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**Financial Opening, Deposit Insurance, and Risk in a Model of Banking Competition<sup>1</sup>**

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**Abstract**

This paper studies the impact of competition on the determination of interest rates and banks' risk-taking behavior under different assumptions about deposit insurance and the dissemination of financial information. It finds that lower entry costs foster competition in deposit rate sand reduce banks' incentives to limit risk exposure. Although higher insurance coverage amplifies this effect, two alternative arrangements (risk-based contributions to the insurance fund and public disclosure of financial information) help to reduce it. Moreover, uninsured but fully informed depositors and risk-based full deposit insurance yield the same equilibrium risk level, which is independent of entry costs. The welfare implications of the different arrangements are also explored.

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## SUMMARY

The paper studies the impact of increased competition, arising from the relaxation of entry barriers, on the determination of interest rates and banks' risk-taking behavior in a model of banking competition for deposits. In a standard environment in which public information about banks' risk exposure is limited, competition, by reducing bank margins and, in turn, incentives to invest in portfolio monitoring, is detrimental to the solvency of the system. Moreover, the negative effect of competition on portfolio risk is amplified by the existence of (explicit or implicit) deposit insurance.

However, two alternative arrangements (risk-based contributions to the insurance fund and public disclosure of financial information) are shown to mitigate the negative impact of competition. In both, portfolio risk is known, priced, and charged to the bank—in the first case, by the deposit insurance agency and, in the second, directly by depositors. This similarity between the two alternative arrangements is further illustrated by the fact that the equilibrium levels of risk of uninsured but fully informed depositors and of fully insured deposits under a risk-based deposit insurance scheme are the same. Moreover, the disciplining effect is maximized in these two limiting cases, in which the risk premium is computed over the entire portfolio.

The final section of the paper explores the welfare implications of increasing the deposit insurance coverage levels, and relaxing entry barriers, and shows that, when risk is fully priced, as in the limiting cases mentioned above, both alternative scenarios are welfare superior to the benchmark. Indeed, for environments close to these two cases, financial opening improves welfare, because the negative impact of increased competition on risk becomes negligible.

## I. INTRODUCTION

Whereas in the past, regulators aimed at limiting “disruptive competition” as a way of promoting sound banking practices, current approaches tend to rely more on market forces on the belief that competition, by improving efficiency and reducing costs, not only leads to a better allocation of resources, but also limits the vulnerability of the banking sector to adverse shocks.<sup>1</sup> Thus, while still centered around bank solvency issues, the new regulatory framework fosters competition in the banking sector through the elimination of credit and interest rate controls, despecialization of banks, and opening of the domestic financial markets to international competition.<sup>2</sup>

In the aftermath of the financial crises in Southeast Asia, the issue of competition and solvency is again at the center of the economic discussion. Many experts claim that bad lending practices in those countries were in part caused by the burden that “excessive” foreign lending imposed on the domestic banking sector in the form of increased foreign competition, while others blame protectionist practices in the past for the fragility of the domestic financial sector at the time of financial opening.

A final assessment of the impact of competition on bank soundness remains elusive, in part because several factors interact with competition in the determination of risk-taking behavior in the banking industry. In particular, governments that explicitly or implicitly guarantee bank deposits reduce the incentives of depositors and, in turn, of banks, to monitor lending practices, and thus increase the probability of bank failures. In this sense, deposit insurance may limit the scope for market discipline and reduce the beneficial effect of competition in banks’ asset quality.<sup>3</sup> One could argue, however, that monitoring by market participants is only conceivable when information on bank assets and the associated risk is fully disclosed, which is rarely the case.<sup>4</sup> Under such circumstances, a deposit insurance agency may be in a privileged position to evaluate the quality of banks’ portfolios and to exert a disciplining effect simply by charging banks a risk-based contribution to the insurance fund. Thus, the agency could easily play the role of an informed investor.

The aim of this paper is to assess the impact of increased competition on banks’ risk-taking behavior taking into account the disciplining effect introduced by either a

<sup>1</sup> See, for instance, Ali and Greenbaum (1997).

<sup>2</sup> See, e.g., Dewatripont and Tirole (1994).

<sup>3</sup> The relationship between deposit insurance and bank failures is discussed in Mishkin (1992), Keeley (1990) and O’Driscoll (1988). However, it is important to stress that a deposit insurance scheme may prevent bank runs prompted by exogenous changes in market sentiment, thus promoting financial stability, as Diamond and Dybvig (1983) show in their seminal paper.

<sup>4</sup> Even when information is disclosed, risk assessment may be subject to substantial uncertainty and lead to erratic behavior on the part of market participants. Cordella and Levy Yeyati (1998) analyze how information disclosure affects the probability of banking crises both in the case in which risk is chosen by the bank, and in the case in which it is exogenous.

risk-based deposit insurance scheme or by the disclosure of financial information to the public. To do so, we use a model of spatial competition *à la* Salop (1979), in which banks and depositors are located around a unit circle that represents the “product specification space.”

Our model shares some of the features of Besanko and Thakor (1992) and Chiappori et al. (1995), being however very different in nature. While they assume that banks’ failure probability is either independent of banks’ portfolio decisions (in the first case), or zero (in the second), we introduce moral hazard considerations by allowing banks to privately choose the probability of success of their asset portfolio. This allows us to study the trade-off between competition in price (deposit rate) and in quality (low credit risk).

To simplify the analysis, we assume that banks choose their investments from a pool of projects, abstracting from competition for loans,<sup>5</sup> and that loans are completely financed by deposits, abstracting from issues related with the interbank money market or the equity-debt ratio. On the other hand, we explore the extent to which the moral hazard problem can be reduced by providing banks’ creditors with information about the banks’ risk exposure.

Spatial competition models provide a simple and rich framework in which banks face an imperfectly elastic demand for financial services, because of the fiction of the transportation costs.<sup>6</sup> Within the proposed framework, increased competition may be modeled as a reduction of entry barriers (the fixed installation costs of Salop’s model), for example, as a result of internal competition from non-deposit financial institutions (through the introduction of products such as mutual funds), or external competition arising from the relaxation of regulations on foreign participation in the banking sector.

We consider the following cases: i) a benchmark scenario in which banks have private information about the level of risk of their portfolios, and the deposit insurance scheme (DIS) is financed through flat-rate contributions,<sup>7</sup> ii) a scenario in which risk information is disclosed to the deposit insurance agency, which charges a risk-based premium on deposits to fund the DIS; and iii) a scenario in which risk information is disclosed directly to the public, which thus demands a deposit rate commensurate with the implicit risk. For each case, we examine the impact of a change in deposit insurance coverage, and in entry costs on the equilibrium deposit rate and risk level, making the distinction between the short run (holding the number of banks constant after the change) and the long run (allowing new entry).

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<sup>5</sup> For a rigorous discussion of the problems arising from “double-sided” Bertrand competition in banking, see Yanelle (1989 and 1997), and Gottardi and Yanelle (1996).

<sup>6</sup> This approach has become popular in the recent literature on imperfect competition in banking. See, for instance, Matutes and Vives (1995) and (1996) for models of banking competition *à la* Hotelling, and Besanko and Thakor (1992), Chiappori et al. (1995), and Economides (1996) for applications of the circular version used in this paper.

<sup>7</sup> We define this scenario as the benchmark simply because is the most commonly found.

The main results of this analysis are the following:

1. In the benchmark scenario, an increase in insurance coverage increases deposit rates and risk.<sup>8</sup> Higher coverage increases the interest rate elasticity of deposit supply, induces tougher price competition and lowers bank margins, thus reducing banks' incentive to monitor their risk position. Since the portfolio risk is unknown to depositors, the supply of funds does not respond to changes in risk, and the marginal cost of relaxing monitoring practices is given by the now lower *per deposit* profits.

2. Lower entry costs in this context yields the same result. Since banks can only compete in prices, tougher competition induce higher deposit rates, reducing incentives to invest in monitoring.<sup>9</sup>

3. In the two alternative scenarios, for any given level of coverage, the "pricing" of risk causes banks to shift from price competition (resulting in lower deposit rates) to quality competition (reflected in lower risk). Both scenarios lead to higher bank profits in the short run, and a greater number of banks in the long run.

4. This similarity between the two alternative regimes, in which risk is no longer private information and can be "priced" (in the first case by the deposit insurance agency; in the second, by depositors), is further illustrated by the fact that the equilibrium level of risk in the case of uninsured but fully informed depositors and in the case of fully insured deposits under a risk-based DIS is the same. Hence, discipline can be exerted either by the insurance agency or by the market. Moreover, the disciplining effect is maximized (the equilibrium risk level is at its minimum) when the risk premium is computed over the entire portfolio.

5. The negative impact of financial opening on risk behavior is smaller in either of the alternative scenarios than under the benchmark, reflecting the relatively higher marginal cost of risk taking. Indeed, we show that in the extreme cases in which a risk premium is charged over the whole portfolio (the limiting cases of point 4 above), the equilibrium failure probability is independent of either transportation or entry costs.

In the final section of the paper, we discuss the welfare implications of increasing the deposit insurance coverage levels, and reducing entry costs. Unlike in the standard monopolistic competition model, here welfare also depends, negatively, on risk. Thus, for example, an increase in insurance coverage, associated with fewer banks but higher risk, is welfare improving only in the presence of very high entry costs, when the gains from reducing the (excessive) number of firms outweighs the decline in portfolio quality. The same argument

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<sup>8</sup> See Matutes and Vives (1995) for a similar result in an Hotelling duopoly model.

<sup>9</sup> We also show that the same is true of a decline in transportation costs, as a result, for example, of the elimination of branching restrictions.

applies to the welfare comparison across scenarios. However, we show that, when risk is fully priced, as in the limiting cases of point 4, both alternative scenarios are welfare superior to the benchmark. Finally, we show that, as we approach these two cases, financial opening improves welfare, since the negative impact of increased competition on risk vanishes.

## II. THE MODEL

We consider a spatial competition model *à la* Salop (1979), where  $n$  banks are located symmetrically around a unit circle that represents the “product specification space.” A typical bank  $i$  collects funds from depositors offering an interest rate  $r_i$ , and invests the deposits in projects that have stochastic returns. In particular, we suppose that the gross returns on a portfolio of size  $S$ , are  $RS$ , if the project succeeds, and 0, if the project fails, in which case the bank goes bankrupt and is liquidated. As in Rochet and Tirole (1996), depositors face a moral hazard problem since the banks privately choose the probability that the project succeeds. More precisely, we suppose that each bank  $i$  chooses its “monitoring effort,” and we make the hypothesis that the probability of success  $q_i$  for a project  $i$ ,  $q_i \in [0, 1]$ , is equal to the monitoring effort of bank  $i$ . In the model, a fraction  $\alpha$  of the failed bank’s outstanding deposits is reimbursed, on a proportional basis, by a DIS funded by bank contributions. Throughout the paper, we assume that the total contribution of the banking system to the deposit insurance agency is (ex-post) constant and, without great loss of generality, we normalize it to zero.<sup>10</sup>

Funds are supplied to the banks by a continuum of depositors, uniformly distributed along the circumference. Each depositor has the option to invest a unit of cash in bank deposits,<sup>11</sup> incurring a transportation cost of  $t$  per unit of distance, or in an outside risk-free homogeneous asset, which returns net of transportation costs we assumed to be equal to zero for simplicity.<sup>12</sup>

Suppose that  $n$  banks are symmetrically located around the circle, and consider a depositor located at any point  $x$  between bank  $i$  and bank  $i + 1$ : Letting  $r_i \in [0, R]$ , denote the deposit rate charged by bank  $i$ , his (expected) utility is given by

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<sup>10</sup> This simplification implicitly fixes bank total contributions *ex ante*, thereby endogeneizing the government’s expected contribution to the insurance fund. By keeping the cost of insurance to banks constant, it facilitates comparison across different regimes. On the other hand, endogeneizing total bank contributions complicates the model without altering the qualitative results.

<sup>11</sup> This setup implicitly assumes an inelastic aggregate supply of funds. It can be shown, however, that introducing a positive interest rate elasticity of the aggregate deposit supply, as in Besanko and Thakor (1992), does not affect the results of the paper.

<sup>12</sup> Distances along this circle should be interpreted as differences between the individual consumer’s preferred product specification, and those offered by existing banks. Thus, geographical considerations (location and number of branches) are only one aspect of those characterizing the product specification space, which may also include ATMs, PC banking, overdraft facilities, etc..

$$U_x = \begin{cases} [q_i^e + (1 - q_i^e)a] r_i - tx, & \text{if he deposits with bank } i; \\ [q_{i+1}^e + (1 - q_{i+1}^e)a] r_{i+1} - t(\frac{1}{n} - x), & \text{if he deposits with bank } i + 1; \\ U_x^O = 0 & \text{if he invests in the outside asset;} \end{cases} \quad (1)$$

where  $q_i^e$  (resp.  $q_{i+1}^e$ ) denotes the depositors' common expectation of the probability of success of bank  $i$  (resp. bank  $i + 1$ ), given their information, and  $a$  denotes the share of deposits that are insured under the DIS.

