

# Regulation and Bankers' Incentives

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## Abstract

We formally analyze and compare the effects of minimum capital requirements, capital buffers, reserve requirements and loan loss provisions on the incentive of bankers to exert effort and take excessive risk. We find that these regulations impact differently the behavior of bankers and characterize conditions under which they make it easier or harder to implement the first best solution. In the case of deposit funded banks, both a capital buffer and a reserve requirement provide adequate incentives to bank managers, although the former is a more powerful instrument. Loan loss provision may provide bank managers with incentives to gamble when the fund is accumulating (i.e. in good times). Policy implications may help informing current regulatory debates (e.g. the complementarity of implementing a counter-cyclical capital buffer in countries running dynamic loan loss provision systems): in good times bank supervisors should either prefer the use of a capital buffer or complement loan loss provisions with a higher minimum capital requirement and stronger supervision of risk-taking activities.

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# 1 Introduction

In the aftermath of the financial crisis 2008-2009 the trend towards the harmonization of banking regulation has gained momentum. New regulation is being introduced with the aim of making banks safer and more resilient to shocks. The Basel Committee on Banking Supervision, for instance, promulgated a new version of its Accord (called Basel III) determining higher minimum capital requirements for banks and the conditions under which they should build extra capital buffers like, for example, the conservation and counter-cyclical ones. In the same spirit, accounting bodies (e.g. the International Financial Reporting Standards) have been revising the rules for the recognition of loan losses with the objective of achieving a timelier and more adequate loan loss provision fund.

While the introduction of new and harmonized regulation and standards may have positive outcomes, it would also have unintended consequences. It is a matter of fact that banking systems around the world show key differences that in turn justify the enactment of different banking regulations.<sup>1</sup> For example, several countries (e.g. Spain, Peru and Uruguay) have introduced cyclically-adjusted loan loss provision regulation (also called dynamic or statistical provisions) long before the Basel III's counter-cyclical capital buffer proposal. How would these two instruments work together? Should they do it? Should regulators prefer the use of one instrument over the other? Indeed, questions like these are part of the current regulatory debate in several jurisdictions around the world.

This paper aims to inform the ongoing debate by analyzing how different bank regulations affect bankers' incentives to exert effort in monitoring loans and take excessive risk by shifting to risky projects. More precisely, we propose a formal model, based on Holmstrom and Tirole (1997) and inspired by Biais and Casamatta (1999), to investigate the effects of minimum capital requirements, capital buffers, reserve requirements and loan loss provisions. We do the analysis considering two extreme bank funding structures. On the one hand, in the case of a market funded bank we assume that outside investors are sophisticated investors operating in financial markets. On the other hand, small and non-

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<sup>1</sup>According to Ayadi et al. (2015), there is no evidence that any common set of best practices is universally appropriate for promoting well-functioning banks. Regulatory structures that will succeed in some countries may not constitute best practice in other countries that have different institutional settings. Barth et al. (2013) find that there is no broad cross-country evidence as to which of the many different regulations and supervisory practices employed around the world work best.

sophisticated depositors provide external funding to a deposit funded bank. In this case, we follow Dewatripont and Tirole (1994) by assuming that a bank regulator represents depositors.

We find that regulations impact differently the incentives of bankers and characterize conditions under which they make it easier or harder to implement the first best solution. In the case of a market funded bank, the requirement of a capital buffer hardens the participation constraint of external investors; it may prevent a bank from existing if it is too large. Reserve requirements and the accumulation of a loan loss provision fund are bad instruments to provide the correct incentives to the bank manager in the sense that both of them need to be complemented by more internal equity. The intuition for this result is that, given the moral hazard problems, external investors require a larger skin of the bank manager on the portfolio of loans when they are subject to extra requirements. When the equity provided by the bank manager is large enough, external investors do not need to receive a large fraction of portfolio returns and large revenues are left available to compensate the bank manager in such a way that she will get incentives to exert effort and abstain from excessive risk taking. However, the impact of reserve requirement regulation is larger than the impact of loan loss provision regulation because reserve requirements are funded directly by external investors whereas loan loss provisions are deducted from the returns on the portfolio of bank loans.

Perhaps more interesting results arise in the case of a deposit funded bank. In this case, capital buffer regulation makes it easier to provide the correct incentives to bank managers. More precisely, capital buffers are perfect substitutes to minimum capital requirements: To require extra capital is a direct mechanism to increase the skin of the bank manager on the bank as to mitigate the moral hazard problems. Reserve requirements also make it easier to provide the correct incentives to bank managers but it is a less powerful instrument than capital buffers: Reserve requirements are imperfect substitutes to minimum capital requirements. The reason for this is that while capital requirements affect the funding structure of the bank (the liability side of the balance sheet), reserve requirements affect the structure of the investment (the asset side) by restricting the possibility of investing the funds put on reserve in more productive opportunities. The accumulation of a loan loss provision fund, however, makes it more difficult to provide the correct incentives to

bank managers. Since part of the return of the portfolio of loans need to be put on reserve under this regulation, the fraction left available to compensate the bank manager is smaller in such a way that she may have incentives to gamble by taking more risks and shirking.

