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# Capital and Liquidity in a Dynamic Model of Banking

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## Abstract

This paper analyzes capital requirements in combination with a particular kind of cash reserves, that are invested in the risk-free asset, from now on, compensated reserves. We consider a dynamic framework of banking where competition may induce banks to gamble. In this set up, we can capture the two effects that capital regulation has on risk, the capital-at-risk effect and the franchise value effect (Hellman. et. al. 2000). We show that while capital alone is an inferior policy, compensated reserves, will complement capital requirements, by creating franchise value, and are therefore efficient in solving moral hazard problems.

*Keywords:* Capital requirements, Compensated Reserves, Dynamic Framework, Moral hazard.

*JEL classification:* G21; G28

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# 1 Introduction

The recent financial crisis has re-opened a debate concerning the stability of the banking system and the use of safety nets. Deposit insurance systems and safety nets, in general, create a conflict for governments: although they prevent banking panics and their spill over effects, they may also reduce market discipline and consequently increase the probability of occurrence of such crises. There is therefore no doubt on the need to adopt measures that limit the risk that banks take in order to have a stable system. Establishing capital requirements is one of those measures adopted by regulators since the mid 1980s. The common justification for bank capital is the reduction in moral hazard generated by deposit insurance. It is argued that if shareholders have a larger stake in the bank, the incentives to engage in risk are lower because shareholders are less likely to be bailed out than depositors. The positive effects of capital requirements on risk have been widely analyzed from a theoretical point of view (see Buser et. al. 1981, Repullo, 2004 or Morrison and White 2005). Nevertheless, other studies have reached the opposite result (Besanko and Kanatas 1994, Blum, 1999, Koehn and Santomero, 1980 or Genotte and Pyle 1991). Overall, the theoretical literature has raised doubts about the effects of capital requirements on risk (Hellman et. al. 2000, Gale 2010 and Plantin 2015).

In particular, Hellman et. al. (2000) analyze moral hazard in a dynamic model, and show that capital requirements are not an efficient tool. On one side, increased capital requirements induce banks to take lower risk projects since they are more exposed to losses on these projects, and so they will decide to undertake safer ones, thus reducing their probability of failure. This is the capital-at-risk-effect, usually contemplated in the literature. However, there is another effect at place. As the amount of capital is increased, the per-period future profits of the bank decrease, and hence, the franchise value decreases. This dynamic effect of capital, the negative franchise-value effect, is ignored in static models. Hence, the total effect of capital on risk is ambiguous, depending on which effect prevails. The authors show that Pareto efficient outcomes can be achieved by adding interest rate controls as a regulatory instrument. This result is in line with Keeley's well-known paper (1990). Keeley argues that banking competition erodes the value of banks' franchise values. He finds a significant relationship between competition, reduction in franchise values and increase in the number of bank failures in the US during the 1980s. In Hellman et. al. (2000) an interest rate cap creates charter value.

We extend Hellman et. al. (2000) in order to analyze capital and compensated liquidity requirements. We show how a combination of capital and compensated reserves turns out to be efficient in order to solve the moral hazard problem. The advantage of compensated reserves is that they always increase the franchise value, while the effect of capital alone is ambiguous. We also demonstrate that both policies complement each other. Finally, our proposal improves over the one described in Hellman et. al. (2000), a policy of capital and interest rate controls. We do not need to limit competition in order to create charter value. A cap on interest rates, would increase competition from the non-banking sector.

Shadow banks or non-banks institutions would have higher incentives to move into financial intermediation, creating time-inconsistency problems for the regulator. Our proposal avoids this issue.

We build on the model by Hellman et. al. (2000). We consider a bank operating for  $T$  periods. There is deposit insurance and so the bank faces moral hazard problems. In particular, it can choose between two projects, a safe asset or a risky one, that yields a lower expected return. However, the gambling asset has greater return in case of success. Banks are subject to prudential regulation by the government, and are required an amount of capital. We show that in the competitive equilibrium, banks would voluntarily hold no capital, and under certain conditions, would invest in the gambling asset. In this context capital requirements alone are an inferior policy (Hellman et. al. 2000). We extend this setup and analyze jointly capital and compensated reserves requirements. We show how for a given level of capital, implementing a policy of compensated reserves requirements can be Pareto efficient, and avoids the problems generated by a policy of interest rate caps.

Recently, a growing strand of literature has looked at the interaction between liquidity and capital instruments. The underlying argument in these papers is that these tools are not independent.<sup>1</sup> Along these lines Repullo (2005) examines the role of a lender of last resort. He demonstrates that contrary to capital, liquidity requirements do not influence banks' moral hazard. De Nicolo et al. (2014) examine the role of capital, liquidity and Prompt Corrective Actions (PCA) in a dynamic model of banking. Overall, their results support the argument that capital and liquidity requirements can be seen as substitutes. There exists an inverted Ushaped relationship between bank lending, welfare, and capital requirements but liquidity requirements unambiguously reduce lending, efficiency and welfare. Similarly, Vives (2014) shows, in a model of financial crisis, that solvency and liquidity requirements are partial substitutes. Calomiris et. al. (2015) also develop a theory of liquidity requirements. They look at the interaction between capital and liquidity, in a context where both policies can influence liquidity and insolvency risk. They show that cash holdings improve bank incentives to manage risk in the remaining, non-cash portfolio of risky assets. In our case, contrary to these papers we find that capital and compensated reserves are complementary policies.

