Limits to Bank Regulation: the Case of Deposit Rate Ceilings

Draft

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Abstract The recent financial crisis has led researchers and regulators to take a harder look at existing forms of bank regulation. However, the pretext typically is that tightenings or changing existing regulation will be sufficient to achieve the goal of a well functioning banking sector.

In a companion paper (Nielsen and Weinrich, 2015) we show that in a more complex environment than is normally assumed in models of bank regulation, capital requirements may not work as intended if at all. The purpose of the present work is to understand if the other traditional form of bank regulation, deposit rate ceilings, may perform better. The answer provided is negative: for both types of regulations it may happen that, as regulators tighten these in order to deter banks from investing in high-risk asset classes, they also deter banks from using low-risk asset classes, which we interpret as normal lending to firms. This means that banks may turn to investing in safe assets, like government bonds. Our results then propose an explanation as to why funding to firms (in particular to SME) dried up in the later phase of the crisis despite the ample funds held by banks, partially as a result of the loose monetary policy of the ECB.

Put together, the two sets of results point to a need for reassessing the scope for regulating the financial sector in the context of moral hazard. We may have to search for entirely different and possibly more drastic approaches to bank regulation.

Keywords: Bank regulation, deposit rate ceilings, moral hazard.

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Limits to Bank Regulation; the Case of Deposit Rate Ceilings

by
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1 Introduction

The financial crisis starting in 2007 has lead to a reevaluation of existing bank regulation, which relies heavily on capital requirements. In practice, the main effort has been on improving the functioning of capital requirements and on supplementing it with other regulatory instruments. As is well known, until the 80's deposit rate ceilings, were the main regulatory tool, but the apparent underperformance of the banking sector combined with a desire to use seemingly more market oriented types of regulation lead to the adoption of capital requirements. This happened despite the lack of any convincing theoretical models demonstrating the superiority of capital requirements. In fact, in later research, on comparing the two regulatory regimes economists came out in favor of deposit rate ceilings.[3] To the best of our knowledge, Nielsen and Weinrich (2012) are the first to show formally that, depending on the extend of the moral hazard problem, either of the two instruments may welfare dominate the other as an instrument for regulating banks.

In a companion paper Nielsen and Weinrich (2015) we examine the efficiency and consequences of capital requirements in a broader context and conclude that in an environment with constant financial innovation these may have unexpected consequences.[4] In particular, when capital requirements are sufficiently high to deter banks from using high-risk asset classes, the may also deter banks from using low-risk asset classes, which we interpret as normal lending to firms. In such a situation banks may prefer to invest in safe assets, like government bonds. This may explain why funding to firms (in particular SME) froze up in the later phase of the crisis despite the ample funds held by banks, partially as a result of the loose monetary policy by the ECB.[5] The purpose of the present study is to offer a partially parallel analysis for the case of deposit rate ceilings as a regulatory instrument. Put together, Nielsen and Weinrich (2015) and the present paper point to the limits to bank regulation. Whether it be capital requirements or

[3]The most notable example is Hellman et al. (2000).

[4]See also Nielsen (2012) for a similar argument in the context of competitive markets.

[5]It is notable that the recent crisis in financial markets was characterized by a large reduction in lending to private businesses (in particular Small and Medium Sized Enterprises) by banks, who in stead placed their available funds in safer assets, in particular government debt instruments. See Reichlin (2014) for a documentation of this phenomena. This is consistent with the results of Nielsen and Weinrich (2015) and, as we show here, may also happen when deposit rate ceilings are being used.

deposit rate ceilings, regulation may have unintended consequences by inducing banks to use assets that are too safe (from the point of view of society) or may not work or all.

