluntarily. Without regulation, the capital-to-asset ratio would be higher in the first period the greater is the liquidity risk. Shareholders will provide more capital to bank because higher risk implies a higher dividend payment if the economy is in benign conditions whereas shareholders will loose their investment anyway in a downturn. When the economy is in a downturn in the second period, the capital-to-asset ratio would be lower the greater is the liquidity risk because the expected value of delayed loans will be small. With a strongly counter-cyclical capital requirement, the regulator does not impose an additional constraint in the downturn but, if at all, in the first period. However, the regulator may force the bank to issue more equity in the first period. This will be the more likely the lower are liquidity risks. However, imposing higher capital-to-asset ratios the banker would be able to extract more rents when the economy is in benign conditions without being able to sufficiently compensate shareholders for this in the downturn. Accordingly, the banker will be unable to comply with the regulation and disintermediation takes place.

The papers closest to ours are Dietrich and Hauck (2010), Hart and Zingales (2011) and Yilmaz (2009). Dietrich and Hauck (2010) analyze the impact of different regulation mechanism on bank lending and risk-taking in a one-period framework, in which banks face an exogenous debt overhang resulting from decisions in the past. We extend this framework by endogenizing a bank's decision to take on the risk of a debt overhang. In a model similar to ours, Hart and Zingales (2011) analyze the impact of their counterproposal to Basel III. They conclude that a margin call based on the market's evaluation of banks' probability of default achieves financial stability without affecting banks' lending decisions. In contrast to our model, banks' capital endowment is given and granting loans only incurs the cost of funding. In a discrete-time infinite horizon environment Yilmaz (2009) analyzes the impact of capital requirements on the trade off between financial stability and bank lending. In line with our results, he finds that a binding capital requirement reduces banks' risk taking but only at the cost of curtailing bank lending. Our paper takes a step further by evaluating different types of countercyclical capital ratios and by comparing these results with other regulatory proposals.

Another related study is Lorenzoni (2008). There, excessive lending may also occur in equilibrium which might cause excessive economic volatility. The reason is that agents do not take into account the effect of their lending decisions on asset prices on future spot markets. Our paper differs therefrom in two respects. First, Lorenzoni (2008) does not consider the credit intermediation process by banks. Second, economic volatility may cause lending booms but not vice versa.

The remainder of the paper is organized as follows. Section 2 presents the set up of the model. The benchmark model is solved in Section 3 assuming no regulation to be in place. Section 4 compares the benchmark model with the margin call of Hart and Zingales (2011), countercyclical capital ratios in a weak and strong form and with the liquidity ratio of Basel III. Section 5 concludes.

2 Set up

2.1 Agents and technologies

A banker manages a bank that lives for two periods and three dates, $t = 0, 1, 2$. At the beginning of each period, at date $t = 0$ and $t = 1$, the banker raises funds from investors, invests the amount a_t in a short-term asset, and grants l_t as loans. While the short-term asset is always risk-free and generates a zero net return in each period, loan earnings can be risky. In particular, they depend crucially on the economic
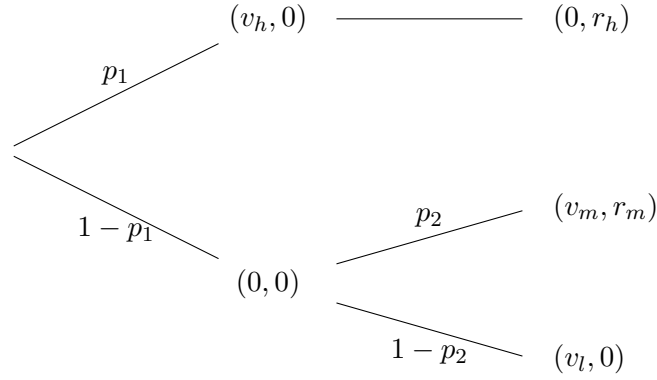
Figure 1: Loan earnings (per unit).
Note: At each node, the first entry refers to loans granted at $t = 0$ and the second entry to loans granted at $t = 1$.

conditions at the end of the first period. At this date $t = 1$, the economy either is in benign conditions or experiences a downturn. If the conditions are benign, loans granted at the beginning will be repaid already after the first period. In this "good" situation, the banker faces profitable opportunities for granting new loans, which mature at the end of the second period. If, however, the economy experiences a downturn in the first period, the bank is in a "bad" situation at $t = 1$. Some loans granted at the beginning will default while others will delay, and new loans will earn small and risky returns. If the economy recovers in the second period, both types of loans will be relatively successful. If the economy fails to recover, however, the delayed and the new loans will have only small returns or yield even nothing.

We translate this scenario into our model in the following way. Since loan earnings depend on the conditions of the economy, we have to distinguish between a "good" (g) and a "bad" (b) state of the economy at $t = 1$ (figure 1). Let $p_1 \in [0.6, 1)$ be the probability of the good state. The probability of the bad state is $1 - p_1$. When the bad state has occured at $t = 1$, the economy will recover at $t = 2$ with probability $p_2 \in [0.6, 1)$ while the recovery will hold off with probability $1 - p_2$.[5]

Loans granted at $t = 0$ earn a high rate of return $v_h > 1$ at $t = 1$ in the good state.[6] In the bad state, the returns are smaller and accrue not until $t = 2$. The rate of return will be intermediate v_m if the economy recovers and only v_l otherwise, with $0 \leq v_l < v_m < v_h$. The expected return μ of loans granted at $t = 0$ satisfies $\mu := p_1 v_h + (1 - p_1)[p_2 v_m + (1 - p_2)v_l] > 1$.

There are thus two types of risk. First, loans granted at $t = 0$ can be collected either early or late.

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[5]Restricting attention to $p_1, p_2 \geq 0.6$ reduces complexity without changing results qualitatively.
[6]Unless otherwise indicated all returns are per unit.

Second, if they are late, their return can be either intermediate or low. We conceptualize these types of risk in the following way. Starting with the second risk type, let δ be the difference between the return v_m in the recovery state and the return v_l in the non-recovery state. Then, for a given conditional mean $p_2 v_m + (1 - p_2)v_l$, increases in δ reflect higher risk. As for the first type of risk, let Δ be the difference between the high early return v_h and the (conditional) mean of the smaller late return $p_2 v_m + (1 - p_2)v_l$. Given a constant unconditional mean μ, a larger Δ or δ reflects a higher mean preserving spread and thus more risk.[7] State-dependent returns can thus be rewritten as

$$v_h = \mu + (1 - p_1)\,\Delta, \tag{1}$$

$$v_m = \mu - p_1\Delta + (1 - p_2)\,\delta, \tag{2}$$

$$v_l = \mu - p_1\Delta - p_2\delta. \tag{3}$$

Loans granted at $t = 1$ will generate their returns always at $t = 2$. If these "new" loans are granted in the good situation at t $= 1$, their returns $r_h > 1$ are high and certain. If granted in the bad situation, their earnings are lower and risky. They will be $r_m \in (1, r_h)$ if the economy recovers. Otherwise, new loans will generate nothing. Assuming $p_2 r_m > 1$, granting new loans yields a positive net return even in the bad situation.

Bank assets will generate their returns only if the banker employs his specific skills. Acquiring and maintaining these skills is associated with private and non-verifiable costs for the banker, who incurs them at the date when the assets are originated. The risk-free asset is rather easy to manage so that we normalize the associated costs to zero. The costs associated with loans, however, are an increasing and convex function c of the loan volume l_t with $c(0) = c'(0) = 0$. This assumption is based on the notion that loans, although yielding identical rates of returns, differ in the complexity of their respective underlying projects. Hence, the banker starts to grant loans to those projects which are the easiest to manage and adds the least complex among the remaining projects first to his portfolio.

The banker possesses no funds on his own. Investors, among whom there is perfect competition, are endowed with plenty funds and have access to a risk-free storage technology. All agents are risk neutral and patient so that they are, in principle, willing to wait for any payoff until the final date. As for investors,

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[7]For given probabilities p_1 and p_2, there are linear relationships between our risk measures Δ and δ and the respective standard deviations Σ and σ according to $\Sigma = \Delta\sqrt{p_1(1 - p_1)}$ and $\sigma = \delta\sqrt{p_2(1 - p_2)}$. Note, combinations of Δ and δ are restricted by $\Delta \in ((1 - p_2)\delta, (\mu - p_2\delta)/p_1)$ and by $\delta \in (0, \mu/(p_1 + p_2 - p_1 p_2))$.

having access to a risk-free storage technology implies that they will provide funds to the banker amounting to what they expect will be repaid by the banker. The objective of the banker is to maximize his expected payoff net of his lending costs.