The rest of the paper is organized as follows. Section 2 presents the basic features of the model. Section 3 examines the decentralized economy with banks and no regulation. Section 4 analyzes both capital and compensated liquidity requirements, as complementary instruments to solve the moral hazard problem, introduced by deposit insurance. Capital regulation with interest rates caps is discussed in section 5. Finally, section 5 contains a policy debate and section 6 summarizes the concluding remarks.

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<sup>1</sup>The Basel Committee has proposed a new global set of liquidity requirements, the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), to complement capital requirements.

## 2 The Model

The model is based on Hellman et. al. (2000). We consider a bank operating for  $T$  periods. In each period, the bank offers an interest rate  $r_i$  on its deposits. There is deposit insurance in this economy and consequently, the volume of deposits depends only on the interest rate offered. The bank competes with other banks that offer an interest rate  $r_{-i}$  on their deposits. The total volume of the bank's deposits are  $D(r_i, r_{-i})$ , where the volume of deposits increases in the bank's own interest rate and decreases in the competitors' one ( $D_1 > 0$ ,  $D_2 < 0$ ). The bank is subject to a capital requirement that is a proportion of the deposits it mobilizes  $kD(r_i, r_{-i})$ . Therefore, total assets invested are equal to  $(1 + k)D(r_i, r_{-i})$ .

The bank faces moral hazard problems since its asset allocation decision is done after funds have been raised. In particular, this bank can choose between two projects: project I is the safe asset, that yields a return  $R$  with probability one. Project II, or the gambling asset, yields a return  $R^H$  with probability  $p$  and  $R^L$  with probability  $(1 - p)$ . The prudent asset has higher expected return ( $R > pR^H + (1 - p)R^L$ ), but the gambling asset has greater return in case of success ( $R^H > R$ ). We also assume that  $R^L = 0$ , which guarantees that in case of failure the bank is closed.

Banks are subject to prudential regulation by the government. Therefore, if a bank were to gamble and it fails, the bank would lose its charter value and it would be closed. In this economy, the regulator can observe the return of the bank at the end of the period but it is not able to detect good investments by monitoring.

Finally, it is assumed that bank capital is costly. The opportunity cost of capital ( $\rho$ ) is exogenous and  $\rho > R$ .<sup>2</sup>

In this paper, our idea is to analyze capital requirements in combination with a particular kind of cash reserves, that are invested in the risk-free asset. We will refer to them, from now on, as compensated reserves. By assumption, these reserves are lost, whenever the bank fails.

## 3 Competitive Equilibria and Capital

This benchmark section, that characterizes the equilibrium in the economy without regulation, is based on Hellman et. al. (2000).

We will derive the expected discounted profits of the bank with the two alternative investment choices. First, the per period profit of a bank that chooses the safe investment is:  $\pi_P(r_i, r_{-i}) = b_P(r_i)D(r_i, r_{-i})$ , where  $b_P(r_i) = R(1 + k) - r_i - \rho k$ , that is, the benefit per unit of deposit net of costs.

On the other side, the profit from investing in the gambling asset is  $\pi_G(r_i, r_{-i}) = b_G(r_i)D(r_i, r_{-i})$ , where  $b_G(r_i) = p[R^H(1 + k) - r_i] - \rho k$ . In this case, with probability  $p$ ,

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<sup>2</sup>This is a standard assumption in the banking literature, see Brusco and Castiglionesi 2007 or Allen et. al. 2011, among others.

the project is successful, depositors are paid and the bank receives the difference. With probability  $1 - p$ , the bank is closed and the banker loses the charter.

Banks maximize the expected discounted profits,  $V = \sum_{t=0}^T \delta^t \pi^t$ . As in Diamond (1989), we will look at the limit as  $T \rightarrow \infty$ . Banks will choose strategies corresponding to an infinitely repeated static Nash equilibrium.

The sequence of events is as follows: For a given level of capital, banks offer a deposit rate. Depositors then choose the bank in which to deposit their money. Finally, banks select the project, the returns are realized and the regulator supervises the balance sheet of banks. It can be seen that the investment process takes place in two steps, the deposit funding and the project selection step.

We focus first on the project selection step, assuming that banks have  $D(r_i, r_{-i})(1 + k)$  units to invest.

The expected discounted profits from investing in the safe asset are:  $V_P(r_i, r_{-i}) = \sum_{t=0}^{\infty} \delta^t \pi_P^t = \pi_P(r_i, r_{-i})/(1 - \delta)$ , while the expected discounted profits from investing in the gambling asset are:  $V_G(r_i, r_{-i}) = \sum_{t=0}^{\infty} \delta^t \pi_G^t = \pi_G(r_i, r_{-i})/(1 - p\delta)$ .