Based on these results we propose some policy implications that may help informing current regulatory debates. More precisely, our results shed light on the complementarity of implementing a counter-cyclical capital buffer in countries already running dynamic loan loss provision systems. We find that in the case of deposit funded banks both a capital buffer and an already constituted loan loss provision fund (which works as a reserve requirement) provide adequate incentives to bank managers, being the former a more powerful instrument than the latter. However, loan loss provision regulation may provide bank managers with incentives to gamble in periods when the fund is accumulating (i.e. in good times). Hence, in good times bank supervisors should either prefer the use of capital buffers or complement loan loss provisions with higher minimum capital requirements and stronger supervision of risk-taking activities.

In the next section we revise relevant literature to which our paper contributes. In Section 3 we introduce the basic model. In Section 4 we analyze the case of a market funded bank and in Section 5 we study the case of a deposit funded bank. In Section, 6 we compare the results, derive policy implications and make final comments. Proof of the main propositions and other technicalities are in the Appendix.

## 2 Related literature

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## 3 The basic model

We consider the following extension of Holmstrom and Tirole (1997) inspired by Biais and Casamatta (1999). There are two kind of risk neutral investors: *bank managers* and *external investors*.

*Bank managers.* There is a continuum of *bank managers*. Each bank manager is endowed with initial equity  $E$  and the ability to manage a bank. A bank may be visualized as a portfolio of loans  $L > E$ . The managers' equity may serve as inside financing to the

bank. In order to complete the financing of the loan portfolio, bank managers need to raise funds from *external investors*. The loan portfolio yields a return  $R^\theta$ , which is contingent on the state of the world  $\theta$  and perfectly verifiable. The distribution of such returns is affected by bank managers' decisions, which are not observable by third parties. In the same spirit of Jensen and Meckling (1976), we consider that there are two sources of moral hazard. First, each bank manager chooses the level of effort to exert in detecting good investment opportunities. Exerting effort is privately costly for the bank manager but it improves the distribution of portfolio returns ( $R^\theta$ ) in the sense of first-order stochastic dominance. We denote by  $B$  the bank manager's cost of exerting effort (or equivalently the utility from shirking). Second, each bank manager chooses the riskiness of the portfolio. Taking more risk leads to a deterioration of the distribution of portfolio returns in the sense of second-order stochastic dominance.

*External investors.* There is a continuum of external investors with excess of funds but without the ability to directly invest in a portfolio of loans. They could provide outside financing to the bank or invest in an alternative project with a rate of return  $r$ . In the next section we will consider the case of market investors, while in Section 5 we will assume that external investors are depositors.

*Lending technology and moral hazard.* For simplicity, we assume that there are three states of the world,  $\theta \in \{u, m, d\}$ , with corresponding returns:  $R^u > R^m > L > R^d$ . In order to keep things in the simplest way and without loss of generality we further assume that  $R^d = 0$ . Assume also that a bank manager can choose between two levels of risk and two levels of effort.

Consider the case in which the bank manager does not take excessive risk. If she does not exert effort, then the three states of nature are equally probable. If she exerts effort, however, the distribution of portfolio returns improves in the sense of first order stochastic dominance: the probability of the good state ( $\theta = u$ ) increases by  $\epsilon$  and the probability of the bad state ( $\theta = d$ ) decreases by  $\epsilon$ . Denote by  $\bar{V}$  the expected outcome under effort and by  $\underline{V}$  the expected outcome when shirking. To further simplify the analysis, we assume that the project has positive net present value (NPV) only if the manager exerts effort and that effort is socially optimal:  $\bar{V} > \underline{V} + B$ . If a bank manager switches to riskier projects, the probability of the medium state ( $\theta = m$ ) is reduced by  $\alpha + \beta$ , the probability

of the good state ( $\theta = u$ ) is increased by  $\alpha$  and that of the bad state ( $\theta = d$ ) by  $\beta$ . We assume that this riskier distribution is dominated in the sense of second order stochastic dominance, which is equivalent to:  $\alpha(R^u - R^m) < \beta R^m$ . Under this assumption the NPV of the bank's loan portfolio is reduced by risk-taking. Since effort is socially optimal, then the first best solution is clearly characterized by effort and no risk-taking.