The efficient, first-best loan volume for the first period l_0^{fb} is thus given by $\mu - 1 = c'(l_0^{fb})$. For loans granted at the beginning of the second period, the first-best loan volume depends on the state of the economy at $t = 1$. If the good state occurs at this date, the first-best loan volume $l_{1,g}^{fb}$ satisfies $r_h - 1 = c'(l_{1,g}^{fb})$. In the bad state, the first-best loan volume $l_{1,b}^{fb}$ is given by $p_2 r_m - 1 = c'(l_{1,b}^{fb})$. Note that since the costs to the banker are non-verifiable, a third party cannot tell whether the lending volume is actually efficient.

2.2 Contracting friction and capital structure

At the beginning of each period, the banker can raise fresh funds from investors by issuing new deposits d_t and equity e_t. However, the relationship between the banker and investors suffers from an agency problem. This problem exists because the bank's assets will generate their returns only if the specific skills of the banker are employed. Thus, the banker has an informational advantage vis-à-vis investors. As a consequence, the banker might have an incentive to renegotiate or even refuse repayments to investors once he has invested their funds (Hart and Moore, 1994).

Demandable deposits mitigate this incentive. This is because any attempt to renegotiate repayments to depositors would result in an immediate run of depositors on the bank. Such a run destroys the value of the bank completely. However, depositors will immediately run on the bank not only if the banker attempts to hold them up but also if the bank's prospective earnings fall short of the depositors' claims. Hence, the downside of deposits is that when asset values are risky, deposits imply a risk of bankruptcy even if the banker does not misbehave.[8]

If the banker wishes to protect the bank against fluctuations in loan earnings, he shall also issue equity shares. The benefit of equity shares is that their value correlates with the value of the bank. Equity shares thus serve as a buffer. The downside is that the value of equity shares to shareholders is smaller than the value of the bank, which may cause a financial constraint for the banker. This is due to the banker's informational advantage and the insufficient disciplining effect of equity capital, which allows him

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[8]A full-fledged analysis of the underlying agency conflict based on first-principles is provided by Diamond and Rajan (2000, 2001), who show that deposits mitigate the agency conflict but come at the cost of financial fragility.

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to retain some share of the bank's profits (after satisfying depositors' claims). We assume that at each point in time, shareholders can force the banker to pay them only a share $1 - \lambda \leq 0.5$ of the bank's current profits, net of its liabilities vis-à-vis depositors. In order to focus on the interesting cases in which the resulting conflict of interest between investors and the banker at least potentially imposes a restriction on the banker's behavior, we restrict attention to cases in which $(1 - \lambda)p_2 r_m < 1$ and $(1 - \lambda)p_1 v_h < 1$ will hold. Hence, for each loan granted either at $t = 0$ or in the bad situation at $t = 1$, the banker can pledge less to shareholders than what he needs to refinance the loan. Accordingly, in these instances the banker relies on refinancing through deposits at least to some extent.

Since investors are competitively organized and have the same outside option, they will be made indifferent between becoming a depositor or a shareholder by committing to repay them the same expected amount. Doing so, the banker is free to choose between two modes of operation. In the "safe" mode, he makes sure that deposits can be repaid already at the next date irrespective of the state so that there is no risk of a bank run. In the "risky" mode, however, the banker can repay deposits only if his returns turn out to be sufficiently large.

3   Bank behavior without regulation

At the end of each period, the banker's profits are the loan earnings and asset returns net of the payments to investors and the costs of managing the loan portfolio. The banker's aim at $t = 0$ and $t = 1$ then is to maximize his expected profits subject to his respective budget constraint. At these dates, the banker has to decide on how much funds to raise, which capital structure to implement, and how to invest the available funds. In this section, we disentangle these decisions. To this end, we specify the respective budget constraints and objective function of the banker for each period and each possible state and explore the behavior of the banker. By backward induction, we first investigate the behavior of the banker in the second period. Then, we turn to the first period.

3.1   The banker's optimum strategy at $t = 1$

At the beginning of the second period, the economy is either in the good or in the bad state. Let us begin with the banker's behavior at $t = 1$ in the good state. In this state, loans granted at $t = 0$ yield a return $v_h l_0$ at $t = 1$, the banker must repay d_0 to existing depositors and the risk-free assets yield a return a_0.

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Consequently, the bank's profits at $t = 1$ in the good state are given by $(v_h - \Omega_0) l_0$, where $\Omega_0 := \frac{d_0 - a_0}{l_0}$ is the net outflow of liquidity at $t = 1$ per unit of loans granted at $t = 0$. It measures how strongly the bank refinances loans by unstable funding sources. We will see below that this ratio satisfies $\Omega_0 \in (0, 1)$. Therefore, the bank's profits at $t = 1$ are positive in the good state, $(v_h - \Omega_0) l_0 > 0$, and the banker's optimization problem in this state is

$$\max_{l_{1,g}, a_{1,g}, d_{1,g}} \pi_{1,g} = \lambda \left[r_h l_{1,g} + a_{1,g} - d_{1,g} \right] - c \left(l_{1,g} \right) \tag{4}$$

$$\text{s.t.} \quad l_{1,g} + a_{1,g} = \left[v_h - \Omega_0 \right] l_0 + d_{1,g} + e_{1,g}, \tag{5}$$

$$l_{1,g}, a_{1,g} \geq 0, \tag{6}$$

$$d_{1,g} \in \left[0, r_h l_{1,g} + a_{1,g} \right], \tag{7}$$

$$e_{1,g} = (1 - \lambda) \left[r_h l_{1,g} + a_{1,g} - d_{1,g} \right] - (1 - \lambda) \left[v_h - \Omega_0 \right] l_0. \tag{8}$$

Equation (5) reflects the budget constraint of the banker at $t = 1$ in the good state. At this date, the banker can extend new loans $l_{1,g}$ and invest $a_{1,g}$ in new risk-free assets. For these purposes, he can use the current profits $(v_h - \Omega_0) l_0$ of the bank, issue new deposits $d_{1,g}$ and raise the amount $e_{1,g}$ from shareholders. According to (7), the volume of new deposits must not exceed the bank's total profits $r_h l_{1,g} + a_{1,g}$ at $t = 2$. According to (8), the shareholders will provide an amount equal to what they will receive in $t = 2$ less the amount they could extract at $t = 1$. At $t = 2$, they will receive a share $1 - \lambda$ of the bank's final profits $r_h l_{1,g} + a_{1,g} - d_{1,g}$. At $t = 1$, they could force the banker to pay them a share $1 - \lambda$ of the bank's current profits. In principle, $e_{1,g}$ can also be negative. In this case, shareholders will extract the amount $|e_{1,g}|$ from the bank at $t = 1$. Finally, $\pi_{1,g}$ as specified in (4) reflects the banker's payoff at the end of the second period. He will obtain a share λ of the bank's profits at this date and he incurs the costs of managing the second period's loan portfolio.

In conjunction with (7) and (8), the budget constraint (5) implies that the banker does not face an upper limit on new loans in the good state at $t = 1$. This is for two reasons. First, pre-existing deposits do not pose a restriction on new loans because the banker can repay them easily in the good state, in which the bank's profits are positive. Second, the new loans' own funding liquidity, which is the maximum net value of new loans to investors $(r_h - 1)$, is strictly positive. Therefore, the banker can raise enough funds to completely refinance new loans by borrowing against their prospective earnings. We can conclude

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Lemma 1. *If the economy is in the good state at date $t = 1$, the banker's decision on investment and capital structure and his payoff have the following properties:*

$$l_{1,g}^* = l_{1,g}^{fb}, \tag{9}$$

$$a_{1,g}^*, d_{1,g}^* \geq 0, \tag{10}$$

$$\Omega_{1,g}^* = 1 - \frac{1-\lambda}{\lambda}(r_h - 1) - [\mu + (1 - p_1)\Delta - \Omega_0]\frac{l_0}{l_{1,g}^{fb}}, \tag{11}$$

$$\pi_{1,g}^* = (r_h - 1)l_{1,g}^{fb} + \lambda[\mu + (1 - p_1)\Delta - \Omega_0]l_0 - c\left(l_{1,g}^{fb}\right). \tag{12}$$

In the good state, the banker effectively aims at maximizing the later returns $r_h l_{1,g}$ of the new loans net of their funding costs $l_{1,g}$ and his private costs $c(l_{1,g})$ of managing these loans. Moreover, the banker is indifferent between any possible amount $a_{1,g}$ he can invest in the safe assets as these assets have a zero net return. The banker faces no financial constraint in the good state. Consequently, he will grant loans according to the first best. The risk-free new loans are refinanced in part by the bank's profits at $t = 1$ and by issuing new equity shares ($\Omega_{1,g}^* < 1$). The purpose of these new shares is not to buffer against losses. Instead, the profit maximizing banker wishes to dilute the already existing shareholders' interest, who would profit from future loan earnings even without injecting fresh funds into the bank. If the funds that he can raise against prospective loan earnings from shareholders exceed the banker's liquidity needs, he will not only grant loans but also invest in the safe asset ($\Omega_{1,g}^* < 0$). If, however, the amount raised from shareholders is too small to refinance new loans, he will issue deposits in addition ($\Omega_{1,g}^* > 0$).

