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# A NOTE ON MODELLING BANKING BEHAVIOR IN THE FACE OF INTEREST RATE REGULATION*

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Abstract

Regulation of banking behavior has been widespread in Greece. We believe, that if there exists uncertainty over the regulation timing, the banks tend to make behavioral decisions which carry over to the periods where the regulation has been lifted and therefore, cause nonoptimal results both during the regulation period (which is expected) and the period when the regulation has been lifted.

## 1. Introduction

Regulation in the Banking Sector by the Government, or the Central Bank has been heavy for the last years, as well as widespread both in Greece and in Europe. The Banking Regulation has included all kinds of rulles which have intended to positively and clearly determine the structure and, most of all, the conduct of the greek banks in the market for banking services.

In Greece, the regulation of this sort has had an important impact on the whole economic activity of the country, not only because it had remained very heavy for a large number of years (it had included even the smallest detail), but also because the money markets in Greece were almost nonexistent and the market for Banking Services had been the closest substitute. One could virtually identify the banking market with the money market.

In this paper we model the banks' behavior with respect to two of the leading strategic variables of a bank. That is, i) the deposit interest rate and ii) the network expansion decision (i.e. the establishment of new branches throughout the jurisdiction of the central bank).

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We believe that the banks responded in a specific way to the regulation imposed by the central bank, and consequently by the government. The way they responded was a typical optimizing behavior under constraints. The main constraint has been the regulation of different types. Another constraint has been the uncertainty over the timing of imposing or lifting regulation rules.

We model therefore, the banks' behavior under these constraints, to show that this behavior may have induced specific results even after the regulation has been lifted.

The case of Greece is a special one. During the period of the 1970's, the banking system was operating under strict control from the government and the central bank. After the mid - 70's, the government became the owner of the larger part of the banking sector, controlling almost the 80% of the total assets of the sector. At the same time, the central bank had no significant independence, from the government.

The regulation rules included that the commercial banks were not able to decide about their interest rates, both the lending rates and their borrowing (deposit) rates. The central bank used a perplex system of rules which enabled the monetary authorities to restrict greatly the range of the loan rates. Also, the central bank had been able to determine centrally the deposit interest rates.

In the beginning of the 80's nothing changed. Aroung the middle of the 1980's
1 however, slowly but steadily, the central bank took some dramatic steps indicating that the government was ready to pass onto a deregulation era. Strong regulation still remains, but it has been reduced substantially. In a country where the money markets practically did not exist, this regulation intended to achieve other presumably socially desirable targets. We are not about to examine whether those targets were achieved. We, however, argue that because of certain irreversibilities of the capacity investment of the banking firms, the optimizing decisions of the banks under regulatory constraints, bring about results which carry over to the period where these constraints are lifted. When the central Bank dictates the interest rates to the banks, the banks will respond by deciding over the only strategic variable they can. This variable is the size of the branch-network. A decision over the establishment of a new branch carries a nonreversible positive cost. Under the described regulatory environment, the banks will establish a network, the extent of which depends on the regulated interest rate. The size of this network may be nonoptimal under a "nonregulated" environment. After a period of time, however, the central Bank decides to implement deregulation of the interest rate restrictions. Consequently now, the banks find themselves at an environment, where they can decide over both the interest rate and the size of their branch-networks. Therefore, the previously

established branch network which was created during the regulation period, will carry over to the period of deregulation.

In an environment of perfect competition, where all bank services are offered at competitive rates, this problem boils down to one of temporary disequilibrium. In a case of the banking sector in Greece, both the firms' concentration and the dominance of the state ownership indicate an oligopolistic banking market.

We argue that a preestablished possibly nonoptimal network can result to a nontrivial divergence of the deposit interest rate from this of a continuously nonregulated environment. This divergence can prevail in a monopolistic environment, but it could also occur under oligopolistic market conduct. In fact, we argue that this possibly nonoptimal established network will induce firms to compete less in the deposit - interest - rate space, and hence it will increase the depositors' loss. Therefore, we argue that the uncertainty over deregulation will induce a lessening of competition after the deregulation, and therefore a reduction in the interest rates of depositors' funds. We should add at this point that this effect cannot sustain in the long-run, i.e. when the costs of network expansion have been completely recuperated. On the other hand, we can argue that the deposit-interest -rate can be different from the optimal level for some period after the interest rate deregulation.