Our results then suggest that traditional regulatory instruments, whether they be capital requirements or deposit rate ceiling, may be inadequate for safeguarding the financial system from the consequences of excessive risk takings by banks. If this is really the case, the next question is , if there are other ways of making sure that banks play the role they are suppose to, namely transforming medium risk long maturity lending to firm into short maturity safe assets for depositors. As for proposals one find at one extreme a small minority of economists and regulators advocating a system of "narrow banking", while others propose to increase "market discipline" by abandoning deposit insurance and/or introducing new types of bank financing, like Contingent Convertible Capital Instruments.[6] One example of such alternative types of regulation has already been implemented in the UK where the ring-fencing of the retail arms of banks from their other activities has been put into law. Whether this regulation will work as intended, remains to be seen.

Deposit rate ceilings have been mostly ignored, both by regulators and economists, since their replacement by capital requirements some 30 year ago. This may be explained by the obvious inefficiencies created when low ceilings were combined with high levels of inflation. Apart from such imperfect implementations it has been noted that these ceilings create excess profits for banks, which are essentially transfers from depositors who are forced to accept interest rates below equilibrium levels. However as already Besanko and Thakor (1992) observed, if, realistically, capital is costly, the cost of capital requirements will ultimately be born by depositors: "...raising the capital standard is virtually isomorphic to reimposing Reg Q ceilings on deposit interest rates" (page 911).

With this in mind, the question about the efficiency the two regulatory instruments is still open. The purpose of Nielsen and Weinrich (2012) was to answer this question in a theoretical model of monopolistic bank competition. A crucial assumption of that paper is that the excess profits generated by a ceiling do not simply constitute a transfer from depositors to bank owners, but will lead to costly excess entry in the banking industry and thus cause a deadweight loss to society. While we assume free entry, this effect is present whenever some degree of entry is allowed and also includes the costly non-price incentives created by banks to attract depositors.[7] Nielsen and Weinrich (2015) as well as the present work provides an extension of this comparison to a situation, which from the point of view of regulators is more complex, since banks may either invest is assets which are, from the point of view of society, too risky or too safe.

We present our argument in the context of two diverse models, one where banks compete

[6] For an advocacy of Narrow Banking, see James (2012) . For a description of Contingent Convertible Capital Instruments, see Avdjiev et al. (2013) and Mathers (2011).

[7] See f.i. Janicki and Prescott (2006)for evidence on increased entry of bank in the US between 1960 and 1966.

only on the interest rate they offer and hence reap excess profits when these are bounded above and one with monopolistic competition. The first model is deliberately simplistic, but none the less useful in explaining the main intuition behind our results. It also serves to demonstrate that the issue of entry cost is of secondary importance when arguing that deposit rate ceilings may be impotent. The other model, based on the model of Repullo (2004) (and modifications of it made in Nielsen and Weinrich, 2012) assumes a Salop-type market, with free entry. As compared to Repullo(2004) there are three novelties in the model presented here:

(i) We assume free entry rather than an arbitrary given number of banks. This means that the number of banks (or the services offered by these) may be inefficiently high.

(ii) We assume an outside option available to depositors, so that these are not forced to place there savings with banks. Among other things, this opens up the possibility of financial repression where, in equilibrium, banks do not attract all depositors.[8]

(iii) We assume three assets, two with stochastic returns, one risk free, rather than one stochastic and one risk free asset. Since the moderately risky asset, which we shall interpret as lending to firms, is the, from the view of society, desirable one, this increases the complexity of the objective of regulators: the regulatory policy must be designed not only to prevent excessive risk taking by banks, but also to prevent insufficient risk taking by these.

Asymmetric information about the investment activities by banks create a moral hazard problem when banks find it more attractive to invest in high-risk assets (due to their limited liability, hence limited exposure to negative outcomes), which is an obvious interpretation of what happened up to the onset of the financial crisis in 2007. As we show, deposit rate ceilings can, depending on the properties of the two asset classes, deter such behavior.[9] However, an unintended consequence may be that banks turn to using the safe asset instead.

1.1 Organization of paper

To follow, in Section 2, we present the fundamental elements of the model including our central assumptions. In Section 3 we consider our "perfect competition" model, in Section 4 the monopolistic competition version and Section 5 concludes.

[8]Note that in the equilibria studied in Repullo (2004) deposit rates may be negative, something we exclude here.