*Financial contracts.* The financial contract between external investors and a bank manager is a revenue sharing rule specifying what fraction of the bank portfolio's returns accrues to each of the parties in each state of the world. Let  $\delta^\theta$  be the share of the return earned by external investors in state  $\theta$ . We assume the bank manager has limited liability, therefore for every  $\theta$ ,  $\delta^\theta \leq 1$ . In the following section, we will consider the general case and we look for the optimal contract. In Section 5 we will consider a particular case in which external funding takes the form of bank deposits with face value  $D < R^m$  and then  $\delta^u = \frac{D}{R^u}$  and  $\delta^m = \frac{D}{R^m}$ .<sup>2</sup>

*Regulation.* In order to allow banks to operate a banking authority may request that they fulfill some regulations. We will consider the cases of minimum capital requirements, capital buffers, reserver requirements and loan loss provisions.

*Timing.* The sequence of events is as follows. Bank managers raise funds from external investors and invest these funds together with their own internal equity in a portfolio of loans. At this point, they decide whether to take excessive risk or not and the effort they exert in looking for investment opportunities. At the end of the period, loan portfolio returns are realized, regulation enforced and the outcome distributed between the bank manager and external investors.

## 4 A market funded bank

In this section we consider the case of a market funded bank. In this case, bank managers finance their banks with their own equity as well as with outside equity through financial markets.

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<sup>2</sup>The value of  $\delta^d$  may depend on the specific form of regulation as we will discuss below.

#### 4.1 Benchmark case

For further comparison, we first analyze the conditions under which the first best solution can be attained in a context without any kind of regulation. If the resulting conditions hold, an optimal financial contract between a bank manager and external investors can be implemented and a positive NPV bank can be market funded.

Since the first best solution requires that the bank manager chooses to exert effort and to abstain from taking excessive risk, a positive NPV bank can only be financed if the two following incentive compatibility constraints hold. First, the bank manager should prefer to exert effort rather than shirking and enjoying the private benefit  $B$ :

$$(1/3 + \epsilon)(1 - \delta^u)R^u + 1/3(1 - \delta^m)R^m \geq 1/3(1 - \delta^u)R^u + 1/3(1 - \delta^m)R^m + B. \quad (1)$$

The left-hand side of Equation (1) is the expected return of the bank manager if she exerts effort and the right-hand side is the sum of her expected return if she shirks and the private benefit she gets from shirking.

Second, given that the bank manager is exerting effort, she should prefer not to take the riskier project:

$$(1/3 + \epsilon)(1 - \delta^u)R^u + 1/3(1 - \delta^m)R^m \geq (1/3 + \epsilon + \alpha)(1 - \delta^u)R^u + (1/3 - \alpha - \beta)(1 - \delta^m)R^m. \quad (2)$$

The left-hand side of Equation (2) is the expected return of the bank manager if she exerts effort and abstains from excessive risk taking, while the right-hand side is her expected revenue if she exerts effort but takes excessive risk.

A third incentive compatibility constraint should be considered to ensure that the bank manager prefers to exert effort and abstain from taking excessive risk simultaneously. It is straightforward to show that this constraint is redundant given Equations (1) and (2).

In addition to these incentive compatibility constraints we need to consider the participation constraints of external investors and bank managers. The participation constraint of external investors is:

$$(1/3 + \epsilon)\delta^u R^u + 1/3\delta^m R^m \geq (L - E)(1 + r). \quad (3)$$

The left hand side of Equation (3) is the expected return from investing in the bank and the right hand side is the investment plus its opportunity cost. It is not hard to prove that the participation constraint of the bank manager is always satisfied under the assumption that the portfolio of loans has positive NPV.<sup>3</sup>

The optimal contract is a pair  $(\delta^u, \delta^m) \in (0, 1)^2$  such that the two incentive compatibility conditions of the bank manager and the participation constraint of external investors are satisfied. After some manipulations, the three constraints simplify to the condition stated in Lemma 1.

**Lemma 1** *The first best solution is attained and a positive NPV bank can be market funded if the initial equity of bank managers ( $E$ ) is large enough:*

$$E \geq E_0^M \equiv L - \frac{1}{1+r} \left[ \bar{V} - \frac{B}{\epsilon} \left( 1/3 + \epsilon + 1/3 \frac{\alpha}{\alpha + \beta} \right) \right]. \quad (4)$$

For a proof to Lemma 1 see Proposition 1 in Biais and Casamatta (1999).

Lemma 1 states that the initial equity of the bank manager ( $E$ ) must be larger than a minimum level ( $E_0^M$ ) for the loan portfolio to be market funded by external investors. Otherwise stated, given the moral hazard problems external investors require some skin of the bank manager on the portfolio of loans. When  $E$  is large enough, external investors do not need to receive a large fraction of portfolio returns because their investment is limited. Consequently, large revenues are left available to compensate the bank manager in such a way that she will get incentives to exert effort and abstain from excessive risk taking.

The fraction of bank managers that can see their portfolio of loans financed by external investors through financial markets decreases with the magnitude of the moral hazard problems described above, i.e. as  $B$  and  $\alpha$  increases.  $E_0^M$  is increasing in the product of the cost of effort  $B$  and the risk-shifting parameter  $\alpha$ . This product reflects the interaction between the two sources of moral hazard and determines that the larger these problems, the lower the proportion of banks that can be market funded.