Banks will choose to invest in the safe asset if  $V_P(r_i, r_{-i}, k) \geq V_G(r_i, r_{-i}, k)$  and will invest in the gambling asset otherwise. From the previous inequality, the following no gambling condition can be derived:

$$\pi_G(r_i, r_{-i}) - \pi_P(r_i, r_{-i}) \leq (1 - p)\delta V_P(r_i, r_{-i}, k) \quad (1)$$

where  $(\pi_G - \pi_P)$  is the one period rent from gambling and should be less than the lost in the charter value ( $\delta V_P$ ) that the bank gives up if the gamble fails, that happens with probability  $(1 - p)$ . From this condition, we can derive the threshold rate for the bank to choose to invest in the safe asset (assuming a symmetric equilibrium in deposit rates):

$$\hat{r}(k) = \frac{(1 - \delta)}{1 - p} [R - pR^H](1 + k) + \delta[R(1 + k) - \rho k] \quad (2)$$

that is, for  $r \leq \hat{r}(k)$  the bank will invest in the safe asset.

Given the project selection step, we now consider the deposit funding. We will assume that if a competitive equilibrium with no gambling exists, then that will be the equilibrium chosen by banks. If a bank tries to invest in the safe asset, it will choose  $(r_P, k_P) = \arg \max_r \{V_P(r_i, r_{-i})\}$ , that is,  $\max_{r,k} \{\pi_P(r_i, r_{-i})/(1 - \delta)\}$

For a symmetric equilibrium (i.e.,  $r_{-i} = r_P$ ), using the first order condition ( $\partial V_P / \partial r_i = 0$ ) we have that  $b_P(r_P, k) = D(r_P, r_P) / (\partial D(r_P, r_P) / \partial r_i)$  that implicitly determines  $r_P(\alpha)$ . Making use of the fact that  $\varepsilon = (\partial D / \partial r_i)(r / D)$  we can derive the equilibrium interest rate as:

$$r_P(k) = \frac{[R(1 + k) - \rho k]\varepsilon}{1 + \varepsilon} \quad (3)$$

It can be shown that  $\partial V_P / \partial k$  is decreasing in  $k$ . Note when  $k = 0$  and competition for

deposits becomes sufficiently intense, that is,  $\varepsilon \rightarrow \infty$  then  $r_P \rightarrow R$ . If  $r_P(k)$  exceeds  $\hat{r}(k)$ , the bank earns greater profits from gambling.

We focus next in the situation where the bank invests in the gambling asset. Following the same argument as above, we have that for a symmetric equilibrium (i.e.,  $r_{-i} = r_P$ ), using the first order condition ( $\partial V_G / \partial r_i = 0$ ) we obtain  $b_G(r_G, k) = D(r_G, r_G) / (\partial D(r_G, r_G) / \partial r_i)$  that implicitly determines  $r_G(k)$ :

$$r_G(k) = \frac{[R^H(1+k) - \rho k/p]\varepsilon}{1 + \varepsilon} \quad (4)$$

As before, it can be shown that  $\partial V_G / \partial k$  is decreasing in  $k$  and so banks would be willing to hold no capital. In particular, if  $r_G(0) \geq \hat{r}(0)$  or  $\varepsilon \geq \frac{\hat{r}(0)}{R^H - \hat{r}(0)}$ , banks invest in the gambling asset.

This result is summarized in Proposition 1.

**Proposition 1** *When markets are sufficiently competitive, the symmetric equilibrium involves holding no capital and investing in the gambling asset.*

Proof: See Hellman et. al. (2000).

## 4 Compensated Reserve Requirements and Capital

In this section we analyze capital requirements and compensated reserves, as joint tools to tackle the moral hazard problem that arises in an economy with deposit insurance, and no other form of regulation.

We show that a combination of capital and reserves can be efficient in solving the moral hazard problem. In our case, franchise value is created without limiting competition. Finally, our policy improves over the one suggested in Hellman. et. al. (2000), a policy of capital requirements and interest rate controls, which is discussed in the next section.

As before, we assume the bank is subject to a capital requirement, which is a proportion of the deposits it mobilizes  $kD(r_i, r_{-i})$ . Additionally, it needs to post a proportion  $\alpha$  of deposits in compensated reserves,  $\alpha D(r_i, r_{-i})$ . These reserves yield a return of  $R$ . Therefore, total assets invested are equal to  $(1+k)(1-\alpha)D(r_i, r_{-i})$ .

The per period profit of a bank that chooses the safe investment is now:  $\pi_P(r_i, r_{-i}) = b_P(r_i)D(r_i, r_{-i})$ , where  $b_P(r_i) = R(1-\alpha)(1+k) + R\alpha(1+k) - r_i - \rho k = R(1+k) - r_i - \rho k$ , that is, the benefit per unit of deposit net of costs.

On the other side, the profit from investing in the gambling asset is  $\pi_G(r_i, r_{-i}) = b_G(r_i)D(r_i, r_{-i})$ , where  $b_G(r_i) = p[R^H(1-\alpha)(1+k) + R\alpha(1+k) - r_i] - \rho k$ . In this case, with probability  $p$ , the project is successful, depositors are paid and the bank receives the difference. With probability  $1-p$ , the bank is closed.