## 2. The Model

We assume N firms in the Banking market each of which has a cost of network expansion function of:

$$C_i = C_i(\delta_i) \tag{1}$$

where $C_i$ is the cost of network and $\delta_i$ is the size of the network, i is the indicator of the ith firm, $i = 1, \ldots, N$. We also assume that $C_i' > 0$ and $C_i'' > 0$. The banking firms borrow money capital from the depositors at a rate $r_i$ and they lend this money at a rate $R_i$.

The "supply" of funds by the depositors depends on both the interest rate $r_i$ and the extent (size) of the banking network. Thus:

$$S_i = S(r_i, \delta_i, r_{-i}, \delta_{-i}) \tag{2}$$

where $-i$ indicates a vector of values for all firms except i. This function is independent of i and it is the same for all banks. The function $S_i$ is assumed to be twice continuously differentiable in all its variables. Also:

$$\frac{\partial S_i}{\partial \delta_i} > 0, \quad \frac{\partial S_i}{\partial r_i} > 0, \quad \frac{\partial S_i}{\partial \delta_i \partial r_i} > 0, \quad \frac{\partial^2 S_i}{\partial \delta_i^2} < 0, \quad \frac{\partial^2 S_i}{\partial r_i^2} < 0 \qquad (2a)$$

In this paper, we'll assume that $R_i$ is centrally regulated and fixed at a rate R for each banking firm during both the "regulation" and the "deregulation" period. The interest rate on deposits, r, is fixed at a rate $\overline{r}$ during the regulation period (and it is the same for all firms), but is freely determinable (by the banking firms) after the regulation is lifted. We call the regulation period, first period, while we call second period, the period after the abolishment of regulation. The variable $\delta_i$ is freely determined by the banks in both periods.

In the first period, the banks do not have information on the possibility of deregulation. Therefore, they believe that the regulatory stauts of the industry will be sustained in both periods[1]. The banks decide on how large network will maintain under the constraint that $R_i = R$ and $r_i = \overline{r}$. The profit function of the ith firm is:

$$\Pi_i = RS(\overline{r}, \delta_i, \delta_{-i}) - \overline{r}\, S(\overline{r}, \delta_i, \delta_{-i}) - C_i(\delta_i) = RS_i - \overline{r}\, S_i - C_i(\delta_i) \qquad (3)$$

The characterization of equilibrium for each banking firm i includes the first-order conditions of profit maximization.

$$\frac{\partial \Pi_i}{\partial \delta_i} = 0 \rightarrow R\left[\frac{\partial S_i}{\partial \delta_i} + \frac{\partial S_i}{\partial \delta_{-i}} \cdot \frac{\partial \delta_{-i}}{\partial \delta_i}\right] - \overline{r} \cdot \left[\frac{\partial S_i}{\partial \delta_i} + \frac{\partial S_i}{\partial \delta_{-i}} \cdot \frac{\partial \delta_{-i}}{\partial \delta_i}\right] - C_i' = 0 \text{ all i}$$

and if we assume Cournot conjectural variations for the change in other firms' network as a result of a change in a bank's own $\delta_i$, then $\frac{\partial \delta_{-i}}{\partial \delta_i} = 0$ and the first-order conditions are simplified to:

$$\frac{\partial \Pi_i}{\partial \delta_i} = 0 \rightarrow (R - \overline{r})\left\{\frac{\partial S_i}{\partial \delta_i}\right\} - C_i' = 0 \qquad \text{for all i} \qquad (4)$$

If we assume the Hessian to be negative semidefinite, the $\delta_i$'s implied by (4) will be the maximizing levels of branch networks, at a Cournot conjectures oligopolistic environment.

The result of the optimizing decision under equation (4) will be symbolized by $\delta_{ic}$ (standing for constrained $\delta_i$).

The second-order condition is:

$$\frac{\partial^2 \Pi_i}{\partial \delta_i^2} = 0 \rightarrow (R-\bar{r}) \left\{\frac{\partial^2 S_i}{\partial \delta_i^2}\right\} - C_i'' < 0 \qquad \text{for all i.}$$

This is negative because of the assumptions already presented above.

Let us now attempt to describe the equilibrium conditions at the case where there is no constraining regulation on the deposit interest rates. This case implies that the banks decide on both the interest rates they pay on deposits, *and* the branch network they want to maintain.

