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Accounting changes and enforcement of bank capital requirements in a crisis*

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Abstract

A common response to systemic shocks are accounting changes that reduce the impact of losses on banks' regulatory capital. We show that these accounting changes can increase banks' incentive to raise capital. Banks trade off the cost of raising equity and the cost of violating regulatory capital requirements. A systemic crisis weakens the enforcement of capital requirements, which reduces banks' incentives to recapitalize. Reducing the impact of fair value or expected credit losses on banks' regulatory capital lowers the amount of equity that banks have to raise to fulfill regulatory capital requirements. Banks that have no incentive to recapitalize under initial accounting rules can find it optimal to raise the necessary (lower) amount of equity to avoid regulatory intervention after the relaxation of the accounting rules. We discuss ex ante implications of relaxing accounting rules and differences to relaxing capital requirements.

Keywords: bank regulation; capital requirements; recapitalization; regulatory forbearance; fair value accounting; expected losses; financial crisis; COVID-19 crisis

JEL Classifications: G21, G28, M41, M48

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1 Introduction

Severe economic crises such as the financial crisis 2008-2009 or the COVID-19 crisis expose financial institutions to large increases in expected credit losses as well as deterioration in security market prices. In such times, banks, regulators as well as politicians frequently call for changes in accounting rules that determine regulatory capital (e.g., US Congress, 2008; Bernanke, 2009; Meeks and Luetkemeyer, 2020; European Banking Federation, 2020; Federal Deposit Insurance Corporation, 2020). These changes typically shield banks' regulatory capital from market value losses and expected credit losses.¹ A concern is that banks that look healthier after the accounting changes can delay corrective actions and have incentives to gamble instead of raising necessary capital (e.g., Skinner, 2008; Bhat et al., 2011; Huizinga and Laeven, 2012; Barnoussi et al., 2020).

We show that reducing the impact of expected losses on regulatory capital can increase the amount of capital (equity) that banks raise in a systemic crisis. A key motive for banks to raise capital is to fulfill regulatory capital requirements in order to prevent a costly intervention of the regulator. However, in a systemic crisis, the threat of intervention (e.g., liquidation) weakens (too-many-to-fail).² A direct consequence is that the maximum amount of capital that banks are willing to raise to prevent intervention decreases. If this amount is lower than the regulatory capital shortfall under prevailing accounting rules, banks may not find it optimal to raise any capital at all. Relaxing regulatory accounting rules, which reduces the amount of

¹For example, in 2008, IFRS-reporting banks were granted a one-time option to reclassify fair-value securities, which preserved EUR 19.1 billion in regulatory capital in the third quarter of 2008 (Bischof et al., 2022). Similarly, at the beginning of the COVID-19 crisis, banks were allowed to postpone the implementation of the newly introduced expected loss model or were encouraged to be cautious in assessing the impact of COVID-19 on expected losses (European Banking Authority, 2020; European Central Bank, 2020; European Securities and Markets Authority, 2020; CARES Act, 2020). This option reduced the negative impact of increasing provisions for expected losses on regulatory capital (Neisen and Schulte-Mattler, 2021). One example of a mandatory accounting rule change that affected regulatory capital is the implementation of FAS 115-2 and FAS 124-2 in 2009. This amendment limits the amount of impairments that affect regulatory capital to the credit loss impairment for all US-banks (Toksoz, 2022).

²See, for example, Kasa and Spiegel (1999), Mitchell (2001), Acharya and Yorulmazer (2007), Brown and Dinc (2011), and Kelly et al. (2016).

capital necessary to fulfill regulatory capital requirements, can restore incentives for banks to raise capital to prevent intervention.

An important determinant of regulatory capital requirements is how an increase in expected losses is measured and accounted for in regulatory capital. For example, expected credit losses can be measured using fair value accounting, an expected loss model, or an incurred loss model. The impact on regulatory capital also depends on prudential filters that can shield the effect of accounting measurement (fair value losses or expected credit losses) on regulatory capital. We refer to the set of accounting rules and prudential filters that determine the effect of (changes in) expected losses on regulatory capital as regulatory accounting rules. Thus, a change of regulatory accounting rules in a crisis can stem from a change in measurement or a change in prudential filters.³

The regulator has to enforce regulatory capital requirements. Absent regulatory enforcement, banks have no incentive to raise new capital because of a debt overhang problem (e.g., Elizalde and Repullo, 2007; Admati et al., 2018; Dangl and Zechner, 2021). Enforcement is particularly important in a crisis that results in a debt overhang problem and potentially higher required returns that investors demand compared to normal times. A key enforcement mechanism is the threat to liquidate banks that do not meet regulatory capital requirements. In case a bank is liquidated, shareholders lose the charter value (continuation value) of the bank. Banks raise new equity to avoid regulatory intervention if shareholders' expected loss in case of liquidation exceeds the cost of raising equity.

The threat of liquidation (enforcement) depends on the severity of the crisis. The regulator cannot commit to liquidate a bank that is undercapitalized, but makes the liquidation decision after observing the possible proceeds from liquidation. The regulator's objective is to minimize the expected transfer from the deposit insurance fund to depositors, as a tax increase or gov-

³For the effect of expected losses on regulatory capital, it does not matter whether the effect stems from measurement (accounting rules) or prudential filters. However, the difference may matter for transparency. To address concerns of transparency, regulators may prefer changes in prudential filters to changes in measurement or impose disclosure requirements to accompany changes in measurement.

ernment deficit to fund the transfer can be distortionary (e.g., Ballard, et al, 1985; Feldstein, 1999; Acharya and Yorulmazer, 2007; Acharya and Yorulmazer, 2008). If the proceeds from liquidation are lower than the claim of depositors, it can be optimal for the regulator to not intervene, but instead hope for recovery of the bank. In a systemic crisis, the expected proceeds from liquidation decrease (see, e.g., Acharya and Yorulmazer, 2007; Granja et al., 2017), which implies that the regulator is more likely to be lenient with undercapitalized banks. As a consequence, recapitalization incentives of banks decrease in a systemic crisis as banks foresee that the likelihood of enforcement (regulatory intervention) is low.

If regulatory enforcement is not strong enough to induce banks to recapitalize under prevailing regulatory accounting rules, it can be optimal to relax these rules. Thereby, the regulator reduces the impact of unrealized fair value changes and expected credit losses on banks' regulatory capital, which reduces the amount of equity that banks have to raise to fulfill regulatory capital requirements. As a result, the cost of fulfilling regulatory capital requirements decreases, and banks may be willing to bear this lower cost to avoid liquidation.

When deciding whether to relax regulatory accounting rules, the regulator compares the effect of inducing banks to raise additional capital on the expected transfer from the deposit insurance fund to depositors with the effect of bank liquidation. The effects depend on the maximum amount of equity banks are willing to raise to prevent liquidation and the expected proceeds in liquidation. If the wealth transfer from shareholders to insured depositors (debt overhang) is the only cost of raising equity for banks' shareholders, the regulator finds it optimal to always relax the regulatory accounting rules in a crisis if banks are not willing to raise the required capital implied by initial accounting rules. If the cost of raising equity increases due to additional distortions when raising capital in a systemic crisis, banks' maximum willingness to raise capital decreases. It may then no longer be optimal for the regulator to relax the regulatory accounting rules even though banks do not raise any equity in the case.

While relaxing regulatory accounting rules can be beneficial for the regulator in a systemic

crisis when regulatory enforcement is weak, our analysis does not suggest that it is optimal to implement laxer regulatory accounting rules in general. Relaxing regulatory accounting rules is tantamount to relaxing regulatory capital requirements for banks affected by the shock. However, the effect on banks that are not affected by the shock differs. Relaxing regulatory capital requirements allows unaffected banks to increase their leverage, unless the regulator can target reductions in regulatory capital requirements to affected banks. Relaxing specific accounting rules that apply to assets that deteriorate in value in the crisis allows for such a targeted relaxation of capital requirements.

In our model, anticipating that the regulator relaxes regulatory accounting rules in a systemic crisis does not distort ex ante incentives of banks. First, the optimal new regulatory accounting rules imply that banks are indifferent between raising the capital under the relaxed rules and not raising capital under the initial rules. Thus, even though the regulator benefits from relaxing regulatory accounting rules, banks do not. Second, relaxing the accounting rules does not aggravate the problem that the regulator cannot commit to enforcing regulatory capital requirements. Therefore, the distorting effect of the commitment problem on ex ante incentives remains unchanged.

In the main part of the paper, we focus on the positive effect that relaxing regulatory accounting rules can have on banks' incentives to raise capital. We discuss the implications of possible cost of implementing relaxed regulatory accounting rules in an extension.

We contribute to the literature on accounting changes in times of crises. Relaxing accounting rules in crises could be justified by a need to prevent contagion and procyclicality triggered or reinforced by accounting. See, for example, Cifuentes et al. (2005), Allen and Carletti (2008), Plantin et al. (2008), and Abad and Suarez (2018) for theoretical models that investigate such problems and which could motivate calls for accounting changes in a crisis. However, evidence that accounting rules indeed triggered and magnified problems is scarce.⁴ Other papers raise

⁴See, for example, Ryan, 2008, Laux and Leuz, 2010, Bhat et al., 2011, and Badertscher et al., 2012, for the possible role of fair value accounting in the crisis of 2007-2009.