[9]Thus while Hellman et al. (2000) base their recommendation of deposit rate ceilings on the charter value associated with the excess profits derived from these ceilings, which leads to more prudent behavior by banks, we concentrate on the more direct affect that deposit rate ceilings may have - see Remark 1 for more on this.

2 Basic model set-up.

Our model is an extension of Nielsen and Weinrich (2012), who in turn build on Repullo (2004) and Hellman et al. (2000). There are two types of agents in the economy, banks (bank owners) and depositors, both risk neutral. Depositors can either place their wealth, D with banks or in an alternative investment, earning $\sigma > -1$. Banks maximize profit by accepting deposits from depositors and then placing these in one of three asset classes. When discounting future profits banks use the rate ρ.

The safe asset pays the net return γ_0 with probability one while the risky asset ($i = 1$) and the gambling asset ($i = 2$) pay γ_i with probability $1 - \pi_i$ and $\beta_i \geq -1$ with probability π_i (for notational simplicity, we set $\pi_0 = 0$ and $\beta_0 = \gamma_0$). We shall by $E_i, i = 0, 1, 2$ denote the expected returns of these three assets. Finally, there is a cost $C \geq 0$ of setting up a bank, which is lost whenever a bank is declared bankrupt, i.e. when it is unable to repay depositors. We shall assume that there is deposit insurance in place, so that, even if they could, depositors do not have reasons to monitor the behavior of the bank.

We shall retain three main assumptions throughout, the first being,

Assumption 1 $E_1 > E_0 > E_2$

which compares the overall social return from investing in the risky asset with the return of investing in the safe asset and the return from investing in the gambling asset.

Notice that we are here not taking into account possible costs associated with bankruptcy, something that is determined endogenously in the model. None the less, we sometimes consider the stronger assumption:

Assumption 2 $E_1 - \pi_1 C > E_0 > E_2$

Our second assumption,

Assumption 3 $\gamma_2 > \gamma_1, \gamma_0 > \beta_1$

says that moral hazard potentially is a problem, namely that $(\gamma_2 - r)(1 - \pi_2) > (\gamma_1 - r)(1 - \pi_1) > \gamma_0 - r$ for large deposit rates r meaning that banks will choose the gambling asset over the two other ones, whenever the deposit rate is sufficiently high.

Remark 1 *The effects of regulation*

To gain an intuitive understanding of how the two types of regulation work, notice that, ignoring set-up costs and assuming bankruptcy in the bad state, but not in the good state, expected returns are

$$R_i(r) = (1 - \pi_i)\{(1 + \gamma_i) - (1 + r)\}, i = 1, 2 \tag{1}$$

and

$$R_0(r) = \gamma_0 - r$$

Assuming $\pi_1 < \pi_2$, there is a cut-off interest rate $\tilde{r} = \frac{\gamma_1(1-\pi_1)-\gamma_2(1-\pi_2)}{\pi_2-\pi_1}$ such that when $r > \tilde{r}$ (where r is determined by the particular economic environment we are looking at), $R_2(r) > R_1(r)$, i.e. the bank will use the gambling asset rather than the risky one (which is the effect of limited liability). Thus setting a ceiling on r lower than $\tilde{r}$ would directly prevent the bank from using the gambling asset.[10] If banks did not have to pay an interest rate to depositors, they would choose the risky asset over the gambling asset. Finally note that if $\gamma_1(1-\pi_1) \leq \gamma_2(1-\pi_2)$ (but $\pi_1 < \pi_2$), the cut-off value $\tilde{r} \leq 0$, and in this sense the moral hazard problem is "severe". Finally, if $\pi_1 \geq \pi_2$ there is no cut-off interest rate $\tilde{r}$, so if there is bankruptcy in the bad state, banks will always choose the gambling asset ■

Finally, like in Nielsen and Weinrich (2012) and Repullo (2004), we shall assume that capital is expensive and that the risky asset is attractive relative to the alternative:

Assumption 4 $\rho > E_1 > \sigma > \beta_i, i = 1, 2$

The first inequality says that bank owners in general prefer not to invest their own capital in banking activities, i.e. they prefer to keep their capital holdings as low as possible, which is, in turn, the reason why regulation in the form of minimum capital requirements may be needed. The second inequality in combination with Assumption 1 says that it is welfare optimal for society to use the risky asset i.e., under our interpretation, to lend to enterprises. The third inequality implies that if banks use the stochastic assets, in equilibrium where they must offer an interest rate higher than σ they must be bankrupt in the bad state.