The bad state differs from the good state in two respects. First, the banker commands liquidity on his asset side only because of the risk-free asset a_0. As a consequence, the bank faces negative profits at $t = 1$, $a_0 - d_0 = -\Omega_0 l_0 < 0$. Second, the future value of the bank is risky, so that the banker has to decide on the mode of operation.

Given that he opts for the safe mode, his optimization problem is

$$\max_{l_{1,b}, a_{1,b}, d_{1,b}} \pi_{1,b} = \lambda \left[p_2 \left(r_m l_{1,b} + a_{1,b} + v_m l_0 \right) + (1 - p_2) \left(a_{1,b} + v_l l_0 \right) - d_{1,b} \right] - c \left(l_{1,b} \right) \tag{13}$$

$$\text{s.t.} \quad l_{1,b} + a_{1,b} = -\Omega_0 l_0 + d_{1,b} + e_{1,b}, \tag{14}$$

$$l_{1,b}, a_{1,b} \geq 0, \tag{15}$$

$$d_{1,b} \in [0, a_{1,b} + v_l l_0], \tag{16}$$

$$e_{1,b} = (1 - \lambda) \left[p_2 \left(r_m l_{1,b} + a_{1,b} + v_m l_0 \right) + (1 - p_2) \left(a_{1,b} + v_l l_0 \right) - d_{1,b} \right]. \tag{17}$$

This problem is quite similar to the banker's optimization problem in the good state. Again, the objective function (13) reflects that the banker receives a share λ of the bank's final profits while he must bear his private costs of managing the new loans granted at $t = 1$. The budget constraint (14) states that total investments in new loans and the risk-free asset must coincide with the sum of the bank's current profits, the volume of newly issued deposits and the amount that shareholders provide at $t = 1$. The volume of deposits is restricted, see (16). To prevent a run of depositors even if the economy fails to recover at $t = 2$, $d_{1,b}$ may not exceed the bank's profits $a_{1,b} + v_l l_0$ in this situation. The amount $e_{1,b}$ provided by shareholders is equal to the expected payment they receive at $t = 2$, see (17). This is a direct consequence of the negative profits of the bank at $t = 1$, which imply that shareholders are unable to extract anything at this date.

Inserting (14) and (17) in (16) and rearranging terms gives

$$l_{1,b} \in [0, l_1^{\max}] \quad \text{with} \quad l_1^{\max} := \frac{\mu - p_1 \Delta - \lambda p_2 \delta - \Omega_0}{1 - (1 - \lambda) p_2 r_m} l_0. \tag{18}$$

Thus, the banker will face an upper bound for new loans in the bad state if he wishes to operate in the safe mode. This constraint depends on the funding liquidity of new loans and on the strength of the bank's financial position. To understand the funding liquidity of the new loans, recall that these loans will yield no return if the economy fails to recover at $t = 2$, so that the banker cannot refinance them by deposits if he wishes to operate safely. Consequently, the funding liquidity of the new loans is given by their expected net value $(1 - \lambda) p_2 r_m - 1$ from the shareholders' perspective. Since the banker can extract a relatively large personal rent from new loans when the economy recovers at $t = 2$, this funding liquidity of new loans is negative. Hence, as opposed to the good state, the banker cannot raise enough funds to completely

refinance new loans by borrowing against their prospective earnings only. Instead, each loan granted at $t = 1$ is associated with a funding gap $1 - (1 - \lambda)p_2 r_m$, see the denominator in (18). The other determinant of the financial constraint, the bank's financial position, is represented by the numerator in (18) which depends on the characteristics of first-period loans. Each loan granted at $t = 0$ will possibly contribute to close the funding gap for new loans. On the one hand, first-period loans allow the banker to raise fresh funds according to their own funding liquidity $\mu - p_1\Delta - \lambda p_2\delta$. This funding liquidity will be the lower the greater their risks are. A large Δ implies that, from a date $t = 1$ perspective, the value of loans granted at $t = 0$ is low once they delay. With a large δ, the banker has to refinance first-period loans to a large extent by equity capital when he keeps operating in the safe mode. Hence, he can extract more rents for a given value of these loans, which reduces what he can borrow against prospective loan earnings. On the other hand, each unit of first-period loans is associated with a liquidity outflow Ω_0 at $t = 1$. Whenever the risk Δ is too large, this outflow will exceed the funding liquidity of these loans so that they cannot help to close the funding gap for new loans. In this case, the safe mode is unavailable. Otherwise, the maximum volume $l_1^{\max}$ of new loans will be higher, the more loans the banker has granted at $t = 0$, see (18).

If the banker adopts the risky mode at $t = 1$, the bank will fail and no party will get anything if the recovery holds off at $t = 2$. In this case, the banker's program changes to

$$\max_{l_{1,b}, a_{1,b}, d_{1,b}} \pi_{1,b} = \lambda p_2 \left[r_m l_{1,b} + a_{1,b} + v_m l_0 - d_{1,b} \right] - c\left(l_{1,b} \right) \tag{19}$$

$$\text{s.t.} \quad l_{1,b} + a_{1,b} = -\Omega_0 l_0 + p_2 d_{1,b} + e_{1,b}, \tag{20}$$

$$l_{1,b}, a_{1,b} \geq 0, \tag{21}$$

$$d_{1,b} \in \left(a_{1,b} + v_l l_0, r_m l_{1,b} + a_{1,b} + v_m l_0 \right], \tag{22}$$

$$e_{1,b} = (1 - \lambda)p_2 \left[r_m l_{1,b} + a_{1,b} + v_m l_0 - d_{1,b} \right]. \tag{23}$$

A comparison of this optimization problem with the banker's optimization problem in the safe mode reveals two important differences. First, in contrast to the safe mode, the banker does not face an upper restriction on new lending in the risky mode. As the banker can refinance new loans by deposits only, their funding liquidity is sufficiently large, so that $p_2 r_m - 1$ is positive. Second, the return of the first-period loans is smaller in the risky mode than in the safe mode. This is due to the bank run that will occur in the risky mode if the economy fails to recover at $t = 2$ and that will destroy all value.

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Solving the respective optimization problems in the safe and in the risky mode and comparing the resulting payoff of the banker brings us to

Lemma 2. *If the economy is in the bad state at date $t = 1$, the banker's decision on investment and capital structure and his expected payoff have the following properties:*

- *If $\Delta \in [0, \frac{\mu - \lambda p_2 \delta - \Omega_0}{p_1}]$ and $l_0 \in [l_0^{min}, \infty)$, the banker will opt for the safe mode of operation with*

$$l_{1,b}^* = \min\left\{l_{1,b}^{fb}, l_1^{max}\right\},$$

$$a_{1,b}^*, d_{1,b}^* \geq 0,$$

$$\Omega_{1,b}^* = 1 - \frac{1-\lambda}{\lambda}(p_2 r_m - 1) - \frac{(1-\lambda)(\mu - p_1 \Delta) - \Omega_0}{\lambda} \frac{l_0}{\min\left\{l_{1,b}^{fb}, l_1^{max}\right\}},$$

$$\pi_{1,b}^* = (p_2 r_m - 1)\min\left\{l_{1,b}^{fb}, l_1^{max}\right\} + (\mu - p_1 \Delta - \Omega_0)l_0 - c\left(\min\left\{l_{1,b}^{fb}, l_1^{max}\right\}\right),$$

where l_0^{min} is implicitly defined by

$$(1 - p_2)(\mu - p_1 \Delta - p_2 \delta)l_0^{min} = [(p_2 r_m - 1)l_{1,b}^{fb} - c(l_{1,b}^{fb})] - [(p_2 r_m - 1)l_1^{max}(l_0^{min}) - c(l_1^{max}(l_0^{min}))]. \quad (24)$$

- *If $\Delta > \frac{\mu - \lambda p_2 \delta - \Omega_0}{p_1}$ and $l_0 > l_0^{max} > 0$, the banker will close the bank implying $\pi_{1,b}^* = 0$ with $l_0^{max} := \frac{(p_2 r_m - 1)l_{1,b}^{fb} - c(l_{1,b}^{fb})}{\Omega_0 - p_2(\mu - p_1 \Delta + (1 - p_2)\delta)}$.*