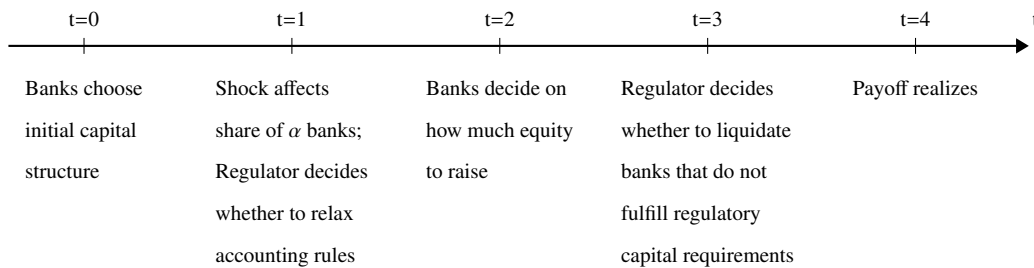
concerns that relaxing accounting rules is a form of regulatory forbearance and can delay banks' response to dealing with the crisis or have negative ex ante incentives (e.g., Ball, 2008; Skinner, 2008; Huizinga and Laeven, 2012; Paananen et al., 2012; Barnoussi et al., 2020). We investigate banks' incentives to raise capital to fulfill regulatory capital requirements and show that banks might be willing to raise capital after relaxing regulatory accounting rules, but not without the relaxation. While accounting changes are associated with forbearance, they can encourage undercapitalized banks to raise at least some capital when regulatory enforcement is too weak to induce banks to raise the amount necessary under the initial accounting rules. Indeed, Bischof et al. (2022) find that many banks supplement the reclassification of available for sale debt securities that preserves capital with real capital increases.

Our paper is also related to the literature on time inconsistency problems in bank regulation (e.g., Mailath and Mester, 1994; Freixas, 1999; Acharya and Yorulmazer, 2007; Bertomeu et al., 2022; Mahieux et al., 2022). These papers focus on the regulator's commitment problem in enforcing capital requirements and the implications for bank's risk-taking and lending behavior. Bertomeu et al. (2022) and Mahieux et al. (2022) investigate the effect of the regulatory commitment problem on banks' risk taking incentives and the implications for optimal regulatory accounting rules (loan loss provisioning) and capital requirements. We investigate the effect of the commitment problem on banks' incentives to recapitalize when incurring losses. In our model, we take the initial regulatory accounting rules as given and show that relaxing regulatory accounting rules as a reaction to a systemic crisis can reduce the cost of the commitment problem for the regulator.

2 Model

There is a continuum of banks with measure one, a regulator, depositors, and shareholders. All parties are risk neutral and the risk-free rate of return is normalized to zero. Banks act in the

interest of initial shareholders. Depositors are passive and fully insured. All parties are risk neutral and the risk-free rate of return is normalized to zero. There are five dates. At date 0, banks originate loans that they finance with insured deposits and equity. At date 1, a subset α of banks is hit by a shock that increases the default risk of the banks' loans. The regulator can relax the accounting rules. At date 2, banks decide how much capital they raise and publish their financial statements. At date 3, the regulator can liquidate banks that do not fulfill regulatory capital requirements. Banks that are not liquidated continue until date 4.



Bank assets and financing at date 0. At date 0, banks originate a loan portfolio (or purchase mortgage backed securities). The loan portfolio requires an initial investment of I and pays off R or zero at date 4. The a priori probability that assets pay R is given by $\mu \in (0, 1)$. We assume that $\mu R > I$ so that lending has positive value.

Banks can finance the loan portfolio (assets) with deposits D and equity $E_0 = I - D$. The equity market is competitive and the only difference between debt and equity is deposit insurance. We normalize the cost of deposit insurance for banks to zero.⁵ As a consequence, deposits are the preferred source of financing. However, banks have to fulfill a minimum regulatory capital ratio of $\gamma \in (0, 1)$, which limits the maximum amount of debt that banks can use to finance the loan portfolio. Without loss of generality, we assume that regulatory capital requirements are based on the initial investment I such that regulatory capital requirements imply $D \leq (1 - \gamma)I$. That is, the net present value of the loans, $\mu R - I$, does not count as regulatory capital. Banks

⁵Deposit insurance premiums are typically underpriced, thereby creating subsidies for banks (e.g., Lee et al., 2015).

have to fulfill the regulatory capital requirement to obtain a bank licence, which assures that banks choose $D \leq (1 - \gamma)I$ at date 0.

Bank shock and impairments at date 1. The share $\alpha \in [0, 1]$ of banks is hit by a shock. α has distribution $G(\alpha)$ and density $g(\alpha)$ and captures the type of shock that banks (the economy) incur(s). If α is close to zero, only a very small share of banks is affected, which resembles an idiosyncratic shock. As α increases, the share of affected banks increases, capturing the possibility of a systemic shock. The realization of α at date 1 is observable, but not verifiable. Thus, regulators and standard setters cannot condition regulatory accounting rules on the share of banks that incur a shock.

For banks that are hit by a shock (affected banks), the probability that assets pay R is given by $p < 1$, with $pR < I$. For unaffected banks, we normalize the probability that the loan portfolio pays R to one, i.e., the payoff of unaffected banks is certain. Thus, the a priori probability of R is given by $\mu = 1 - E[\alpha](1 - p)$.

Banks that incur a shock have to recognize an impairment loss, which reduces the bank's regulatory capital. We take the level of impairment under initial accounting rules as given and denote it by $x_0 \in [0, I - pR]$. For example, under an incurred loss model, x_0 may be close to zero if banks can argue that the shock is “temporary.” In contrast, under fair value accounting, banks have to write down the value of their assets to pR and, absent prudential filters, regulatory capital decreases by $x_0 = I - pR$.

Before the reporting date, the regulator can change regulatory accounting rules to reduce the impact of the shock on regulatory capital. For example, the regulator can introduce prudential filters that shield regulatory capital from unrealized fair value losses or delay the implementation of an expected loss model. We denote the (new) required impairment that is relevant for banks as $x \leq x_0$. Thus, $x < x_0$ if the regulator relaxes the regulatory accounting rules and $x = x_0$ if the regulator does not relax them.⁶

⁶We assume that it is not possible to tighten regulatory accounting rules in a crisis. Further, banks have to

Raising equity at date 2. Banks can raise equity $E_2 \in [0, D]$ at date 2 to reduce their leverage by repaying debt. The effect on the regulatory capital ratio is the same if banks holds the equity as cash, instead of repaying debt, and the regulatory capital requirement for holding cash is zero.

We assume that new shareholders apply a discount factor $\delta_\alpha \in (0, 1]$ when valuing the shares of a bank that wants to raise E_2 at date 2. $\delta_\alpha = 1$ for $\alpha = 0$ and δ_α is (weakly) decreasing in α to capture possible cost of raising equity in a systemic crisis.⁷

Enforcement of regulatory capital requirements at date 3. If affected banks do not fulfill the regulatory capital requirement at date 3, the regulator can initiate the resolution of the banks. We model bank resolution as a process where the regulator tries to sell (liquidate) the assets of an undercapitalized bank by searching for potential buyers among unaffected banks or hedge funds.⁸ As Shleifer and Vishny (1992) and Acharya and Yorulmazer (2008) point out, managing a bank's assets requires specific expertise, for example, in collecting claims from borrowers or in foreclosure. Further, geographic proximity affects the flow of soft information (Petersen and Rajan, 2002; Stein, 2002), which can affect a bidder's ability to manage another bank's loan portfolio after a purchase, and closer buyers may benefit from economies of scale or greater market power (Akkus et al., 2015). Indeed, Granja et al. (2017) find that failed banks are more likely to be acquired by nearby banks whose loan portfolios and services are more similar and argue that these buyers attach a higher value to the bank's assets.⁹ Thus, a buyer's willingness

implement the change in regulatory accounting rules introduced by the regulator. The results are the same if the regulatory accounting rule change involves a choice and no cost of implementation. In Section 6.2, we discuss implications of a regulatory accounting rule change if it is costly for banks to implement the change as suggested by, for example, Bischof et al. (2022) and Neisen and Schulte-Mattler (2021).

⁷Accounting rule changes can also affect δ_α if, for example, the reclassification of assets reduces transparency or is interpreted as negative signal by the market. The effect is similar to other costs of implementing accounting rule changes in a crisis, which we discuss in Section 6.2.

⁸Empirical evidence suggests that the sale of bank assets and mergers are frequently used in bank resolution. For example, the FDIC (2022) reports 532 banks that failed and were acquired by other banks since October 2000. See also Hoffman and Santomero (2008).

⁹Buyers' willingness to pay for the assets also depends on the opacity of the undercapitalized bank that is liquidated. Milgrom and Weber (1982) show that public information aligns the valuation of potential bidders and

to pay for a bank's assets depends on the specific expertise and geographic proximity.

We assume that the maximum price that potential buyers offer for a specific bank's assets is given by $s = \kappa pR$, with $\kappa \in [0, 1]$.¹⁰ The realizations of κ for individual banks are independently and identically distributed (iid), capturing the idiosyncratic component of finding a good match for a bank's assets. The distribution of κ depends on the number of potential buyers, which is directly related to the share of unaffected banks, $1 - \alpha$. The distribution is given by $F(\kappa|\alpha)$ and the density is $f(\kappa|\alpha)$. The distribution and density depend on the severity of the shock. A lower share of potential buyers (higher α) shifts the distribution to the left, reducing the expected price that the regulator can obtain when liquidating the assets. That is, $F(\kappa|\alpha_1) \leq F(\kappa|\alpha_2)$ for all κ and all $\alpha_1 < \alpha_2$, with strict inequality for some $\alpha_1 < \alpha_2$. An intuitive explanation for this assumption is that the smaller the share of potential buyers (unaffected banks), the lower is the probability of finding a buyer with the specific expertise that matches the bank's assets that the regulator wants to sell. This property is a characteristic of standard matching models (e.g., Pissarides, 1985; Mortensen and Pissarides, 1994).