Banks maximize the expected discounted profits,  $V = \sum_{t=0}^T \delta^t \pi^t$  and choose strategies corresponding to an infinitely repeated static Nash equilibrium.

As in the previous section, we focus first in the project selection step, assuming that banks have  $(1+k)(1-\alpha)D(r_i, r_{-i})$  units to invest.

The expected discounted profits from investing in the safe asset are:  $V_P(r_i, r_{-i}) = \sum_{t=0}^{\infty} \delta^t \pi_P^t = \pi_P(r_i, r_{-i})/(1-\delta)$ , while the expected discounted profits from investing in the gambling asset are:  $V_G(r_i, r_{-i}) = \sum_{t=0}^{\infty} \delta^t \pi_G^t = \pi_G(r_i, r_{-i})/(1-p\delta)$ .

Then, banks will choose to invest in the safe asset if  $V_P(r_i, r_{-i}, k) \geq V_G(r_i, r_{-i}, k)$  and will invest in the gambling asset otherwise. From the previous inequality, the following no gambling condition can be derived:

$$\pi_G(r_i, r_{-i}) - \pi_P(r_i, r_{-i}) \leq (1-p)\delta V_P(r_i, r_{-i}, k) \quad (5)$$

where  $(\pi_G - \pi_P)$  is the one period rent from gambling and should be less than the lost in the charter value ( $\delta V_P$ ) that the bank gives up if the gamble fails, that happens with probability  $(1-p)$ . From this condition, we can derive the threshold rate for the bank to choose to invest in the safe asset (assuming a symmetric equilibrium in deposit rates):

$$\hat{r}(\alpha) = \left\{ \frac{(1-\alpha)}{1-p} [(1-p\delta)R - p(1-\delta)R^H] + R\alpha \right\} (1+k) - \delta\rho k \quad (6)$$

that is, for  $r \leq \hat{r}(\alpha)$  the bank will invest in the safe asset. It can be shown that  $\hat{r}(\alpha)$  is increasing in  $\alpha$ . Note that the  $\partial\hat{r}/\partial\alpha = \frac{p(1+k)(1-\delta)}{1-p}(R^H - R) \geq 0$  as by assumption  $R^H > R$  and  $\delta \leq 1$ .

Given the project selection step, we now consider the deposit funding. If a bank tries to invest in the safe asset, it will choose  $(r_P, k_P) = \arg \max_r \{V_P(r_i, r_{-i})\}$ , that is,  $\max_{r,k} \{\pi_P(r_i, r_{-i})/(1-\delta)\}$

For a symmetric equilibrium (i.e.,  $r_{-i} = r_P$ ), using the first order condition ( $\partial V_P/\partial r_i = 0$ ) we have that  $b_P(r_P, k) = D(r_P, r_P)/(\partial D(r_P, r_P)/\partial r_i)$  that implicitly determines  $r_P(\alpha)$ . Making use of the fact that  $\varepsilon = (\partial D/\partial r_i)(r/D)$  we can show that

$$r_P(\alpha) = \frac{[R(1+k) - \rho k]\varepsilon}{1+\varepsilon} \quad (7)$$

which is independent of  $\alpha$ .

The bank will invest in the safe asset whenever  $r_P(\alpha) \leq \hat{r}(\alpha)$ , that is:

$$\frac{\varepsilon}{1+\varepsilon} [R(1-\alpha)(1+k) + R\alpha(1+k) - \rho k] \leq (1+k) \left\{ \frac{(1-\alpha)}{(1-p)} [(1-p\delta)R - p(1-\delta)R^H] + R\alpha \right\} - \delta\rho k \quad (8)$$

or:

$$(1+k)(1-\alpha) \underbrace{\left\{ \left[ \frac{\varepsilon}{1+\varepsilon} - \frac{(1-p\delta)}{(1-p)} \right] R + p \frac{(1-\delta)}{(1-p)} R^H \right\}}_A + R\alpha(1+k) \underbrace{\left[ \frac{\varepsilon}{1+\varepsilon} - 1 \right]}_B \leq \underbrace{[\frac{\varepsilon}{1+\varepsilon} - \delta]\rho k}_C \quad (9)$$



The above equation can be expressed as follows:

$$(1+k)(1-\alpha)A + R\alpha(1+k)B \leq C\rho k \quad (10)$$

And solving for  $\alpha$  yields:

$$\alpha \geq \frac{(1+k)A - C\rho k}{(1+k)[A - BR]} \quad (11)$$

The basic result of this section is summarized in the following proposition:

**Proposition 2** *Any Pareto-efficient outcome can be implemented, for a given level of capital  $k$ , by posting an amount  $\alpha \geq \alpha^*(k)$ , in compensated reserves, where*

$$\alpha^*(k) = \frac{(1+k)A - C\rho k}{(1+k)[A - BR]} \quad (12)$$

and  $A = \left[\frac{\varepsilon}{1+\varepsilon} - \frac{(1-p\delta)}{(1-p)}\right]R + p\frac{(1-\delta)}{(1-p)}R^H$ ,  $B = \frac{\varepsilon}{1+\varepsilon} - 1$ ,  $C = \frac{\varepsilon}{1+\varepsilon} - \delta$