### A. Benchmark Case

First, assume that the riskiness of individual banks' portfolios is not disclosed to the public. Thus, depositors observe posted bank rates, and given their beliefs about the banks' risk position, either invest in the bank that offers the higher expected return net of transportation costs, if this return is positive, or in the outside option, if it is negative. Then, from equation (1), a depositor located at a distance  $x \in [0, \frac{1}{n}]$  of bank  $i$  is indifferent between investing in banks  $i$  and  $i + 1$ , if

$$[q_i^e + (1 - q_i^e)a] r_i - tx = [q_{i+1}^e + (1 - q_{i+1}^e)a] r_{i+1} - t(\frac{1}{n} - x),$$

which, denoting by  $r$ , and  $q^e$  the (common) deposit rate and expected monitoring efforts of all other banks,<sup>13</sup> gives the following deposit supply function for bank  $i$ :

$$S_i(r_i, r, q_i, q_i^e, n) = 2x = \frac{1}{n} + \frac{[a + (1 - a)q_i^e]r_i - [a + (1 - a)q^e]r}{t}. \quad (2)$$

Let us now consider the banks' problem. We assume that banks face quadratic monitoring costs per unit of deposits,<sup>14</sup> and that bank contributions to the DIS are computed *ex-ante* as a fixed proportion of total deposit liabilities. Thus, bank  $i$ 's operating profits can be expressed as

$$\Pi = S_i [(R - r_i)q_i - q_i^2]. \quad (3)$$

We are interested in a symmetric rational expectations Nash equilibrium, which is defined below.

<sup>13</sup> Since we are solving for symmetric equilibria, we can make these assumptions without loss of generality.

<sup>14</sup> The underlying assumption is that the monitoring technology per unit of investment is subject to diminishing marginal returns. The choice of a quadratic formulation is done for sake of simplicity, and does not affect our qualitative results.

**Definition.** A symmetric rational expectations Nash equilibrium is defined as deposit rates  $r^* = r_1^* \dots = r_n^*$ ,  $r^* \in [0, R]$ , monitoring efforts  $q^* = q_1^* = \dots = q_n^*$ ,  $q^* \in [0, 1]$ , and number of banks  $n^* \geq 0$ , such that:

**Local Oligopoly:**

i) Depositors expectation are fulfilled:  $q_1^e = \dots = q_n^e = q^*$ ;

ii) Each bank  $i$  maximizes  $V_i$  at  $r^*, q^*$ , when the other banks offer the same deposit rate and choose the same monitoring effort:

$$q^* = \arg \max_{q_i \in [0,1]} V(q_i, r^*, q^*, n^*),$$

$$r^* = \arg \max_{r_i \in [0,R]} V(r_i, r^*, q^*, n^*);$$

iii) Markets are covered:  $U_x(r^*, q^*, n^*) > U_x^O$  for all  $x$ .

**Free entry:**

The number of banks  $n^*$  is such that:

$$V(r_L^*, q_L^*, n_L^*) = \Pi(r_L^*, q_L^*, n_L^*) - F = 0, \tag{4}$$

where  $F$  represents entry costs, and the subscript  $L$  denotes long-run equilibrium values.

Thus, in a symmetric equilibrium, symmetrically distributed banks offer the same deposit rate. The equilibrium is Nash in that banks maximize conditional to other banks' strategies, and is consistent with rational expectations since depositors' expectations regarding the banks' choice of the (unobserved) monitoring effort  $q$  are unbiased. In addition, the long-run equilibrium is given by the (free-entry) zero profit condition (4).

**B. Local Oligopoly Equilibrium**

We first assume that the number of banks operating in the economy is fixed, and entry costs  $F$  are small enough for banks to make positive profits. Differentiating (3) with respect to  $q_i$  and  $r_i$ , and imposing symmetry and rational expectations, we find that any interior symmetric equilibrium  $(r^*, q^*)$  must satisfy the following equilibrium conditions:<sup>15</sup>

<sup>15</sup> We drop the subscript  $i$  for simplicity, and throughout our analysis we assume that  $l < n$ , so that at equilibrium monitoring is incomplete.

$$\frac{\partial \Pi}{\partial r} = \frac{a + (1 - a)q}{t} [(R - r)q - q^2] - \frac{q}{n} = 0, \quad (5)$$

$$\frac{\partial \Pi}{\partial q} = \frac{R - r - 2q}{n} = 0, \quad (6)$$

from which we have that:

$$r = R - \frac{t}{n[a + (1 - a)q]} - q, \quad (7)$$

and

$$q = \frac{(R - r)}{2}. \quad (8)$$

Using (7), and (8) it is easy to verify that:

$$r^* = R + \frac{a - \sqrt{a^2 + 4t\frac{(1-a)}{n}}}{(1 - a)}, \quad (9)$$

$$q^* = \frac{-a + \sqrt{a^2 + 4t\frac{(1-a)}{n}}}{2(1 - a)}, \quad (10)$$

is the unique solution<sup>16</sup> that satisfies (5)-(6), with  $r^* \leq R$ , and  $q^* \in ]0, 1]$ .

Equations (9) and (10) define the equilibrium deposit rates and risk level for a given number of banks  $n$ , and allow us to sign the short-run impact of changes in insurance coverage  $a$ , product differentiation  $t$ , and number of banks  $n$ , on interest rates and risk. Moreover, replacing (8) in (3), and using the fact that, at a symmetric equilibrium  $S^* = \frac{1}{n}$ , we obtain:

$$\Pi = \frac{q^{*2}}{n}. \quad (11)$$

Thus, in the short run, monitoring efforts and operating profits are positively correlated, or, defining risk as the bank's probability of failing  $(1 - q)$ , risk and profits are negatively correlated. Using (9), (10) and (11), we can conduct (short-run) comparative statics analysis

<sup>16</sup> See Proposition A1 in the Appendix.

for the insurance coverage, the degree of product differentiation, and the number of operating banks.

In turn, in the long run, the zero profit condition 4 must hold, which implies that:

$$V = \frac{q^{*2}}{n^*} - F = 0, \quad (12)$$

from which we can solve for  $n^*$ . The close form solution for  $n^*$ , is rather cumbersome. However, we can use 12 together with (10) to characterize implicitly how changes in the relevant parameters of the model affect the long-run outcome. Formally:

**Proposition 1** *i) In the short run, monitoring effort  $q$ , and bank profits  $\Pi$ , are decreasing in insurance coverage  $a$ , and increasing in product differentiation  $t$ . Deposit rates  $r$  are increasing in insurance coverage  $a$ , and decreasing in product differentiation  $t$ . ii) In the long run, the number of firms  $n$ , is decreasing in insurance coverage  $a$ , and increasing in product differentiation  $t$ . The short-run effects on  $q$  and  $r$  are partially, but not totally, reversed.*

**Proof:** In Appendix.

The intuition behind these results is the following: In the benchmark case, since individual banks cannot affect deposit supply by reducing their risk exposure, the marginal benefit of increasing the monitoring effort depends only on the unit return on a successful project,  $R - r$ . This positive relationship between returns and monitoring is essential to understand the link between bank competition and each bank's choice of risk. For example, a higher level of insurance coverage increases the interest rate elasticity of deposit supply, since it increases the fraction  $q + (1 - q)a$  of depositors' portfolios that is directly affected by changes in the interest rate.<sup>17</sup> This fosters price competition, pushing deposit rates up and reducing banks' returns. In turn, lower returns induce banks to cut on monitoring effort, reducing costs and compensating for the decline in bank profits only in part. In the long run, operating profits return to their original level after the exit of banks. As a result, competition weakens, and the impact on monitoring effort and deposit rates is partially reversed.

A drop in  $t$ , by making bank products better substitutes, and reducing the market power of each individual bank, has similar effects on rates, risk and bank profits. A fall in  $t$  can be associated with increased competition arising, for example, from despecialization, the elimination of branching restrictions, or the introduction of financial innovations that reduce

<sup>17</sup> Another way of seeing this is by noting that, from (2),  $\frac{\partial^2 S}{\partial r \partial a} = \frac{1-q}{t} > 0$ .

geographical barriers. These phenomena yield, according to our model, higher deposit rates, lower portfolio quality, and increased concentration.<sup>18</sup>

### III. ALTERNATIVE SCENARIOS

It is clear that competition has a direct impact only through those product characteristics that are visible to the customers. Thus, in the context of the model, as long as risk is unobservable by depositors, banks cannot use the asset quality to attract new funds. In other words, in the benchmark scenario, where only banks know the riskiness of their portfolios, risk only reflects a bank's *private* incentives to monitoring. Naturally, as soon as risk is revealed, the incentives to increase the "quality" of the product (by increasing monitoring effort,  $q$ ) incorporate the gains in terms of a lower associated risk premium (lower deposit rate,  $r$ ).

In this section, we examine two ways in which risk can be made observable. First, we assume that bank-specific information is disclosed to the deposit insurance agency, which assesses the quality of the portfolio and charges banks a risk-based contribution rate (scenario R). Second, we analyze the case in which risk information is fully revealed to prospective depositors (scenario D). We show that information disclosure in either situation does indeed change the incentive structure of banks, increasing the optimal level of monitoring. Moreover, under conditions that make them comparable, both alternative scenarios have equivalent implications in terms of the equilibrium risk level.

#### A. Risk-Based Deposit Insurance Scheme

In order to make this case comparable with the benchmark, we model risk-based deposit insurance by assuming that each bank contributes  $a(1 - q_i)S_i r_i$  to, and receives  $a(1 - q^R)S_i r_i$  from the DIS, where the superscript  $R$  denotes equilibrium values in the risk-based scenario.<sup>19</sup> This guarantees that, in equilibrium, the net contribution to the deposit insurance fund is zero as in the benchmark case. Banks' operating profits now become

$$\Pi = S [(R - r)q - q^2 - a(q^R - q)r]. \quad (13)$$

<sup>18</sup> A number of recent papers present empirical evidence from the U.S. banking sector that is consistent with these results (see, e.g., Mishkin (1996) and Keeley (1990)). Since we are specifically interested in the impact of increased international competition in the context of the opening of domestic financial markets, we chose not to explore further this approach.

<sup>19</sup> More precisely we assume that the term  $q^R$  is computed *ex-ante*, and thus it does not directly affect banks' maximization problem.

Note that, after imposing symmetry and rational expectations on the first order condition with respect to  $r$ , any interior symmetric equilibrium still has to satisfy equation (7). In turn, from the first order conditions with respect to  $q$ , we have:

$$\frac{\partial \Pi}{\partial q} = \frac{R - r(1 - a) - 2q}{n} = 0, \quad (14)$$

from which, at equilibrium, monitoring effort  $q$  must satisfy:

$$q = \frac{R - (1 - a)r}{2} \geq \frac{(R - r)}{2}. \quad (15)$$

The inequality in (15) indicates that, for any given deposit rate, and any strictly positive insurance coverage level ( $a > 0$ ), the monitoring effort is higher in scenario R than in the benchmark, i.e.,

$$q^R(r) > q^*(r). \quad (16)$$

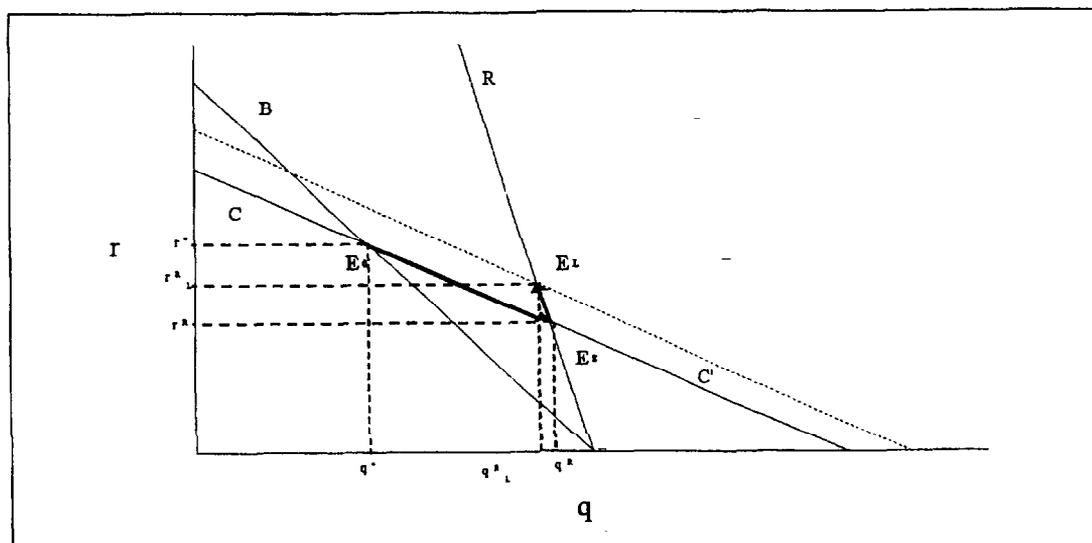
An interior equilibrium can be characterized in the  $(r, q)$  space as the intersection of the curves defined by (7) and (15), which we denote  $C(q)$  and  $R(q)$ , respectively. We use this implicit characterization to obtain the following result.