We assume that shareholders receive nothing when a bank is liquidated and that all proceeds go to the deposit insurance fund. The assumption is without loss of generality and common in the literature (see, e.g., Bertomeu et al., 2022; Mahieux et al., 2022). We relax this assumption in section 6.1. Further, we assume that the regulator requires that the purchase of assets by another bank is financed with (sufficient) equity to assure that the purchase does not cause problems for the buyer.¹¹

reduces the fear of adverse selection, which increases their bids. Granja (2013) finds evidence that bank resolution costs are lower when banks are subject to higher disclosure requirements.

¹⁰ $\kappa > 1$ implies an offer price that exceeds the value of the assets under current bank management. Such an offer could arise if the buyer is better at collecting claims or the acquiring bank can expand its business, resulting in a higher franchise value in the spirit of Perotti and Suarez (2002). Allowing for $\kappa > 1$ does not change our conclusions.

¹¹The assumption is consistent with the requirement by the FDIC that the buyer must be well capitalized and have a CAMELS rating of 1 or 2. See Granja et al. (2017) for the requirements.

Regulator's objective. An important assumption in our model is that the regulator cannot commit to a specific resolution strategy *ex ante* (at date 0), but chooses the strategy that minimizes the expected transfer from the deposit insurance fund to depositors after a shock occurred. The assumption that the regulator cannot commit to liquidation is consistent with the observation that the Federal Reserve only sets capital requirements, but does not commit to any particular intervention measure.¹²

3 Analysis

3.1 Optimal resolution

We solve the model by backwards induction and start with the resolution decision of the regulator at date 3. If banks fulfill their regulatory capital requirement, the regulator is not allowed to intervene. If a bank violates the regulatory capital requirement, the regulator starts a resolution process, soliciting offers for the bank's assets. If the regulator accepts the maximum offer, the assets are sold at the price s . The regulator uses the proceeds from the sale to repay deposits. If $s < D - E_2$, the deposit insurance fund has to cover the difference. If $s > D - E_2$, the deposit insurance fund can use the difference to repay depositors of other banks. If the regulator does not accept the offer, the bank continues until date 4. In this case, the bank repays deposits if it has a payoff of R . If the bank's payoff is zero, the deposit insurance fund has to cover $D - E_2$. Thus, if the regulator does not liquidate the bank, the expected payment that the deposit insurance fund has to make is $(1 - p)(D - E_2)$.

The regulator accepts the offer s if $D - E_2 - s \leq (1 - p)(D - E_2)$. Rearranging terms yields the threshold $\hat{s} = p(D - E_2)$, such that the regulator accepts the offer if and only if $s \geq \hat{s}$. The

¹²See, for example, Dewatripont and Tirole (1994), Bertomeu et al. (2022), and Mahieux et al. (2022) for settings where the regulator cannot commit. The lack of commitment can be due to reputational concerns of regulators (Boot and Thakor, 1993; Morrison and White, 2013) or political pressure (Dewatripont and Tirole, 1994; Brown and Dinc, 2005).

following lemma directly follows from the discussion.

Lemma 1. *There exists a threshold $\hat{\kappa}_{E_2} = \frac{D-E_2}{R}$, such that the regulator accepts the offer $s = \kappa pR$ if $\kappa \geq \hat{\kappa}_{E_2}$ and rejects it otherwise.*

The probability of liquidating a bank that does not fulfill the regulatory capital requirement is given by $q(E_2) = 1 - F(\hat{\kappa}_{E_2}|\alpha)$ and decreases in the threshold $\hat{\kappa}_{E_2}$ and the share of affected banks α .

The threshold $\hat{\kappa}_{E_2}$ is determined by the bank's leverage ratio, defined as the market value of outstanding debt (absent deposit insurance) divided by the market value of assets, $\frac{p(D-E_2)}{pR}$. Thus, the lemma implies that a bank with a higher leverage ratio faces a lower probability of liquidation. Liquidating the bank at a price $s < D - E_2$, results in a payment obligation to the deposit insurance fund of $D - E_2 - s$, which increases by Δ if $D - E_2$ increases by Δ . If the regulator rejects the offer, the expected payment obligation is $(1 - p)(D - E_2)$, which increases by $(1 - p)\Delta$ if $D - E_2$ increases by Δ . The increase in the payment obligation is higher if the regulator liquidates the bank since the deposit insurance fund has to repay depositors with certainty, while the deposit insurance fund has to repay depositors only with probability $1 - p$ if the bank is allowed to continue. It becomes more attractive for the regulator to gamble on bank recovery as $D - E_2$ increases. In contrast, a higher asset value pR increases the price at which the regulator can sell, making it more likely that liquidation is optimal. The regulator is indifferent between liquidation and continuation if $s = \hat{\kappa}_{E_2} pR$.

The probability that the regulator accepts the offer and liquidates the bank also decreases in the share of affected banks α . The reason is that it is more difficult to find a suitable buyer, which increases the probability that the maximum price is below the threshold that the regulator is willing to accept ($\partial F(\hat{\kappa}_{E_2}|\alpha)/\partial \alpha \geq 0$). Thus, regulatory enforcement weakens in case of a systemic shock and if banks have higher leverage ratios.

3.2 Optimal E_2

An unaffected bank fulfills its regulatory capital requirement and has no reason to raise additional capital. Whether an affected bank continues to fulfill the regulatory capital requirement after the shock depends on its initial debt level D and level of required impairment x given the effective accounting rules at date 2. An affected bank continues to fulfill its regulatory capital requirement if $D \leq (1 - \gamma)(I - x)$. In contrast, if $D > (1 - \gamma)(I - x)$, the bank violates the capital requirement. The minimum amount of equity that an affected bank has to raise to fulfill its regulatory capital requirement is given by

$$C = \max\{0, D - (1 - \gamma)(I - x)\}. \quad (1)$$

An affected bank chooses the level of equity E_2 that maximizes the expected payoff to initial shareholders, offering new shareholders a share θ of the bank's equity.

The bank's optimization problem is given by

$$\max_{E_2, \theta} (1 - \theta)(1 - q(E_2))p(R + E_2 - D), \quad (2)$$

subject to

$$q(E_2) = \begin{cases} 0 & \text{if } E_2 \geq C \\ 1 - F(\hat{k}_{E_2}|\alpha) & \text{otherwise} \end{cases} \quad (3)$$

$$E_2 \leq \theta \delta_\alpha (1 - q(E_2))p(R + E_2 - D) \quad (4)$$

$$E_2 \leq E_2^m = \frac{\delta_\alpha p}{1 - \delta_\alpha p} (R - D). \quad (5)$$

The probability of liquidation, $q(E_2)$, is zero if the bank fulfills its regulatory capital requirement (i.e., if $E_2 \geq C$). (4) is the participation constraint of new shareholders. The expected cash flow to total equity if the regulator does not liquidate the bank is $p(R + E_2 - D)$, and new

shareholders apply a discount factor δ_α . If the regulator liquidates the bank, the value of equity is zero. The value of equity is also zero if the payoff of the bank's assets is zero.

(5) is the feasibility constraint, where E_2^m is the maximum amount of equity the bank can raise to fulfill the regulatory capital requirement given the outstanding deposits D and discount factor δ_α that new shareholders apply in a crisis. To raise this amount, the bank has to pledge all equity to new shareholders, i.e., $\theta = 1$.

We first investigate the relaxed optimization problem, ignoring the feasibility constraint (5). In equilibrium, the participation constraint (4) is binding and the expected payoff to initial shareholders equals

$$(1 - q(E_2))p(R + E_2 - D) - \frac{1}{\delta_\alpha}E_2. \quad (6)$$

There are three effects of raising E_2 . The first effect is the wealth transfer from initial shareholders to depositors (the deposit insurance fund), which is strictly increasing in E_2 . The second effect is the cost of issuing equity in the crisis when new shareholders discount future expected cash flows with $\delta_\alpha < 1$. This cost is absent for $\delta_\alpha = 1$. The third effect is the change in the likelihood of liquidation. Given these effects, it is not optimal to choose $E_2 > C$. $E_2 \in (0, C)$ cannot be optimal either since a marginal increase in E_2 increases the probability of liquidation for $E_2 < C$ (Lemma 1). The following lemma directly follows from the discussion.

Lemma 2. *An affected bank either raises no equity or just sufficient equity to satisfy the capital requirement, i.e., $E_2^* \in \{0, C\}$.*

If the bank does not raise any equity, it faces a positive probability of liquidation $q(0) > 0$ and (6) is given by $(1 - q(0))p(R - D)$. If the bank raises C , the liquidation probability $q(C)$ is zero and (6) is given by $p(R + C - D) - \frac{1}{\delta_\alpha}C$. Thus, $E_2^* = C$ if

$$\left(\frac{1}{\delta_\alpha} - p\right)C \leq q(0)p(R - D). \quad (7)$$

The left hand side is the bank's cost of recapitalization, which stems from the wealth transfer

to depositors (the deposit insurance fund) and a discount factor $\delta_\alpha < 1$. The right hand side is the benefit of recapitalization, which stems from preventing a possible liquidation of the bank.