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<sup>3</sup>See the Appendix A for a similar proof to the one which is required here.

## 4.2 Capital buffer

We now compare the previous benchmark results with those resulting from the introduction of different forms of banking regulation. We start analyzing the case of capital buffers. Capital requirements address how banks are funded, not what assets they invest in or hold. They do not require setting aside funds and not investing them productively so that they affect only the liability side of the balance sheet.<sup>4</sup> Hence, in a market funded bank the introduction of a capital buffer  $P$  may only change the results on Lemma 1 if it is too high. More precisely, if  $P < L - E$  then external investors fulfill the capital buffer with the equity they have already put into the bank. In this case, Lemma 1 holds. However, if  $P$  is larger than the amount of outside equity that ensures that the bank manager exerts effort and refrain from risk taking activities, i.e. if  $P > L - E$ , then the first best solution cannot be attained and no positive NPV bank can be funded by the market.

## 4.3 Reserve requirement

We now consider the case in which regulation imposes a reserve requirement  $P$  to be put aside in order for the bank to be authorized to operate. Differently from a capital buffer, a reserve requirement affects the asset side of the balance sheet of the bank by imposing restrictions to the type of assets the bank can invest in or hold. In this case, the total investment on the bank is  $L + P$ , i.e. the portfolio of loans plus the reserve requirement. This extra funding does have an opportunity cost  $r$ . In addition to that, the reserve requirement also affects the optimal contract because it changes the distribution of portfolio returns between bank managers and external investors: the latter will now receive a payment coming from the reserve fund even in the case that the state of nature is bad ( $\theta = d$ ). Hence, the participation constraint of external investors is now:

$$(1/3 + \epsilon)\delta^u R^u + 1/3\delta^m R^m + (1/3 - \epsilon)P \geq (L + P - E)(1 + r). \quad (5)$$

The left-hand side of Equation (5) is the expected returns for external investors when the bank manager exerts effort and abstains from excessive risk taking, while the right-hand side is the amount of funds raised from outside investors plus its opportunity cost.

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<sup>4</sup>See Admati et al. (2013) for a detailed discussion about bank equity and capital regulation.

It is easy to see that the incentive compatibility constraints of the bank manager are as in Equations (1) and (2). However, while in the benchmark case the participation of the bank manager is assured by the assumption that the portfolio of loans has positive NPV, in this case the reserve requirement  $P$  makes the participation constraint of the bank manager tighter. In the Appendix A, we derive a sufficient condition that assures the participation of bank managers. We show that the bank manager will be willing to participate as long as  $P$  is small enough with respect to the net present value of the bank, which in practice seems not to be a demanding condition.<sup>5</sup>

After some manipulations, Equations (1), (2) and (5) simplify to the condition on the following proposition.

**Proposition 1** *When regulation takes the form of a reserve requirement  $P$ , then the first best solution can be attained and a positive NPV bank can be market funded if the initial equity of bank managers ( $E$ ) is large enough:*

$$E \geq E_1^M \equiv E_0^M + P \left( \frac{2/3 + r + \epsilon}{1 + r} \right). \quad (6)$$

*Proof:* See Appendix B.

The introduction of reserve requirement regulation increases the size of the investment by external investors, which is costly due to the opportunity cost of capital  $r$ . At the same time, it increases the expected return accruing to them but less than proportionally to the investment plus its opportunity cost. As a result, external investors require a larger proportion of the returns of the bank portfolio in order to participate. In turn, this reduces the proportion of returns accruing to the bank manager, which affects her incentives to exert effort and take risk. In order to satisfy the bank manager incentive compatibility constraints and soften the external investors' participation constraint, the bank manager needs to have a larger skin on the bank portfolio of loans, i.e.  $E$  has to be larger.

Comparing with the benchmark case, the introduction of a reserve requirement reduces the set of bank managers for which the first best solution can be attained, i.e.  $E_0^M < E_1^M$ .

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<sup>5</sup>More precisely, we prove that  $P \leq \frac{NPV}{2/3 + \epsilon + r}$  is sufficient to guarantee the participation of the bank manager, where  $NPV \equiv \bar{V} - L(1 + r)$  is the net present value of bank loans. Otherwise stated, this condition implies that the reserve requirement is small enough with respect to the bank's NPV. Moreover, it can be proved that this is also a sufficient condition to assure the participation of the bank manager in all the cases where some kind of regulation is considered in this paper.

In this sense, reserve requirement regulation makes it more difficult to provide the correct incentives to bank managers.

#### 4.4 Loan loss provision

A loan loss provision is an expense that is reserved for defaulted loans. In terms of our model, it is an amount of loan returns set aside for the event that the state of nature is bad (remember that  $R^d = 0$  by assumption).