**Proposition 2** *Deposit rates are lower, and monitoring effort and the number of banks higher, under a risk-based DIS than under a flat-rate DIS.*

**Proof:** In Appendix.

Figure 1 illustrates the steps of the proof. From the first order conditions with respect to  $q$ , the equilibrium condition (8) for the benchmark implicitly defines the line  $B(q)$ , while in the risk based scenario the equilibrium condition is, as we have already noticed, given by the line  $R(q)$ . It is easy to see that these lines have slopes equal to  $-2$  and  $-2/(1 - a)$  respectively, and that they intersect for  $r = 0$  at  $q = R/2$ , respectively. Curve  $C(q)$ , on the other hand, is common to both scenarios, concave, and everywhere flatter than  $B(q)$ . Thus, a switch from a flat-rate to a risk-based DIS is represented by a rightward movement along curve  $C(q)$ , from the initial equilibrium point  $E_0$  to a new short-run equilibrium  $E_S$  associated with higher monitoring and, since  $C(q)$  is downward-sloping for all  $q$  to the right of  $E_0$ , lower deposit rates.

Figure 1. The Risk-Based Case



Proposition 2 implies that, for a given number of banks, if risk is correctly assessed and charged to the bank by the deposit insurance agency, at the equilibrium a bank offers higher quality and lower deposit rates as compared with the flat-rate case. Intuitively, there is now a second way in which risk enters as a cost in a bank's maximization problem, namely as a proportionally higher contribution. As banks improve asset quality, depositors demand lower deposit rates, improving margins, which, combined with a higher probability of success, increase banks' expected profits in the short-run. This reflects the fact that, in this context, banks can credibly commit to a lower risk level, reducing the cost of funds and improving banks' overall performance.<sup>20</sup>

As shown in Figure 1, higher short-run profits induce new entry in the long run, which in turn shifts curve  $C(q)$  upwards to  $C'(q)$ , moving the equilibrium from  $E_S$  to  $E_L$  and partially reversing the short-run effect.

### 1. Insurance coverage

One can readily see from equilibrium conditions (7) and (14) that an increase in  $a$  increases both the incentives to raise deposit rates for a given monitoring effort, and the incentives to raise monitoring effort for a given deposit rate, as

<sup>20</sup> It is interesting to note that the result is not driven by differences in the total cost to banks of the deposit insurance scheme, which for all cases considered is zero in equilibrium, but by differences in the marginal cost under each scheme.

$$\frac{\partial^2 \Pi}{\partial r \partial a} = \frac{1-q}{n} [(R-r) - q] q > 0, \quad (17)$$

and

$$\frac{\partial^2 \Pi}{\partial q \partial a} = \frac{r}{n} > 0. \quad (18)$$

Since deposit rates and monitoring effort are negatively correlated, the net effect is ambiguous. In terms of Figure 1, an increase in coverage shifts  $C(q)$  downwards and  $R(q)$  upwards. The first shift can be explained along the same lines as in the benchmark: As the DIS becomes more comprehensive, the interest rate elasticity of deposit supply increases, and price competition tends to get tougher. As before, the resulting increase in deposit rates reduces incentives to monitor. However, as coverage grows, risk is further penalized through higher contributions, creating incentives to raise investment in monitoring, which are reflected in the shift of curve  $R(q)$ . This, in turn, exerts a negative influence on deposit rates. Although it is not possible to determine in general which of these two effects prevails, it can be shown that, for large levels of initial coverage, further increments in coverage have a beneficial effect on risk. This follows directly from (18): higher insurance coverage leads to higher deposit rates, strenghtening the disciplining effect of a risk-based deposit insurance scheme. Formally,

**Remark 1** *For a sufficiently high coverage level  $a$ , a further increase in coverage reduces bank risk.*

**Proof:** In Appendix.

The point is illustrated in the simulations presented in Figures 4 to 6.<sup>21</sup> Monitoring levels in both scenarios converge for small values of  $a$ . On the other hand, while in the benchmark monitoring declines monotonically with  $a$ , in scenario R it increases with  $a$ , as coverage approaches one. For smaller values of  $a$ , monitoring can either increase or decrease with coverage. Note also that monitoring increases with coverage only for low values of  $F$ , which are associated with strong competition and high equilibrium deposit rates.

## B. Public Disclosure

Assume now that a bank's risk choice  $q_i$  is known by depositors. This implies that, after replacing expected risk levels by their actual values, the deposit supply function modifies to:

<sup>21</sup> Figure 3 to 10 present numerical solutions for the long run equilibrium values of welfare  $W$ , monitoring effort  $q$ , deposit rate  $r$ , and number of banks  $n$ , under the three scenarios discussed in the paper. Equilibria are interior and the market is covered in all cases.

$$S_i(r_i, q_i, r, q) = \frac{1}{n} + \frac{r_i[a + (1 - a)q_i] - r[a + (1 - a)q]}{t}.$$

It can be shown that public disclosure induces a higher equilibrium monitoring level in the long run. The analysis will proceed in the same way as in the previous section.

First, note that from the first order conditions with respect to  $r$ , we have that equation (5) should hold at equilibrium. This implies any interior symmetric equilibrium  $(q^D, r^D)$ , where the superscript denotes the disclosure scenario, must satisfy (7). On the other hand, from the first order condition with respect to  $q$  we have:

$$\frac{\partial \Pi}{\partial q} = \frac{R - r - 2q}{n} + \frac{qr(1 - a)(R - r - q)}{t} = 0. \quad (19)$$

Solving (19) for  $q$ , we obtain

$$q = \frac{(R - r)}{2} - \frac{t}{(1 - a)nr} + \sqrt{\left[\frac{R - r}{2}\right]^2 + \left[\frac{t}{(1 - a)nr}\right]^2} > \frac{(R - r)}{2}. \quad (20)$$

The inequality in (20) indicates that, for any given deposit rate  $r$ , marginal returns from monitoring are higher under the disclosure regime than under the benchmark, so that:

$$q^D(r) > q^*(r).$$

An interior equilibrium can be characterized in the  $(r, q)$  space as the intersection of the curves defined by (7) and (20),  $C(q)$ , and  $D(q)$ , respectively. We use this implicit characterization to obtain the following result:

**Proposition 3** *Deposit rates are lower, monitoring efforts, and the number of banks higher under a public disclosure regime than under the private information (benchmark) regime.*

**Proof:** In Appendix.

Figure 2. The Disclosure Case

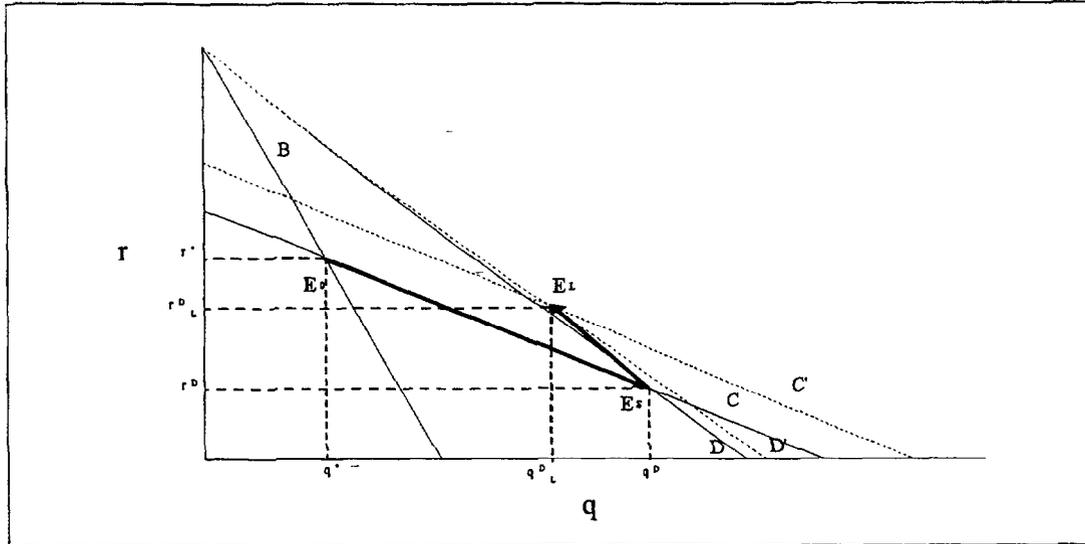


Figure 2 illustrates this result. As before,  $B(q)$  represents the straight line determined by equation (8), associated with the benchmark case. In the short run, after a change from a flat-rate to a risk-based deposit insurance scheme, the system goes from  $B(q)$  to  $D(q)$ , moving the equilibrium along curve  $C(q)$  to point  $E_S$ . In the long run, as higher profits induce new entry, both  $C(q)$  and  $D(q)$  shift upward to  $C'(q)$  and  $D'(q)$ , respectively, and the short-run impact of the regime switch on the equilibrium pair  $(q^D, r^D)$  is partially undone, as the equilibrium moves from  $E_S$  to  $E_L$ .

### 1. Insurance coverage

From (20), we know that  $R - r - 2q < 0$ . In turn, keeping  $q$  constant and differentiating equation (19) implicitly, we have that

$$\frac{\partial r}{\partial a} \Big|_q = - \frac{\frac{qr(R-r-q)}{t}}{\frac{1}{n} - \frac{q(1-a)(R-2r-q)}{t}} < 0. \quad (21)$$

Thus, an increase in coverage  $a$  translates into a downward shift of curve  $D(q)$ . On the other hand, as before, a positive change in  $a$  results in an upward shift of  $C(q)$ . Combining both effects, we obtain that under disclosure, as in the benchmark case, higher insurance coverage corresponds to a higher deposit rate, and a lower monitoring effort. Not surprisingly, *the negative effect of increased insurance coverage on monitoring is larger in the presence of public disclosure* ( see Figure 4), since in addition to the reduction in monitoring incentives generated by the decline in bank profits, deposit insurance has the effect of limiting the

disciplining effect of information disclosure, as the risk premium demanded by depositors is proportional to the uninsured portion of the portfolio, now smaller.

### C. Equivalence Between Risk-Based Deposit Insurance and Public Disclosure.

Propositions 2 and 3 confirm the intuition that information disclosure (to the deposit insurance agency in the first case, to the public in the second) creates a “market” for risk, and therefore forces the bank to internalize the associated cost, thus generating incentives to limit risk by investing more in monitoring. Given that the incentive mechanisms are similar under both alternative scenarios, we would expect that under certain conditions, both full disclosure and risk-based deposit insurance yield equivalent results in terms of risk-taking behavior. This is examined next.