The profits for banks, depositors and the regulator are determined as a function of the deposit rate, the level of capital the amount posted in compensated reserves, and the banks' investment choice. The Pareto frontier is defined by the set of outcomes such that no agent can improve on this allocation without hurting some other agent. The Pareto frontier is represented by figure 1. The line represented by  $\hat{r}(\alpha)$  is the no gambling condition and the line  $r_P(\alpha)$  is the equilibrium interest rate, conditional on prudent investment. Rates where  $r_P(\alpha)$  is above  $r(\alpha)$  cannot be implemented, as banks would be gambling in that region.

Additionally, we can show that as long as markets are sufficiently competitive the amount of reserves will be strictly positive, that is  $\alpha > 0$ . This means that the curves  $r_P(\alpha)$  and  $\hat{r}(\alpha)$  intersect at a positive  $\alpha$ .

In order to show it, we substitute by  $\alpha = 0$  the two curves  $r_P(\alpha)$  and  $\hat{r}(\alpha)$ . The no gambling condition,  $\hat{r}(\alpha)$ , given in equation (6), becomes:

$$\hat{r}(0) = \frac{(1+k)}{1-p}[(1-p\delta)R - p(1-\delta)R^H] - \delta\rho k \quad (13)$$

Equation  $r_P(\alpha)$ , given in (7), at  $\alpha = 0$  does not change:

$$r_P(0) = \frac{[R(1+k) - \rho k]\varepsilon}{1+\varepsilon} \quad (14)$$

We want to show that  $r_P(0) > \hat{r}(0)$ , which implies that for any level of capital, the only equilibrium in the economy, involves holding a positive amount of reserves. The above condition can be written as follows:

$$\frac{[R(1+k) - \rho k]\varepsilon}{1+\varepsilon} > \hat{r}(0) \quad (15)$$

which operating yields that,

$$\epsilon > \bar{\epsilon} = \frac{\widehat{r}(0)}{R(1+k) - \rho k - \widehat{r}(0)} \quad (16)$$

This result is summarized in the following proposition:

**Proposition 3** *When markets are sufficiently competitive, and for any capital level, the amount posted in reserves is always positive.*

Additionally, the condition  $C\rho k > (1+k)BR$  assures that  $\alpha < 1$ .<sup>3</sup>

Finally, it can be demonstrated that  $\alpha^*(k)$  is decreasing in the level of capital, which implies that capital and reserves can be seen as complements.

We derive  $\alpha^*(k)$ , defined in equation (12), with respect to  $k$ :

$$\frac{\partial \alpha^*(k)}{\partial k} = \frac{(A - C\rho)(1+k)(A - BR) - [(1+k)A - C\rho k](A - BR)}{(1+k)^2(A - BR)^2} \quad (17)$$

Eliminating  $(A - BR)$  on the numerator and denominator:

$$\frac{\partial \alpha^*}{\partial k} = \frac{(A - C\rho)(1+k) - [(1+k)A - C\rho k]}{(1+k)^2(A - BR)} \quad (18)$$

Or:

$$\frac{\partial \alpha^*(k)}{\partial k} = \frac{C\rho k - (1+k)C\rho}{(1+k)^2(A - BR)} \quad (19)$$

which becomes

$$\frac{\partial \alpha^*(k)}{\partial k} = \frac{-C\rho}{(1+k)^2(A - BR)} \quad (20)$$

It can be shown that as  $\epsilon \rightarrow \infty$ ,

$$\frac{\partial \alpha^*(k)}{\partial k} < 0 \quad (21)$$

Note that as  $\epsilon \rightarrow \infty$ ,  $A, C > 0$ , and  $B \rightarrow 0$ .

## 5 Capital Requirements and Interest Rate Controls

The next step is to show that the policy regime of the previous section dominates any policy of capital requirements and interest rate controls.

Note that in the analysis of the previous section, capital requirements in isolation can just be interpreted as a situation were  $\alpha = 0$  (Hellman et. al. 2000).

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<sup>3</sup>This condition is satisfied as long as markets are sufficiently competitive. Note that when  $\epsilon \rightarrow \infty$ ,  $B \rightarrow 0$  and the condition is automatically satisfied.