It is easy to see that once the loan loss provision fund is constituted it works as a reserve requirement. Hence, considering that the size of that fund is  $P$ , Proposition 1 holds for the case of an already constituted loan loss provision fund. However, when the fund needs to be constituted portfolio cash flows are affected. In other words, part of the return on the loan portfolio are kept as a reserve in order to constitute the fund for loan loss provision. This affects the distribution of returns between bank managers and external investors with some implications for incentives. In this context the optimal contract will have to satisfy the following two bank manager's incentive compatibility constraints:<sup>6</sup>

$$\begin{aligned} (1/3 + \epsilon)(1 - \delta^u)(R^u - P) + 1/3(1 - \delta^m)(R^m - P) &\geq \\ 1/3(1 - \delta^u)(R^u - P) + 1/3(1 - \delta^m)(R^m - P) + B & \end{aligned} \quad (7)$$

and

$$\begin{aligned} (1/3 + \epsilon)(1 - \delta^u)(R^u - P) + 1/3(1 - \delta^m)(R^m - P) &\geq \\ (1/3 + \epsilon + \alpha)(1 - \delta^u)(R^u - P) + (1/3 - \alpha - \beta)(1 - \delta^m)(R^m - P). & \end{aligned} \quad (8)$$

The participation constraint of external investors is now affected by the loan loss provision since the cash flow of the bank changes because of this regulation:

$$(1/3 + \epsilon)\delta^u(R^u - P) + 1/3\delta^m(R^m - P) \geq (L - E)(1 + r). \quad (9)$$

Given this new set of constraints, we are able to state the following result.

**Proposition 2** *When regulation takes the form of a loan loss provision and a fund sized  $P$  is accumulating, then the first best solution can be attained and a positive NPV bank*

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<sup>6</sup>For simplicity we are working under the assumption that  $P < R^m$ . Otherwise, it may be the case that the cash flow from the return of the portfolio of loans is not enough to fulfill the provision requirement. Relaxing this assumption does not change the qualitative results of the model but makes the algebra more complicated.

can be market funded if the initial equity of bank managers ( $E$ ) is large enough:

$$E \geq E_2^M \equiv E_0^M + P \left( \frac{2/3 + \epsilon}{1 + r} \right). \quad (10)$$

*Proof:* Omitted (could be done following the same steps as in Appendix B).

The introduction of a loan loss provision regulation reduces both the external investors and the bank manager expected return from investing in the bank. In turn, external investors require a larger participation on the expected returns of the bank portfolio in order to participate, which reduces further the expected return accruing to the bank manager and affects its incentives to exert effort and take risk. As in the case of reserve requirements, it is necessary to increase the participation of the bank manager in the financing of the bank portfolio in order to relax the participation constraint of external investors and satisfy the incentive compatibility constraints of the bank manager. As a consequence, the proportion of bank managers with initial equity between  $E_0^M$  and  $E_2^M$  fails to be financed by external investors and credit rationing becomes more prevalent. In this sense, when the fund is accumulating loan loss provision regulation makes it more difficult to provide the correct incentives to bank managers determining that a larger proportion of positive NPV banks fail to get funded by the market.

#### 4.5 Comparisons

Both a reserve requirement and the accumulation of a provision for loan losses make it more difficult to provide the correct incentives to bank managers. They need to be complemented by an increase in internal equity in order to reestablish incentives. However, the impact of reserve requirement regulation is larger than the impact of loan loss provision regulation when the fund is accumulating, i.e.  $E_2^M < E_1^M$ . The difference comes from the fact that whereas reserve requirements (e.g. an already constituted loan loss provision fund) are funded by investors and hence pay an opportunity cost, loan loss provisions are deducted from loan returns. The direct implication of this difference is that the proportion of positive NPV bank portfolio getting funding from external investors is larger under loan loss provision regulation than when a reserve requirement is applied.

## 5 A deposit funded bank

In this section we study the case in which external investors are depositors. The deposit contract is a particular case of the general financial contract described in the setup of the model. More precisely,  $\delta^u = \frac{D}{R^u}$  and  $\delta^m = \frac{D}{R^m}$ , where  $D$  is the face value of the deposit contract, i.e. the payoff for making a deposit of amount  $L - E$ .

A particular feature of depositors is that they are small and non-sophisticated agents without the incentive or the capacity to monitor bank managers. This feature has some implications that help to simplify our analysis. First, we assume that depositors use only deposit contracts so that other forms of outside financing are not available to the bank. Second, following Dewatripont and Tirole (1994) we consider that depositors are represented by some kind banking authority.

### 5.1 Benchmark case: minimum capital requirement

We first analyze the benchmark case in which the banking authority requires a minimum level of capital to bank managers in order to raise deposits and operate the bank. More precisely, we derive the minimum capital requirement that makes the first best solution attainable. Since in the first best solution the bank manager chooses to exert effort and to abstain from taking excessive risk, then the two following incentive compatibility conditions must hold. First,

$$(1/3 + \epsilon)(R^u - D) + 1/3(R^m - D) \geq 1/3(R^u - D) + 1/3(R^m - D) + B. \quad (11)$$

The left-hand side of Equation (11) is the expected return of the bank manager, after paying depositors the fixed amount  $D$ , when she exerts effort and the right-hand side is the sum of her expected return when she shirks and the benefit she gets from shirking.