In order to compare the two scenarios in a meaningful way, it is necessary to focus on the comparable cases in which the portion of the portfolio over which the risk premium is computed is the same, namely when deposits are fully insured in scenario R ( $a = 1$ ), and not insured in scenario D ( $a = 0$ ). We will denote these cases  $R_1$  and  $D_0$ , respectively. Using (7) and (15), substituting in equation (13), and imposing the free entry condition, the reader can easily verify that, in scenario  $R_1$ , the symmetric local oligopoly equilibrium  $(r^{R_1}, q^{R_1}, n^{R_1})$  is characterized by:

$$\begin{aligned} r^{R_1} &= \frac{R}{2} - \frac{\sqrt{2Ft}}{\sqrt{R}}, q^{R_1} = \frac{R}{2}, n^{R_1} = \sqrt{\frac{tR}{2F}}, & \text{if } R \leq 2; \\ r^{R_1} &= (R - 1) - \sqrt{Ft}, q^{R_1} = 1, n^{R_1} = \sqrt{\frac{t}{F}}, & \text{if } R > 2. \end{aligned} \quad (22)$$

Similarly, from (7) and (20), the symmetric local oligopoly equilibrium in scenario  $D_0$ ,  $(r^{D_0}, q^{D_0}, n^{D_0})$ , is characterized by:

$$\begin{aligned} r^{D_0} &= \frac{R}{2} - \frac{2\sqrt{Ft}}{R}, q^{D_0} = \frac{R}{2}, n^{D_0} = \sqrt{\frac{t}{F}}, & \text{if } R \leq 2; \\ r^{D_0} &= (R - 1) - \sqrt{Ft}, q^{D_0} = 1, n^{D_0} = \sqrt{\frac{t}{F}}, & \text{if } R > 2. \end{aligned} \quad (23)$$

It follows directly from the comparison of (22) and (23) that

**Proposition 4** *i) The equilibrium monitoring effort in the public disclosure scenario with uninsured deposits (scenario  $D_0$ ) is the same as in the case of a risk-based deposit insurance scheme with fully insured deposits (scenario  $R_1$ ); ii) At any interior equilibrium ( $q < 1$ ), equilibrium deposit rates are higher, and the number of firms smaller, under scenario  $R_1$  than under scenario  $D_0$ .*

Proposition 4 confirms that, when the bank-specific risk is “priced” over the whole portfolio, both schemes are equivalent in terms of their disciplining effect on banks’ risk choice. However, they affect interest rate competition differently. This is because, when monitoring is incomplete ( $q < 1$ ), the equilibrium risk level of deposits is strictly positive. Accordingly, the deposit supply is more elastic in case  $R_1$  than in the case  $D_0$ , resulting in tougher price competition (higher deposit rates), lower operating profits and a smaller number of firms, in the first scenario.<sup>22</sup>

Furthermore, it can be readily seen from (22) and (23) that, under these two limiting scenarios, risk does not depend on entry costs  $F$ . In the long run, tougher price competition from new entrants results in higher deposit rates and lower operating profits for banks. Since the cost of risk is largely born by the banks, the reduction in the quasi-rents as a result of lower entry costs is fully capitalized by depositors. Finally, note that for intermediate cases ( $0 < a < 1$ ), monitoring is higher under disclosure than under a risk-based DIS, for small values of  $a$ , and vice versa. This follows from the fact that both alternative regimes yield higher monitoring effort than the benchmark in general, and that they converge to the benchmark on opposite extremes. The simulations at the end of the paper illustrate these results.

It is intuitive to think that the combination of both disciplining mechanisms (risk-based DIS and public disclosure) cannot yield a level of risk below that resulting from the application of only one of them. In fact, it is easy to verified that this is the case: for a given degree of insurance coverage, risk is strictly lower when both mechanisms are in place. However, one cannot improve upon the limiting cases by combining them: either relying exclusively on risk-adjusted penalties (by insuring deposits in full), or on public discipline (by eliminating deposit insurance altogether) yields a lower level of risk than any intermediate scheme. Formally,

**Remark 2** *For any given level of coverage  $a$ ,  $a \in ]0, 1[$  the combination of risk-based deposit insurance and public disclosure results in a level of risk (i) that is strictly smaller than in either of the alternative scenarios, (ii) and strictly higher than in the limiting cases  $R_1$  and  $D_0$ .*

**Proof:** In Appendix.

<sup>22</sup> Note that, from (2), for  $q < 1$ ,

$$\frac{\partial S}{\partial r} \Big|_{R_1} = \frac{1}{t} > \frac{\partial S}{\partial r} \Big|_{D_0} = \frac{q}{t}.$$

### D. Financial Opening

As we noticed in the introduction, we can model the impact of increased competition among banks as a result of the opening of the banking sector, simply by examining how the system responds to a fall in entry costs  $F$ . Financial opening, in this context, may be interpreted as a process of further exposing the banking sector to domestic and international competition, through the relaxation of costly regulations and entry requirements.

Since the first order conditions do not depend on  $F$ , in the short run deposit rates and monitoring are not affected. The level of profits, however, now exceeds entry costs, thus attracting new banks. In all the scenarios considered, financial opening, by increasing the number of banks and depressing intermediation margins, reduces the level of monitoring effort in the long run. Formally:

**Proposition 5** *An increase in the number of banks increases deposit rates and risk in all three scenarios.*

**Proof:** In Appendix.

Although according to Proposition 5, increased competition is in general detrimental to bank soundness, the effect differs significantly as we compare the benchmark with the alternative scenarios. In the benchmark, deposit supply does not respond to actual risk because individual risk is not observed, and therefore can not be “priced” by the market. Therefore, the only incentive for banks to reduce their level of risk comes from its negative impact on bank expected returns per deposit (which fall with competition) net of their monitoring costs (which are not affected by competition).

Under a risk-based DIS, the easing of entry requirements reduces bank margins, and thus per deposit returns for banks. However, the fact that risk now makes funds more costly due to higher contributions, however, limits the extent to which banks cut their investment in monitoring. This can be readily seen by noting that: a) a drop in  $F$  in the benchmark and the R scenarios can be represented in the  $(r, q)$  space as an upward movement along curves  $B(q)$  and  $R(q)$ , respectively, as a result of an outward shift of curve  $C(q)$  (see Figure 1); b)  $B(q)$  is flatter than  $R(q)$ ; c) from (7), the vertical shift of curve  $C(q)$  is greater in the benchmark ( $\frac{\partial C(q)}{\partial n}$  is decreasing in  $q$ ); and d) there are more new entrants in the benchmark scenario ( $\frac{\partial n}{\partial F} > \frac{\partial n^R}{\partial F}$ ).<sup>23</sup> We can thus state that

**Remark 3** *A risk-based deposit insurance scheme attenuates the negative effect on risk monitoring arising from increased competition, as compared with a flat-rate DIS.*

<sup>23</sup> Using (4), (3) and (7), we can express the free entry condition as

$$V = \frac{qt}{n^2 [a + (1-a)q]} - F = 0,$$

In the limit (scenario  $R_1$ ), as (22) indicates, the monitoring effort does not depend on  $F$ , that is, the negative impact of competition on risk is completely offset.

Figures 8 to 10 provide numerical simulations illustrating the previous results. In particular, Figure 8 shows how changes in entry costs  $F$  are associated with smaller changes in  $q$  in the presence of a risk-based DIS than under the benchmark case. As expected, the mitigating effect of a risk-based scheme disappears as  $a$  gets smaller and both scenarios converge. On the other hand, as  $a$  increases, the sensitivity of  $q$  to changes in entry costs becomes smaller. When coverage is complete the equilibrium risk no longer depends on  $F$ .<sup>24</sup>

Whether the effect of increased competition on risk is greater or smaller under disclosure than under the benchmark is less straightforward. However, as in the previous case, in the limit (scenario  $D_0$ ), monitoring effort is again independent of  $F$ . Figure 8 shows how public disclosure partially offsets the negative effect of lower entry costs on risk, and how this effect decreases with the level of coverage  $a$ . This leads to the obvious conclusion that the gains from disclosure in terms of limiting risk are dissipated as deposit insurance coverage increases.<sup>25</sup>

#### IV. WELFARE CONSIDERATIONS

Independently of who eventually pays for the cost of failed investments, it should be clear that, other things equal, a higher probability of default implies, *ex-ante*, a lower level of welfare. To see this more clearly, note that total welfare also can be expressed as total investment returns minus monitoring, installation and transportation costs.<sup>26</sup>

$$W = Rq - q^2 - nF - \frac{t}{4n}, \quad (24)$$

from which,

$$dW = (R - 2q) dq + \left( \frac{t}{4n^2} - F \right) dn. \quad (25)$$

Thus, any change in the environment affects welfare through its impact both on risk and on the number of banks. On the one hand, for any  $\alpha \in ]0, 1[$ , the equilibrium monitoring level in

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and differentiating implicitly,

$$\frac{\partial n}{\partial F} = - \frac{-1}{\frac{at}{n^2[a+(1-a)q]^2} \frac{\partial q}{\partial n} - \frac{2}{n} F'}$$

which is increasing in  $n$  and  $q$  (recall that  $\frac{\partial q}{\partial n} < 0$ ).

<sup>24</sup> Using (7) and (15) it is easy to verify that, as in the benchmark, an increase in the degree of substitutability (a decline in  $t$ ) is associated with a reduction in risk monitoring effort.

<sup>25</sup> Reliance on market discipline based on public disclosure is thus consistent with the elimination of deposit insurance schemes as predicated, for example, by the New Zealand approach.

<sup>26</sup> Because of the symmetric environment, in equilibrium the market can be divided in  $2n$  identical segments. Therefore, total transportation costs are  $2n \int_{x=0}^{1/2n} tx dx = \frac{t}{4n}$ .

all three scenarios is below  $\tilde{q} = \frac{R}{2}$ , which maximizes per deposit profits for the economy as a whole, for a given  $n$ . Hence, other things equal, an increase in  $q$  leads always to a higher level of welfare.<sup>27</sup> On the other hand, higher  $q$  is always associated with higher operating profits, which in the long run drives up the number of banks. If the initial number of banks,  $n$ , is greater than  $\tilde{n} = \frac{1}{2}\sqrt{\frac{t}{F}}$ , the level that maximizes the gains from diversification (lower transportation costs  $t$ ) net of installation costs  $F$ , for a given  $q$ , then new entry can only reduce welfare. In those cases, the net effect of a risk-reducing change depends on parameters. If, on the other hand,  $n < \tilde{n}$ , a risk-reducing change unambiguously improves welfare.<sup>28</sup>

### A. Insurance Coverage

An example of the trade-off between lower risk and excessive number of firms is the impact of a change in insurance coverage, which we discuss next. We focus on the benchmark scenario for simplicity, but the qualitative results carry on to the alternative scenarios. Replacing (8) and (12) into (24), we obtain:

$$W = (R - q)q - \frac{Ft}{4q^2}. \quad (26)$$

As was shown in Section 2, higher coverage implies lower values of  $q$  and  $n$ , so that:

$$\frac{\partial W}{\partial a} > 0 \Leftrightarrow \frac{\partial W}{\partial q} < 0 \quad (27)$$

Taking derivatives of (26) with respect to  $q$ ,

$$\frac{\partial W}{\partial q} = (R - 4q) + \frac{Ft}{2q^3} \quad (28)$$

and

$$\frac{\partial^2 W}{\partial q^2} = -4 - \frac{3Ft}{2q^4} < 0 \quad (29)$$

<sup>27</sup> For scenarios B and R, this can be seen directly from (8) and (15), respectively. For case D, it suffices to notice that, for  $a = 0$ ,  $q^D = \frac{R}{2}$ , and that, from (21),  $q^D$  is decreasing in  $a$ .

<sup>28</sup> In contrast with the traditional Salop model, risk considerations enter the definition of welfare, and optimality cannot be defined solely in terms of the number of firms. Indeed, a change in the market environment that increases the number of firms further above the Salop optimal, may prove to be welfare improving.

which implies that  $\frac{\partial W}{\partial q}$  is increasing in  $q$  (in turn, decreasing in  $a$ ), that is:

$$\left. \frac{\partial W}{\partial q} \right|_{a=0} < 0 \Rightarrow \frac{\partial W}{\partial q} < 0, \quad \forall a \in [0, 1].$$

In particular, for  $a = 0$ ,  $n = \sqrt{\frac{t}{F}}$  and  $q = (tF)^{1/4}$  which, combined with (28), imply that  $\left. \frac{\partial W}{\partial q} \right|_{a=0} < 0$  if, and only if

$$Ft > \left( \frac{2}{7}R \right)^4. \quad (30)$$

Thus, as coverage increases, and price competition drives down the number of operating banks, losses arising from higher risk are weighted against gains from limiting excessive entry.<sup>29</sup> From (28), while the former are proportional to  $R$ , the latter increase in  $F$ . Hence, for relatively high values of  $F$ , this second effect dominates, and higher insurance coverage is indeed welfare improving. Conversely, for low entry costs, the deterioration in portfolio quality as a result of higher coverage prevails, and the sign of the net effect is negative. Condition 30 is also a sufficient condition for  $\frac{\partial W}{\partial a} > 0$ , for any  $a \in [0, 1]$ . Figure 3 presents simulations that illustrate this point.

This result offers an alternative, and possibly more interesting, lecture. Note that  $F$  can also be interpreted as fixed operating costs. Limiting deposit insurance coverage reduces the interest rate elasticity of deposit supply, weakening price competition. Thus, it is consistent with a larger number of banks. If fixed costs are high, for example, due to cost inefficiencies, gains in terms of lower risk and higher diversification are lost to higher per deposit costs.

## B. Alternative Scenarios

The same trade-off between risk and number of banks is present when we compare welfare across scenarios. Both alternative scenarios lead to lower risk, on one side, and a higher long run number of banks, on the other, with the net welfare effect from switching across regime difficult to assess. However, simulations suggest that the alternative regimes are welfare improving in general (Figure 3 and 7). In particular, they show how the risk-based and disclosure scenarios converge to the benchmark at  $a = 0$  and  $a = 1$ , respectively, and how, as we approach the limiting cases  $R_1$  and  $D_0$  on the opposite extremes, welfare becomes unambiguously higher under the alternative regimes. We can go a step further to prove this last result more formally:

<sup>29</sup> Note that, in this case,  $n = \sqrt{\frac{t}{F}} > \frac{1}{2}\sqrt{\frac{t}{F}} = \tilde{n}$ .

