Documentos de Trabajo

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Documento No. 09/15
Noviembre 2015

ISSN 0797-7484

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October 31, 2015

Abstract

We formally compare the effects of minimum capital requirements, capital buffers, liquidity requirements and loan loss provisions on the incentives of bankers to exert effort and take excessive risk. We find that these regulations impact differently the behavior of bankers. In the case of investment banks, the application of capital buffers and liquidity requirements makes it more difficult to achieve the first best solution. In the case of commercial banks, capital buffers, reserve requirements and traditional loan loss provisions for expected losses provide adequate incentives to bank managers, although the capital buffer is the most powerful instrument. Counter-cyclical (so-called dynamic) loan loss provisions may provide bank managers with incentives to gamble. The results inform policy makers in the ongoing debate about the harmonization of banking regulation and the implementation of Basel III.

JEL classification numbers: G21, G28

Keywords: Banking regulation, minimum capital requirement, capital buffer, liquidity requirement, (counter-cyclical) loan loss provision, commercial banks, investment banks, bankers' incentives, effort, risk.

*The views expressed herein are those of the authors and do not necessarily represent the views of the institutions to which they are affiliated. The authors would like to thank Marc Rennert, participants to the 30 Jornadas Anuales de Economía at Banco Central del Uruguay and the 10 Seminar on Risk, Financial Stability and Banking at the Banco Central do Brasil for their comments.

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Resumen

Se analizan en un modelo formal los efectos de los requerimientos mínimos de capital, de los colchones de capital, de los requerimientos de liquidez y de las provisiones sobre los incentivos de los banqueros para realizar esfuerzo y no tomar riesgos en exceso. Estas regulaciones afectan el comportamiento de los banqueros de manera diferenciada. En el caso de los bancos de inversión, la aplicación de colchones de capital y requerimientos de liquidez hacen más difícil implementar el primer óptimo. En el caso de bancos comerciales, los colchones de capital, los requerimientos de liquidez y los sistemas tradicionales de provisiones por pérdidas esperadas proveen los incentivos adecuados al banquero, siendo los colchones de capital el instrumento más poderoso. Provisiones contracíclicas, también llamadas dinámicas, pueden proveer incentivos inadecuados al banquero. Los resultados de este trabajo informan el debate actual sobre la armonización de la regulación bancaria y la implementación de Basilea III.

JEL: G21, G28

Palabras clave: Regulación bancaria, requerimiento mínimo de capital, colchones de capital, requerimientos de liquidez, provisiones (contracíclicas), bancos comerciales, bancos de inversión, incentivos del banquero, esfuerzo, riesgo.

1 Introduction

In the aftermath of the financial crisis 2008-2009 the trend towards the harmonization of financial regulation has gained momentum. New regulation is being introduced and applied to a broader set of financial institutions with the aim of avoiding regulatory arbitrage and making financial institutions 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, such as the conservation and the counter-cyclical ones, as well as enhanced liquidity requirements. 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 system. At the same time, several jurisdictions start to apply to investment banks capital and liquidity regulation similar to that already enacted to commercial banks.[1]

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.[2] For example, several countries (e.g. Spain, Peru and Uruguay) introduced counter-cyclical loan loss provision regulation (also called dynamic or statistical provisions) long before the Basel's III counter-cyclical capital buffer proposal. How would these two instruments work together? Should these countries continue their counter-cyclical provisions once Basel III has been implemented? Should regulators prefer the use of one instrument over the other? Answering this kind of questions requires to consider the impact of regulations on banker's incentives. The reaction of bankers to different regulations may, in turn, depend on the type of bank they are managing. More precisely, would the same capital or liquidity regulation provide the same incentives to a

[1] For example, the Dodd-Frank Act in the U.S., and the Capital Requirement Regulation (CRR) and the Capital Requirement Directive (CRD 4) in Europe impose new capital and liquidity requirements to investment banks which are in line with the regulation to commercial banks.