Second,

$$(1/3 + \epsilon)(R^u - D) + 1/3(R^m - D) \geq (1/3 + \epsilon + \alpha)(R^u - D) + (1/3 - \alpha - \beta)(R^m - D). \quad (12)$$

The left-hand side of Equation (12) is the expected return of the bank manager when she exerts effort and abstains from excessive risk taking, while the right-hand side is the sum

of her expected return when she exerts effort but takes excessive risks.

As before, a third constraint should be added to ensure that the manager prefers to exert effort and abstain from risk taking rather than shirking and taking risk. It is straightforward to show that it is redundant given (11) and (12).

The participation constraint of depositors is:

$$(2/3 + \epsilon)D \geq (L - E)(1 + r). \quad (13)$$

The following proposition summarizes the conditions under which a bank can be funded by depositors.

**Proposition 3** *The first best solution is attained and a positive NPV bank can be deposit funded if the initial equity of bank managers ( $E$ ) is larger than the minimum capital requirement  $E_0^D$ :*

$$E \geq E_0^D \equiv L - \frac{2/3 + \epsilon}{1 + r} \min \left[ R^u - \frac{B}{\epsilon}; \frac{(\alpha + \beta)R^m - \alpha R^u}{\beta} \right]. \quad (14)$$

*Proof:* Omitted (could be done following the same steps as in Appendix B).

As in the case of the market funded bank, a deposit funded bank requires the investment of initial equity from the bank manager. In other words, given the moral hazard problems depositors require some skin of the bank manager on the portfolio of loans. The intuition is the same as before, when  $E$  is large the return required by depositors to participate is limited and it leaves enough return to compensate the bank manager in such a way she has the incentives to exert effort and abstain from excessive risk taking.

Notice that the minimum amount of equity required when the bank is funded with deposits is larger than or equal to the one required when the bank is funded by external investors (i.e.,  $E_0^M \leq E_0^D$ ). The reason is that while in the market funded bank case we looked for the optimal contract between bank managers and external investors, in the deposit funded bank case we are adding other constraint, which is the fact that depositors' payoff are flat.

## 5.2 Capital buffer

Now we analyze the case in which regulation takes the form of a capital buffer  $P$ . In this case, the extra capital needs to be financed by the bank manager since external investors (i.e. depositors) can only use deposits. Hence, the participation constraint of the bank manager is tighter than in the benchmark case (remember however that we are assuming that the sufficient condition that guarantees her participation is fulfilled, see Appendix A) and the participation constraint of depositors is softer:

$$(2/3 + \epsilon)D \geq (L - E - P)(1 + r). \quad (15)$$

It is not difficult to realize that the incentive compatibility constraints of the bank manager remains unchanged with the introduction of capital buffer regulation, i.e. Equations (11) and (12) hold.

The following proposition summarizes the conditions under which a bank can be funded by depositors when capital buffer regulation is enacted.

**Proposition 4** *When regulation takes the form of a capital buffer  $P$ , then the first best solution can be attained and a positive NPV bank can be deposit funded if the initial equity of bank managers ( $E$ ) is larger than the minimum capital requirement  $E_1^D$ :*

$$E \geq E_1^D \equiv E_0^D - P \quad (16)$$

*Proof:* Omitted (could be done following the same steps as in Appendix B).

The introduction of a capital buffer enlarges the set of bank managers for which the first best solution can be attained with respect to the benchmark case, i.e.  $E_1^D < E_0^D$ . To require extra capital is a direct mechanism to increase the skin of the bank manager on the bank and then mitigates the moral hazard problems. In this sense, capital buffer regulation makes it easier to provide the correct incentives to bank managers. Moreover, capital buffers are perfect substitutes to minimum capital requirements.

### 5.3 Reserve requirement

We now consider the case in which regulation imposes a reserve requirement  $P$  that may be kept aside in order for the bank to be authorized to operate. In this case, the total investment on the bank is  $L + P$ , i.e. the portfolio of loans plus the reserve requirement. Differently from the market funded bank case, in the deposit funded bank the reserve requirement needs to be financed by the internal investor, i.e. the bank manager. In addition to that, the reserve requirement also affects the optimal contract because of their effects on the distribution of portfolio returns between bank managers and external investors: the latter will now receive a payment coming from the reserve fund even in the case that the state of nature is bad ( $\theta = d$ ). Hence, the participation constraint of external investors is:

$$(2/3 + \epsilon)D + (1/3 - \epsilon)P \geq (L - E)(1 + r). \quad (17)$$

The left-hand side of Equation (17) is the expected returns for depositors when the bank manager exerts effort and abstains from excessive risk taking, while the right-hand side is the amount of funds raised from depositors plus its opportunity costs. The following proposition summarizes the results.