Lemma 3. *The maximum amount of equity that a bank is willing to raise to fulfill its regulatory capital requirement is given by*

$$\bar{C} = q(0) \frac{\delta_\alpha p}{1 - \delta_\alpha p} (R - D) \quad (8)$$

with $\bar{C} \leq E_2^m$. \bar{C} increases in p , R , and δ , and it decreases in D and α .

\bar{C} is the capital shortfall for which (7) is binding and thus defines the maximum amount of capital that a bank is willing to raise to fulfill its regulatory capital requirement. Thus, if $C \leq \bar{C}$, the bank raises the required capital to prevent liquidation and $E_2^* = C$. If $C > \bar{C}$, the bank prefers to risk liquidation and choose $E_2^* = 0$.

Comparing (8) with (5) shows that \bar{C} is strictly lower than E_2^m if enforcement is not strict (i.e., if $q(0) < 1$) and equal to E_2^m if enforcement is strict ($q(0) = 1$). Thus, the binding constraint when a solvent bank decides to raise capital is generally its willingness to raise capital, not its ability: The bank's willingness to raise C implies that it is feasible to raise the required amount and the solution to the relaxed optimization problem is a solution to the overall problem. The wedge between the bank's ability and its willingness to raise funds arises due to the regulator's commitment problem. \bar{C} increases in the probability of liquidation $q(0)$, which is negatively related to the share of affected banks α in a crisis.

The bank's ability and willingness to raise capital depend on the terms at which the bank can raise equity, δ_α , which also depends on the share of affected banks α . The higher δ_α , the lower are the cost of raising equity, making recapitalization advantageous for a larger range of C . We can state the following proposition, which directly follows from the discussion above.

Proposition 1. *There exists a threshold $\bar{\delta}(C) > 0$ for which $\bar{C} = C$:*

$$\bar{\delta}(C) = \frac{C}{q(0)p(R - D) + pC}, \quad (9)$$

such that the bank raises capital $E_2^ = C$ to fulfill the regulatory capital requirement if $\delta_\alpha \geq \bar{\delta}(C)$ and does not raise any capital ($E_2^* = 0$) if $\delta_\alpha < \bar{\delta}(C)$. $\bar{\delta}(C)$ decreases in p , R , and it increases in D and α .*

3.3 Optimal C

The regulator can relax the regulatory accounting rules, choosing $x \in [0, x_0]$ to reduce affected banks' capital shortfall. Under the initial accounting rules in place before the shock, an affected bank has to raise at least

$$C_0 = \max\{0, D - (1 - \gamma)(I - x_0)\} \quad (10)$$

to fulfill its regulatory capital requirement. By choosing $x \in [0, x_0]$, the regulator de facto chooses $C \in [0, C_0]$.

When deciding about the optimal level of C , the regulator takes into account the subsequent decision by banks and has rational expectations about \bar{C} . There are two cases. First, if $C \leq \bar{C}$, banks raise capital C and the cost to the deposit insurance fund is given by $\alpha(1 - p)(D - C)$. Second, if $C > \bar{C}$, banks do not raise capital and the regulator starts a resolution process at date 2. The expected cost to the deposit insurance fund in case of resolution depends on the density $f(\kappa|\alpha)$ that determines how high possible offers for banks' assets will be. The regulator accepts an offer if $\kappa \geq \hat{\kappa}_{E_2}$ (Lemma 1). Since banks choose $E_2^* = 0$ when deciding not to fulfill regulatory capital requirements (Lemma 2), we can drop the index and define $\hat{\kappa} \equiv \hat{\kappa}_{E_2=0}$ in what follows. Given the optimal liquidation policy of the regulator, a share $F(\hat{\kappa}|\alpha)$ of affected banks will not be liquidated because the offer price is too low. Thus, the regulator's optimization problem is

given by

$$\min_{C \in [0, C_0]} \mathbb{1}_{C \leq \bar{C}} \alpha(1-p)(D-C) + \mathbb{1}_{C > \bar{C}} \left(\alpha F(\hat{\kappa}|\alpha)(1-p)D + \int_{\hat{\kappa}}^1 \alpha(D - \kappa p R) f(\kappa|\alpha) d\kappa \right). \quad (11)$$

The following proposition characterizes the optimal decision of the regulator.

Proposition 2. *The regulator relaxes regulatory accounting rules and chooses $C^* = \bar{C}$ if the following two conditions are both satisfied: (i) $\bar{C} < C_0$ and (ii)*

$$\bar{C} \geq \hat{C} = \frac{p}{1-p} \int_{\hat{\kappa}}^1 (\kappa R - D) f(\kappa|\alpha) d\kappa. \quad (12)$$

If these conditions are not satisfied, the regulator does not relax regulatory accounting rules and chooses $C^ = C_0$. \hat{C} increases in p and R and decreases in D and α .*

Two conditions have to be satisfied for the regulator to be willing to relax regulatory accounting rules. First, banks are not willing to recapitalize under prevailing accounting rules, which is captured by condition (i). Otherwise, if $C_0 \leq \bar{C}$, the regulator is able to enforce $C = C_0$. In this case, it is not optimal for the regulator to relax the accounting rules.

Second, the maximum amount of equity that banks are willing to raise to prevent intervention must be sufficiently high, which is captured by condition (ii). Since the cost to the deposit insurance fund is decreasing in C , it is optimal for the regulator to choose $C = \bar{C}$ when relaxing regulatory accounting rules. The regulator relaxes the accounting rules if the expected cost to the deposit insurance fund is lower when banks raise \bar{C} than under resolution:

$$\alpha(1-p)(D - \bar{C}) \leq \alpha F(\hat{\kappa}|\alpha)(1-p)D + \int_{\hat{\kappa}}^1 \alpha(D - \kappa p R) f(\kappa|\alpha) d\kappa. \quad (13)$$

Rearranging terms yields

$$(1-p)\bar{C} \geq \int_{\hat{\kappa}}^1 (\kappa p R - pD) f(\kappa|\alpha) d\kappa, \quad (14)$$

which directly leads to (12). The regulator trades off the reduction in the expected cost to the deposit insurance fund if banks raise \bar{C} and the expected benefit of collecting funds in the resolution process from the sale of assets exceeding the market value of debt.

The threshold \hat{C} increases in p and R . A higher p implies that it is less likely that the deposit insurance fund benefits from the additional equity that the bank raises to reduce its debt level. At the same time, the bank's assets are more valuable and the expected sales proceeds in the resolution process increase. Therefore, the regulator is less willing to relax regulatory accounting rules if p and R increase. An increase in the level of debt D reduces the threshold \hat{C} since an increase in D makes it more attractive for the regulator to hope for recovery of the bank and reducing the level of debt reduces the cost to the deposit insurance fund if the bank defaults. An increase in α also reduces \hat{C} since a larger share of affected banks reduces the expected sales proceeds in the resolution process. Consequently, the regulator's benefit of resolution decreases and the regulator is more willing to relax the regulatory accounting rules.

Substituting (8) into (12) yields

$$\frac{\delta_\alpha p}{1 - \delta_\alpha p} \int_{\bar{\kappa}}^1 (R - D) f(\kappa|\alpha) d\kappa \geq \frac{p}{1 - p} \int_{\bar{\kappa}}^1 (\kappa R - D) f(\kappa|\alpha) d\kappa, \quad (15)$$

which is always satisfied for $\delta_\alpha = 1$, since $\kappa \leq 1$. As \bar{C} is strictly decreasing when δ_α decreases and reaches zero for $\delta_\alpha = 0$, there exists a threshold $\hat{\delta}$ such that (15) holds with equality for $\delta_\alpha = \hat{\delta}$ and is not satisfied for $\delta_\alpha < \hat{\delta}$. We summarize the role of δ_α in the following proposition.

Proposition 3. *Assume that $\bar{C} < C_0$ so that affected banks do not raise the required capital to fulfill regulatory capital requirements under the prevailing regulatory accounting rules. There exists a threshold $\hat{\delta} < 1$, such that (15) holds with equality and*

(i) $\delta_\alpha \geq \hat{\delta}$ implies $\bar{C} \geq \hat{C}$, and it is optimal for the regulator to relax regulatory accounting rules so that affected banks raise $C = \bar{C}$.

(ii) $\delta_\alpha < \hat{\delta}$ implies $\bar{C} < \hat{C}$; the regulator does not relax regulatory accounting rules, and

banks do not raise any capital.

$\hat{\delta}$ is (weakly) decreasing in α .

An interesting implication of the proposition is that the regulator is less willing to relax regulatory accounting rules if it is more costly for banks to raise capital because of a lower δ_α . A driving force of the decision to relax regulatory accounting rules instead of liquidating undercapitalized banks is that the expected sales proceeds are lower than the expected payoff of the assets under the management of the current bank. If the loss in liquidation is the only friction ($\delta_\alpha = 1$), it is strictly optimal to relax regulatory accounting rules and induce banks to raise capital if $\bar{C} < C_0$.

Illustration We illustrate the optimal actions in Figure 1, assuming that κ is uniformly distributed with the lower limit depending on the severity of the shock α , i.e., $\kappa \sim \mathcal{U}(1 - \alpha, 1)$.