[2] 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.

commercial bank manager than to an investment bank one? Should regulators apply the same rules for commercial and investment banks? 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 four different regulations: (i) minimum capital requirements, (ii) capital buffers, (iii) liquidity requirements and (iv) (counter-cyclical) loan loss provisions. Our analysis considers two kinds of financial institutions, which differ in their funding structures. First, we consider an investment bank, which is market funded and raises funds from outside sophisticated investors operating in financial markets. Second, we consider a commercial bank, which is a deposit funded bank and raises funds from small and non-sophisticated depositors.

We find that regulations impact the incentives of bankers differently and we characterize conditions under which they make it easier or harder to implement the first best solution. In the case of the investment bank, the requirement of a capital buffer hardens the participation constraint of external investors; it may prevent a bank from existing if the requirement is too large. Liquidity requirements make it harder to provide the correct incentives to the bank manager in the sense that it needs to be complemented by more internal equity. The intuition for this result is that, given the moral hazard problems, external investors require a larger participation 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. Hence, the harmonization of capital and liquidity requirements to investment banks may have unintended consequences if the incentives of bankers and their reaction to new regulation are not taken into account.

In the case of the commercial bank, the requirement of a capital buffer facilitates the provision of the correct incentives to bank managers. More precisely, capital buffers

are perfect substitutes to minimum capital requirements in order to provide the right incentives to bank managers: requiring extra capital is a direct mechanism to increase the participation of the bank manager on the bank so as to mitigate the moral hazard problems. Liquidity requirements also make it easier to provide the correct incentives to bank managers, but they are a less powerful instrument than capital buffers. 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. In this sense, we say that liquidity requirements are imperfect substitutes to minimum capital requirements. This result is also valid for the case of traditional provision systems for expected loan losses. The accumulation of a counter-cyclical 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 needs 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 derive several policy implications that may help to inform current regulatory debates. First, the harmonization of capital and liquidity requirements to investment banks may have unintended consequences due to the reaction of bankers to new regulation. A capital buffer may prevent positive NPV investment banks from existing and a liquidity requirement makes it more difficult to provide the correct incentives to bank managers. Hence, the correct design of capital and liquidity regulation for investment banks should consider the potential negative effects on efficiency and social welfare. Second, our results also shed light on the complementarity of implementing a counter-cyclical capital buffer for commercial banks in countries already running counter-cyclical loan loss provision systems. Capital buffers and traditional provisions for expected loan losses (which works as a reserve requirement) provide adequate incentives to bank managers, the former being a more powerful instrument than the latter. However, counter-cyclical 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 counter-cyclical

loan loss provisions with higher minimum capital requirements and stronger supervision of risk-taking activities.

In the next section, we revise related literature. In Section 3, we introduce the basic model. In Section 4, we analyze the case of a market funded investment bank, and in Section 5, we study the case of a deposit funded commercial 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

This paper contributes to the on-growing literature on banking regulation by considering the effects of prudential regulation on the incentives of bank managers. Managers' incentives are particularly relevant in banking because asymmetric information determines that, in addition to the traditional effort problem, another moral hazard problem is likely to exist under the form of risk shifting. Hence, the outcome of the same prudential regulation may be very different when one considers these moral hazard problems as, for example, Arango and Valencia (2015) have highlighted.

One strand of the banking regulation literature has focused on microeconomic aspects by analyzing the optimal bank's funding structure. In general, it looks for optimal financial contracts in presence of the two moral hazard problems described previously, i.e. effort and risk-shifting. When dealing exclusively with the effort problem, debt contracts arise as the optimal ones (see, for example, Calomiris and Kahn, 1991; Diamond and Rajan, 2001; and Diamond and Rajan, 2012). The reason is that short-term debt acts as a threat to bank managers: if they do not diligently manage the loan portfolio, then debt holders would not roll over their financing. Hence, debt contracts are needed in order to impose some market discipline to bank managers.