**Proposition 5** *When regulation takes the form of a reserve requirement  $P$ , then the first best solution can be attained and a positive NPV bank can be deposit funded if the initial equity of bank managers ( $E$ ) is larger than the minimum capital requirement  $E_2^D$ :*

$$E \geq E_2^D \equiv E_0^D - P \left( \frac{1/3 - \epsilon}{1 + r} \right). \quad (18)$$

*Proof:* Omitted (could be done following the same steps as in Appendix B).

As in the case of capital buffer regulation, reserve requirement regulation relaxes the participation constraint of depositors so that they require a lower proportion of the return from the portfolio of loans. In turn, a higher proportion of the return is accruing to the bank manager who now receives stronger incentives to exert effort and refrain from taking excessive risk. In this sense, reserve requirements make it easier to provide the correct incentives to the bank manager:  $E_2^D < E_0^D$ . However, since the reserve requirement needs to be put aside and cannot be invested in loans it introduces inefficiencies that

in turn determine that this instrument be less powerful than capital regulation: reserve requirement are imperfect substitutes to minimum capital requirements, i.e.  $E_1^D < E_2^D$ .

#### 5.4 Loan loss provision

In periods where the loan loss provision fund has to be accumulated part of the cash flow from the bank portfolio of loans needs to be kept aside as a reserve, affecting the distribution of returns between bank managers and depositors. In this context, the optimal contract will have to satisfy the following two incentive compatibility constraints:

$$\begin{aligned} (1/3 + \epsilon)(R^u - P - D) + 1/3(R^m - P - D) &\geq \\ 1/3(R^u - P - D) + 1/3(R^m - P - D) + B & \end{aligned} \quad (19)$$

and

$$\begin{aligned} (1/3 + \epsilon)(R^u - P - D) + 1/3(R^m - P - D) &\geq \\ (1/3 + \epsilon + \alpha)(R^u - P - D) + (1/3 - \alpha - \beta)(R^m - P - D). & \end{aligned} \quad (20)$$

The participation constraint of depositors is the same as in the benchmark case (see Equation (13)). Given this new set of constraints we are able to state the following proposition.

**Proposition 6** *When regulation takes the form of a loan loss provision and a fund sized  $P$  is accumulating, then the first best solution can be attained and a positive NPV bank can be deposit funded if the initial equity of bank managers ( $E$ ) is larger than the minimum capital requirement  $E_3^D$ :*

$$E \geq E_3^D \equiv E_0^D + P \left( \frac{2/3 + \epsilon}{1 + r} \right). \quad (21)$$

*Proof:* Omitted (could be done following the same steps as in Appendix B).

The impact of the introduction of a loan loss provision regulation is twofold. On the one hand it reduces the bank manger expected return. This implies that bank managers need to put more skin in the business to get the right incentives to exert effort and abstain from excessive risk taking. On the other hand, depositors require lower returns compared to the benchmark case because they receive something in the bad state. As a net result of these two effects it is necessary to increase the participation of the bank manager in the financing of the bank portfolio in order to satisfy the incentive compatibility constraints.

As a consequence, a proportion of bank managers with initial equity between  $E_0^D$  and  $E_3^D$  fails to be financed by depositors, credit rationing becomes more prevalent and more positive net present value banks fail to get funded by the market. As in the case of market funded bank, loan loss provision regulation makes it more difficult to provide the correct incentive to bank managers determining that a larger proportion of positive NPV bank fails to get funded by depositors.

## 5.5 Comparisons

In the case of a deposit funded bank both a capital buffer and reserve requirement regulation are substitutes to minimum capital requirements. In this sense, these regulations make it easier to provide the correct incentives to the bank manager in order she exerts effort and refrains from taking excessive risk. However, a capital buffer is a perfect substitute to minimum capital requirement while a reserve requirement is only an imperfect one. Hence, capital buffer is a more powerful instrument than reserve requirements to provide good incentives to the bank manager.

We also find that loan loss provision regulation makes it more difficult to provide the correct incentive to the bank manager in times where the fund is accumulating. Hence, this regulatory instrument is dominated by reserve requirements, which in turn is dominated by capital buffers, in terms of their power to provide good incentives to the bank manager.

## 6 Concluding remarks

In this paper we propose a formal model to investigate the effects of minimum capital requirements, capital buffers, reserve requirements and loan loss provisions on the bankers' incentives to exert effort and take excessive risk. We characterize the conditions under which these regulations make it easier or harder to implement the first best solution in two extreme market structures. On the one hand, in the case of a market funded bank we assume that outside investors are sophisticated investors operating in financial markets. On the other hand, small and non-sophisticated depositors provide external funding to a deposit funded bank.