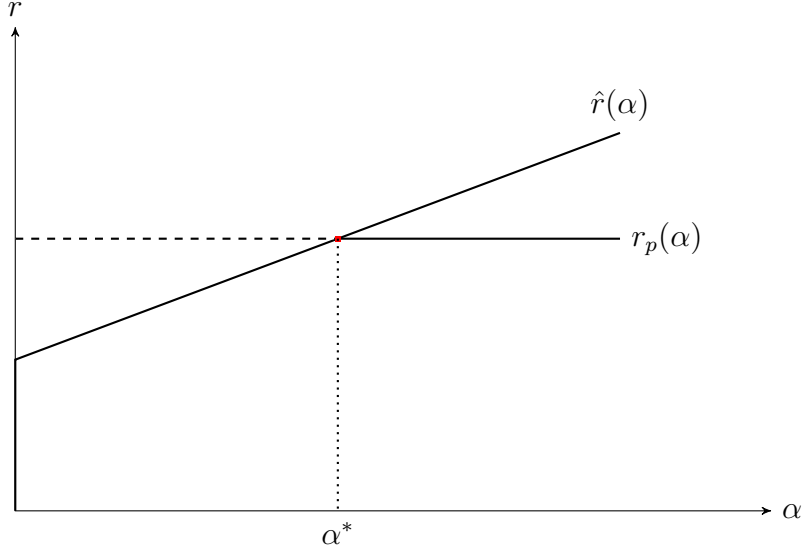


Figure 1: Pareto Frontier with Compensated Reserves

As in the previous sections, we focus first in the project selection step. In this case, the no gambling condition is obtained by substituting the value  $\alpha = 0$ , in equation (6), that is:

$$\hat{r}(k) = \frac{(1+k)}{1-p} [(1-p\delta)R - p(1-\delta)R^H] - \delta\rho k \quad (22)$$

It can be observed that the no gambling condition is not necessarily upward sloping as:

$$\partial\hat{r}(k)/\partial k = (1/(1-p))[(1-p\delta)R - p(1-\delta)R^H] - \delta\rho \quad (23)$$

which implies that  $\partial\hat{r}(k)/\partial k \leq 0$  for  $\delta \geq \hat{\delta} = (R - pR^H)/[R - pR^H + (1-p)(\rho - R)]$ .<sup>4</sup>

This implies that for farsighted banks (high  $\delta$ ), increasing the amount of capital actually increases the bank's incentives to gamble. As mentioned in Hellman et. al. (2000) *the intuition for this result comes from the fact that this dynamic analysis takes into account the effect of increasing capital requirements on bank's franchise value. Hence, increasing capital has two effects: the positive capital-at-risk effect (the greater the amount of the bank's own capital at risk, the greater the extent to which the bank internalizes the cost of gambling) and the franchise value effect, which is negative.* Note that on the other side, compensated reserves create franchise value, and increasing the amount posted in reserves does not increase bank's incentives to gamble (the no gambling condition given by equation (6) is always upward sloping).

For the rest of the analysis, we assume that  $\delta \leq \hat{\delta}$  and so the gambling condition is upward sloping.

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<sup>4</sup>It can be shown that the efficiency of non-compensated reserves, traditional liquidity requirements, and capital, to avoid moral hazard problems will also depend on the value of delta.

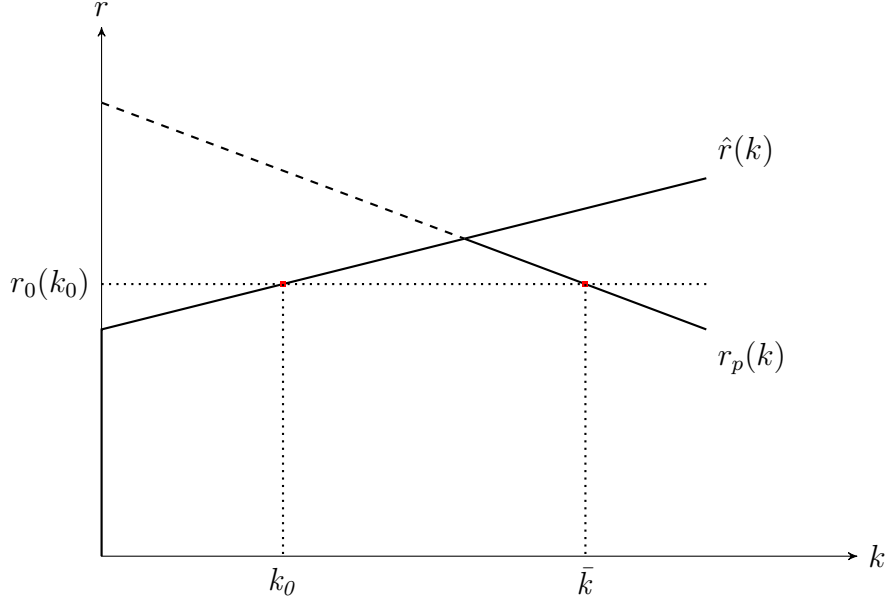


Figure 2: Capital and Interest Rates Control

Next, we consider the deposit funding step. In this case, the equilibrium interest rate, would be obtained by substituting the value  $\alpha = 0$  in equation (7). As this equation is independent of  $\alpha$ , the equilibrium interest rate is that of equation (7).

The Pareto frontier in the case of capital requirements is represented by figure 2. The bank will invest in the safe asset whenever  $r_P \leq \hat{r}$ , or  $k = \bar{k}$ .