In dealing exclusively with the risk-shifting problem, Bolton et al. (2015) develop a model that includes shareholders, debtholders, depositors and bank managers in order to capture the risk-taking incentives of each of these players. Equity contracts arise as the optimal ones (see also Admati et al., 2013 and the references therein). The reason for this is that once debt is in place, bank managers (and also shareholders) have incentives

to take excessive risk at the expense of creditors: creditors do not benefit from the high returns in the event of success but they are burdened with the increased cost in the event of default. Feess and Hege (2012) find that capital requirements differentiated according to the bank size are good instruments to deal with the risk-shifting problem.

Finally, Acharya et al. (2012), Acharya et al. (2014) and Hellwig (2009) consider both moral hazard problems simultaneously. In all these papers debt and equity pose a trade-off for regulators: debt is good for monitoring incentives while equity is good for prudent investment. Hence, the prescription of these models is to require banks hybrid funding contracts.

Our work also consider both moral hazard problems simultaneously and assume that bank manager's incentives are linked to shareholders' value as in Holmstrom and Tirole (1993). We contribute to the above mentioned literature by analyzing the impact that different banking regulations have on the implementation of the first best optimal solution via the incentives that they provide to bank managers. As it may become clear below, this effort allows us to build a link between the strand of the literature taking a microeconomic perspective and the one focusing on the design of banking regulation from a macro-prudential perspective.

The strand of the literature focusing on the design of macro-prudential policies has looked for mechanisms that minimizes the frequency and cost of systemic failures (see, for example, Galati and Moessner, 2011, for a review). In doing so, it considers the macroeconomic consequences of bank managers' decisions. This strand of the literature has pointed out that capital requirements may add procyclicallity (Benigno, 2013; Brunnermeier et al., 2009; Hanson et al., 2011; and Repullo and Suarez, 2013). Different policy options have been proposed to tackle this problem. For example, Repullo et al. (2010) propose cyclically adjusted capital requirements; Allen and Carletti (2013) suggest the use of counter-cyclical capital ratios or loan loss provisions; the Committee of European Banking Supervisors (2009) and the Basel Committee on Banking Supervision (2010) recommend the construction of capital buffers during economic booms; Burroni et al. (2009) suggest the use of counter-cyclical loan loss provisions. In this paper, we analyze the effect of different policies on banker's risk-taking and monitoring incentives. Hence, we complement the previously mentioned analyses by assessing the relative power of different

macro-prudential instruments given the asymmetric information problems that are present in the banking industry.

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^θ, which is contingent on the state of the world θ 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^θ) 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 $R^d = 0$. We also assume 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 ϵ and the probability of the bad state ($\theta = d$) decreases by ϵ. Denote by $\overline{V}$ 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: $\overline{V} > \underline{V} + B$. 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 α and that of the bad state ($\theta = d$) by β. 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 accrue to each of the parties in each state of the world. Let δ^θ be the share of the return earned by external investors in state θ. We assume the bank manager has limited liability, therefore for every θ, $\delta^\theta \leq 1$. In the following section, we will consider the case of an investment bank which raises funds from the financial market, and we look for the optimal contract that implements the first best solution. In Section 5, we will consider the 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 $\delta^m = \frac{D}{R^m}$.[3]

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, liquidity requirements and loan loss provisions.

Timing. The sequence of events is as follows. Bank managers raise funds from external

[3]The value of δ^d may depend on the specific form of regulation as we will discuss in the following sections.

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 The investment bank: a market funded bank

In this section, we consider the case of an investment bank which is market funded. In this case, bank managers finance their banks with their own equity as well as with outside equity raised from sophisticated investors through financial markets.