- *In all other cases, the banker will opt for the risky mode of operation with*

$$l_{1,b}^* = l_{1,b}^{fb},$$

$$a_{1,b}^* = 0,$$

$$\Omega_{1,b}^* = \frac{1 - (1-\lambda)p_2 r_m}{\lambda p_2} - \frac{(1-\lambda)p_2(\mu - p_1 \Delta + (1 - p_2)\delta) - \Omega_0}{\lambda p_2} \frac{l_0}{l_{1,b}^{fb}},$$

$$\pi_{1,b}^* = (p_2 r_m - 1)l_{1,b}^{fb} + (p_2(\mu - p_1 \Delta + (1 - p_2)\delta) - \Omega_0)l_0 - c\left(l_{1,b}^{fb}\right).$$

As long as the risk Δ is not too large, the banker can choose between the safe and the risky mode in the bad state of the economy. In the safe mode, in which new loans have a negative funding liquidity, the banker faces a financial constraint. This constraint is tighter, the lower is the volume l_0 of loans granted at $t = 0$. In the risky mode, the banker sacrifices the bank's assets when the recovery holds off. Hence,

whenever the first-best loan volume is feasible in both modes, he chooses the safe mode. If the volume of loans granted at $t = 0$ is too small, however, the financial constraint becomes binding in the safe mode because the banker can raise only few funds against late loan earnings. In this situation, he is willing to operate in the safe mode only if $l_0 \geq l_0^{\min}$ so that the resulting losses due to underinvestment in new loans, as specified on the right hand side of (24), do not exceed the foregone earnings from first-period loans when the recovery holds off in the risky mode, which are reflected by the left hand side of (24). Otherwise, the banker will opt for the risky mode, which allows for a first-best provision of new loans. Note that $l_0^{\min}$ is increasing in both, Δ and δ. The reason is twofold. First, higher risks imply that the banker will give up less by opting for the risky mode as loan earnings will be rather small when the recovery holds off. Second, higher risks also imply for the safe mode that the funding liquidity of late loans and thus his profits are lower. Therefore, the banker has stronger incentives to take the risky mode for higher values of Δ and δ. In case of a relatively large Δ, the safe mode is not available at all. In this situation, the banker will operate in the risky mode as long as this mode is associated with a non-negative profit. Otherwise, the banker will close the bank at $t = 1$.

3.2   The banker's optimum strategy at $t = 0$

Knowing the optimum capital structure and lending decision at $t = 1$ for a given l_0, we next derive the banker's optimal business strategy at the beginning of the first period at $t = 0$. Like in the preceding section, we first clarify the banker's optimization problem at this date. Then, we discuss the resulting optimal behavior of the banker.

At $t = 0$, the banker's optimization problem is

$$\max_{l_0, a_0, d_0} \Pi = p_1 \pi_{1,g}^* + (1 - p_1) \, \pi_{1,b}^* - c(l_0) \tag{25}$$

$$\text{s.t.} \;\; l_0 + a_0 = \mathfrak{d}_0 + e_0, \tag{26}$$

$$l_0, a_0, d_0 \geq 0 \tag{27}$$

$$\mathfrak{d}_0 = \begin{cases} p_1 d_0 & \text{if } \; \Delta > \frac{\mu - \lambda p_2 \delta - \Omega_0}{p_1} \; \text{ and } \; l_0 > \frac{(p_2 r_m - 1) l_{1,b}^{\mathrm{fb}} - c\left(l_{1,b}^{\mathrm{fb}}\right)}{\Omega_0 - p_2(\mu - p_1 \Delta + (1 - p_2)\delta)} > 0, \\ d_0 & \text{otherwise,} \end{cases} \tag{28}$$

$$e_0 = (1 - \lambda) p_1 \left[v_h - \Omega_0 \right] l_0. \tag{29}$$

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The objective function (25) reflects the banker's expected profits from the $t = 0$ perspective. With probability p_1 he will find himself in the good state at $t = 1$. We know from Lemma 1 that the banker will obtain $\pi^*_{1,g}$ in this state. With probability $1 - p_1$, the banker will be in the bad state at $t = 1$ so that his expected payoff is $\pi^*_{1,b}$ as specified in Lemma 2. Finally, the banker has to bear the lending costs $c(l_0)$ associated with loans granted at $t = 0$ irrespective which state will occur. The budget constraint (26) states that the total amount invested in loans and in the risky asset at $t = 0$ must coincide with the total amount $\mathfrak{d}_0 + e_0$ obtained from depositors and shareholders at this date. According to (28), depositors provide the amount d_0 as long as they are certain to get repaid at date $t = 1$. If, however, they expect the banker to close the bank at $t = 1$ in the bad state, they will only provide $p_1 d_0$ because in this scenario, they will get a repayment in the good state only, which occurs with probability p_1. According to (29), the shareholders will provide an amount equal to what they expect to be able to extract from the bank at date $t = 1$. This amount coincides with the share $1 - \lambda$ of the bank's profits at $t = 1$ in the good state.

For the mode of operation, in which the bank will not be closed at $t = 1$ irrespective of the state of the economy, substitution of (28) and (29) in the budget constraint (26) yields $l_0 = \Omega_0^{-1}(d_0 - a_0)$ with

$$\Omega_0 = \frac{1 - (1 - \lambda)p_1 \left[\mu + (1 - p_1)\,\Delta\right]}{1 - (1 - \lambda)p_1} \in (0, 1). \tag{30}$$

Accordingly, an increase in $d_0 - a_0$ at $t = 0$ will be associated with an increase in loans l_0 by a factor greater than one. This in turn implies that at $t = 1$ the liquidity available to the banker must not be lower than Ω_0 per unit of loans in order to prevent a run, i.e. to keep the bank in business. As this inevitable liquidity outflow at $t = 1$ is lower than what is raised and invested in loans at $t = 0$, the banker can shift liquidity from the present to the future by means of lending. This option can be particularly valuable when the banker expects a financial constraint for later businesses.

We can use the leverage Ω_0 of the bank at $t = 0$ as given in (30) to further clarify the banker's upper limit on new loans at $t = 1$ in the bad state of the economy in the safe mode. Substitution of (30) in (18) yields

$$l_{1,b} \in [0, l_1^{\max}] \quad \text{with} \quad l_1^{\max} = \psi l_0 = \frac{\mu - p_1 \Delta - \lambda p_2 \delta - \frac{1 - (1-\lambda)p_1 [\mu + (1-p_1)\Delta]}{1 - (1-\lambda)p_1}}{1 - (1-\lambda)p_2 r_m} l_0. \tag{31}$$

The parameter ψ reflects the overall relative contribution of loans granted at $t = 0$ to fill the funding gap for

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new loans in the bad situation at $t = 1$. It measures the financial leeway that the banker gains in case of an economic downturn when he has increased his loan portfolio by one unit at $t = 0$. Clearly, ψ is decreasing in both, Δ and δ, and the banker cannot refinance any new loan in the safe mode when $\psi < 0$. Accordingly, we can define Δ_ψ as the largest Δ such that $\psi \geq 0$ for all $\Delta \leq \Delta_\psi$, i.e. $\Delta_\psi := \frac{\mu - 1 - [1 - (1-\lambda)p_1]\lambda p_2 \delta}{\lambda p_1}$ is the largest Δ for which the safe mode is still available at $t = 1$ in the bad state.

As the solution to the banker's optimization problem at $t = 0$, we obtain

Proposition 1. *For a given δ the banker's optimum lending and capital structure decision at $t = 0$ is*

1. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{A} = \left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta \leq \Delta_A) \right\}$.*

2. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^B \geq l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \psi l_0^B < l_{1,b}^{fb}$ for all $\Delta \in \mathcal{B} = \left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_A) \wedge (\Delta \leq \Delta_B) \right\}$.*

3. *to operate in the risky mode at $t = 1$ and to grant loans according to $l_0 = \min\{l_0^C, l_0^{max}\} < l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{C} = \left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_B) \wedge (\Delta \leq \Delta_C) \right\}$.*

4. *to operate in the risky mode already at $t = 0$ and to grant loans according to $l_0 = l_0^D < l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{D} = \left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_C) \right\}$.*

with

$$\Delta_A : l_{1,b}^{fb} = \frac{\mu - 1 - \lambda p_1 \Delta_A - [1 - (1-\lambda)p_1]\lambda p_2 \delta}{[1 - (1-\lambda)p_2 r_m][1 - (1-\lambda)p_1]} l_0^{fb} \tag{32}$$

$$\Delta_B : \left(\Pi_B(l_0^B) = \Pi_C(l_0^C) \right) \vee (\Delta = \Delta_\psi) \tag{33}$$

$$\Delta_C : \Pi_C(l_0^{max}) = \Pi_D(l_0^D) \tag{34}$$

$$l_0^B : 0 = \mu - 1 - c'(l_0^B) + (1-p_1)\psi \left[p_2 r_m - 1 - c'(\psi l_0^B) \right] \tag{35}$$

$$l_0^C : 0 = \mu - 1 - c'(l_0^C) - (1-p_1)(1-p_2)(\mu - p_1 \Delta - p_2 \delta) \tag{36}$$

$$l_0^D : 0 = \mu - 1 - c'(l_0^D) - (1-p_1)(\mu - p_1 \Delta) \tag{37}$$

In principle, the banker can choose between four different strategies. The proposition states that from the viewpoint of the banker, there a unique ordering of these strategies between the banker. To understand this ordering, it is useful to disentangle these strategies in detail.