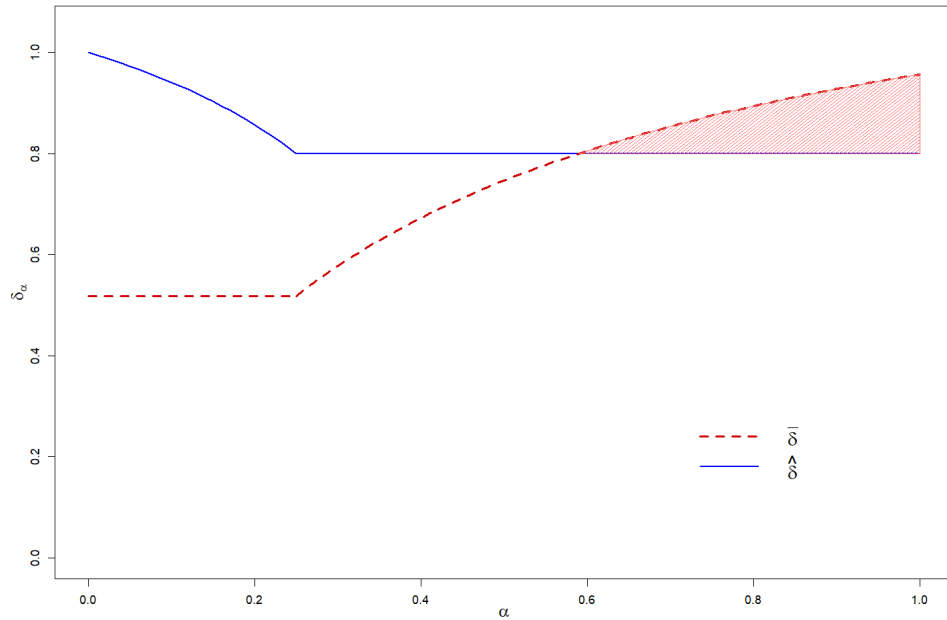


Figure 1: The figure depicts $\bar{\delta}$ and $\hat{\delta}$ for $I = 1, R = 1.1, p = 0.75, D = 0.825, \gamma = 0.175$.

The dashed red line is the threshold $\bar{\delta}(C_0)$ in Proposition 1 for which $\bar{C} = C_0$ if the regulator

does not relax regulatory accounting rules such that $C = C_0$. To simplify the notation, we define $\bar{\delta} \equiv \bar{\delta}(C_0)$. For combinations of (δ_α, α) that lie above this line, $\bar{C} > C_0$, and the bank finds it optimal to raise capital C_0 . The regulator will never relax regulator accounting rules in this region. For combinations of (δ_α, α) that lie below this line, $\bar{C} < C_0$ and the bank does not raise any capital given prevailing accounting rules.

The dashed red line is weakly increasing in α . For small α , the probability of liquidation is 1 if the bank does not fulfill its regulatory capital requirement, and $\bar{\delta}$ is independent of α in this case. For larger α the probability of liquidation decreases in α , which reduces the bank's willingness to raise capital, and the threshold $\bar{\delta}$ for which $\bar{C} = C_0$ is increasing.

The solid blue line is the threshold $\hat{\delta}$ in Proposition 3 for which $\bar{C} = \hat{C}$. For combinations of (δ_α, α) that lie above this line, $\bar{C} > \hat{C}$ and the regulator finds it optimal to relax the accounting rules if $\bar{C} < C_0$. For combinations of (δ_α, α) that lie below this line, $\bar{C} < \hat{C}$ and the regulator does not find it optimal to relax the accounting rules.

The shaded area highlights all (δ_α, α) -combinations for which the regulator is willing to relax regulatory accounting rules such that banks only have to raise \bar{C} .

3.4 Optimal D

At date 0, taking into account the implications of a possible shock at date 1 and subsequent optimal decisions by the regulator and the bank, the value of equity is given by

$$V = \int_0^1 \left((1 - \alpha)(R - D) + \alpha \left[\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(p(R - D) - \left(\frac{1}{\bar{\delta}_\alpha} - p \right) C_0 \right) + \mathbb{1}_{\delta_\alpha < \bar{\delta}} (1 - q(0)) p(R - D) \right] \right) g(\alpha) d\alpha, \quad (16)$$

with $\bar{\delta} \equiv \bar{\delta}(C_0)$ to simplify the notation (see Proposition 1).

Conditional on a shock α , a bank does not incur a loss with probability $1 - \alpha$ and the equity value is $R - D$. With probability α , the bank incurs a loss. In this case, the expected value of

equity depends on the cost of refinancing δ_α . If $\delta_\alpha \geq \bar{\delta}$, the bank raises C_0 to fulfill its regulatory capital requirement. Otherwise, if $\delta_\alpha < \bar{\delta}$, the bank does not raise C_0 . In this case, the expected value of equity is $(1 - q(0))p(R - D)$. Note that the bank's expected payoff does not depend on whether the regulator relaxes the regulatory accounting rule. The reason is that the regulator sets the new accounting rules such that the bank is indifferent between raising capital to fulfill the regulatory capital requirement given the new accounting rules and not raising any capital. Thus, the expected payoff is equivalent in both cases.

The bank chooses the optimal level of debt D to maximize the value of the bank to initial shareholders:

$$\max_D [V - E_0] \quad (17)$$

subject to

$$D \leq (1 - \gamma)I \quad (18)$$

$$E_0 = I - D \quad (19)$$

$$V - E_0 \geq 0 \quad (20)$$

Conditions (18) and (19) are the regulatory capital and budget constraints at date 0, respectively. Condition (20) is the participation constraint of initial shareholders.

Substituting (16) and (19) into the objective function and rearranging terms (see Appendix) yields

$$V - E_0 = \mu R - I + (1 - \mu)D - \int_0^1 \alpha \left[\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(\frac{1}{\delta_\alpha} - p \right) C_0 + \mathbb{1}_{\delta_\alpha < \bar{\delta}} q(0) p(R - D) \right] g(\alpha) d\alpha. \quad (21)$$

If the bank does not use any debt, the shareholder value is given by the net present value of investing in the loan portfolio, $\mu R - I$. The benefit of debt stems from the value of deposit insurance, which is given by $(1 - \mu)D$. The cost of using debt stems from the possibility that a shock to the economy can result in a violation of the regulatory capital requirement, which

is the term in the integral. There are two possibilities. First, if the bank raises C_0 to fulfill its regulatory capital requirement (i.e., if $\delta_\alpha \geq \bar{\delta}$), shareholders incur the cost of raising capital in a crisis and a reduction in the value of deposit insurance. Second, if the bank does not raise C_0 (i.e., if $\delta_\alpha < \bar{\delta}$), shareholders bear a cost that equals the expected loss of the continuation value from liquidation, $q(0)p(R-D)$, irrespective of whether the regulator relaxes the accounting rules or not.

The bank trades off these costs and benefits when choosing D . Since the bank can choose $D = 0$ and $\mu R - I > 0$, the participation constraint (20) is satisfied. To discuss the determinants of the optimal level of D at date 0, we first note that it is strictly optimal for the bank to choose $D \geq (1 - \gamma)(I - x_0)$: For $D < (1 - \gamma)(I - x_0)$, $C_0 = 0$ and the bank does not have to raise capital after a shock. Thus, only the positive effect of debt exists and it is optimal to increase debt. The first-order condition (FOC) for the optimal choice of $D \geq (1 - \gamma)(I - x_0)$ is given by

$$\frac{\partial(V - E_0)}{\partial D} = E[\alpha](1 - p) - \int_0^1 \alpha \left(\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(\frac{1}{\delta_\alpha} - p \right) - \mathbb{1}_{\delta_\alpha < \bar{\delta}} \left(pq(0) - \frac{\partial q(0)}{\partial D} p(R - D) \right) \right) g(\alpha) d\alpha. \quad (22)$$

The first term is the marginal benefit of deposit insurance, using $\mu = 1 - E[\alpha](1 - p)$. The integral captures the expected marginal effect of debt on shareholder value, stemming from a violation of the regulatory capital requirement under initial accounting rules when incurring a shock. If the bank raises C_0 after a shock, an ex-ante increase in D increases the cost of raising capital in a crisis (if $\delta_\alpha < 1$) and results in the loss of the marginal benefit of deposit insurance. In contrast, if the bank does not raise C_0 after a shock, a marginal increase in debt increases shareholder value. First, a higher D reduces the shareholders' loss in the case of liquidation. Second, the regulator is less likely to liquidate an undercapitalized bank if D increases ($\partial q(0)/\partial D < 0$).¹³ We now turn to four specific cases to develop the intuition for the

¹³The effect of a marginal increase in D on the boundaries of the indicator function is zero. The reason is that at the threshold $\bar{\delta}$, the cost of raising C_0 equals the expected loss when raising no capital.

determinants of the optimal choice of D .

No distortion when raising capital at date 2. If $\delta_\alpha = 1$ for all possible realizations of α , the FOC reduces to

$$\frac{\partial(V - E_0)}{\partial D} = \int_0^1 \alpha \left(\mathbb{1}_{1 < \bar{\delta}} \left(1 - p + pq(0) - \frac{\partial q(0)}{\partial D} p(R - D) \right) \right) g(\alpha) d\alpha. \quad (23)$$

Since $\partial q(0)/\partial D < 0$, the FOC is non-negative and it is optimal for a bank to choose maximum leverage, $D = (1 - \gamma)I$. If, for $D = (1 - \gamma)I$, $1 \geq \bar{\delta}$ for all possible realizations of α , banks raise C_0 when incurring a shock and the marginal benefit of increasing debt beyond $C_0 = 0$ at date 0 is zero. However, when $\delta_\alpha = 1$ for all α , a bank is indifferent between holding a capital buffer at date 0 and raising equity after a shock. If, for $D = (1 - \gamma)I$, $1 < \bar{\delta}$ for some possible realizations of α , the FOC is positive at $D = (1 - \gamma)I$ and it is strictly optimal to choose the maximum leverage allowed by the regulatory capital constraint at date 0. In this case, the benefit of increased debt stems from higher deposit insurance, a lower stake in case of liquidation, and weaker enforcement.