3 Perfect Competition

A model with competitive markets for deposits is more transparent than the monopolistic competition model and produce general results that help us understand what is going on in the latter. Another reason to study the competitive case for the case of deposit rate ceilings is to compare with the results of Nielsen and Weinrich (2015). We proceed to define an equilibrium in this model:

Definition 1 *Competitive Equilibrium with Deposit Rate Ceilings*

[10] In the literature (f.i. Hellman et al. (2000) the focus has often been on an indirect effect of deposit rate ceilings, namely that they create excess profits and thus a franchise value for the bank, which is lost in case of bankruptcy, and which therefore induces the banks to take fewer risks. In our model, which assumes free entry, only the direct effect is present (a bank's franchise value is its set-up cost, C, independently of of the type of regulation, if any).

For $\overline{r} \geq \sigma$, an $(i, r^*) \in \{0, 1, 2\} \times [\sigma, \overline{r}]$ s.t.
(i) $R_i(r^*) \geq 0$ with $=$ if $r^* < \overline{r}$.
(ii) $R_i(r^*) \geq R_j(r), j \in \{0, 1, 2\}, \forall r' \in (r^*, \overline{r}]$ ■

The first condition says that banks do not earn negative profits in equilibrium. The second condition says that no bank can earn a positive profit by offering a higher interest rate to depositors (in which case the bank would capture the whole market) and/or using another asset. Note that this in particular means, that if $R_i(r^*) > 0$ then $r^* = \overline{r}$, i.e. banks only earn non-zero profits in equilibrium, if the deposit rate ceiling, $\overline{r}$ is binding. The definition means that we have an equilibrium with a binding interest rate and where asset i is being used, only if $R_i(\overline{r}) \geq R_j(\overline{r}), j = 0, 1, 2$.

Capital requirements work on the asset side, while deposit rate ceilin'gs work on the liability side of the balance sheet of the bank. Since deposit rate ceilings do not take into account the nature of the investments of the bank one might speculate that the potential problems for capital requirements we identified before would not be relevant in the context of deposit rate ceilings. Here we want to briefly point out that this is not necessarily so. While it is the case that deposit rate ceilings will not induce banks to invest in the safe asset, they may still not work at all, as was the case for capital requirements.
We shall first assume $\sigma \geq 0$ and $\beta_1 < 0, \beta_2 < 0$in line with Assumption 4 made above. We note that in the competitive model, the safe asset will never be used in equilibrium, since for any r, $R_1(r) \geq E_1 - r > E_0 - r$. We consider two cases.

Case 1: $\gamma_1(1 - \pi_1) > \gamma_2(1 - \pi_2)$.
Then $R_1(0) > R_2(0)$ and $R_1(\gamma_1) = 0 = R_2(\gamma_2)$ with $\gamma_1 < \gamma_2$ (by assumption), so there is some $r_{rg} \in (0, \gamma_1)$ s.t. $R_1(r_{rg}) = R_2(r_{rg})$. For $r < r_{rg}$ the risky asset will be preferred over the gambling assets by the banks. This means that for $r < r_{rg}$, the banks will use the risky asset. However if σ is sufficiently large, i.e. $\sigma > r_{rg}$ a deposit rate ceiling will not work. See Figure 1 for an illustration.