The first strategy builds upon the fact that the only way for the banker to always collect everything from each loan is to operate in the safe mode at any time. Hence, when lending according to the first best at $t = 0$ will not lead to a financial constraint in the bad state at $t = 1$ according to (31), the banker maximizes his expected profits by always granting loans according to the first-best. Furthermore, his expected profits will not depend on intra-marginal changes in risks. This strategy, henceforth denoted as strategy A, is the most preferred one but may be impossible to follow. If risks are not small or if l_0^{fb} is relatively small compared to $l_{1,b}^{\text{fb}}$, continuing with the safe mode at $t = 1$ when the bad state materializes will be either associated with a financial constraint or even infeasible. If strategy A is not available, the banker pursues one of the following three alternative strategies which differ with respect to how he adapts to risk and the implied financial constraint.

Strategy B is to ease the financial constraint (31) without abandoning the safe mode by adjusting loans at $t = 0$. An increase in first-period loans above the first-best level will result in an efficiency loss in the first period, but in an efficiency gain in the second period as it will make the financial constraint less tight in a downturn. Therefore, when keeping at the safe mode, the banker optimally deviates from the first-best by overinvesting in loans at $t = 0$ in order to attenuate the underinvestment in loans at $t = 1$ such that these marginal costs and benefits are balanced. Henceforth, l_0^{B} denotes the so defined optimum volume of loans granted at $t = 0$. This optimum l_0^{B} implies that underinvestment in the bad state will be more severe the larger is risk, whereas the effect of risk on overinvestment at $t = 0$ is less clear. On the one hand, higher risk tightens the financial constraint in the bad state at $t = 1$, which would make the banker be more willing to grant even more loans at $t = 0$. On the other hand, higher risk also reduces the influence that the banker can exert on the financial constraint as changes in l_0 have only little effect on the potential efficiency gains at $t = 1$. If Δ is already close to Δ_ψ, overinvestment at $t = 0$ has almost no value as it barely eases the financial constraint at $t = 1$ when the bad state occurs. Hence, for $\Delta = \Delta_\psi$, the banker will grant only the first-best loan volume at $t = 0$ and no loans in the bad state at $t = 1$. The optimal lending pattern associated with strategy B implies that the expected profits of the banker will be strictly lower for higher magnitudes of risks as the financial constraint will be tighter then.

Strategy C is to adopt the risky mode in the bad state at $t = 1$ in order to ease the associated financial constraint. According to Lemma 1, a banker pursuing this strategy will always grant new loans according to the first-best at $t = 1$ but will be unable to collect first-period loans when the recovery holds off after the economy has fallen in a downturn. The banker optimally responds to the drop in expected returns

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on loans by choosing a loan volume l_0^C at $t = 0$ that is below the first-best in order to balance its lower marginal returns with its costs. Since the conditional mean of loan earnings increases in Δ and δ once the risky mode is adopted, this optimum loan volume is the higher the larger are risks. However, when the banker grants too much loans at $t = 0$, his liquidity gap in the bad state may be too large to leave him with any positive profit at $t = 1$ even in the risky mode. Hence, granting loans above $l_0^{\max}$ does not belong to a subgame-perfect strategy. Investors would anticipate the incentive of the banker to go bankrupt in a downturn and be thus not willing to provide so many funds. Instead, to signal his credibility to repay deposits issued at $t = 0$ even in the bad state, the banker must not grant loans higher than $l_0^{\max}$. Once the banker has decided to definitely follow strategy C, he eventually chooses a loan volume of $\min\{l_0^C, l_0^{\max}\}$. Regarding the banker's expected profit, the properties of $l_0^{\max}$ and l_0^C have two implications. First, when the banker would deviate only little from the first-best with strategy B, he strictly prefers B over C. Otherwise he would unnecessarily forfeit those loan earnings that accrue when the recovery after a downturn delays. In addition, he would grant significantly less loans at $t = 0$ which also reduces expected profits. Second, expected profits associated with strategy C are strictly increasing in δ, whereas the effect of Δ can be negative for large risks if p_2 and λ are sufficiently large. The reason for the latter effect is that in this case $l_0^{\max}$ is binding and further decreasing in Δ.

Finally, strategy D is to opt for the risky mode already at $t = 0$ implying an outright failure at $t = 1$ when the bad state materializes at this date. With this strategy, the banker will grant loans l_0^D that are not only less than indicated by the first-best but actually smaller than l_0^C because with strategy D the returns on loans in the bad state cannot be collected irrespective whether the economy recovers later on or not. Accordingly, for a given level of risk, the expected profit of the banker associated with strategy D is strictly smaller than the expected profit associated with strategy C as long as the banker would then grant loans according to l_0^C. The optimum loan volume l_0^D of strategy D, and thus the banker's expected profits, will be larger for greater Δ. Changes in δ have no such effect on the optimal loan volume and on expected profits because, if the banker already pursues the riskiest strategy, he simply does not care about loan earnings at all once they delay.

3.3 Implications for financial stability and bank regulation

The dynamic interdependencies between current and future lending and capital structure decisions have particular implications for financial stability and bank regulation. Taking the bank considered here as

representative and the risks of macroeconomic or systemic nature, the growth of bank credit may initially be excessive compared to the first-best but only to fall short of the efficient level later on should the business cycle cool down. This pattern will occur when both types of risk are neither too small nor too large. This case may thus resemble the situation in advanced economies. Of course, procyclicality has been the result in other models (Kiyotaki and Moore, 1997). Our dynamic banking perspective differs from those explanations in two ways. First, procyclicality is because banks expecting a financial constraint later tend to grant more loans in the present in order to mitigate the future financial constraint. Second, and most importantly, in other models procyclicality is a matter of differing tightness of financial constraints over the cycle with underinvestment being just less severe in good times. In our model, procyclicality may even imply overinvestment in loans.

Things are different, however, when risks are more pronounced. In an attempt to gamble for resurrection, banks will switch to the risky mode of operation once the economy falls into a recession. Bank lending shows a different pattern in this case. Initially, the presence of relatively large risks will depress lending compared to the first-best. Later on, bank lending will recover irrespective of the state, although the banks' capital structure becomes fragile should the bad state materialize. Hence, the model predicts that there is a strong secular trend in credit growth but that the banking sector collapses at $t = 2$ should the recovery following an economic downturn be too slow or too weak. Note the interesting point with this case, which is the direction of causality. In contrast to other explanations, it is not a strong credit expansion preceding a banking crisis that also causes the crisis. Instead, it is the anticipated risk of a potential failure that makes banks initially rather cautious in terms of capital structure and lending and later on more aggressive once the economic conditions worsen. This case helps to explain some aspects of financial crises in emerging countries where liquidity risks are not too small.

For very large risks, finally, the banking system will be depressed and even more fragile, so that banks already fail in a temporary economic downturn. This situation may thus refer to little developed countries. Also here, it is the volatile real economy that causes the lending behavior and stability of the banks.

Although generating these different outcomes, the driving force is in any case a conflict of interest between investors and the banker which results in a trade-off between stability and efficiency of the banking sector.[9] The question is whether and how regulators should act. There are two potential avenues to follow.

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[9]Efficiency here refers to the absence of deviations from the first-best loan volumes at the dates when loans are to be granted, whereas stability refers to the absence of any deadweight loss at the dates when loan earnings are to be collected.

When there are further social costs associated with bank failures, the market outcome presented in this section will be biased towards excessive risk-taking by banks. The next interesting question then is how banks can be prevented from such excessive risk taking at the lowest cost, where this cost is in terms of lost efficiency.