4.1 Benchmark case: minimum capital requirement

For further comparison, we first analyze the benchmark case in which a minimum level of capital is required to bank managers in order to operate the bank. More precisely, we compute the minimum level of equity capital that allows the existence of an optimal financial contract between a bank manager and external investors so that the first best solution is attainable and a positive NPV investment 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:

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

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.[4]

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 investment bank can be market funded if the initial equity of bank managers (E) is large enough. In particular:*

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

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

[4]See the Appendix A for a similar proof to the one which is required here.

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 α increases. E_0^M is increasing in the product of the cost of effort B and the risk-shifting parameter α. 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.

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.[5] Hence, in a market funded bank the introduction of a capital buffer P may only change the results on Lemma 1 if the required buffer is too high. More precisely, if $P < L - E_0$, then the requirement is fulfilled with the amount of equity that external investors 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 $P > L - E_0$, then the first best solution cannot be attained and no positive NPV bank can be funded by the market.

4.3 Liquidity requirement

We now consider the case in which a liquidity requirement P has to be put aside in order for the bank to be authorized to operate. Differently from a capital buffer, a liquidity 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 liquidity requirement. This extra

[5] See Admati et al. (2013) for a detailed discussion about bank equity and capital regulation.

funding does have an opportunity cost r. In addition to that, the liquidity 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:

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

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.

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.[6]

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 liquidity requirement P, then the first best solution can be attained and a positive NPV investment bank can be market funded if the initial equity of bank managers (E) is large enough:*

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

Proof: See Appendix B.

[6]More precisely, we prove that $P \leq \frac{NPV}{2/3+\epsilon+r}$ is sufficient to guarantee the participation of the bank manager, where $NPV \equiv \overline{V} - L(1 + r)$ 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 through this paper.

The introduction of a liquidity requirement 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's incentive compatibility constraints and soften the external investors' participation constraint, the bank manager needs to have a larger participation on the bank portfolio of loans, i.e. E_1^M has to be larger than E_0^M.

4.4 Comparisons

Compared to the benchmark case, higher capital buffers for investment banks harden the participation constraint of external investors. It may prevent a bank from existing if the requirement is too large. Liquidity regulation, in the form of a reserve requirement, makes it more difficult to provide the correct incentives to bank managers. It needs to be complemented by an increase in internal equity in order to reestablish incentives. Putting differently, if a liquidity requirement is enacted, 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 to satisfy the incentive compatibility constraints of the bank manager. As a consequence, a larger proportion of bank managers fails to be financed by external investors and credit rationing becomes more prevalent.

These results show that the introduction to investment banks of capital and liquidity regulation similar to the regulation of commercial banks may have unintended consequences due to their effect on bankers' incentives. First, it may prevent positive NPV investment banks from existing, which reduces efficiency and social welfare. Second, it may be the case that liquidity regulation actually increases risk taking by bankers, again reducing welfare, if it is not complemented with higher capital requirements. Moreover, the correct design of liquidity and capital regulation for investment banks (i.e. the rules that provide the correct incentives to bank managers) should consider the efficiency and welfare costs of having a smaller investment banking industry.

5 The commercial bank: a deposit funded bank

In this section, we study the case of a commercial bank where 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,

$$(1/3 + \epsilon)(R^u - D) + 1/3(R^m - D) \geq 1/3(R^u - D) + 1/3(R^m - D) + B. \tag{7}$$

The left-hand side of Equation (7) 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,

$$(1/3+\epsilon)(R^u - D) + 1/3(R^m - D) \geq (1/3+\epsilon+\alpha)(R^u - D) + (1/3-\alpha-\beta)(R^m - D). \tag{8}$$

The left-hand side of Equation (8) 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 (7) and (8).