Based on our theoretical results we can propose policy implications that may help

informing ongoing regulatory debates. More precisely, our results shed light on the complementarity of implementing a counter-cyclical capital buffer in countries already running dynamic loan loss provision systems (e.g. Spain, Peru and Uruguay among others). We find that in the case of deposit funded banks both a capital buffer and an already constituted loan loss provision fund (which works as a reserve requirement) provide adequate incentives to bank managers, being the former a more powerful instrument than the latter. However, loan loss provision regulation may provide bank managers with incentives to gamble in periods when the fund is accumulating (i.e. in good times). Hence, in good times bank supervisors should either prefer the use of capital buffers or complement loan loss provisions with higher minimum capital requirements and stronger supervision of risk-taking activities.

## Appendix

### A Bank managers' participation

In this appendix we derive a sufficient condition that assures the participation of the bank manager in the case of a market funded bank under reserve requirement regulation. Following the same steps we follow below it can be shown that the same condition is also sufficient to guarantee the participation of the manager in the other cases we have considered through the paper.

The bank manager participation constraint is:

$$(1/3 + \epsilon)(1 - \delta^u)R^u + 1/3(1 - \delta^m)R^m \geq (1 + r)E. \quad (22)$$

Considering the participation constraint of the external investors with equality (see Equation 5) we get:

$$\delta^u = \frac{(L + P - E)(1 + r) - 1/3\delta^m R^m - (1/3 - \epsilon)P}{(1/3 + \epsilon)R^u}. \quad (23)$$

Substituting 23 into 22 and after some manipulations we get:

$$NPV \equiv \bar{V} - (1+r)L \geq (2/3 + \epsilon + r)P. \quad (24)$$

Hence, a sufficient condition that assures the participation of the manager is that the capital buffer  $P$  is relatively small with respect to the NPV of the bank, i.e.  $P \leq \frac{NPV}{2/3 + \epsilon + r}$ .

## B Proof of Proposition 1

To prove the Proposition we first determine the conditions under which the pair  $(\delta^u, \delta^m) \in [0, 1]^2$  exists and satisfies Equations (1), (2) and (5). Note that there is not loss of generality in considering the case where inequality (5) is binding and therefore it is equivalent to

$$\delta^u = \frac{(L + P - E)(1 + r) - 1/3\delta^m R^m - (1/3 - \epsilon)P}{(1/3 + \epsilon)R^u}. \quad (25)$$

Replacing (25) this value into Equations (1) and (2) we get the following conditions:

$$\delta^m \geq \frac{(L + P - E)(1 + r) - (1/3 - \epsilon)P - (1/3 + \epsilon)(R^u - \frac{B}{\epsilon})}{1/3R^m}, \quad (26)$$

and

$$\delta^m \leq \frac{\alpha(L + P - E)(1 + r) + (1/3 + \epsilon)[(\alpha + \beta)R^m - \alpha R^u] - (1/3 - \epsilon)\alpha P}{R^m[\alpha(2/3 + \epsilon) + \beta(1/3 + \epsilon)]}. \quad (27)$$

Furthermore, considering that  $\delta^u \in [0, 1]$ , we get the following two additional conditions:

$$\delta^m \leq \frac{(L + P - E)(1 + r) - (1/3 - \epsilon)P}{1/3R^m}, \quad (28)$$

and

$$\delta^m \geq \frac{(L + P - E)(1 + r) - (1/3 - \epsilon)P - (1/3 + \epsilon)R^u}{1/3R^m}. \quad (29)$$

It is easy to see that Equation (29) is redundant given Equation (26). Therefore, a solution for the pair  $(\delta^u, \delta^m)$  exists if there exists  $\delta^m \in [0, 1]$  such that Equations (26), (27) and (28) hold. Notice that the right-hand side of Equation (26) is always lower than the the right-hand side of Equation (28) because  $R^u > \frac{B}{\epsilon}$ . Finally, the right-hand side of Equation (26) is lower than the right-hand side of Equation (27) if the following condition

holds:

$$\frac{(L + P - E)(1 + r) - (1/3 - \epsilon)P - (1/3 + \epsilon)(R^u - \frac{B}{\epsilon})}{1/3} \leq \frac{\alpha(L + P - E)(1 + r) + (1/3 + \epsilon)[(\alpha + \beta)R^m - \alpha R^u] - (1/3 - \epsilon)\alpha P}{\alpha(2/3 + \epsilon) + \beta(1/3 + \epsilon)}. \quad (30)$$

Working out the previous inequality we get that a solution exists if and only if:

$$E \geq I + P - \frac{1}{1 + r} \left[ \bar{V} - \frac{B}{\epsilon} (1/3 + \epsilon + 1/3 \frac{\alpha}{\alpha + \beta}) + (1/3 - \epsilon)P \right], \quad (31)$$

or equivalently,  $E \geq E_0^M + P \left( \frac{2/3 + r + \epsilon}{1 + r} \right)$ .

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