[Figure 1]

Case 2: $\gamma_1(1 - \pi_1) < \gamma_2(1 - \pi_2)$.
Then $R_1(0) < R_2(0)$ and $R_1(\gamma_1) = 0 = R_2(\gamma_2)$ with $\gamma_1 < \gamma_2$ (by assumption), so there is no r s.t. $R_1(r) = R_2(r)$. See Figure 2 for an illustration.

[Figure 2]

We interpret Case 2 as a situation where the moral hazard problem is severe, that is, not only is the return from the gambling asset higher than the return from the risky asset in case of success, but for any feasible interest rate, banks will prefer to use the gambling asset. Note that in this situation we have $E_1 < (1 - \pi_2)\gamma_2$, so that it the low return in the bad state that makes the gambling asset inferior to the risky asset. This incidentally ties in with what was shown in Nielsen and Weinrich(2012), namely that when the moral hazard problem is severe, deposit rate ceilings may not work.

4 Monopolistic Competition

4.1 Model and equilibrium definition

Like in Repullo(2004) and Nielsen and Weinrich(2012) a Salop model with identical depositors positioned on the unit circle and n banks positioned at equal distance from each other is considered. Depositors have a cost μ per units of distance traveled to the bank, which is best interpreted as the cost of not getting the, from the depositors point of view, optimal product. In the beginning of each period potential banks enter the market after which each of them decides on (i) the deposit interest rate to offer, (ii) the amount of capital to raise and (iii) the assets to invest in with the objective to maximize the discounted sum of future profits, using ρ as discount factor. At the end of the period, the asset returns are realized and, if possible, banks pay back their deposits plus interests to their depositors, else they are declared bankrupt and leaves the market. Like Repullo (2004), we consider symmetric subgame perfect equilibria, where the criteria is whether a one-shot deviation pays for the bank or not. Unlike Repullo(2004), there is a cost C for setting up a bank and we do not assume that n is fixed, but allow for free entry, which will happen as long as profits are positive. In such a situation there may be too many banks in equilibrium and this is particularly a problem when there is a regulator imposed ceiling on deposit rates that drives up a profits. In Nielsen and Weinrich(2012) we find the first best number of banks, $n^* = 1/2\sqrt{\mu/\rho C}$ when there is only the safe asset and the gambling asset. This is still the optimal number of banks when there is also a risky asset which is optimal, i.e. it is remains the first best number of banks. We shall now in addition to Assumption 3 assume:

Assumption 5 $\gamma_0 > \sigma + \frac{\mu}{2}$

which says that the opportunity costs, $\sigma + \frac{\mu}{2}$, of the depositor for using the bank, when there are only 2 banks operating is lower than the expected return of the safe asset. Thus we require that even in the case where there are only 2 banks, it is from the point of view of society desirable that depositors use these banks and that these banks invest in the risky asset.

Ignoring the participation constraint, demand for deposit services for a bank offering the deposit r' when its two neighbors offer r and there are n banks in the market is then (see Repullo, 2004 and Nielsen and Weinrich, 2012):

$$\mathcal{D}(r', r, n) = \frac{1}{n}D + \frac{r' - r}{2\mu}D^2 \tag{2}$$

We now turn to defining an equilibrium for the model, concentrating for simplicity on equilibria where banks use only one of the three assets.[11] We first define the profit, excluding set-up costs of a bank investing in asset i when there are n banks in equilibrium and the ceiling on the deposit rate is $\overline{r}$ (but ignoring the participation constraint):

$$\max_{r' \leq \overline{r}, i \in \{0,1,2\}} P(r', i; r, n, \overline{r}) \equiv \frac{1-\pi_i}{1+\rho} \{[\gamma_i - r']\mathcal{D}(r', r, n) + C\}$$

where r is the interest rate charged by other banks and where we assume bankruptcy in the bad state. We include C here, since in equilibrium, this is the discounted sum of all profits (if the bank survives).