**Proposition 6** *i) At an interior equilibrium ( $q < 1$ ), for sufficiently low levels of insurance coverage, welfare is higher under the public disclosure scenario than under the benchmark; ii) At an interior equilibrium, if  $R > \frac{5}{2} (Ft)^{\frac{1}{4}}$ , for sufficiently high levels of insurance coverage, welfare is higher under a risk-based deposit insurance scheme than under the benchmark.*

**Proof:** In Appendix.

First note that the condition on the second part of Proposition 6 is not particularly strong, as it is required for markets to be covered for all possible levels of coverage, in the benchmark case.<sup>30</sup> Thus, we can claim that, in general, as we approach the limiting cases  $R_1$  and  $D_0$ , both alternative regimes are welfare improving with respect to the benchmark.

Another way of interpreting the proposition is by noting that, when  $a = 0$ , all three regimes yield the same equilibrium number of firms (Figure 6). Furthermore, since public disclosure is also associated with a higher monitoring effort, it follows from the discussion of equation (23) above that for low enough values of coverage, information disclosure is welfare improving, as there are no offsetting effects arising from a change in the number of banks. However, in scenario  $R_1$  the number of banks is higher than in the benchmark. Not surprisingly, then, a risk-based scheme is welfare improving for relatively low levels of entry costs, when the losses from excessive entry are more than compensated by the reduction in risk.

### C. Financial Opening

Once entry costs  $F$  are allowed to change, a new (negative) term,  $ndF$ , which represents savings from the relaxation or removal of costly entry regulations, is added to expression (25), which now becomes

$$dW = (R - 2q) dq + \frac{t}{4n^2} dn + d(nF). \quad (31)$$

<sup>30</sup> From (1), in the benchmark scenario, the condition for market coverage is  $\frac{1}{2r} \leq \frac{n[a+(1-a)q]}{t}$ . On the other hand, from (5), we have that  $\frac{n[a+(1-a)q]}{t} = \frac{1}{[(R-r)-q]}$ , and, from (6), we know that in equilibrium  $r = R - 2q$ . Combining them, the market coverage condition may be rewritten as  $R \geq \frac{5}{2}q$ . Finally, since  $q$  is decreasing in  $a$ , the market is covered for any  $a \in [0, 1]$  if  $R \geq \frac{5}{2}q|_{a=0}$  or, using  $q|_{a=0} = (tF)^{\frac{1}{4}}$  from (10) and (12),  $R \geq \frac{5}{2} (tF)^{\frac{1}{4}}$ .

Furthermore, it is easy to show that  $d(nF) < 0$ ,<sup>31</sup> which in turn implies that the sole negative impact of financial opening comes from the first terms on the right hand side of (31), which represents the welfare effect arising from a deterioration of portfolio quality.

Thus, as we approach the limiting cases  $R_1$  and  $D_0$ , and the impact of financial opening on  $q$  vanishes, the effect of increased competition on welfare becomes unambiguously positive. That this is the case in the limit, can be seen directly from equations (22) and (23). Figure 7 further illustrates this point. The figure shows how welfare is monotonically decreasing in  $F$  for high values of insurance coverage in scenario R, and for low values of insurance coverage in scenario D. It also shows how the levels of welfare converge to those in the benchmark as the portion of the portfolio over which risk is charged declines (low  $a$  in scenario R, and high  $a$  in scenario D).

## V. FINAL REMARKS

This paper examined the impact of increased competition on banks' risk-taking behavior, under different assumptions regarding deposit insurance arrangements and disclosure of information. The paper showed how the interaction between these two factors is crucial in determining the effect of competition on bank soundness. Our benchmark scenario depicted the situation mostly encountered in the real world, namely one with limited information availability and a flat-rate explicit (or implicit) deposit insurance scheme. In this context, deposit insurance fosters price competition at the cost of inhibiting risk monitoring by banks. Further competition from new entrants facing lower entry costs has a similar effect. The discussion ignored any gains that may arise from an increase in cost efficiency of banks, which may reduce profit losses and thus the incentives to reduce risk. However, any such gains should be weighted against the likely deterioration of bank asset quality. In addition, it is realistic to assume that, while the effect on monitoring and risk is likely to be immediate, the improvement in efficiency may not materialize in the short run.

We showed that the negative link between competition and bank soundness is (partially) offset when disclosure of financial information enables market participants to charge a differentiated risk premium to individual banks. In the limit, when the whole portfolio is charged a fair insurance premium, risk becomes independent of the degree of external competition. Moreover, in those cases, disclosure is welfare superior to the private

<sup>31</sup> The free entry condition implies that, in equilibrium,  $F = \Pi$ . Substituting (7) into (3),

$$nF = n\Pi = \frac{qt}{n[a + (1-a)q]}$$

Finally, taking derivatives,

$$\frac{d(n\Pi)}{dn} = \frac{at}{n[a + (1-a)q]^2} \frac{\partial q}{\partial n} - \frac{qt}{n^2[a + (1-a)q]} < 0,$$

since, from Proposition 5,  $\frac{\partial q}{\partial n} < 0$ .

information environment. We also showed that this role can be alternatively fulfilled by an informed deposit insurance administrator that demands a risk-adjusted contribution to the deposit insurance fund.

The previous analysis may be used to illuminate two different historical experiences. Several studies of the case of the U.S. banking sector illustrate how the elimination of branching restrictions was followed by a process of rapid concentration, and how banking deregulation and increased competition from non-bank financial institutions since the early 1980s adversely affected bank profits and bank failure probability.<sup>32</sup> On the other hand, preliminary evidence from New Zealand, a case closely related to one of our alternative scenarios (zero deposit insurance combined with public disclosure of financial information) suggests that financial deregulation coupled with reliance on market discipline may improve cost efficiency as well as banks' performance.<sup>33</sup>

The equivalence result in Section 3 leaves open the question about the relative advantages of having an informed regulator with the capacity to penalize risk (as in the risk-based deposit insurance scenario) as compared to having informed uninsured consumers (the public disclosure case). Here, we suggest two ways in which the former may improve upon the latter, at least in terms of its market disciplining effect. First, the authorities may find it difficult to announce the elimination of deposit insurance in a credible way: If this is the case, the perception of implicit insurance limits the disciplining effect from informed depositors. Second, the regulator may benefit from economies of scale in the monitoring technology whereas, even when information is available, small investors may find cost-ineffective to analyze the solvency of each bank, again reducing the degree of discrimination across institutions. Finally, as was shown in Section 3, the point cannot be dismissed by choosing to have both a risk-based DIS and public disclosure, since, in this case, the resulting risk level would be strictly greater than that of the limiting cases.

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<sup>32</sup> See, e.g., Mishkin (1996), and Keeley (1990).

<sup>33</sup> On this, see Nicholl (1997). One has to bear in mind that several other factors distinguish both experiences, most importantly the fact that as a result of the financial reform, virtually all commercial banks in New Zealand are foreign-owned. Domestic banks, it seems, preferred to avoid the increasingly competitive environment.

**Proposition A1** *The pair  $(r^*, q^*)$  defined in (9) and (10) is the only symmetric local oligopoly equilibrium.*

**Proof:** Computing the second order condition at  $(r^*, q^*)$  we have:

$$\frac{\partial^2 V(q^*, r^*)}{\partial r^2} = -\frac{1}{n} < 0; \frac{\partial^2 V(q^*, r^*)}{\partial q^2} = -\frac{2}{n} < 0; \frac{\partial^2 V(q^*, r^*)}{\partial r \partial q} = -\frac{1}{n},$$

ensuring the negative semi-definiteness of the Hessian matrix. The pair  $(r^*, q^*)$  is indeed a local maximum for all banks.

To prove that it is a global maximum, notice (i) that the first order conditions with respect to  $q_i$  are independent from the strategies played by the other banks, and (ii)  $V_i(\cdot)$  is concave in  $q_i$ . (i) and (ii) imply that if no deviation satisfying the first order conditions with equality (i.e., making no restrictions on the strategy space) exists, then, *a fortiori*, no profitable deviation exists when we restrict the strategy space, imposing  $q_i \leq 1$ .

Assume that the first order conditions with respect to  $q_i$  hold with equality and substitute (8) in (5). When  $q$  is optimally chosen, the first order conditions (with respect to  $r_i$ ) for the bank's maximization reduce to

$$\frac{\partial V}{\partial r_i} = \frac{(R - r_i)}{2} \left[ \left( a + (1 - a) \frac{(R - r_i)}{2} \right) \frac{(R - r_i)}{2} - 1 \right].$$

For  $r < R$ , the function has at most two zeros. This, together with the fact that  $(r^*, q^*)$  is a local maximum, and that profits are zero at  $r = 0$ , and  $r = R$ , implies that no profitable deviations from  $(r^*, q^*)$  exist which thus is a global maximum.

In order to prove that  $(r^*, q^*)$  is the only symmetric equilibrium, first notice that since  $(r^*, q^*)$  is the only symmetrical critical point, no other interior symmetric equilibrium exists. Finally, the reader may easily check that no corner allocation other than the trivial equilibrium  $(r^*, 0)$ , and no active banks, case that we ignore in our analysis, is an equilibrium. This completes the proof.

### Proof of Proposition 1

i) Partially differentiating (10) with respect to  $a$ , and  $t$ , we have that, for  $t < n$ ,

$$\frac{\partial q^*}{\partial a} = \frac{an + 2t(1-a) - \sqrt{a^2n^2 + 4nt(1-a)}}{2(1-a)^2\sqrt{a^2n^2 + 4nt(1-a)}} < 0,$$

and

$$\frac{\partial q}{\partial t} = \frac{t}{\sqrt{a^2n^2 + 4nt(1-a)}} > 0.$$

The rest of the results follow directly from (12) and (8).

ii) Totally differentiating (12), we obtain:

$$\frac{dV}{da} = \frac{2q}{n} \left( \frac{\partial q^*}{\partial a} + \frac{\partial q^*}{\partial n} \frac{dn}{da} \right) - \frac{q^{*2}}{n^2} \frac{dn}{da} = 0, \quad (32)$$

Denoting  $q_L^*$  the long run monitoring effort, and, using (32), we have that

$$\frac{dq_L^*}{da} = \frac{\partial q^*}{\partial a} + \frac{\partial q^*}{\partial n} \frac{\partial n}{\partial a} = \frac{q^*}{n} \frac{dn}{da} < 0, \quad (33)$$

Finally, comparing the short- and long-run effects of change in  $a$ , from (33) we have that

$$\frac{\partial q_L^*}{\partial a} - \frac{\partial q^*}{\partial a} = \frac{\partial q^*}{\partial n} \frac{\partial n}{\partial a} > 0.$$

The rest of the follows directly from (8). Using the same kind of argument, the reader may easily check that  $\frac{\partial q_L^*}{\partial t} > 0$ , and that  $\frac{\partial q_L^*}{\partial t} - \frac{\partial q^*}{\partial t} < 0$ .

## Proof of Proposition 2

In the proof we assess the impact of a switch between regimes, first keeping the number of banks constant, part a), and, second letting the number of banks adjust to make the free-entry condition hold, part b).

Part a) Assume that the number of firms  $n$  is fixed. In the benchmark scenario, the local oligopoly equilibrium is characterized, in the  $(q, r)$  space, by the intersection of the curves implicitly defined by (7) and (8), curves  $C(q)$  and  $B(q)$  in Figure 1. Similarly, in the risk based scenario, an interior equilibrium ( $q < 1$ ) is characterized by the intersection of the curves implicitly defined by (7) and (15),  $C(q)$  and  $R(q)$ .

Differentiating (7) with respect to  $q$  we have that

$$\frac{\partial C(q)}{\partial q} = \frac{t(1-a)}{n[a+(1-a)q]^2} - 1 \quad (34)$$

and

$$\frac{\partial^2 C(q)}{\partial q^2} = -\frac{t(1-a)^2 q}{[a+(1-a)q]^3} < 0. \quad (35)$$

The reader may easily verify, using (8), that  $q^R > \frac{R-r}{2}$  implies that  $\frac{t(1-a)}{n[a+(1-a)q]} < q < 1$  which, together with (34), implies that  $\frac{\partial C(q)}{\partial q} \in [-1, 0]$ . In turn, the reader can easily verify that  $C(q)$  is everywhere flatter than  $B(q)$ , i.e.,

$$\frac{\partial B(q)}{\partial q} = -2 < \frac{\partial C(q)}{\partial q}$$

Hence, given that we know that  $C(q)$  is concave from (35), and that from (15), we know that  $R(q)$  lies above  $B(q)$ , we can immediately infer that its intersection with  $R(q)$  can only be southeast of  $q^*$ , at a point  $(r^R, q^R)$  such that  $r^R < r^*$ , and  $q^R > q^*$ .