The profit function of the ith firm is:

$$\Pi_i = RS(r_i, \delta_i, \delta_{-1}, r_{-i}) - rS(r_i, \delta_i, \delta_{-i}, r_{-i}) - C_i(\delta_i) = RS_i - rS_i - C_i(\delta_i) \tag{5}$$

The first order conditions are:

$$\frac{\partial \Pi_i}{\partial r_i} = 0 \rightarrow R \left\{\frac{\partial S_i}{\partial r_i} + \frac{\partial S_i}{\partial r_{-1}} \cdot \frac{\partial r_{-1}}{\partial r_i}\right\} - r_i \left\{\frac{\partial S_i}{\partial r_i} + \frac{\partial S_i}{\partial r_{-1}} \cdot \frac{\partial r_{-i}}{\partial r_i}\right\} - S_i = 0$$

$$\rightarrow (R - r_i) \cdot \frac{\partial S_i}{\partial r_i} - S_i = 0 \tag{6}$$

because of Cournot conjectures, and

$$\frac{\partial \Pi_i}{\partial \delta_i} = 0 \rightarrow R \left\{\frac{\partial S_i}{\partial \delta_i} + \frac{\partial S_i}{\partial \delta_{-1}} \cdot \frac{\partial \delta_{-1}}{\partial \delta_i}\right\} - r \cdot \left\{\frac{\partial S_i}{\partial \delta_i} + \frac{\partial S_i}{\partial \delta_{-1}} \cdot \frac{\partial \delta_{-i}}{\partial \delta_i}\right\} - C_i' = 0$$

$$\rightarrow (R - r_i) \cdot \frac{\partial S_i}{\partial r_i} - S_i = 0 \tag{7}$$

since $\frac{\partial \delta_{-1}}{\partial \delta_i} = 0$, considering again Cournot conjectures.

The second-order conditions is that the Hessian matrix be negative semidefinite or equivalently:

$$\frac{\partial^2 \Pi_i}{\partial r_i^2} \leqslant 0 \tag{8}$$

and

$$\begin{vmatrix} \dfrac{\partial^2 \Pi_i}{\partial r_i^2} & \dfrac{\partial^2 \Pi_i}{\partial r_i \partial \delta_i} \\ \\ \dfrac{\partial^2 \Pi_i}{\partial \delta_i \partial r_i} & \dfrac{\partial^2 \Pi_i}{\partial \delta_i^2} \end{vmatrix} \geqslant 0 \tag{9}$$

Inequality (8) holds by assumption. The determinant in the inequality (9) can be written as:

$$\frac{\partial^2 \Pi_i}{\partial r_i^2} \cdot \frac{\partial^2 \Pi_i}{\partial \delta_i^2} - \left[ \frac{\partial^2 \Pi_i}{\partial r_i \partial \delta_i} \right]^2 \geqslant 0$$

and $$\frac{\partial^2 \Pi_i}{\partial r_i^2} = (R - \dot{r}_i) \cdot \frac{\partial^2 S_i}{\partial r_i^2} - 2 \cdot \left[ \frac{\partial S_i}{\partial r_i} \right] \leqslant 0 \tag{10}$$

Now, the system of equations (6) and (7) will be solved to give us the values of $\delta_i$ and $r_i$ at the case when the banking firms act unconstrained from the monetary authorities.

Thus, equations (6) and (7) determine the values of the unconstrained $\delta_i$ and $r_i$,

$$\delta_i = \delta_{iu} \quad \text{and} \quad r_i = r_{iu}$$

where u stands for the word "unconstrained".

## 3. A Comparison between constrained and unconstrained optimization

At this point it is important to note that the $\bar{r}$ (i.e. the fixed rate of interest) is being centrally determined and thus, we have not made any assumptions about the level of this $\bar{r}$ yet.

**Assumption 1:** Let $\bar{r}$ be such that $\bar{r} \leqslant r_{iu}$ for all i[2].

This assumption has the meaning that the monetary authorities attempt to keep the interest rates at a lower level than the unconstrained equilibrium level.

After the introduction of assumption 1, we shall attempt to compare the network expansion of the banking firm between the two cases. To do this, we consider equation (4) and (7). In fact we rewrite these equations in the following form: (For simplicity we drop the suscript i)

$$\frac{\partial \Pi(\delta,\bar{r})}{\partial \delta} = 0 \rightarrow (R-\bar{r}) \quad \left\{\frac{\partial S(\delta_c, \bar{r})}{\partial \delta}\right\} - C'(\delta_c) = 0 \tag{4a}$$

and
$$\frac{\partial \Pi(\delta,\bar{r})}{\partial \delta} = 0 \rightarrow (R-r_u) \quad \left\{\frac{\partial S(\delta_u, r_u)}{\partial \delta}\right\} - C'(\delta_u) = 0 \tag{7a}$$

We try to see whether $\delta_c$ is greater or smaller than $\delta_u$. To make this comparison possible, we have to impose one extra assumption:

**Assumption 2:** The function $\frac{\partial S(\delta, r)}{\partial \delta} \cdot (R-r)$ is monotonic in r, for all firms.