The participation constraint of depositors is:

$$(2/3 + \epsilon)D \geq (L - E)(1 + r). \tag{9}$$

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

Proposition 2 *The first best solution is attained and a positive NPV commercial bank can be deposit funded if the initial equity of bank managers (E) is larger than the minimum capital requirement* E_0^D*:*

$$E \geq E_0^D \equiv L - \frac{2/3 + \epsilon}{1 + r} \min \left[R^u - \frac{B}{\epsilon}; \frac{(\alpha + \beta)R^m - \alpha R^u}{\beta} \right]. \tag{10}$$

Proof: Omitted (it 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 that 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' payoffs 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:

$$(2/3 + \epsilon)D \geq (L - E - P)(1 + r). \tag{11}$$

It is not difficult to see that the incentive compatibility constraints of the bank manager remains unchanged with the introduction of capital buffer regulation, i.e. Equations (7) and (8) hold.

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

Proposition 3 *When capital regulation takes the form of a capital buffer P, then the first best solution can be attained and a positive NPV commercial bank can be deposit funded if the initial equity of bank managers (E) is larger than the minimum capital requirement E_1^D:*

$$E \geq E_1^D \equiv E_0^D - P \tag{12}$$

Proof: Omitted (it 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. $E_1^D < E_0^D$. Requiring extra capital is a direct mechanism to increase the participation of the bank manager on the bank and then it 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 in order for the banker to exert effort and refrain from excessive risk taking.

5.3 Liquidity requirement

We now consider the case in which regulation imposes a liquidity 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 liquidity requirement. Differently from the market funded bank case, in the deposit funded bank the liquidity requirement needs to be financed by the internal investor, i.e. the bank manager. In addition to that, the liquidity 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:

$$(2/3 + \epsilon)D + (1/3 - \epsilon)P \geq (L - E)(1 + r). \tag{13}$$

The left-hand side of Equation (13) 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 cost. The following proposition summarizes the results.

Proposition 4 *When regulation takes the form of a liquidity requirement P, then the first best solution can be attained and a positive NPV commercial bank can be deposit funded if the initial equity of bank managers (E) is larger than the minimum capital requirement E_2^D:*

$$E \geq E_2^D \equiv E_0^D - P\left(\frac{1/3 - \epsilon}{1 + r}\right). \tag{14}$$

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

As in the case of capital buffer regulation, liquidity 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 to refrain from taking excessive risk. In this sense, liquidity requirements make it easier to provide the correct incentives to the bank manager: $E_2^D < E_0^D$. However, since the liquidity requirement needs to be put aside and cannot be invested in loans, it introduces inefficiencies.

As a result, this instrument is less powerful than capital buffers: liquidity requirements are imperfect substitutes to minimum capital requirements, i.e. $E_1^D < E_2^D$.

5.4 Loan loss provision

The traditional loan loss provision system consists in anticipating the expected losses due to non-repayment of the loan and accounting them as a reduction to the loan's face value when the loan is granted. At maturity, if the loan is repaid the provision is released but if it is not the provision covers (part of) the losses. Other things equal, a loan loss provision for expected losses affects the capital of the bank at the moment the loan is granted because the loss is anticipated and counted. Hence, we use the following modeling shortcut to introduce loan loss provisions: when a loan L is granted, then the banker needs equity capital E in order to provide internal financing to the loan and also an amount P to cover the provision for loan losses, i.e. in order not to fall short the minimum capital requirement. Assuming that P is kept in riskless assets, then a loan loss provision for expected losses has the same effects than the reserve requirement analyzed in the previous section. Hence, Proposition 4 holds for the case of loan loss provisions for expected loses.

Several jurisdictions manage counter-cyclical loan loss provision systems (also called dynamic provisions). Under counter-cyclical provisioning a loan loss provision fund is accumulated in periods where the expected losses are lower than the long-run, or through-the-cycle, level of losses. The fund is constituted and counter-cyclical provisions are not released in periods with low default rates. In practice, it is common that bankers use current profits to build the counter-cyclical provision fund. Hence, part of the return from the bank portfolio of loans is kept aside to build the fund, affecting the distribution of returns between bank managers and depositors with implications for the bankers' incentives. Once the fund is accumulated, it is used to cover losses for loan non-repayment as in the traditional loan loss provision system. In order to keep the framework as simple as possible, we abstract from modeling the use of the fund and focus on the accumulation phase. More precisely, we assume that in periods where the bank loan repays, an amount P of the cash flow is accumulated to the counter-cyclical loan loss provision fund. In this context, the optimal contract will have to satisfy the following two incentive compatibility