Finally, it is immediate to check that, if in scenario R monitoring is complete ( $q = 1$ ), the point  $C(1)$  is southeast of  $(r^*, q^*)$  and the previous result still holds.

Part b) By construction of the contribution scheme, we know that in scenario R, at a symmetric equilibrium

$$\Pi = S((R-r)q - q^2)$$

so that, using (4), (3) and (7), we can express the free entry condition as

$$V = \frac{qt}{n^2[a+(1-a)q]} - F = 0. \quad (36)$$

The reader may easily check that (36) is increasing in  $q$ . This in turn implies that for a given number of banks, bank profits are higher under scenario R than under the benchmark, and that in the long run the number of operating banks is higher under scenario R than under the benchmark.

Differentiating (36) implicitly, and denoting as before the long-run equilibrium by a subscript L, we have:

$$\frac{\partial q_L}{\partial n} = -\frac{\frac{\partial V}{\partial n}}{\frac{\partial V}{\partial q}} = \frac{2q[a + (1-a)q]}{an} > 0.$$

Moreover, we have that

$$\frac{\partial r_L}{\partial n} = \frac{\partial r}{\partial q} \frac{\partial q}{\partial n} + \frac{\partial r}{\partial n}. \quad (37)$$

Differentiating (7) with respect to  $q$  and  $n$ , and substituting these expressions into (37) we obtain

$$\frac{\partial r_L}{\partial n} = \frac{(a + 2q - 2aq)t}{an^2(a + (1-a)q)} - \frac{2q(a + (1-a)q)}{an},$$

and, simplifying,

$$\frac{\partial r_L}{\partial n} = \frac{t}{n} - [a + (1-a)q]q - \frac{at}{2n[a + (1-a)q]}. \quad (38)$$

From equation (5), we know that, at the equilibrium,

$$\frac{t}{n} = (R - r - q)(a + (1-a)q), \quad (39a)$$

and, from (15), we know that for all  $q > q^*$ :

$$R - r^R < 2q^R.$$

This, together with (39a), implies that

$$\frac{t}{n} < (a + (1-a)q^R)q^R$$

and, substituting into (38), that  $\frac{\partial r_L}{\partial n} < 0$ .

### Proof of Remark 1

Solving (15) in term or  $r$ , and equating it to (7), we obtain:

$$\frac{R - 2q^R}{(1-a)} - R + q^R + \frac{t}{n[a + (1-a)q^R]} = 0,$$

from which, differentiating implicitly, we can compute:

$$\frac{\partial q^R}{\partial a} = \frac{\frac{(R-2q^R)}{(1-a)^2} - \frac{t}{n} \frac{1-q}{[a+(1-a)q^R]^2}}{\frac{2}{1-a} - 1 + \frac{t}{n} \frac{(1-a)}{[a+(1-a)q^R]^2}}$$

Since the denominator is always positive, the sign of the expression is the sign of the numerator. Recalling that, from (20),  $R > 2q^R$ , the reader may easily check that the numerator is positive for values of  $a$  sufficiently close to unity

### Proof of Proposition 3

Along the lines of the proof of Proposition 2, using the fact that bank profits can again be expressed as in (36).

### Proof of Remark 2

i) After imposing symmetry and rational expectations, from the first order condition with respect to  $r$  we have that equation (7), should still hold at equilibrium, while from the first order condition with respect to  $q$  we now have:

$$\frac{R - (1-a)r - 2q}{n} + \frac{qr(1-a)(R-r-q)}{t} = 0. \quad (40)$$

Comparing with (14) and (19), it is immediate to check that (40) introduces a new, positive term, equal to  $\frac{qr}{n}$  in the first case, and to  $\frac{qr(1-a)(R-r-q)}{t}$ , in the second. It follows that, for any given  $r$ , and  $a \in ]0, 1[$ ,  $q^n(r) > \max \{q^R(r), q^D(r)\}$ , where the superscript  $n$  denotes the new combined scenario. Finally,  $q^n(r^n) > \max \{q^R(r^R), q^D(r^D)\}$  follows directly from the application of the steps of the proof of Proposition 2.

ii) Equation (40) can be rearranged to obtain

$$\frac{R - 2q}{n} + r(1-a) \left[ \frac{(R-r-q)q}{t} - \frac{1}{n} \right] = 0. \quad (41)$$

In turn, from (7),

$$\frac{(R-r-q)q}{t} = \frac{q}{n[a+(1-a)q]},$$

and, replacing into (41) and simplifying,

$$\frac{R - 2q}{n} - \frac{r(1-a)}{n} \left[ \frac{(1-q)a}{[a + (1-a)q]} \right] = 0,$$

where the second left-hand side term is positive. Hence,  $\frac{R-2q^n}{n} > 0$ , and  $q^n < q^{R_1} = q^{D_0} = \frac{R}{2}$ .

### Proof of Proposition 5

First note that, since  $F$  does not appear in the first order conditions of the problem,  $q$  and  $r$  remain unchanged in the short run, while they are affected by new entry in the long run. Therefore, the long run impact of a drop in  $F$  coincides with that of an increase in  $n$ , and thus can be assessed simply by conducting comparative statics of the short run solutions with respect to the number of firms.

i) The equilibrium in the benchmark scenario can be characterize as the intersection of curves  $B(q)$  and  $C(q)$ , determined by equations (8) and (7). An increase in the number of banks,  $n$ , shifts  $C(q)$  outwards, without affecting  $B(q)$ . This implies that an increase in  $n$  moves the equilibrium along downward sloped  $B$ , from which  $\frac{\partial q^R}{\partial n} > 0$ ,  $\frac{\partial r^R}{\partial n} < 0$ .

ii) The equilibrium in scenario R can be characterize as the intersection of curves  $R(q)$  and  $C(q)$ , determined by equations (15) and (7). Since  $R(q)$  is downward sloped and does not depend on  $n$ , the same argument of point i) applies to obtain  $\frac{\partial q^R}{\partial n} > 0$ ,  $\frac{\partial r^R}{\partial n} < 0$ .

iii) The equilibrium in scenario R can be characterize as the intersection of curves  $D(q)$  and  $C(q)$ , determined by equations (20) and (7). Unlike the two previous cases, curve  $D(q)$  now shifts outward as  $n$  increases.

First note that, from (19), we know that

$$\frac{nr(R-r-q)(1-a)}{t} = 1 - \frac{(R-r-q)}{q} < 1.$$

Then

$$\frac{n(r-q)(1-a)(R-r-q)}{t} < 1,$$

which implies that

$$\frac{\partial D(q)}{\partial q} = -\frac{\frac{2}{n} - \frac{r(1-a)(R-r-2q)}{t}}{\frac{1}{n} - \frac{q(1-a)(R-2r-q)}{t}} < -1.$$

Combining this result with Proposition 3, we have that  $\frac{\partial D(q)}{\partial q} < \frac{\partial C(q)}{\partial q} \in [-1, 0]$ .

Next, define

$$\Delta r(q) \equiv D(q) - C(q)$$

Note that, since  $D(q)$  is steeper than  $C(q)$ , we know that

$$\frac{\partial \Delta r(q_0^R)}{\partial q} < 0. \quad (42)$$

On the other hand, we know that in equilibrium, it has to be the case that  $\Delta r(q^R) = 0$ . Suppose we start at an equilibrium  $q_0^R$ . Then, if

$$\frac{\partial D(q_0^R)}{\partial n} < \frac{\partial C(q_0^R)}{\partial n} \quad (43)$$

we have that  $\frac{\partial \Delta r(q_0^R)}{\partial n} < 0$ , that is, an increase in the number of firms turns  $\Delta_r(q_0^R)$  negative. This together with (42) in turn implies that, if condition (43) is satisfied, the new equilibrium  $q_1^R$  can only be to the right of the old one, i.e.  $q_1^R < q_0^R < 0$ , so that  $\Delta_r(q_1^R) = 0$ .

To complete the proof, it is thus sufficient to show that (43) is always verified. Differentiating (7), and using (20),

$$\frac{\partial C(q)}{\partial n} = \frac{t}{n^2 [a + (1-a)q^*]} = \frac{R-r-q}{n}.$$

In turn, differentiating (20), and simplifying, we have that

$$\frac{\partial D(q)}{\partial n} = \frac{-\frac{R-r-2q}{n^2}}{\frac{1}{n} - \frac{q(1-a)(R-2r-q)}{t}} < \frac{-\frac{R-r-2q}{n^2}}{\frac{q(1-a)r}{t}},$$

and from (20),

$$\frac{-\frac{R-r-2q}{n^2}}{\frac{q(1-a)r}{t}} = \frac{R-r-q}{n}.$$

so that (43) is always verified.

### Proof of Proposition 6

We prove i), and ii), for  $a = 0$ , and  $a = 1$ , respectively. By continuity, the results hold for values of  $a$  sufficiently close to 0, and 1.

i) Substituting (23) into (24), it is easy to verify that welfare in scenario  $D_0$  may be written as

$$W_{D_0} = \frac{R^2}{4} - \frac{5}{4}\sqrt{Ft}.$$

Similarly, using (5) and (6), and setting  $a = 0$ , welfare in the benchmark scenario can be expressed as

$$W_{B_0} = R(Ft)^{\frac{1}{4}} - \frac{9}{4}\sqrt{Ft},$$

from which

$$\Delta W_0 \equiv W_{D_0} - W_{B_0} = \frac{R^2}{4} - R(Ft)^{\frac{1}{4}} + \sqrt{Ft} = \left(\frac{R}{2} - \sqrt{Ft}\right)^2 > 0.$$

ii) The reader can check that, for  $a = 1$ , in the benchmark,  $q = (tF)^{1/3}$  and, in turn,  $\frac{t}{n} = (tF)^{1/3}$ . Replacing into (24), we can then compute

$$W_{B_1} = \left(R - \frac{1}{4} - 2(Ft)^{\frac{1}{3}}\right)(Ft)^{\frac{1}{3}}.$$

Similarly, using (22), we obtain

$$W_{R_1} = \frac{R^2}{4} - \frac{(1 + 2R)\sqrt{Ft}}{2\sqrt{2R}},$$

and, combining both equations,

$$\Delta W_1 \equiv W_{R_1} - W_{B_1} = \frac{R^2}{4} - \frac{(1 + 2R)\sqrt{Ft}}{2\sqrt{2R}} - \left(R - \frac{1}{4} - 2(Ft)^{\frac{1}{3}}\right)(Ft)^{\frac{1}{3}}. \quad (44)$$

Taking derivatives and simplifying,

$$\frac{\partial \Delta W_1}{\partial R} = \frac{1}{4} \left[ 2R - 4(Ft)^{\frac{1}{3}} - \frac{\sqrt{2Ft}}{\sqrt{R}} + \frac{\sqrt{Ft}}{\sqrt{2R^{\frac{3}{2}}}} \right]. \quad (45)$$

It is easy to check that

$$R \geq \frac{5}{2}(tF)^{\frac{1}{4}} \implies \frac{\partial \Delta W_1}{\partial R} > \frac{1}{4} \left[ (Ft)^{\frac{1}{4}} - \frac{2\sqrt{Ft}}{\sqrt{5(Ft)^{\frac{1}{4}}}} \right] > 0.$$

Therefore, the difference in welfare is increasing in  $R$ . To complete the proof, it suffices to show that  $\Delta W_1 > 0$ , for  $R \geq \frac{5}{2}(tF)^{\frac{1}{4}}$ . But this condition, combined with the fact that an

interior equilibrium in scenario  $R_1$  requires that  $q = \frac{R}{2} < 1$ , implies in turn that  $Ft < (\frac{4}{5})^4$ . Next, substituting  $R = \frac{5}{2} (Ft)^{\frac{1}{4}}$  into (45), and denoting the new resulting equation  $\Phi(Ft)$ , we have that

$$\Phi(Ft) = \left(\frac{5}{2}\right)^2 \sqrt{Ft} + \left(1 + 8 (Ft)^{\frac{1}{3}} - 10 (Ft)^{\frac{1}{4}}\right) (Ft)^{\frac{1}{3}} - \frac{2 \left[1 + 5 (Ft)^{\frac{1}{4}}\right]}{\sqrt{5}} Ft^{\frac{3}{8}}, \quad (46)$$

Plotting  $\Phi(Ft)$ , it is immediate to check that the expression is positive for  $Ft < (\frac{4}{5})^4$ .