4 Pre-emptive regulatory measures

4.1 Regulatory margin calls

Hart and Zingales (2011) devise a market based capital regulation for large and complex financial institutions. In contrast to Basel III, this capital requirement is not based on the balance sheet but rather on balance sheet information regarding the fragility of an institution. Based on the market assessment of the institution's probability of default, the institution is forced to issue additional equity to build up buffers against potential losses. Hart and Zingales (2011) propose to take the credit default swap (CDS) price of financial institutions as a proxy for the market's expectation regarding banks' probability of default. Each time the CDS price exceeds a certain threshold the margin call is triggered and the institution has to issue additional equity. If the institution is unable to raise equity as required, the regulator will take over and decide on how to recapitalize or liquidate the institution. This take over entails a haircut for shareholders while the management of the bank has to resign and thus entirely looses its share of the bank's returns.

We convey this regulatory proposal into our model in the following way. Any market participant inside or outside the bank may enter into a CDS contract on the bank.[10] As we assume that all market participants have complete knowledge regarding the state of the economy and the expected returns on bank loans, this credit default swap is fairly priced: The CDS price is zero if the banker chooses a safe capital structure and becomes positive for a risky capital structure. With a safe capital structure the banker is always able to fully pay off all deposits. Hence, the bank never defaults so that the expected payment of the CDS contract is zero. Each time the banker operates in the risky mode, the bank's probability of default is positive, as the bank might either default after the first or after the second period. Hence, the price market participants are willing to pay for the CDS contract is positive. We assume that the regulator aims to prevent a default at all times so that the threshold of the margin call is set to zero. Hence, operating

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[10]Note that we do not explicitly have to consider debt for the analysis, as an underlying is not a requisite for market participants to agree on a CDS contract.

in the risky mode at $t = 1$ or at $t = 0$ always triggers the margin call whereas a margin call never occurs in the safe mode.

If the margin call is triggered, the banker is forced to raise additional capital from shareholders to prevent a take over. Shareholders are only willing to provide capital up their expected share of the bank's returns. Hence, in order to increase equity, the banker has to lower the amount of deposits. This however leads to a restriction on bank loans. The CDS price only declines to zero, if the banker is able to provide a safe capital structure. As the safe capital structure is only feasible for certain liquidity risks, we obtain

Proposition 2. *With a margin call in place, for a given δ the banker's optimum lending and capital structure decision at $t = 0$ is*

1. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{A} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta \leq \Delta_A) \right\}$.*

2. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^B \geq l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \psi l_0^B < l_{1,b}^{fb}$ for all $\Delta \in \mathcal{B}_{mc} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_A) \wedge (\Delta \leq \Delta_\psi) \right\}$.*

3. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = 0$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{E}_{mc} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_\psi) \right\}$.*

The margin call does not affect bank lending in the safe mode. Each time the banker wants to operate in the risky mode, the margin call forces the banker to operate according to the safe mode. Loan granting is, however, only feasible for lower liquidity risks, i.e. for $\Delta \leq \Delta_\psi$. For larger liquidity risks, the margin call entirely hampers loan granting. Granting loans according to the benchmark model with a risky capital structure either in the first or in the second period would trigger the margin call. However, the banker would be unable to raise a sufficient amount of equity to prevent the take over. With the take over the banker looses all his shares of the bank's returns. As granting loans generates private costs for the banker, he circumvents these losses by providing no loans at all both in the first period and in the second period if the economy is in the bad situation.

Although the underlying model of Hart and Zingales' proposal bears resemblance to our model the results differ to some extend. Likewise to Hart and Zingales (2011), we can conclude that a margin call is able to maintain financial stability. But as we consider the banker's private costs of granting loans, we find that depending on the magnitude of the liquidity risk, a credit crunch might occur.

4.2 Countercyclical capital ratio

Basel II is widely criticized for encouraging pro-cyclical behavior (see e.g. Kashyap *et al.*, 2008; Goodhart, 2008; Repullo and Suarez, 2008). Due to the risk-weighted capital requirement banks tend to lend more during booms which might amplify a credit bubble and thus the deepness of a potential recession. In response to the recent financial crisis, regulators hence decided to reduce pro-cyclicality by implementing a countercyclical capital buffer in Basel III. A larger capital requirement in good times is supposed to tighten banks' lending opportunities. As raising capital might be difficult in bad times, a lower requirement allows banks to use their capital buffer to cover losses and thus not to decrease lending.

The effectiveness of such a capital ratio in terms of financial stability and capital allocation crucially depends on the regulator's ability to identify the state of the economy. The countercyclical capital ratio of Basel III ties the capital requirement to the deviation of the credit-to-GDP ratio with respect to its trend. However, as the indicator is negatively correlated with the business cycle, Repullo *et al.* (2010) argue that pro-cyclicality is rather increasing with such a design. They therefore propose to smooth bank lending with a simple multiplier based on GDP growth. In our setting, the regulator has perfect knowledge about the state of the economy so that we do not have to consider the impact of different indicators. Anyhow, we arrive at the conclusion that the effect of a countercyclical capital requirement crucially depends on the degree of countercyclicality and the liquidity risk in the economy.

In analogy to Basel III, we define the bank's capital ratio κ as the value of equity over all risky loans. The value of equity equals the bank's assets subtracted by its deposits.[11] Implementing a countercyclical capital requirement, the banker faces lower capital requirements in the downturn, e.g. in the bad situation at $t = 1$, while the regulator imposes a higher regulatory capital ratio in the upswing, e.g. in all other situations. We distinguish between a weak and a strong from of countercyclicality. With a weak countercyclicality the regulatory capital ratio in the bad situation at $t = 1$ deviates only slightly from the regulatory capital ratio in the other situations. If this difference increases, banks face a strongly countercyclical capital ratio.

Without a regulation in place, the bank's capital ratio depends on the liquidity risk. Larger liquidity risks imply an increasing spread between first-period returns which materialize at $t = 1$ and their expected delayed returns in $t = 2$. The bank's ability to raise equity in the bad situation at $t = 1$ is lower the lower the expected returns when first-period loans are delayed. The capital ratio in the bad situation at $t = 1$

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[11]It is thus not necessarily equivalent to the investment provided by shareholders.

is thus the lower the larger the liquidity risk. In contrast, higher liquidity risks imply higher expected returns if first-period loans materialize already after the first period. As shareholders provide more equity in the first period the larger the bank's returns, the capital ratio is the larger the higher the liquidity risks. Accordingly, a regulatory capital ratio becomes binding in the bad situation at $t = 1$ for larger liquidity risks, while first period's investment decisions are affected for lower liquidity risks. In the good situation at $t = 1$, loans are assumed to be safe so that a capital requirement does not affect the bank's capital structure. As the banker is able to raise more deposits in the risky mode, it furthermore holds for both periods that the capital ratio in the risky mode is always lower than in the safe mode. Thus, a regulatory capital ratio is feasible which affects the risky but not the safe mode.

If the regulatory capital ratio in the first period deviates only slightly from the ratio imposed in the second period, the regulator is able to restrict the risky mode in both periods without affecting the safe modes.[12] We define this scenario as a weakly countercyclical capital requirement.

In the second period, the regulation becomes binding for larger liquidity risks. With a risky capital structure, the banker is therewith unable to fulfill the regulatory capital ratio while granting loans according to the first-best. Likewise to the restricted safe mode in the benchmark model, the capital ratio imposes a restriction on bank lending for the risky mode. In order to fulfill the capital ratio the banker has to reduce bank lending. As this restriction depends on loans granted at $t = 0$, the banker is incentivized to loosen this restriction by increasing bank lending in the first period. Loosening the restriction by pro-cyclical lending is however only feasible, if the banker does not face a financial restriction in the first period. The effect of the regulatory capital ratio in the first period is less complex. The regulation becomes binding for lower liquidity risks. For these risks, choosing a risky capital structure in the first period is not feasible as shareholders are unwilling to provide enough equity to fulfill the required capital ratio. We obtain

Proposition 3. *With a weakly countercyclical capital requirement in place, for a given δ the banker's optimum lending and capital structure decision at $t = 0$ is*

1. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{A} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta \leq \Delta_A) \right\}$.*

2. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^B \geq l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and*

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[12]This restricts the regulatory capital ratio in the first period to $\kappa_{0,w} \in (1 - \frac{1 - (1 - \lambda)p_1[\mu + (1 - p_1)\Delta]}{\lambda p_1}, 1 - \frac{1 - (1 - \lambda)p_1[\mu + (1 - p_1)\Delta]}{1 - (1 - \lambda)p_1})$ and in the second period to $\kappa_{1,w} \in (1 - \frac{1 - (1 - \lambda)p_2 r_m}{\lambda p_2}, 1 - \frac{1 - (1 - \lambda)p_2 r_m}{\lambda})$.