Given assumption 2, we can state two cases:

**CASE 1:** $\frac{\partial S(\delta, r)}{\partial \delta} \cdot (R-r)$ is decreasing in r, i.e.

$$\frac{\partial^2 S(\delta, r)}{\partial \delta \, \partial r} \cdot (R-r) - \frac{\partial S(\delta, r)}{\partial \delta} \leqslant 0 \tag{11}$$

Given case 1 and assumption 1 (i.e. $\bar{r} \leqslant r_u$), it is easily shown through equation (4a) and (7a) that $\delta_c > \delta_u$, since $\frac{\partial^2 S}{\partial \delta^2} > 0$, and $C''(\delta) > 0$.

**CASE 2:** $\frac{\partial S(\delta, r)}{\partial \delta} \cdot (R-r)$ is increasing in r,

$$\text{i.e.} \quad \frac{\partial^2 S(\delta, r)}{\partial \delta \, \partial r} \cdot (R-r) - \frac{\partial S(\delta, r)}{\partial \delta} \geqslant 0 \tag{12}$$

Given case 2 and assumption l, it is easily understood that $\delta_c < \delta_u$ since

$$\frac{\partial^2 S}{\partial \delta^2} \quad \text{and } C''(\delta) > 0.$$

The conclusion of this comparison is apparently not unambiguous since we have found two interesting cases. Under a regime of strict deposit interest rate regulation, banks may or may not expand their network depending on their savings function. Naturally here, we do not imply that each firm will expand or contract at the same manner. This will be determined by the cost function Q(6j) of each firm i. It could also/be possible that some firms may expand their network while others may contract their network. This depends on their specific savings function.

## 4. The Case of a Specific Timing of a Regulatory Process

In our general model, we were able to characterize the behavior of the banking firms, both at a case of regulation, i.e. strictly determined deposit interest rates, and at a case of complete liberty on the part of the banking firms to decide on both the network size and the deposit interest rate.

We have to point out that a decision on network is, to a certain extent, a decision on nonreversible investment. Therefore, firms who have already expanded, and operate a network of a certain size, cannot close down some brances with no capital losses.

Assume now the following timing of a regulatory process:
The central monetary authorities have determined a regulatory system (supported by historical and economic reasoning). This regulatory system dictates the rate of interest paid to the depositors. The banking firms do not foresee any change of the regulatory environment in the future (or they assign some probability to it), thus, they follow an optimizing behavior and install the optimal size of network under a fixed interest rate. Then, after the decisions of the banks have been made, the central monetary authorities lift their regulatory restrictions and essentially let the banks decide on their own deposit interest rates. We shall remind the reader that the period of regulatory constraints is called first period, and the period with no contraint is called second period.

### *4.1. The first Period*

During the first period, the equilibrium decisions of the banking firm i can be characterized by equation (4), which after dropping the subscript i can be written:

$$\frac{\partial \Pi(\delta, \bar{r})}{\partial \delta} = 0 \rightarrow (R - \bar{r}) \quad \left\{ \frac{\partial S(\delta, \bar{r})}{\partial \delta} \right\} - C'(\delta_c) = 0 \qquad \text{for all firms.}$$

which will determine $\delta$ to be $\delta = \delta_c$.

Hence, the firm operates under the two values $(\bar{r}, \delta_c)$. We know that $\bar{r} < r_u$ by assumption 1 and at case 1 we have $\delta_c > \delta_u$ if (11) holds, or at case 2 we have $\delta_c < \delta_u$ if (12) holds.

### *4.2. The Second Period*

At the second period, the monetary authorities allow the deposit interest rates to be determined by the banks. The banks may now adjust their deposit interest rates and they also may increase, if they decide their network. However, they cannot reduce their network without imposing positive costs to the firm. We have to consider the two cases in order to comprehend the adjustment of the interest rate.