Let us assume that the level of capital is such that banks would be in the no gambling region, as shown in figure 2. Hellman et. al.(2000) demonstrate that there is always a policy regime consisting of both capital requirements and interest rate controls that dominates a policy that uses only capital requirements (see Proposition 4, Hellman et. al. 2000), that is, assume a level of capital  $k_o$  and interest rate ceiling  $r_o$  in figure 2 would be Pareto superior to a level of capital given by  $\bar{k}$ . Then, for that level of capital,  $k_o$ , we can determine the critical  $\alpha^*(k_o)$  so that for any  $\alpha \geq \alpha^*(k_o)$ , banks will not gamble with capital and compensated reserves (see figure 1). By comparing the two figures, it is straightforward to see that depositors and banks get the same return (the no gambling interest rate,  $r_P$  is the same in both cases), but compensated reserves create resources for the regulator, and hence Pareto dominate capital requirements.

Finally, a policy of limiting competition is time inconsistent. In the long run, banks would have incentives to compete and attract depositors by means of other non-interest benefits. Additionally, a cap on interest rate would increase competition from the non-banking sector. Any institution paying an interest rate  $r_h$ , with  $r_h > r_i$  would attract all depositors making extraordinary profits. In this way, shadow banks or non-banks institutions would have higher incentives to move into financial intermediation increasing non-bank competition and

putting pressure on the interest rate. Consequently, this non-bank competition would push the Central Bank to eliminate the original policy of interest rates controls (as it happened in the late 80s in the US).

These results are summarized in Proposition 4.

**Proposition 4** *For any given level of capital,  $k_o$ , a policy of capital and compensated reserves, that requires banks to post a fraction of their liabilities,  $\alpha \geq \alpha^*(k_o)$ , with the regulator, dominates any policy of capital requirements and interest rate ceilings, that imposes a level of capital  $k_o$  and interest rate ceiling  $r_o$ .*

## 6 Policy Implications

Before the last financial crisis, most of the regulatory efforts were concentrated on capital requirements. The basic argument being that capital requirements should be imposed in order to mitigate the moral hazard problem created by deposit insurance. Nevertheless, although the regulation based on the capital requirements has certainly merits, it has not proved to be completely effective in preventing bank failure, and indeed there is still a debate on whether it is or not an efficient policy (Hellman et. al. 2000).

On the other side a regulation system that focuses only on contemporaneous bank risk may insufficiently capture banks' incentives to take risks in the future. In that respect, regulation should recognize time-inconsistency problems. Technological innovation and the development of financial markets have made these concerns more acute (Boot and Ratnovski 2016).

Hellman et. al. (2000) provides a nice benchmark to think about these issues. Their dynamic framework allows to capture the two effects that increasing capital may have on the level of risk: the positive or capital at risk effect, which states that increasing capital induces banks to take lower risk projects, as they are more exposed to losses on those projects, and the negative or the franchise value effect, which shows that increasing capital decreases the charter value of the bank (defined as the present value of expected future profits). In that case banks might have incentives to increase risks. This negative effect cannot be contemplated in statics models. Hellman. et al. (2000) demonstrate in this way that capital alone is an inferior policy and how adding interest rate controls to capital can generate an efficient outcome.

This result of limiting competition is in line with the well known paper by Keeley (2000). The author argues that banking competition erodes the value of banks' franchise values. He finds a significant relationship between competition, reduction in franchise values and increase in the number of bank failures in the US during the 1980s. Therefore, moral hazard problems are more severe in competitive environments.

The problem of limiting competition, is that it might be time inconsistent. In the long run, banks would have incentives to compete and attract depositors by means of other non-interest benefits (like debit or credit cards bonuses, a system of points to be changed by

other goods or other types of discounts). Additionally, a cap on interest rate would increase competition from the non-banking sector. Shadow banks or non-banks institutions would have higher incentives to move into financial intermediation increasing non-bank competition and putting pressure on the interest rate. As a result, the Central Bank would be forced to eliminate the original policy of interest rates controls.

Our paper attempts to shed light on regulatory proposals that can create charter value for banks, without limiting competition, and hence may reduce moral hazard problems in our current competitive framework. We show that a combination of capital and compensated reserve requirements can be a Pareto efficient policy. For a given level of capital, compensated reserve requirements increase charter value, and hence reduce banks' incentives to gamble. Differently from recent papers (De Nicolo et. al. 2014 or Vives 2015), we show that capital and reserves complement each other.

Recently, a growing strand of literature has looked at the interaction between liquidity and capital instruments. The underlying argument in these papers is that these tools are not independent (see Calomiris et. al. 2015, De Nicolo 2014 or Vives 2015). Although tightening liquidity regulation can reduce the risk of bank runs and freezing of the interbank market, there has been a vigorous debate about the negative impact of liquidity regulation on bank profitability. The objective of the liquidity coverage ratio (LCR) is to encourage banks to either increase the ratio of high quality liquid assets (HQLA) to other assets, decrease the ratio of short-term wholesale funding to more stable deposit and equity funding or a combination of the two. Beyond that, the design does not provide predictions about how banks will respond along other dimensions such as the impact on the size of bank balance sheets (Banerjee and Mio 2014). In that sense, our proposal of compensated reserves will reduce the negative effect of liquidity requirements on bank profitability.