Definition 2 *Symmetric, full Participation Equilibrium with deposit rate ceiling* $\overline{r} \geq \sigma$

A vector (i^*, n^*, r^*) s.t.
(i) $r^* - \mu/2n \geq \sigma$.
(ii) The solution to (3) when $r = r^*$ and $n = n^*$ is (i^*, r^*) .
(iii) $P(r^*, i^*; r^*, n^*\overline{r}) = C$ ■

Condition (i) guarantees full participation, so that even the depositor furthest from the bank will use it, while Condition (iii) implies that no more banks want to enter the market.

4.2 Equilibrium without regulation

Let n and r be given and suppose that the present value of the bank is C next period, if the bank survives. Then (since we have bankruptcy in the bad state) if all banks offer the deposit rate r, we can write the expected discounted profit (including the set up costs) of a bank as

$$V_B(n, r; \gamma, \pi) = \frac{D}{n} \frac{(\gamma - r)(1-\pi)}{1+\rho} - C + (1-\pi)\frac{C}{1+\rho} = \frac{\rho+\pi}{1+\rho}\left[\frac{D}{n}\frac{1-\pi}{\rho+\pi}(\gamma - r) - C\right]$$

In equilibrium $V_B(n, r; \gamma, \pi) = 0$, which gives a negative relationship between n and r. From the analysis of Repullo (2004) we know that there is the following relationship between n and r in equilibrium:

$$\hat{r}(0, n; \gamma, \pi) = \gamma - \frac{\mu}{nD} \tag{3}$$

This gives a positive relation between n and r. We then find $n(0; \gamma, \pi)$ and $r(0; \gamma, \pi)$ where the curves describing (3) and $V_B(r, n; \gamma, \pi) = 0$ intersect in the n - r plane, see Figure 3.

[11] It can be show that this only excludes equilibria where banks combine the safe and the risky assets.

[Figure 3]

It is easy to check that in fact

$$n(0;\gamma,\pi) = \sqrt{\frac{(1-\pi}{\rho+\pi}\frac{\mu}{C}} \text{ and } r(0;\gamma,\pi) = \gamma - \frac{1}{D}\sqrt{\frac{\mu C(\rho-\pi)}{1-\pi}}$$

as we found in Nielsen and Weinrich (2012). For these however to describe a symmetric equilibrium, it is necessary that $r(0;\gamma,\pi) > \beta$ so that in fact the bank is bankrupt in the bad state.

4.3 The possible ineffectiveness of deposit rate ceilings

We use this set-up just described to analyze a binding interest rate ceiling. If $\overline{r} < r(0;\gamma,\pi)$ we move down the curve described by $V_B(r,n) = 0$ (and n increases). As $\overline{r}$ becomes smaller than β however, we move to an equilibrium without bankruptcy.

Let $V_{Bi}(n,r) = 0$ refer to the zero profit condition for asset $i = 1,2$ and $V_{B0}(n,r) \equiv \frac{D}{n}(\gamma_0 - r) - \rho C = 0$ be the zero profit condition for the prudent asset. If the government sets a ceiling equal to $\overline{r}$ we have an equilibrium for a certain asset, say i, if $n = \overline{n}$ is s.t. $V_{Bi}(\overline{n},\overline{r}) = 0$ and no bank finds it profitable to deviate to another asset at that pair $(\overline{n},\overline{r})$. A necessary condition for this is that $V_{B-i}(\overline{n},\overline{r}) \leq 0$ and $V_{B0}(\overline{n},\overline{r}) \leq 0$, that is, that the lines describing $V_{B-i}(n,r) = 0$ and $V_{B0}(n,r) = 0$ lie below the line describing $V_{Bi}(n,r) = 0$ at $n = \overline{n}$. If this was not the case, the bank would make positive profits by switching to the asset, who's zero profit line lies above $V_{Bi}(n,r) = 0$ at $n = \overline{n}$ and retaining the same interest rate and hence the same number of depositors. When using this asset it would also want to change the interest rate it offers (and hence the number of depositors) but that would only make profits higher. Since switching to this asset implies positive profits, a situation where all banks use asset i is consequently not an equilibrium.