$$l_{1,b} = \psi l_0^B < l_{1,b}^{fb} \ \text{for all} \ \Delta \in \mathcal{B}_{\kappa_w} = \left\{ \Delta \in \left[(1-p_2)\delta, \tfrac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_A) \wedge (\Delta \leq \Delta_{B,\kappa_w}) \right\}.$$

3. to operate in the risky mode at $t = 1$ and to grant loans according to $l_0 = \min\{\max\{l_0^C, l_{0,\kappa}^C\}, l_{0,\kappa}^{max}\}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \min\{l_{1,b}^{fb}, l_{1,\kappa}^{max}\}$ for all $\Delta \in \mathcal{C}_{\kappa_w} = \left\{ \Delta \in \left[(1-p_2)\delta, \tfrac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_{B,\kappa_w}) \wedge (\Delta \leq \Delta_{C,\kappa_w}) \wedge (\Delta \leq \Delta_{\psi_\kappa}) \right\}.$

4. to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = 0$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{E}_{\kappa_w} = \left\{ \Delta \in \left[(1-p_2)\delta, \tfrac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_{\psi_\kappa}) \wedge (\Delta \leq \Delta_{C,\kappa_w}) \right\}.$

5. to operate in the risky mode already at $t = 0$ and to grant loans according to $l_0 = l_0^D < l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{D}_{\kappa_w} = \left\{ \Delta \in \left[(1-p_2)\delta, \tfrac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_{C,\kappa_w}) \right\}.$

with

$$\Delta_{B,\kappa_w} : \left(\Pi_B(l_0^B) = \Pi_{C,\kappa}(\max\{l_0^C, l_{0,\kappa}^C\}) \right) \vee (\Delta = \Delta_\psi) \tag{38}$$

$$\Delta_{C,\kappa_w} : \left(\Pi_{C,\kappa}(\min\{l_{0,\kappa}^C, l_{0,\kappa}^{max}\}) = \Pi_D(l_0^D) \quad iff \quad \Delta > \frac{1 - \lambda p_1 (1 - \kappa_{0,w}) - (1-\lambda)p_1 \mu}{(1-\lambda)p_1(1-p_1)} \right) \tag{39}$$
$$\vee \left(\Delta = \frac{1 - \lambda p_1 (1 - \kappa_{0,w}) - (1-\lambda)p_1 \mu}{(1-\lambda)p_1(1-p_1)} \right)$$

$$l_{0,\kappa}^C : 0 = \mu - 1 - c'(l_{0,\kappa}^C) - (1-p_1)(1-p_2)(\mu - p_1 \Delta - p_2 \delta) + (1-p_1)\psi_\kappa \left[p_2 r_m - 1 - c'(\psi_\kappa l_{0,\kappa}^C) \right] \tag{40}$$

$$l_{0,\kappa}^{max} : \left(\Omega_0 - p_2 \left(\mu - p_1 \Delta + (1-p_2)\delta \right) \right) l_{0,\kappa}^{max} = (p_2 r_m - 1) \min\{l_{1,b}^{fb}, l_{1,\kappa}^{max}\} - c\left(\min\{l_{1,b}^{fb}, l_{1,\kappa}^{max}\} \right) \tag{41}$$

These results support the argument of Caprio (2010) that the effect of a countercyclical capital ratio on bank's risk taking is ambiguous. As the regulation only affects the risky modes, expected returns in the safe mode of both periods remain unchanged. Compared with the benchmark case, the banker thus always prefers a safe capital structure over a risky capital structure, if this is already optimal without a regulation. The restrictions on bank loans in the second period imply lower expected returns when the banker operates in the risky mode at $t = 1$. If the capital ratio in the second period is large enough, the banker might thus prefer the restricted safe mode to a larger extend than in the benchmark scenario, i.e. also for $\Delta \in [\Delta_B, \Delta_{B,\kappa_w}]$. Whether financial stability increases also for larger liquidity risks, depends on the relationship between the regulatory capital ratio in the first and second period. When the risky mode is feasible in the first period, the expected returns remain unchanged. As the regulation lowers expected returns when the banker operates in the risky mode in the second period, he prefers the risky mode in

the first period already for smaller liquidity risks than in the benchmark model. If, however, the required capital ratio in the first period is sufficiently large, the risky mode is not feasible for these lower liquidity risks. In this case, financial stability also increases for higher liquidity risks, i.e. for $\Delta \in [\Delta_C, \Delta_{C,\kappa_{\mathrm{w}}}]$. Instead of defaulting already at $t = 1$, the bank only defaults if the economy does not recover until the end of the second period.

Implementing a strongly countercyclical capital ratio changes the results to some extend. We define a strongly countercyclicality in the following way. While no regulatory capital ratio is imposed in a downturn, the capital ratio in an upswing is so high that for low liquidity risks both the safe and risky mode are restricted in the first period.[13] The impact of the regulatory capital ratio in the safe mode is likewise to the risky mode. As expected returns of first-period loans are too low if they materialize at $t = 1$, the banker is unable to raise the required amount of equity. Accordingly, bank lending in the first period is not feasible at all. We obtain

Proposition 4. *With a strongly countercyclical capital requirement in place, for a given δ the banker's optimum lending and capital structure decision at $t = 0$ is*

1. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = 0$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{E}_{\kappa_s} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta \leq \Delta_{A,\kappa_s}) \right\}$.*

2. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{A}_{\kappa_s} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{A,\kappa_s}) \wedge (\Delta \leq \Delta_A) \right\}$.*

3. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^B \geq l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \psi l_0^B < l_{1,b}^{fb}$ for all $\Delta \in \mathcal{B}_{\kappa_s} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{A,\kappa_s}) \wedge (\Delta > \Delta_A) \wedge (\Delta \leq \Delta_B) \right\}$.*

4. *to operate in the risky mode at $t = 1$ and to grant loans according to $l_0 = \min\{l_0^C, l_0^{max}\} < l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{C}_{\kappa_s} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{A,\kappa_s}) \wedge (\Delta > \Delta_B) \wedge (\Delta \leq \Delta_{C,\kappa_s}) \right\}$.*

5. *to operate in the risky mode already at $t = 0$ and to grant loans according to $l_0 = l_0^D < l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = 0$ for all $\Delta \in \mathcal{D}_{\kappa_s} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{C,\kappa_s}) \right\}$.*

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[13]This restricts the regulatory capital ratio in the first period to $\kappa_{\mathrm{s}} = 1 - \frac{1 - (1-\lambda)p_1[\mu + (1-p_1)\Delta_{A,\kappa_s}]}{1 - (1-\lambda)p_1}$.

with

$$\Delta_{A,\kappa_s} = \frac{[1 - (1 - \lambda)p_1]\kappa_s - (1 - \lambda)p_1(\mu - 1)}{(1 - \lambda)p_1(1 - p_1)} \tag{42}$$

$$\Delta_{C,\kappa_s} : \left(\Pi_C(l_0^{max}) = \Pi_D(l_0^D) \quad iff \quad \Delta > \frac{1 - \lambda p_1(1 - \kappa_s) - (1 - \lambda)p_1\mu}{(1 - \lambda)p_1(1 - p_1)} \right)$$
$$\vee \left(\Delta = \frac{1 - \lambda p_1(1 - \kappa_s) - (1 - \lambda)p_1\mu}{(1 - \lambda)p_1(1 - p_1)} \right) \tag{43}$$

In contrast to a weak countercyclicality, the impact on financial stability is ambiguous. However, a strong countercyclicality might lead to undesired effects on bank lending. In the second period, the banker's decisions remain unchanged. As the risky mode is not restricted, the banker at least prefers the risky mode at $t = 1$ over the risky mode at $t = 0$ for all liquidity risks if he prefers the risky mode at $t = 1$ for the benchmark model as well. If the capital ratio in the second period is large enough, the banker might thus prefer the risky mode at $t = 1$ to a larger extend than in the benchmark scenario, i.e. also for $\Delta \in [\Delta_C, \Delta_{C,\kappa_s}]$. In this case, financial stability increases as the bank failure does not occur at $t = 1$ but only if the economy does not recover until $t = 2$. However, a larger regulatory capital ratio in the first period leads to a disintermediation. It hampers loan granting for low liquidity risks, i.e. for all $\Delta < \Delta_{A,\kappa_s}$, so that a credit crunch occurs. Other than under a margin call, this credit crunch eliminates bank lending with a safe capital structure, i.e. financial stability remains unchanged but credit allocation is inhibited. This result is in line with Caprio (2010) who argues that if capital ratios are too high banks might be unable to take sufficiently large risks to compensate their shareholders.