## 7 Concluding Remarks

This paper follows Hellman et. al. (2000) and considers a dynamic framework of banking where competition may induce banks to gamble. In this set up, we can capture the two effects that capital regulation has on risk: on one side, increased capital requirements induce banks to take lower risk projects since they are more exposed to losses on these projects, and so they will decide to undertake safer ones, thus reducing their probability of failure. This is the capital-at-risk-effect, usually contemplated in the literature. However, there is another effect at place. As the amount of capital is increased, the per-period future profits of the bank decrease, and hence, the franchise value decreases. This dynamic effect of capital, the negative franchise-value effect, is ignored in static models. As the result of this, the total effect of capital on risk is ambiguous and capital results in an inferior policy.

We show how a combination of capital and compensated reserves requirements turns out to be efficient in order to solve the moral hazard problem. The advantage of compensated reserves is that they always increase the franchise value for a given level of capital. Differently

from recent papers (De Nicolo et. al. 2014 or Vives 2015), we show that capital and reserves complement each other. Finally, our proposal improves over the one described in Hellman et. al. (2000), a policy of capital requirements and interest rate controls.

We do not need to limit competition in order to create charter value. A cap on interest rates, would increase competition from the non-banking sector since by increasing the interest rate or non-interest rate benefits, extraordinary rents would be created. Shadow banks or non-banks institutions would have higher incentives to move into financial intermediation and consequently that policy would be time inconsistent since the central bank would be pushed to eliminate it. Our proposal avoids this problem.

Although tightening liquidity regulation can reduce the risk of bank runs and freezing of the interbank market, there has been a vigorous debate about the negative impact of liquidity regulation on bank profitability. In that sense, our proposal of compensated reserves would reduce the negative effect of liquidity requirements on bank profitability.

## References

1. Allen, F., Carletti, E., Marquez, R. 2011. Credit Market Competition and Capital Regulation. *Review of Financial Studies* 24(4), 983-1018
2. Banerjee, R., Hitoshi, Mio. 2014. The Impact of Liquidity Regulation on Banks. BIS Working Papers No 470.
3. Besanko, B., Kanatas, G. 1996. The Regulation of Bank Capital: Do Capital Standards promote Bank Safety?. *Journal of Financial Intermediation*, 5(2), 160-183.
4. Blum, J. 1999, Do Capital Adequacy Requirements Reduce Risks in Banking?. *Journal of Banking and Finance*, 23, 755-771.
5. Boot, A., Ratnovski, L. 2016. Banking and Trading. *Review of Finance* 20 (6). 2219-2246.
6. Brusco, S., Castiglionesi, F. 2007. Liquidity Coinsurance, Moral Hazard and Financial Contagion. *Journal of Finance*, 62(5), 275-2302.
7. Buser, A.H. Chen and Kane E.J. 1981. Federal Deposit Insurance, Regulatory Policy, and Optimal Bank Capital. *Journal of Finance* 35 (1), 51-60
8. Calomiris, C.W, Heider, F., and Hoerova, M. 2015. A Theory of Bank Liquidity Requirements. *Columbia Business School Research Paper*. 14-39.
9. De Nicolo, G., Gamba, A., and Luccchetta, M. 2014. Microprudential Regulation in a Dynamic Model of Banking. *Review of Financial Studies*, 27(7), 2097-2138.
10. Diamond, D.W. 1989. Reputation Acquisition in Debt Markets. *Journal of Political Economy*, 97(4), 828-862.
11. Gale, D. 2010. Capital Regulation and Risk Sharing. *International Journal of Central Banking*, 187-204.
12. Genotte, G., Pyle, D. 1991. Capital Controls and Bank Risk. *Journal of Banking and Finance* 15 (5), 805-824.
13. Hellman, T.F., Murdock, K.C., and Stiglitz, J. 2000. Liberalization, Moral Hazard in Banking and Prudential Regulation: Are Capital Requirements enough? *American Economic Review* 90(1), 147-165.
14. Keeley, Michael C. 1990. Deposit insurance, Risk and Market Power in Banking. *American Economic Review* 80, 5: 1183-1200.
15. Koehn, M., Santomero A.S. 1980, Regulation of Bank Capital and Portfolio Risk. *Journal of Finance*, 35, 1235-1244.



16. Morrison, A. and White, L. 2005. Crises and Capital Requirements in Banking. *American Economic Review* 95(5), 1548-1572.
17. Plantin, G. 2015. Shadow Banking and Bank Capital Regulation. *Review of Financial Studies*, 28 (1), 146-175.
18. Repullo, R. 2004. Capital Requirements, Market Power, and Risk-Taking in Banking, *Journal of Financial Intermediation*,13, 156-182
19. Repullo, R. 2005. Liquidity, Risk Taking, and the Lender of Last Resort. *International Journal of Central Banking* 1, 47-80.
20. Vives, X. 2014. Strategic Complementarity, Fragility, and Regulation. *Review of Financial Studies* 27 (12), 3547-3592.