constraints:[7]

$$\begin{aligned}(1/3+\epsilon)(R^u-P-D)+1/3(R^m-P-D)\geq\\ 1/3(R^u-P-D)+1/3(R^m-P-D)+B\end{aligned} \tag{15}$$

and

$$\begin{aligned}(1/3+\epsilon)(R^u-P-D)+1/3(R^m-P-D)\geq\\ (1/3+\epsilon+\alpha)(R^u-P-D)+(1/3-\alpha-\beta)(R^m-P-D).\end{aligned} \tag{16}$$

The participation constraint of depositors is the same as in the benchmark case (see Equation (9)). Given this new set of constraints we are able to state the following proposition.

Proposition 5 *When regulation takes the form of a counter-cyclical loan loss provision and a fund sized P is accumulating, then the first best solution can be attained and a positive NPV commercial bank can be deposit funded if the initial equity of bank managers (E) is larger than the minimum capital requirement E_3^D:*

$$E\geq E_3^D\equiv E_0^D+P\left(\frac{2/3+\epsilon}{1+r}\right). \tag{17}$$

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

The impact of the accumulation of a counter-cyclical loan loss provision fund is twofold. On the one hand it reduces the bank manager expected return. This implies that bank managers need to put more skin in the business to get the right incentives to exert effort and to abstain from excessive risk taking. On the other hand, depositors require lower returns compared to the benchmark case because they will 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. Hence, when the fund is accumulating, counter-cyclical loan loss provision regulation makes it more difficult to provide the correct incentive to bank managers determining that a larger proportion of

[7]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.

positive NPV commercial banks fail to get funded by depositors. Otherwise stated, the accumulation of loan loss provisions needed to be complemented with higher minimum capital requirements so that the combination of regulatory tools reestablish the incentives of bank managers.

5.5 Comparisons

In the case of a commercial deposit funded bank, both a capital buffer and liquidity requirement regulation make it easier to provide the correct incentives to the bank manager. In this sense, we say that they are substitutes to minimum capital requirements. However, the consequences of implementing one or the other are not exactly the same due to the cost each regulation implies. Thereby, a capital buffer is a perfect substitute to minimum capital requirement while a reserve requirement is only an imperfect one. Hence, a capital buffer is a more powerful instrument than a reserve requirement in order to provide good incentives to the bank manager.

We also find that traditional loan loss provision for expected losses make it easier to provide the correct incentives to bank managers. However, counter-cyclical 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, i.e. $E_3^D > E_2^D$, which in turn is dominated by capital buffers, i.e. $E_2^D > E_1^D$, 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, liquidity 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. We find that the effect of these regulations on banker's incentives differs according to the bank's funding structure.

For the case of market funded banks (e.g. investment banks), capital buffers and liquid-

ity requirements similar to that of commercial banks may have unintended consequences due to their impact on bankers' incentives. Capital buffers may prevent positive NPV investment banks from existing and liquidity requirements 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, so that the correct design of capital and liquidity regulation for investment banks should consider the potential negative effects on efficiency and social welfare.