In the previously called case 1 (which seems to be the most interesting case), where $\delta_c > \delta_u$ and (11) holds i.e.:

$$\frac{\partial^2 S(\delta, r)}{\partial \delta \, \partial r} \cdot (R - r) - \frac{\partial S(\delta, r)}{\partial \delta} \leqslant 0 \tag{11'}$$

each banking firm will adjust interest rates to achieve:

$$\frac{\partial \Pi_i(\delta_{ic}, r_i)}{\partial r_i} = 0 \rightarrow (R - r_i) \quad \left\{ \frac{\partial S_i(\delta_{ic}, r_i)}{\partial r_i} \right\} - S_i\,(\delta_{ic}, r_i) = 0 \tag{13}$$

The result of this equilibrium equation can be named: $r_i = r_{ic}$. Now, since we know that $\delta_{ic} > \delta_{iu}$ and we know that (11) holds, we can state that

$$(R - r_{iu}) \left[ \frac{\partial S_i(\delta_{ic}, r_{iu})}{\partial r_i} \right] - S_i(\delta_{ic}, r_{iu}) < 0 \tag{14}$$

We know however that $\frac{\partial^2 \Pi_i}{\partial r_i^2} < 0$. Therefore, $r_{ic}$ has to be smaller than $r_{iu}$ to make (13) hold.

Therefore, in case 1 the banks will tend to keep their interest rates below the unconstrained levels, because they have overexpanded their network.

In case 2 however, $\delta_{ic} < \delta_{iu}$ therefore each bank will presumably have no trouble to expand their network to the unconstrained level and also to increase their interest rate to the unconstrained level.

Nonetheless, it is quite interesting to describe what happens if the banking firm cannot increase its network (or at least, there exist a certain time period for which the firm cannot do it). If this is the case, and (12) holds i.e.:

$$\frac{\partial^2 S(\delta, r)}{\partial \delta \, \partial r} \cdot (R - r) - \frac{\partial S(\delta, r)}{\partial \delta} \geqslant 0 \tag{12'}$$

each banking firm i will try to momentarily adjust their interest rate to achieve (13) i.e.:

$$\frac{\partial \Pi_i (\delta_{ic}, r_i)}{\partial r_i} = 0 \rightarrow (R - r_i) \quad \left\{ \frac{\partial S_i (\delta_{ic}, r_i)}{\partial r_i} \right\} - S_i (\delta_{ic}, r_i) = 0 \qquad (13)'$$

and this will result to $r_i = r_{ic}$, which is the interest rate constrained by the temporarily fixed network.
Given (12) and $\delta_{ic} < \delta_{iu}$ we can state that

$$(R - r_{iu}) \left[ \frac{\partial S_i(\delta_{ic}, r_{iu})}{\partial r_i} \right] - S_i(\delta_{ic}, r_{iu}) < 0 \qquad (14)'$$

which is the same as expression (14) and therefore, $r_{ic} < r_{iu}$.

This latter result seems very interesting. If the network cannot be momentarily adjusted, then the interest rates seem to lag behind the rates of the unconstrained cases.

## 5. Conclusions

The greek monetary authorities have shown a rather erratic behavior towards banking regulations. It is true that for an extended period of time, the deposit interest rates and the loan rates were completely fixed at levels dictated by the Bank of Greece. During that period, the commercial banks were left with only one other dimension of banking strategy, the size of their branch network. Therefore, they had to decide on how much to expand their network. We believe, that this investment decision contains to a certain extent, a nonreversible investment decision with significant sunk costs. A branch which is fully in operation, cannot be easily shut down without positive and significant costs in terms of goodwill lost and also in terms of abolished competitive edges. (Moreover, the existing regulation imposes additional costs on branch closings). Lately, the greek monetary authorities have decided to abolish regulation on interest rates.

In this paper, we were able to construct a model which takes into account this timing of the regulatory process, and we showed that if the banks tend to overexpand their network during the "regulation era", they would be very reluctant to increase their interest rates "enough" after the abolishment of the interest rate regulation.

On the other hand, if firms have kept a "small" branch network but they cannot expand their network momentarily (after the displacement of the regulation on interest rates) they would also tend to keep their interest rates at "low" levels.

We have not worked on specific measures of policy which can be taken to revert this case. It can be reasonable however, that the monetary authorities may impose lower bounds (minima) on the interest rate variance. This is exactly what the greek authorities are currently doing.

## Footnotes

1. This assumption appears very strict and unrealistic. It can be easily replaced by an assumption where the firms assign a probability distribution over the possibilities of different deregulation timing schemes. Nonetheless, the conclusions of the paper would not be altered in any qualitative way, sinse we don't intend to model the behavior of the firms under uncertainty of regulation changes. Instead we aspire to show the results of a certain regulatory timing process which has happened in reality in Greece and to a certain degree in other countries also. It is worth mentioning, that perfect knowledge of the timing of the regulatory changes, althouth it never existed, could induce optimal behavior of the firms, but it could not contradict our main results.

2. Introducing this assumption may appear purely ad hoc. This has been generally true in reality however. We admit that a different assumption could be used, which could alter the findings of the paper with no methodological changes.

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