Solving for n, these lines can be described as follows:

$$n_0(r) = \frac{D(\gamma_0 - r)}{\rho C} \text{ and } n_i(r) = D\frac{(\gamma_i - r)(1-\pi_i)}{(\rho+\pi_i)C}, i = 1,2$$

with inverses $r_0(n)$ and $r_i(n), i = 1,2$.

Before we proceed, denote

$$n_{00} = \frac{D\gamma_0}{\rho C} \text{ and } n_{i0} = D\frac{\gamma_i(1-\pi_i)}{(\rho+\pi_i)C}, i = 1,2$$

as the intersections of the zero-profit lines with the first axis and note that the intersections of these with the second axis are respectively γ_0 and $\gamma_i, i = 1, 2$. We proceed to present two cases where deposit rate ceilings may not work.

Case (i) Since $\gamma_2 > \gamma_1$ if $n_{20} > n_{10}$ there can be no equilibrium, with or without deposit rate ceiling where the risky asset is being used and there is full participation. For an illustration see Figure 4. Notice that, under the condition, $\pi_1 < \pi_2$, this condition is stronger than assuming $(1-\pi_2)\gamma_2 > (1-\pi_1)\gamma_1$.

[Figure 4]

Case (ii) We next consider another possibility, that

$$n_{10} > n_{20} \text{ i.e. } D\frac{\gamma_1(1-\pi_1)}{(\rho+\pi_1)C} > D\frac{\gamma_2(1-\pi_2)}{(\rho+\pi_2)C} \tag{4}$$

but

$$\max\{r_0(n), r_2(n)\} > r_1(n), \forall n \tag{5}$$

Let $\hat{r}_{10}$ be defined by $n_1(\hat{r}_{10}) = n_0(\hat{r}_{10})$, $\hat{r}_{12}$ be defined by $n_1(\hat{r}_{12}) = n_2(\hat{r}_{12})$ and $\hat{r}_{20}$ be defined by $n_2(\hat{r}_{20}) = n_0(\hat{r}_{20})$. Note that these values can be negative

Lemma 1 *Under the condition (4), (5) is equivalent to*

$$\hat{r}_{10} > \hat{r}_{20} \tag{6}$$

Proof: At the point $n' = n(\hat{r}_{10})$ we have, because of (7), that $r_0(n') = r_1(n') < r_2(n')$. Then, using (4), also $r_1(n) < r_2(n), \forall n \leq n'$. On the other hand for $n > n'$, we have $r_0(n) > r_1(n)$. It follows that (5) holds ■

We have

$$\hat{r}_{10} = \frac{\gamma_0(\rho+\pi_1) - \gamma_1(1-\pi_1)\rho}{\rho+\pi_1-(1-\pi_1)\rho} = \gamma_0 - \frac{(\gamma_1-\gamma_0)(1-\pi_1)\rho}{\pi_1(1+\rho)}$$

$$\hat{r}_{20} = \frac{\gamma_0(\rho+pi_2) - \gamma_2(1-\pi_2)\rho}{\rho+\pi_2-(1-\pi_2)\rho} = \gamma_0 - \frac{(\gamma_2-\gamma_0)(1-\pi_2)\rho}{\pi_2(1+\rho)}$$

and

$$\hat{r}_{12} = \frac{\gamma_2(1-\pi_2)(\rho+\pi_1) - \gamma_1(1-\pi_1)(\rho+\pi_2)}{(1-\pi_2)(\rho+\pi_1)-(1-\pi_1)(\rho+\pi_2)} = \gamma_2 - \frac{(\gamma_2-\gamma_1)(1-\pi_1)(\rho+\pi_2)}{(\pi_2-\pi_1)(1+\rho)}$$

Thus $\hat{r}_{10} > \hat{r}_{20}$ is equivalent to

$$\frac{(\gamma_1-\gamma_0)(1-\pi_1)}{\pi_1} < \frac{(\gamma_2-\gamma_0)(1-\pi_2)}{\pi_2} \text{ i.e. } (\gamma_1-\gamma_0)\frac{(1-\pi_1)}{\pi_1} < (\gamma_2-\gamma_0)\frac{\gamma_2(1-\pi_2)}{\pi_2} \tag{7}$$

This condition should be compared with the condition needed for non-implementation in the competitive case: $(1-\pi_2)\gamma_2 > (1-\pi_1)\gamma_1$.