No regulatory enforcement. The bank also chooses maximum leverage if the regulator never enforces regulatory capital requirements, i.e., if $q(0) = 0$. This case arises if $F\left(\frac{(1-\gamma)I}{R}|\alpha\right) = 1$ so that the regulator never receives an offer for which it is optimal to liquidate the bank. For $q(0) = 0$, $\bar{\delta} = \frac{C_0}{pC_0} = \frac{1}{p} \geq 1$. Thus, $\delta_\alpha < \bar{\delta}$ for all α and the bank never raises C_0 . The FOC reduces to

$$\frac{\partial(V - E_0)}{\partial D} = E[\alpha](1 - p), \quad (24)$$

and the only effect that remains is the marginal benefit of deposit insurance. The bank optimally chooses maximum leverage.

Perfect regulatory enforcement. If the regulator could commit to liquidating an undercap-

italized bank, i.e., $q(0) = 1$, the effect of D on $q(0)$ disappears and the FOC reduces to

$$\frac{\partial(V - E_0)}{\partial D} = \int_0^1 \alpha \left(1 - \mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \frac{1}{\delta_\alpha} \right) g(\alpha) d\alpha. \quad (25)$$

A bank may now hold a regulatory capital buffer if it is sufficiently likely that it raises C_0 after a shock and the cost of raising capital in these states is sufficiently high (i.e., if δ_α is sufficiently low). With commitment, leverage no longer affects the probability of liquidation ($\partial q(0)/\partial D = 0$), and the marginal benefit of higher leverage decreases. Thus, with commitment, it becomes more likely that the bank is willing to hold a buffer.

Banks always recapitalize after a shock. If $\delta_\alpha \geq \bar{\delta}$ for all α , an affected bank always raises the necessary capital to fulfill the initial regulatory capital requirement. If, in addition, $\delta_\alpha < 1$ for some α , it is strictly optimal to choose $D = (1 - \gamma)(I - x_0)$. That is, the bank holds a buffer at date 0 to cover the possible regulatory accounting loss x_0 since raising capital at date 0 is less costly than in a crisis. Further, since the bank is always willing to raise the capital, it loses the benefit of deposit insurance for the amount C_0 anyway. However, given the remaining benefit of deposit insurance, the bank does not choose a buffer above $(1 - \gamma)x_0$.

4 Implications

Initial accounting rules. The level of impairment x_0 plays an important role for banks' ex ante leverage choice. Absent impairments that reduce regulatory capital, the bank does not hold a regulatory capital buffer because the bank does not violate the capital requirement in a crisis and never faces a cost of raising capital at a discount. If the probability that the bank is willing to raise capital in a crisis is very high, because x_0 and thus C_0 are relatively low, a bank might want to hold a capital buffer ex ante in order to avoid raising capital at a discount in crisis times. As long as the bank is willing to hold a buffer, the buffer increases in the required impairment as the amount that the bank has to raise to fulfill its regulatory capital requirement increases.

However, a higher impairment makes it more likely that the bank does not raise the required amount in a crisis, i.e., that $\bar{C} < C_0$. In both cases, the bank's equity value depends on the regulatory enforcement strength $q(0)$. As the regulator is less willing to liquidate the bank if the bank is more leveraged ($\partial q(0)/\partial D < 0$), the bank strategically increases leverage to reduce regulatory enforcement, which increases the equity value. Thus, with stricter accounting rules that increase the impairment, a bank might be less willing to hold a capital buffer ex-ante.

Systemic crisis versus idiosyncratic shocks. We show that it can be optimal for the regulator to suspend an expected loss model or introduce prudential filters that shield banks' regulatory capital from increasing credit risk. Our model does not suggest that these regulatory interventions are generally beneficial, or that it is generally optimal to shield banks' regulatory capital from expected credit losses or fair value changes. The benefit arises when regulatory enforcement is weak (low $q(0)$) and/or cost of raising equity are high (low δ_α). Both of these conditions are more likely met in a systemic shock, when α is high. Macroprudential regulation has to take into account that it might not be optimal to enforce these rules ex post. Enforcement of regulatory capital requirements after a systemic shock is a key challenge in macroprudential regulation, in addition to potentially high cost of raising equity that banks face. Regulatory accounting rules that are less strict in a systemic crisis compared to normal times can be an optimal response to the problem that the regulator cannot commit to enforce regulatory capital requirements in a crisis under stricter accounting rules.

Ex ante incentives. Relaxing regulatory accounting rules in a systemic crisis might raise concerns that it creates negative ex ante incentives. For example, as Acharya and Yorulmazer (2007) point out, weakened regulatory enforcement (regulatory forbearance) in a systemic crisis can increase banks' incentive to invest in correlated assets ex ante, which can increase the probability of systemic shocks.

In our model, the regulator faces a commitment problem and may not liquidate an under-

capitalized bank. The regulator's weakened incentives to intervene if a systemic shock hits a sufficiently large number of banks, reduces undercapitalized banks' incentive to recapitalize to fulfill regulatory capital requirements and, at the same time, can create ex ante incentives to take on correlated assets, as in Acharya and Yorulmazer (2007).

A relaxation of regulatory accounting rules is a response to this commitment problem. If the regulator can set the new regulatory accounting rules optimally such that banks are indifferent between raising capital and not raising capital, relaxing regulatory accounting rules does not involve additional ex ante incentives beyond those that stem from the initial commitment problem. The reason is that, while affected banks do benefit from the commitment problem, they do not benefit from the relaxed regulatory accounting rules in our model. For the same reason, the decision to relax regulatory accounting rules in a crisis also does not affect bank's ex-ante incentive to hold a capital buffer. This incentive is again only influenced by the commitment problem and the effect of debt on the commitment problem, not the relaxation of regulatory accounting rules. To improve banks' ex ante incentives, it is important to address the commitment problem.

5 Comparison to alternative mechanisms

5.1 Relaxing regulatory capital requirements

Instead of adjusting the regulatory accounting rules that determine how changes in credit risk and unrealized losses affect regulatory capital, the regulator can directly change the regulatory capital requirements. In our model, this amounts to reducing γ , which also reduces the regulatory capital shortfall C and thus the required capital that affected banks have to raise. An important difference is that reducing γ relaxes the regulatory capital requirement for all banks, not just for affected ones. Banks that are not affected by the shock can take advantage of the relaxed capital requirement and pay out capital to shareholders, which increases their leverage.

The regulator can limit such payouts by restricting dividends and repurchases. The regulator could also choose more specific changes in the regulatory capital requirement. One example is to reduce the weight of high-risk assets when calculating risk weighted assets. Still, in this case, unaffected banks that hold high-risk assets that the shock did not affect also experience a drop in regulatory capital requirement. Moreover, changing risk weights does not help with respect to standard leverage constraints.

Changing regulatory accounting rules directly affects the calculation of regulatory capital, which enters different definitions of regulatory capital ratios. Moreover, depending on the specific changes in the accounting rules, unaffected bank may not benefit from the change. For example, if the regulator introduces prudential filters that shield regulatory capital from fair value losses of available for sale debt securities, banks benefit only if they hold available for sale debt securities that deteriorate in value. Similarly, if the regulator suspends the expected loss model and allows banks to work with weakened assumptions to reduce the impact of changes in expected losses on regulatory capital, banks do no benefit unless they have a loan portfolio for which the credit risk (expected loss) increases.

Another difference is that accounting rules affecting regulatory capital are potentially easier and quicker to change than regulatory capital requirements. Further, accounting changes might be easier to justify in public, as the debate on the role of fair value accounting in 2008 and the implementation of the expected loss model in the COVID crisis suggest. There was immediately broad support for a change in the rules, although the potential consequences had not yet been analysed in detail (e.g., Fiechter, 2011; Meeks and Luetkemeyer, 2020).

5.2 Nationalization and public funds

Nationalization. An alternative to selling the assets of an undercapitalized bank is a nationalization of the bank. A key difference between a nationalization and an asset sale is that the regulator immediately gets the sales proceeds and uses them to repay deposits. In the case of

a nationalization, the bank continues to operate and payoffs from assets are used to repay deposits at maturity. Whether a nationalization is better than relaxing regulatory accounting rules to induce banks to raise capital or a liquidation/forbearance, depends on the costs and benefit of a nationalization.

For example, ownership in a profitable bank could allow the regulator to steer funds in activities that create a social benefit (Elliott, 2009). In our setting, the benefit could involve using these funds to repay depositors of banks that fail. However, in many countries, a nationalization of banks is no option for regulators as it can also involve high costs (see, e.g., La Porta et al., 2002; Elliott, 2009; Brown and Dinc, 2011). In particular, the regulator might not have enough capacity to manage the assets and hiring and incentivizing management can be difficult for a nationalized bank. There can also be strong political opposition against a nationalization of banks.

Public funds. The regulator can also provide banks with the capital they need to fulfill regulatory capital requirements. There are two alternatives. First, the public funds are not voluntary. In this case, the regulator could inject public funds at punitive conditions to create an off-equilibrium threat for banks and to provide incentives to recapitalize. Such a recapitalization, however, would be tantamount to (partial) nationalization (e.g., Elliott 2009), and the arguments above apply.