Figure 3. Welfare and DIS Coverage

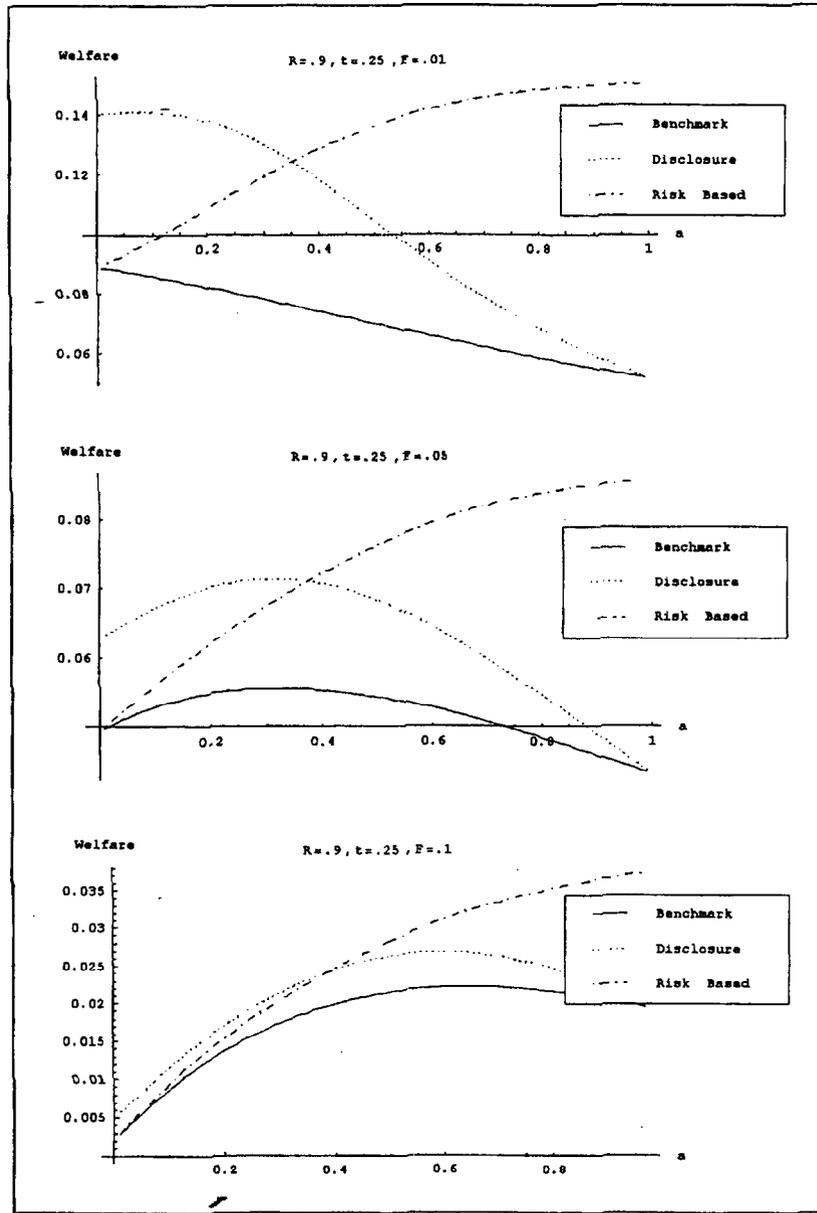


Figure 4. Monitoring and DIS Coverage

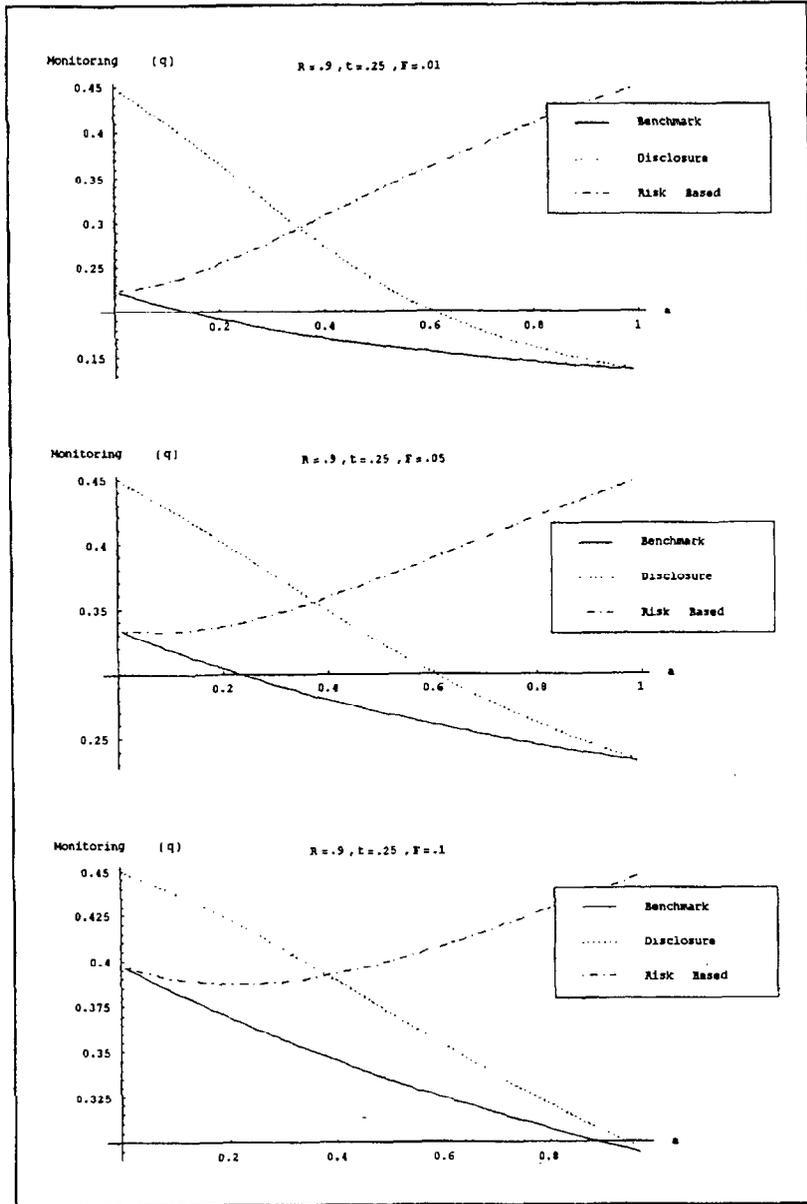


Figure 5. Deposit Rates and DIS Coverage

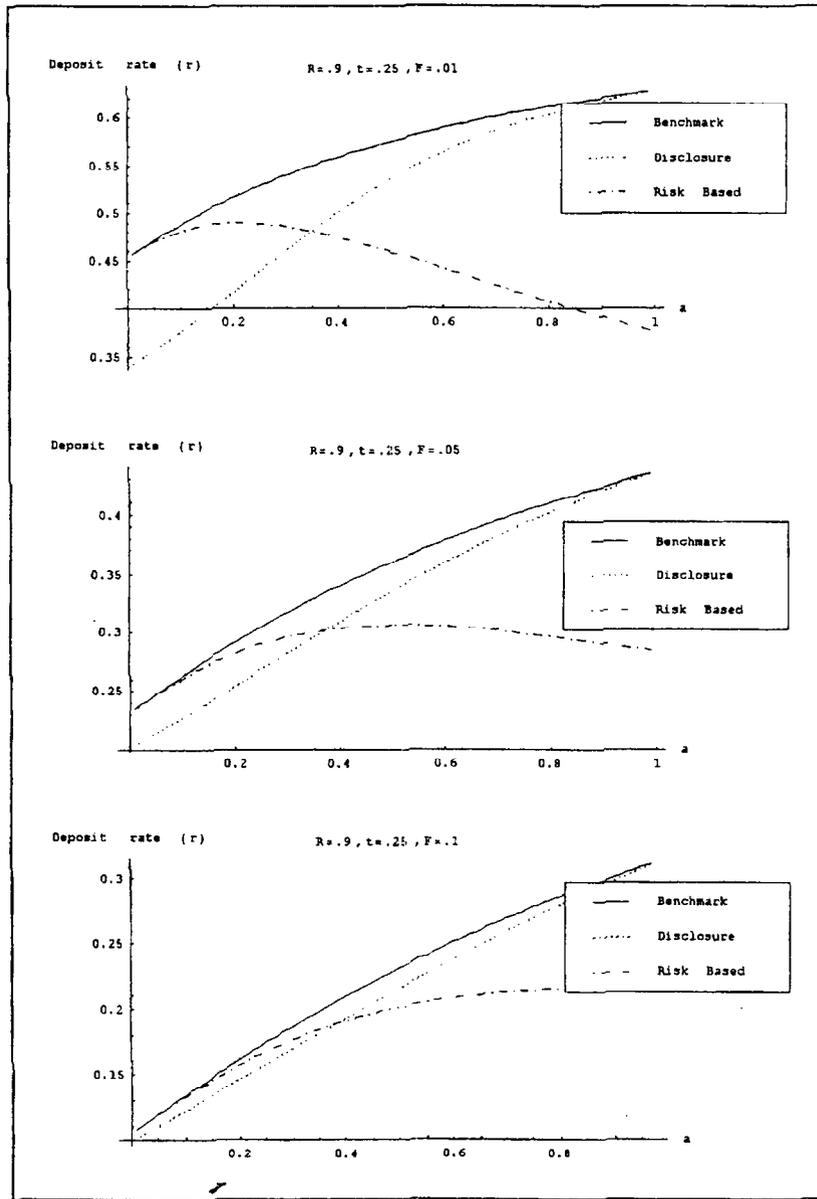


Figure 6. Number of Banks and DIS Coverage

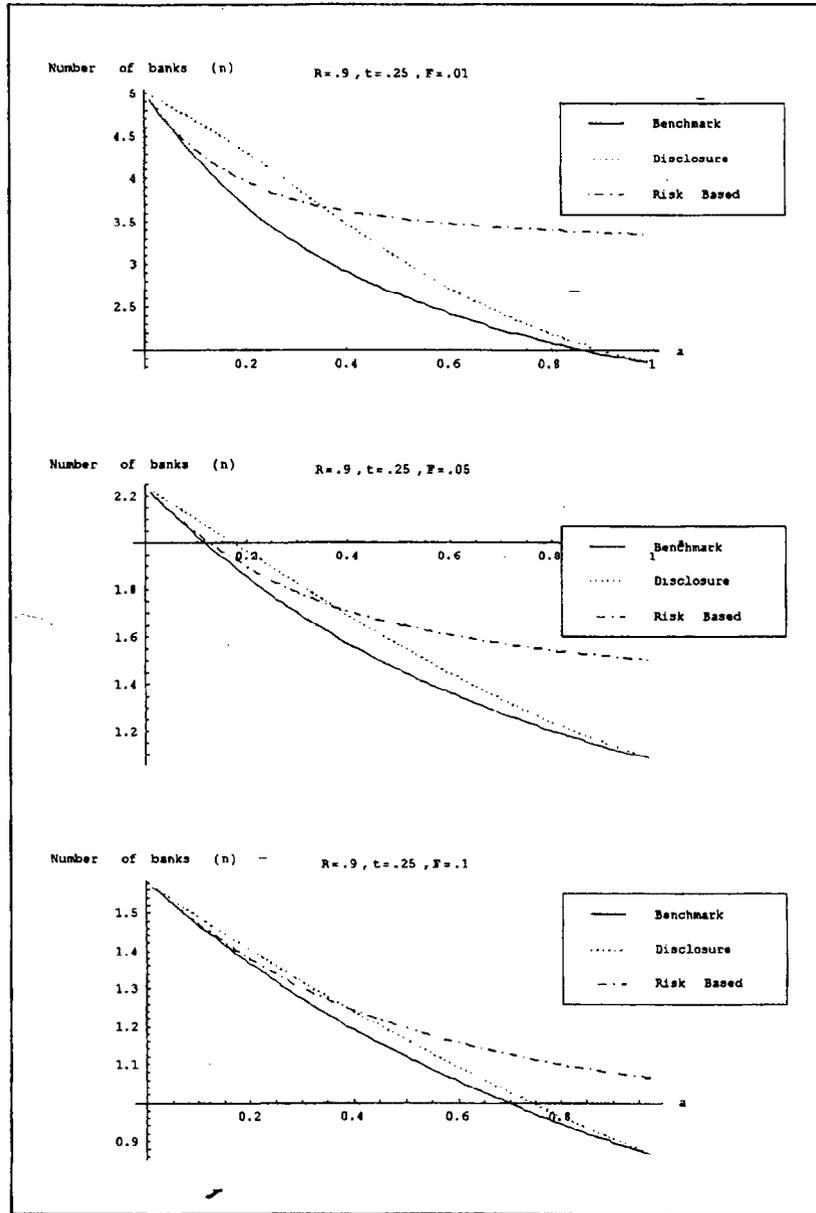


Figure 7. Welfare and Financial Liberalization