Lemma 2 *There are parameter values such that Assumptions 1, 3 and 4 as well as (4) and (7) hold.*

Proof: pick $\gamma_1 < \gamma_2$ and $\pi_1 < \pi_2$ (implying that $\frac{1-\pi_1}{\pi_1} > \frac{1-\pi_2}{\pi_2}$) s.t. $\frac{\gamma_(1-\pi_1)}{\pi_1} > \frac{\gamma_2(1-\pi_2)}{\pi_2}$ and s.t. (4) holds with $\rho = \gamma_2$. To see that this is possible, note that starting with $\pi_1 = \pi_2$ and $\gamma_1 = \gamma_2$ we have equality in the two conditions. Lowering π_1 gives us $\frac{\gamma_(1-\pi_1)}{\pi_1} > \frac{\gamma_2(1-\pi_2)}{\pi_2}$ and (4) with $\rho = \gamma_2$. Thus for a small increase in γ_2 these inequalities continue to hold.

Next note that (7) holds with $\gamma_0 = \gamma_1$ so also for $\gamma_0 < \gamma_1$, but close to γ_1. With $\rho = \gamma_2$, (4) holds whenever $\beta_i < \gamma_1, i = 1, 2$. By choosing β_1, β_2, C and σ, we make sure that also (1) holds.

Finally, note that in (5) we did not take into consideration that we must have an interest rate lower than the equilibrium interest rate. Thus this condition need only hold for n higher than the number of banks in a risky equilibrium ■

For an illustration, see Figure 5 where we have also inserted the conditions on full participation and the condition that $n \geq 2$.

[Figure 5]

Is there in this figure an equilibrium at all? The answer is yes. By imposing a deposit rate ceiling $\overline{r} = r'$ the government ensures that an equilibrium with the prudent asset exists, since no bank can get a positive profit by using another asset and offering a deposit rate lower than r'.

Interpretation We have found a situation where when the regulator sets the ceiling on deposit rates so low as to deter banks from using the gambling asset, they inadvertently induce banks to use the safe asset in stead. As a consequence, there are no deposit rate ceilings that implements the, from the point of view of society, optimal asset; deposit rate ceilings fail as a regulatory instrument. Furthermore, if regulators aim to make banks use the second best asset, i.e. the safe asset, they need not set the ceiling so low that the risky asset dominates the gambling safe. A higher ceilings suffice and would imply a lower cost, since excess entry will be lower. Like in Nielsen and Weinrich (2015) we can also hypothesize the following situation. Initially the gambling asset constitutes less a moral hazard problem, but due to financial innovation, it becomes more attractive to banks. To counter this, regulators may decide to lower the deposit rate ceiling. However, in stead of forcing banks to use the risky asset, this tightening of regulations lead them to use the safe asset.

5 Conclusions

In Nielsen and Weinrich (2015) we show that capital requirements may become impotent, when there are both more risky and less risky assets than the optimal one. We also propose that an explanation for the events during the recent financial crisis, namely that the increased capital requirements, a response by regulators to the failure to prevent banks from using too risky asset, may have had the undesired effect of inducing these to use too safe asset. This may in turn explain why firms had difficulties obtaining capital in the later phase of the crisis. In this contribution we ask, if the answer to this problem, may lie in using other regulatory instruments, in particular interest ceilings. At least from a theoretical point of view, the answer is negative; the exactly identical problem may arise with this instrument. While neither of the two contributions offer decisive evidence of the impotence of traditional regulatory attempts to prevent moral hazard by banks, none the less we think they prompt us to ask, if there is a inherent complexity to the nature of banking regulation, that should lead us to investigate entirely different approaches to it than those hitherto used.

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