Second, taking on the public funds is voluntary, such as, for example, in the case of TARP funds. Of course, the regulator can put pressure on banks to take the funds, but the maximum threat is still to liquidate the bank. Thus, the pressure that the regulator can exert is the same as in the case of a recapitalization in the capital market. Therefore, the question is whether the regulator can induce banks to raise more capital when providing public funds and whether it is optimal for the regulator to offer public funds. If the regulator provides funds at the same terms as the capital market, the maximum amount a bank is willing to raise is \bar{C} . Banks are then indifferent between public and private funds. If public funds are offered at better terms, i.e., if

the regulator applies a lower discount than the market, banks are willing to raise more capital as \bar{C} is increasing in δ_α . For example, the regulator might be better at providing liquidity than the market (e.g., Gorton and Huang, 2004). If the regulator offers public funds at favorable terms compared to private funds, the accounting rules can be relaxed by less, or do not need to be relaxed at all.

6 Extensions

6.1 Shareholder receive part of the liquidation proceeds

If shareholders of affected banks get the proceeds from asset sales in the resolution process that exceed the claim of depositors, i.e., $s - D$ if $s > D$, it has two effects, which we derive formally in the Appendix.

First, liquidation is now less costly for shareholders. As a consequence, undercapitalized banks' incentive to raise capital decreases. The maximum amount a bank is willing to raise if shareholders receive the liquidation proceeds in excess of D is now given by

$$\bar{C}_s = \bar{C} - \frac{\delta_\alpha}{1 - \delta_\alpha p} \int_{D/pR}^1 (\kappa p R - D) f(\kappa|\alpha) d\kappa < \bar{C}. \quad (26)$$

Second, the amount that the regulator receives in liquidation decreases. The threshold \hat{C}_s below which the regulator does not relax regulatory accounting rules is now given by

$$\hat{C}_s = \hat{C} - \frac{1}{1 - p} \int_{D/pR}^1 (\kappa p R - D) f(\kappa|\alpha) d\kappa < \hat{C}. \quad (27)$$

It is optimal for the regulator to relax the regulatory accounting rules if $\bar{C}_s \geq \hat{C}_s$. Substituting

(26) and (27) in this condition, we obtain

$$\bar{C} \geq \hat{C} - \Delta \int_{D/pR}^1 (\kappa pR - D) f(\kappa|\alpha) d\kappa, \quad (28)$$

with $\Delta = \frac{1}{1-p} - \frac{\delta_\alpha}{1-\delta_\alpha p} \geq 0$. $\Delta \int_{D/pR}^1 (\kappa pR - D) f(\kappa|\alpha) d\kappa$ captures the difference between the second effect (on \hat{C}) and the first effect (on \bar{C}) when shareholders receive the sales proceeds in excess of D .

For $\delta_\alpha = 1$, the two effects are equal and $\Delta = 0$. Thus, (28) is equivalent to $\bar{C} \geq \hat{C}$, which is always satisfied for $\delta_\alpha = 1$, as shown in Proposition 3. While the regulator still benefits from relaxing the regulatory accounting rules, the benefit is lower as banks are only willing to raise a lower amount of capital.

As δ_α decreases, Δ increases. The reason is that a decrease in δ_α does not change the effect on \hat{C} . However, the effect on \bar{C} decreases. Intuitively, a decrease in δ_α already reduces the maximum amount of capital that shareholders are willing to raise, \bar{C} , if shareholders do not receive the sales proceeds in excess of D . As a consequence, compared to \bar{C} , the negative incentive effect of receiving the sales proceeds in excess of D is lower if δ_α is lower.

For $\delta_\alpha = \hat{\delta}$, $\bar{C} = \hat{C}$ and $\Delta > 0$. Thus, the left hand side of (28) is strictly larger than the right hand side, and it is strictly optimal for the regulator to relax regulatory accounting rules for $\delta_\alpha = \hat{\delta}$ if shareholders receive part of the sales proceeds. Hence, the threshold $\hat{\delta}_s$ that determines whether it is optimal for the regulator to relax the regulatory capital requirement given the liquidity discount δ_α in the market is strictly lower than the one in Proposition 3.

The realized liquidation proceeds generally also depend on bargaining between the regulator and the buyer. If the regulator receives all proceeds for the deposit insurance funds, the incentives to increase κ are unambiguously strong. In contrast, if the proceeds in excess of deposits go to the bank's shareholders, the regulator does not have a strong incentive to bargain for prices exceeding the claim of deposits. Weak incentives are consistent with evidence that liqui-

liquidation proceeds in excess of liabilities are close to zero (e.g., Walter, 2004). Our model predicts that low liquidation proceeds should occur more often in jurisdictions where shareholders have strong rights in resolution and receive parts of the proceeds. In these jurisdictions, the regulator has no incentives to bargain for a high offering price given that the regulator does not benefit from proceeds exceeding the claim of insured depositors. Weak bargaining incentives increase the amount that an undercapitalized bank is willing to raise to prevent liquidation.

6.2 Cost of implementing relaxed regulatory accounting rules

When implementing relaxed regulatory accounting rules is without cost for an undercapitalized bank, it is always willing to use the relaxed accounting rules and it does not matter whether implementing the changes is mandatory or voluntary. In this section, we discuss implications when implementing relaxed accounting rule changes is costly. The cost can stem from computational cost of deriving alternative accounting measures (Neisen and Schulte-Mattler, 2021) or from lower transparency and adverse market reactions (Bischof et al., 2022).

Consistent with our assumption of symmetric information, we assume a fixed cost K that a bank's shareholders incur when implementing the new accounting rules. We assume that these cost are non pecuniary to avoid that the cost have a direct effect on the payoff available to depositors or the regulator in resolution.

We first discuss the case where banks have a choice whether to use the relaxed accounting rules or not. Examples are the option to reclassify fair-value securities in October 2008 and the option to use the Capital Transitional Arrangement (CTA) during the COVID-19 crisis that allowed banks to shield regulatory capital from fair value losses and expected credit losses respectively. With voluntary adoption, the bank only uses the relaxed accounting rules if it is willing to raise capital to fulfill regulatory capital requirements under the new rules. If the bank does not raise capital, it does not implement the relaxed accounting rule, saving the cost K . As a consequence, the cost of using the relaxed accounting rules reduces the bank's

willingness to raise capital. The maximum amount a bank is willing to raise to fulfill regulatory capital requirements under the new accounting rules is now given by $\bar{C}_K = \frac{q(0)\delta_\alpha p(R-D)-K}{1-\delta_\alpha p}$, where $\bar{C} > \bar{C}_K$, when $K > 0$. The larger the cost of implementing the relaxed accounting rules, the more the regulator has to relax accounting rules to induce bank recapitalization. Thus, the regulator is worse off when banks face a higher cost of implementing changes in regulatory accounting rules. Since \bar{C}_K declines in K , but \hat{C} is unchanged, the regulator is less willing to relax the regulatory accounting rules to induce banks to raise capital as K increases. The effect is equivalent to the effect of $\delta_\alpha < 1$ shown in proposition 3. Thus, an alternative way of thinking about the cost of reclassification is a drop of δ_α , stemming from increased cost of raising capital. However, an important difference between the two is that the cost from a decrease in δ_α matters only if the bank raises capital. Thus, if the cost of reclassification arise only if the bank raises capital, the line of reasoning above applies even when the reclassification is mandatory.

In contrast to voluntary accounting rule changes, mandatory changes have two benefits. First, the direct fixed cost of implementing the change K arises irrespective of whether the bank raise capital or not. Thus, the cost of implementing the relaxed accounting rules does not affect the incentives to raise capital, in contrast to the case with voluntary implementation. Second, mandatory changes do not involve a negative signal for an individual bank, which can reduce the effect on, e.g., the cost of raising capital. However, mandatory changes are often not transitory, affecting bank recapitalization in the future when banks encounter idiosyncratic shocks.

An examples of a mandatory regulatory accounting change is the amendment of the recognition and measurement guidance related to other-than-temporary-impairments (OTTI) of available for sale and held-to-maturity securities, FAS 115-2 and FAS 124-2. According to the amendment, the impairment charge for debt securities is split into the credit loss amount, which is recognized in net income, and the amount related to all other factors (noncredit loss), recognized in other comprehensive income (FASB, 2009, p. 4). Hence, the new regulation limits the amount of impairments that affect regulatory capital to the credit loss impairment (Toksoz,

2022). Another example are prudential filters that determine the effect of accumulated unrealized fair value gains and losses on regulatory capital. Germany and Portugal as well as Italy and Spain introduced such filters in 2009 and 2010, respectively (Bischof et al., 2021).

7 Conclusion

We show that when the regulator is faced with a commitment problem to enforce regulatory capital requirements in a systemic crisis (too-many-to-fail), a relaxation of regulatory accounting rules can induce banks to raise more capital than they would without the change. A key motive for banks to raise capital is to fulfill regulatory capital requirements in order to prevent a costly intervention of the regulator. Weakened regulatory enforcement reduces the expected cost of regulatory intervention when banks violate regulatory capital requirements.

Banks trade off the cost of raising equity and the cost of regulatory intervention. If the amount of capital that is necessary to prevent intervention given the prevailing accounting rules is too high, banks do not raise any capital at all. Relaxing regulatory accounting rules, which reduces the amount of capital necessary to fulfill regulatory capital, can restore incentives for banks to raise capital to prevent intervention. Thus, banks raise the necessary, albeit lower, capital to comply with the capital requirements after the relaxation of regulatory accounting rules. We argue that relaxing regulatory accounting rules is more beneficial than relaxing capital requirements because it allows for a more targeted reduction in capital requirements to affected banks.