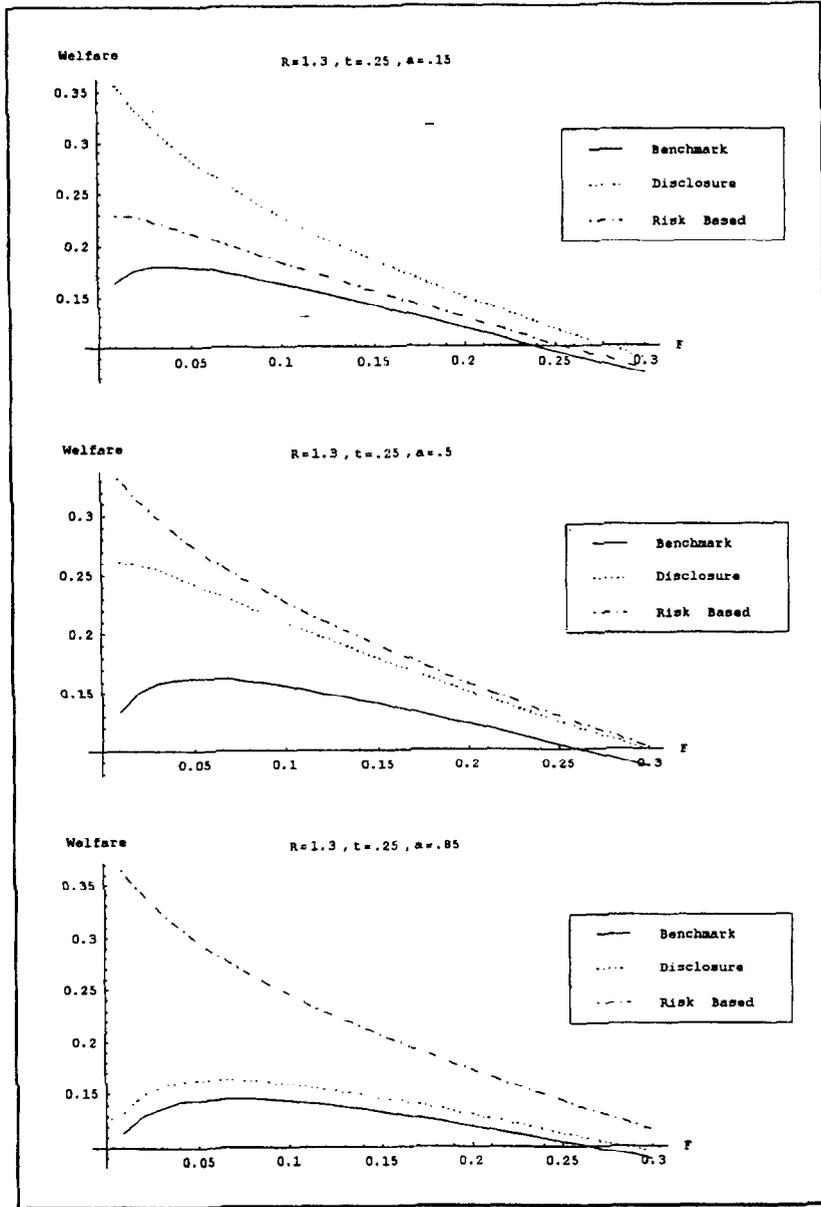


Figure 8. Monitoring and Financial Liberalization

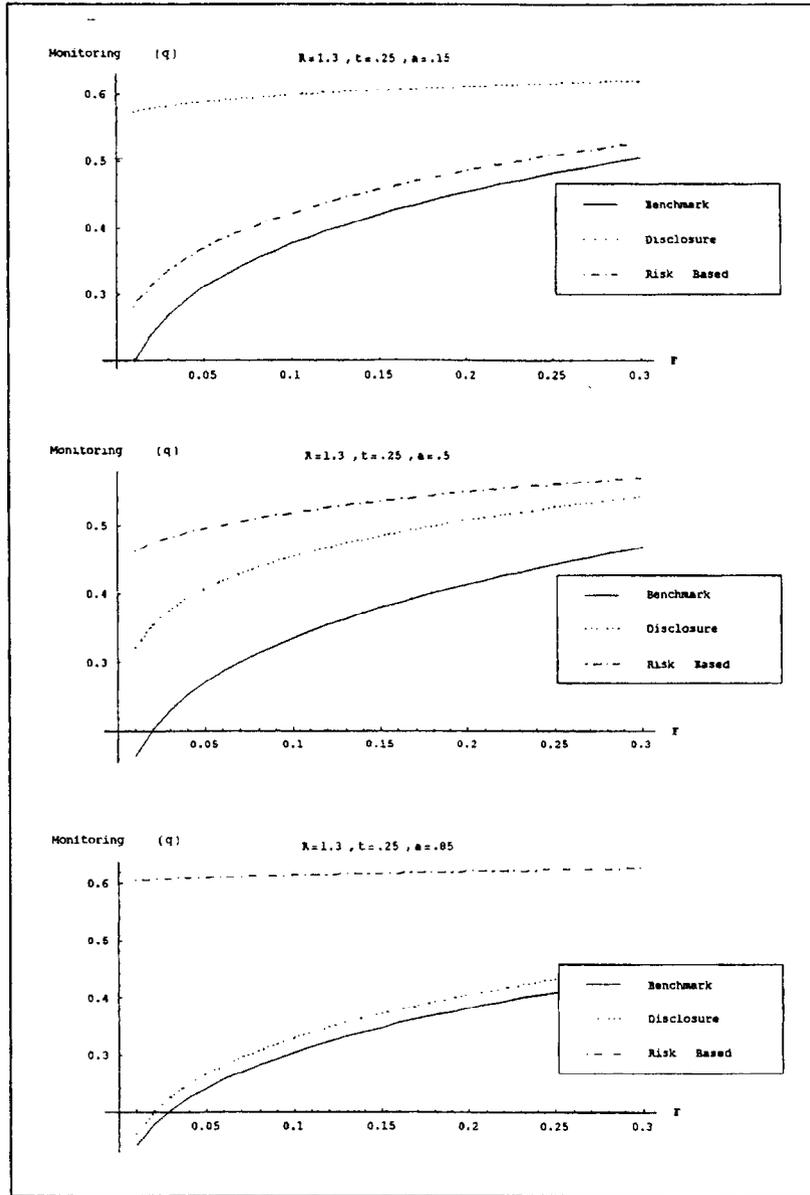


Figure 9. Deposit Rates and Financial Liberalization

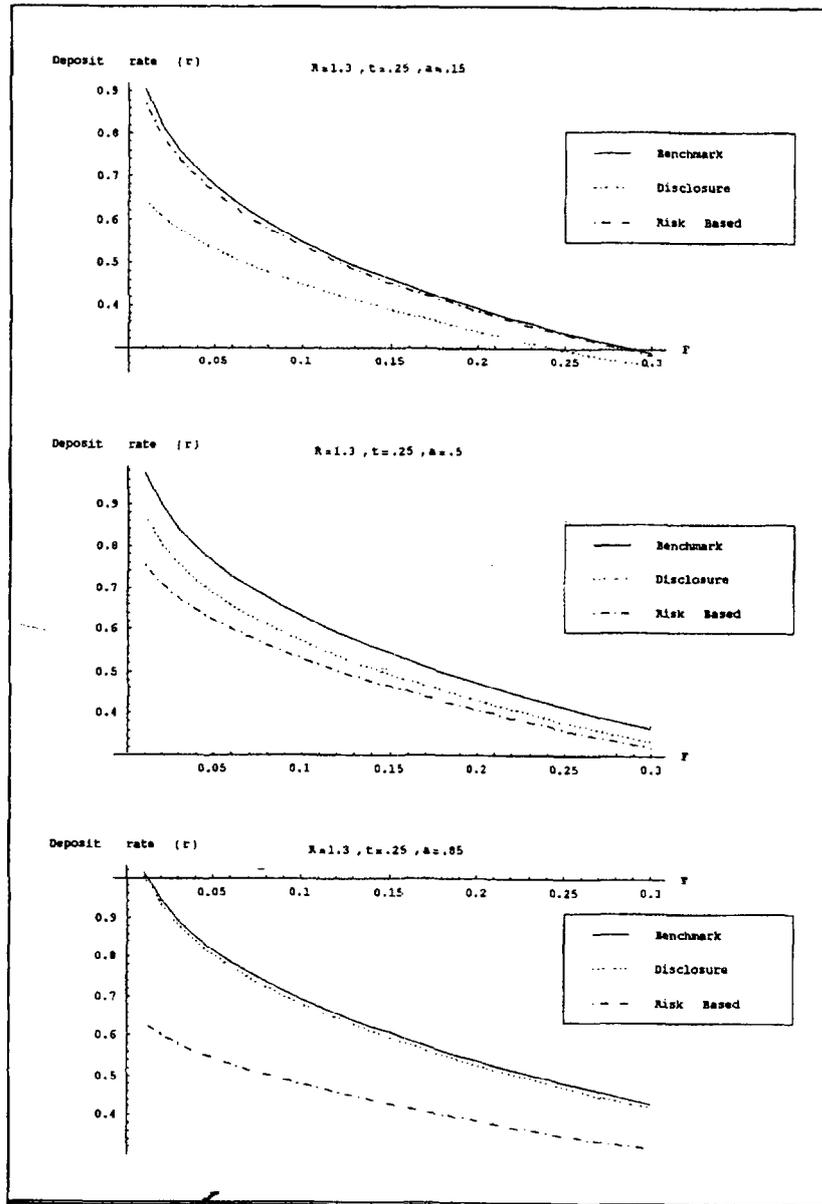
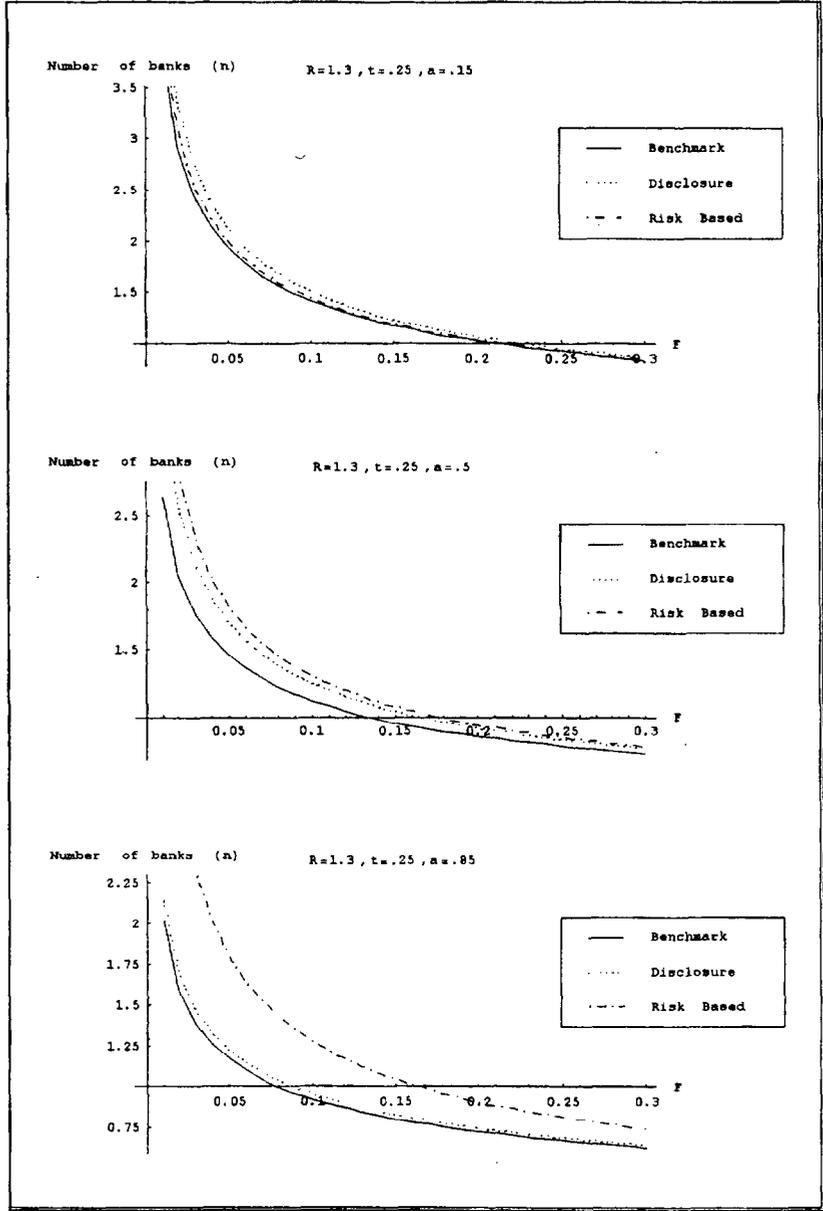


Figure 10. Number of Banks and Financial Liberalization



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