For the case of deposit funded banks (e.g. commercial banks), capital buffers, liquidity requirements and traditional loan loss provision regulation make it easier to provide the correct incentives to the bank manager. Capital buffers are the most powerful of these instruments. By contrast, counter-cyclical loan loss provision regulation makes it more difficult to provide the correct incentives to the bank manager in times where the fund is accumulating. These theoretical results may help informing ongoing regulatory debates. More precisely, our results shed light on the complementary effects of implementing a counter-cyclical capital buffer in countries already running counter-cyclical loan loss provision systems (e.g. Spain, Peru and Uruguay among others).[8] We find that a capital buffer is the most powerful instrument to provide adequate incentives to bank managers. Counter-cyclical loan loss provision regulation may provide bank managers with incentives to gamble in periods during which the fund is accumulating (i.e. in good times). Hence, in good times bank supervisors should either prefer the use of counter-cyclical capital buffers or complement counter-cyclical 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 liquidity requirement. Following the

[8] Our analysis does not focus on particular cases of capital regulation (e.g. counter-cyclical buffers) but on the general instruments (e.g. capital buffers). Hence, our results hold for particular cases. For example, the consideration of a counter-cyclical component affects the calibration of P and once this parameter is determined the results of our model apply.

same steps we follow below, it can be shown that the same condition also guarantee the participation of the manager for the other cases we have considered through the paper.

The bank manager participation constraint is:

$$(1/3+\epsilon)(1-\delta^u)R^u + 1/3(1-\delta^m)R^m \geq (1+r)E. \tag{18}$$

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

$$\delta^u = \frac{(L+P-E)(1+r) - 1/3\delta^m R^m - (1/3-\epsilon)P}{(1/3+\epsilon)R^u}. \tag{19}$$

Substituting 19 into 18 and after some manipulations we get:

$$NPV \equiv \overline{V} - (1+r)L \geq (2/3+\epsilon+r)P. \tag{20}$$

Hence, a sufficient condition that assures the participation of the manager is that the reserve requirement 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

$$\delta^u = \frac{(L+P-E)(1+r) - 1/3\delta^m R^m - (1/3-\epsilon)P}{(1/3+\epsilon)R^u}. \tag{21}$$

Replacing (21) into Equations (1) and (2) we get the following conditions:

$$\delta^m \geq \frac{(L+P-E)(1+r) - (1/3-\epsilon)P - (1/3+\epsilon)(R^u - \frac{B}{\epsilon})}{1/3R^M}, \tag{22}$$

and

$$\delta^m \leq \frac{\alpha(L+P-E)(1+r) + (1/3+\epsilon)\big[(\alpha+\beta)R^m - \alpha R^u\big] - (1/3-\epsilon)\alpha P}{R^m\big[\alpha(2/3+\epsilon) + \beta(1/3+\epsilon)\big]}. \tag{23}$$

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

$$\delta^m \leq \frac{(L+P-E)(1+r)-(1/3-\epsilon)P}{1/3R^m}, \tag{24}$$

and

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

It is easy to see that Equation (25) is redundant given Equation (22). Therefore, a solution for the pair (δ^u, δ^m) exists if there exists $\delta^m \in [0,1]$ such that Equations (22), (23) and (24) hold. Notice that the right-hand side of Equation (22) is always lower than the the right-hand side of Equation (24) because $R^u > \frac{B}{\epsilon}$ since, by assumption, effort is socially optimal: $\overline{V} > \underline{V} + B$. Finally, the right-hand side of Equation (22) is lower than the right-hand side of Equation (23) if the following condition holds:

$$\begin{aligned} &\frac{(L+P-E)(1+r)-(1/3-\epsilon)P-(1/3+\epsilon)(R^u-\frac{B}{\epsilon})}{1/3} \leq \\ &\frac{\alpha(L+P-E)(1+r)+(1/3+\epsilon)\big[(\alpha+\beta)R^m-\alpha R^u\big]-(1/3-\epsilon)\alpha P}{\alpha(2/3+\epsilon)+\beta(1/3+\epsilon)}. \end{aligned} \tag{26}$$

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

$$E \geq I + P - \frac{1}{1+r}\Big[\overline{V} - \frac{B}{\epsilon}(1/3+\epsilon+1/3\frac{\alpha}{\alpha+\beta}) + (1/3-\epsilon)P\Big], \tag{27}$$

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

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