If banks have no incentive to recapitalize under prevailing accounting rules, relaxing these rules is always optimal for the regulator if the only cost of raising capital for shareholders is the wealth transfer to depositors. In contrast, if raising capital is also costly because of market frictions in a financial crisis, it can be optimal for the regulator to not relax regulatory accounting rules. While banks do not raise capital in this case, the regulator retains the option to liquidate

some of the undercapitalized banks.

While banks have incentives to invest in correlated assets to increase the likelihood of a systemic crisis, these incentives stem from the regulator's commitment problem to enforce capital requirements. They are not aggravated by the relaxation of accounting rules in our model. The reason is that the regulator sets the new accounting rules such that banks do not benefit, but are indifferent between raising capital to fulfill the regulatory capital requirement under the new accounting rules and the risk of liquidation if they do not raise any capital.

Our analysis offers a novel perspective on the costs and benefits of relaxing regulatory accounting rules in a systemic crisis. While the literature focuses on the concern that changing accounting rules is a form of forbearance, we argue that it might actually be a reaction to weakened regulatory enforcement. Our model suggests that the cost of the regulatory commitment problem is even higher if the relaxation of regulatory accounting rules is prohibited.

Our model does not imply that it is generally optimal to have relaxed regulatory accounting rules, such as, for example, prudential filters. The benefit of relaxing accounting rules only arises in a systemic crisis that is sufficiently severe. Lax regulatory accounting rules are generally not optimal when banks incur idiosyncratic shocks and regulatory enforcement is strong.

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Appendix

Comparative static analysis Lemma 3

$$\begin{aligned}
 - \frac{\partial \bar{C}}{\partial p} &= \frac{q(0)\delta_\alpha(R-D)}{(1-\delta_\alpha p)^2} > 0 \\
 - \frac{\partial \bar{C}}{\partial R} &= \frac{\delta_\alpha p}{1-\delta_\alpha p} \left(\frac{\partial q(0)}{\partial R}(R-D) + q(0) \right) > 0 \text{ given } \frac{\partial q(0)}{\partial R} > 0 \\
 - \frac{\partial \bar{C}}{\partial \delta_\alpha} &= \frac{q(0)p(R-D)}{(1-\delta_\alpha p)^2} > 0 \\
 - \frac{\partial \bar{C}}{\partial D} &= \frac{\delta_\alpha p}{1-\delta_\alpha p} \left(\frac{\partial q(0)}{\partial D}(R-D) - q(0) \right) < 0 \text{ given } \frac{\partial q(0)}{\partial D} < 0 \\
 - \frac{\partial \bar{C}}{\partial \alpha} &= \frac{\partial q(0)}{\partial \alpha} \frac{\delta_\alpha p}{1-\delta_\alpha p} (R-D) \leq 0 \text{ given } \frac{\partial q(0)}{\partial \alpha} \leq 0
 \end{aligned}$$

Comparative static analysis Proposition 1

$$\begin{aligned}
 - \frac{\partial \bar{\delta}(C)}{\partial p} &= -\frac{C}{q(R-D)+C} \frac{1}{p^2} = -\frac{1}{p} \bar{\delta} < 0 \\
 - \frac{\partial \bar{\delta}(C)}{\partial R} &= -\frac{\frac{\partial q(0)}{\partial R} + q(0)}{(q(0)(R-D)+C)^2} \frac{C}{p} < 0 \\
 - \frac{\partial \bar{\delta}(C)}{\partial D} &= -\frac{\frac{\partial q(0)}{\partial D} - q(0)}{(q(0)(R-D)+C)^2} \frac{C}{p} > 0 \text{ given } \frac{\partial q(0)}{\partial D} < 0 \\
 - \frac{\partial \bar{\delta}(C)}{\partial \alpha} &= -\frac{\frac{\partial q(0)}{\partial \alpha} (R-D)}{q(0)(R-D)+C} \bar{\delta} \geq 0 \text{ given } \frac{\partial q(0)}{\partial \alpha} \leq 0
 \end{aligned}$$

Comparative static analysis Proposition 2

$$\begin{aligned}
 - \frac{\partial \hat{C}}{\partial p} &= \frac{\int_{\hat{\kappa}}^1 (\kappa R - D) f(\kappa|\alpha) d\kappa}{(1-p)^2} > 0 \\
 - \frac{\partial \hat{C}}{\partial R} &= \frac{p}{1-p} \left[\int_{\hat{\kappa}}^1 \kappa f(\kappa|\alpha) d\kappa - (D - E_2 - D) f(\hat{\kappa}|\alpha) \frac{\partial \hat{\kappa}}{\partial R} \right] > 0 \text{ for } E_2 = 0 \text{ which is true given Lemma} \\
 &\quad \text{2 and given } \frac{\partial \hat{\kappa}}{\partial R} < 0. \\
 - \frac{\partial \hat{C}}{\partial D} &= -\frac{p}{1-p} \left[\int_{\hat{\kappa}}^1 f(\kappa|\alpha) d\kappa + (D - E_2 - D) f(\hat{\kappa}|\alpha) \frac{\partial \hat{\kappa}}{\partial D} \right] < 0 \text{ for } E_2 = 0 \text{ which is true given} \\
 &\quad \text{Lemma 2 and given } \frac{\partial \hat{\kappa}}{\partial D} > 0. \\
 - \text{A higher } \alpha &\text{ shifts the distribution to the left, i.e. } F(\kappa|\alpha_1) \leq F(\kappa|\alpha_2) \text{ for all } \kappa \text{ and all } \alpha_1 < \alpha_2. \\
 &\text{Hence, } \hat{C} \text{ decreases in } \alpha.
 \end{aligned}$$

Proposition 3 The threshold $\hat{\delta}$ follows directly from equation (15):

$$\hat{\delta} = \frac{\int_{\hat{\kappa}}^1 (\kappa R - D) f(\kappa|\alpha) d\kappa}{\int_{\hat{\kappa}}^1 (R - D - pR(1 - \kappa)) f(\kappa|\alpha) d\kappa} \quad (29)$$

Deriving equation (21) Rearranging (16) yields

$$V = (1 - E[\alpha])(R - D) + \int_0^1 \alpha \left[\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(p(R - D) - \left(\frac{1}{\delta_\alpha} - p \right) C_0 \right) + \mathbb{1}_{\delta_\alpha < \bar{\delta}} (1 - q(0)) p(R - D) \right] g(\alpha) d\alpha \quad (30)$$

$$V = (1 - E[\alpha])(R - D) + \int_0^1 \alpha \left[p(R - D) - \mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(\frac{1}{\delta_\alpha} - p \right) C_0 - \mathbb{1}_{\delta_\alpha < \bar{\delta}} q(0) p(R - D) \right] g(\alpha) d\alpha \quad (31)$$

$$V = (1 - E[\alpha])(R - D) + E[\alpha] p(R - D) - \int_0^1 \alpha \left[\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(\frac{1}{\delta_\alpha} - p \right) C_0 + \mathbb{1}_{\delta_\alpha < \bar{\delta}} q(0) p(R - D) \right] g(\alpha) d\alpha \quad (32)$$

$$V = (1 - E[\alpha](1 - p))(R - D) - \int_0^1 \alpha \left[\mathbb{1}_{\delta_\alpha \geq \bar{\delta}} \left(\frac{1}{\delta_\alpha} - p \right) C_0 + \mathbb{1}_{\delta_\alpha < \bar{\delta}} q(0) p(R - D) \right] g(\alpha) d\alpha f(\alpha) d\alpha \quad (33)$$

Subtracting $E_0 = I - D$ from (19) and taking into account that $\mu = (1 - E[\alpha](1 - p))$, yields (21).

Deriving \bar{C}_s and \hat{C}_s We first derive \bar{C}_s . A bank raises capital C to prevent the risk of liquidation if

$$p(R - D) - \left(\frac{1}{\delta_\alpha} - p \right) C \geq (1 - q(0)) p(R - D) + \int_{D/pR}^1 (\kappa pR - D) f(\kappa|\alpha) d\kappa. \quad (34)$$

Rearranging terms, we obtain \bar{C}_s :

$$C \leq \bar{C}_s = \frac{\delta_\alpha}{1 - \delta_\alpha p} \left(q(0) p(R - D) - \int_{D/pR}^1 (\kappa pR - D) f(\kappa|\alpha) d\kappa \right), \quad (35)$$

Using \bar{C} and rearranging terms yields

$$\bar{C}_s = \bar{C} - \frac{\delta_\alpha}{1 - \delta_\alpha p} \int_{D/pR}^1 (\kappa pR - D)f(\kappa|\alpha) d\kappa < \bar{C} \quad (36)$$

We now derive \hat{C}_s . Given $\bar{C}_s < C_0$, it is optimal to reduce the regulatory accounting rules to $C = \bar{C}_s$ if

$$(1 - p)(D - \bar{C}_s) \leq F(\hat{\kappa}|\alpha)(1 - p)D + \int_{\hat{\kappa}}^{D/pR} (D - \kappa pR)f(\kappa|\alpha) d\kappa. \quad (37)$$

Rearranging terms, we can define the threshold \hat{C}_s :

$$\bar{C}_s \geq \hat{C}_s = \frac{1}{1 - p} \left(\int_{\hat{\kappa}}^1 (\kappa pR - pD)f(\kappa|\alpha) d\kappa - \int_{D/pR}^1 (\kappa pR - D)f(\kappa|\alpha) d\kappa \right). \quad (38)$$

Using \hat{C} and rearranging terms, we get:

$$\hat{C}_s = \hat{C} - \frac{1}{1 - p} \int_{D/pR}^1 (\kappa pR - D)f(\kappa|\alpha) d\kappa < \hat{C}. \quad (39)$$