To sum up, countercyclical capital ratio fails its aim to build up capital buffers to be used in a downturn. Both with a weak and strong countercyclicality, it rather eliminates the banker's opportunity to choose a risky capital structure.

4.3 Liquidity coverage ratio

Basel III furthermore includes a liquidity coverage ratio to ensure that a certain share of banks' liabilities is covered by liquid assets. The aim of the liquidity ratio is to enable banks to survive a proposed stress scenario for a certain time in order to allow extra time for regulators to consider further policy measures.[14]

In our setting, we define the liquidity coverage ratio as $\eta := \frac{a_t}{d_t}$. If the liquidity ratio is equal to or

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[14]The liquidity coverage ratio is defined as stock of high quality liquid assets over net cash outflows over a 30-day time period (Basel Committee on Banking Supervision, 2010).

larger than one, the bank never defaults. However, also a smaller liquidity coverage ratio ensures financial stability as some loans pay off even if the economy does not recover after the second period. We hence focus our analysis on a liquidity ratio $\eta \in (0,1)$ although Basel III demands a liquidity coverage ratio of more than one. Likewise to the policy measures discussed above, a liquidity coverage ratio has no impact on the good situation at $t = 1$. In this situation, loans are risk-free so that total cash comprises both the risk-free asset $a_{1,g}$ and loans $l_{1,g}$. Even if the banker only issues deposits, the liquidity ratio thus equals one. It is strictly larger than one if a share of the assets is financed by equity.

Lemma 1 and 2 indicate that the banker always chooses a fixed ratio between risk-free assets and deposits. Operating in the safe mode therefore allows the banker to fulfill any regulatory liquidity coverage ratio, as he can increase the investment in risky-free assets simply by issuing deposits. As deposits are always paid off in the safe mode, a liquidity ratio might thus only induce a balance sheet extension. Operating in the risky mode leads to a liquidity ratio of zero if no regulation is in place. As the banker cannot increase the liquidity ratio by simply issuing deposits, imposing a regulatory liquidity coverage ratio restricts bank lending. This restriction is the tighter the larger is the ratio. A liquidity ratio larger of one forces the banker to invest all deposits in the risk-free asset. He therefore cannot grant new loans as the expected return for shareholders is too low. Thus, a liquidity ratio larger than or equal to one induces financial stability but entirely hampers bank lending.

Focusing on regulatory ratios which do not impose a full restriction on bank lending in the risky mode, we obtain[15]

Proposition 5. *With a liquidity ratio in place, for a given δ the banker's optimum lending and capital structure decision at $t = 0$ is*

1. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = l_{1,b}^{fb}$ for all $\Delta \in \mathcal{A} = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta \leq \Delta_A) \right\}$.*

2. *to operate in the safe mode at $t = 1$ and to grant loans according to $l_0 = l_0^B \geq l_0^{fb}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \psi l_0^B < l_{1,b}^{fb}$ for all $\Delta \in \mathcal{B}_\eta = \left\{ \Delta \in \left[(1 - p_2)\delta, \frac{\mu - p_2 \delta}{p_1} \right] \middle| (\Delta > \Delta_A) \wedge (\Delta \leq \Delta_{B_\eta}) \right\}$.*

3. *to operate in the risky mode at $t = 1$ and to grant loans according to $l_0 = \min\{\max\{l_0^C, l_{0,\eta}^C\}, l_{0,\eta_C}^{max}\}$, $l_{1,g} = l_{1,g}^{fb}$ and $l_{1,b} = \min\{l_{1,b}^{fb}, l_{1,\eta}^{max}\}$ for all $\Delta \in \mathcal{C}_\eta =$*

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[15]This restricts the liquidity coverage ratio to $\eta \in [0, \min\{\frac{\lambda p_1}{1 - (1 - \lambda)p_1}, \frac{\lambda p_2}{1 - (1 - \lambda)p_2}\})$.

$$\left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu-p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{B_\eta}) \wedge (\Delta \leq \Delta_{C_\eta}) \right\}.$$

4. *to operate in the risky mode already at $t = 0$ and to grant loans according to $l_0 = \min\{l_0^D, l_{0,\eta_D}^{max}\} < l_0^{fb}$,*

   $l_{1,g} = l_{1,g}^{fb}$ *and* $l_{1,b} = 0$ *for all* $\Delta \in \mathcal{D}_\eta = \left\{ \Delta \in \left[(1-p_2)\delta, \frac{\mu-p_2\delta}{p_1} \right] \middle| (\Delta > \Delta_{C_\eta}) \right\}.$

with

$$\Delta_{B_\eta} : \left(\Pi_B(l_0^B) = \Pi_{C,\eta}(\max\{l_0^C, l_{0,\eta}^C\}) \right) \vee (\Delta = \Delta_\psi) \tag{44}$$

$$\Delta_{C_\eta} : \left(\Pi_{C,\eta}(\min\{l_{0,\eta}^C, l_{0,\eta}^{max}\}) = \Pi_D(l_0^D) \right) \vee (\Delta = \Delta_{\psi_\eta}) \tag{45}$$

$$l_{0,\eta}^C : 0 = \mu - 1 - c'(l_{0,\eta}^C) - (1-p_1)(1-p_2)(\mu - p_1\Delta - p_2\delta) + (1-p_1)\psi_\eta \left[p_2 r_m - 1 - c'(l_{1,\eta}^{max}) \right] \tag{46}$$

$$l_{0,\eta_C}^{max} : (\Omega_0 - p_2(\mu - p_1\Delta + (1-p_2)\delta)) l_{0,\eta_C}^{max} = (p_2 r_m - 1)\min\{l_{1,b}^{fb}, l_{1,\eta}^{max}\} - c\left(\min\{l_{1,b}^{fb}, l_{1,\eta}^{max}\} \right) \tag{47}$$

$$l_{0,\eta_D}^{max} : [1 - (1-\lambda)p_1(\mu + (1-p_1)\Delta)] l_{0,\eta_D}^{max} = \left[\frac{1-\eta}{\eta}\lambda p_1 - (1-p_1) \right] a_{0,\eta}^* \tag{48}$$

As bank lending is not affected when the banker operates in the safe mode, bank's lending and capital structure decisions remain unchanged for low liquidity risks. The liquidity coverage ratio leads to a restriction on deposits in the risky mode at $t = 1$ so that the banker might only grant loans lower than the first-best loan volume. If bank lending is restricted already for sufficiently low liquidity risks, the banker prefers the restricted safe mode to a larger extend than in the benchmark scenario, i.e. also for $\Delta \in [\Delta_B, \Delta_{B,\eta}]$. Whether financial stability also increases for larger liquidity risks, depends on the magnitude of the liquidity ratio. The higher the regulatory liquidity coverage ratio and the lower the liquidity risks, the tighter is the restriction on bank lending if the banker already chooses a fragile capital structure in the first period. In this case it is more likely that the banker prefers a potential bank failure at the end of the second period over a bank failure at the end of the first period. Hence, financial stability might also increase for larger liquidity risks, i.e. also for $\Delta \in [\Delta_C, \Delta_{C,\eta}]$.

To sum up, a liquidity coverage ratio as proposed for Basel III leads to the same effects as the margin call while a lower liquidity ratio might be a way to reduce risk-taking without fully hampering credit intermediation.

5 Conclusion

In this paper, we have evaluated the influence of macroeconomic liquidity risks on bank lending over the business cycle. Within a unified dynamic framework with forward-looking banks, the model is able to generate lending cycles, credit crunches, or bank failures depending on the magnitude of liquidity risks in the economy. In order to mitigate expected losses in the downturn, bank lending becomes pro-cyclical for lower liquidity risks, even with a regulation in place. Banks increase lending over time for larger liquidity risks. This credit boom is not excessive but results from an initial underinvestment. Curtailing lending is optimal for larger liquidity risks as the anticipation of a bank failure in the downturn lowers the value of first-period loans. Hence, the expectations about deep recessions are causal for credit booms that later bust.

Against this background we have explored the impact of different new proposals to regulate banks with respect to their implications for financial stability and bank lending. While financial stability increases to some extend, we find that these regulatory measures have some unpleasant effects on bank lending. A strong countercyclical capital ratio is not recommended, as it may amplify pro-cyclical lending or even result in total disintermediation when liquidity risks are low, i.e. when financial stability is already feasible without any regulation. Imposing a regulatory margin call eliminates bank failures but entirely disrupts bank lending for larger liquidity risks. Implementing a liquidity ratio, however, might be a way to reduce risk-taking without fully hampering credit intermediation.

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Appendix

The proofs are available from the authors upon request.