JOURNAL OF FINANCIAL INTERMEDIATION **5,** 184–216 (1996)
ARTICLE NO. 0010

Competition for Deposits, Fragility, and Insurance

CARMEN MATUTES AND XAVIER VIVES*

Institut d'Anàlisi Econòmica (CSIC), Campus UAB, 08193 Bellaterra, Barcelona, Spain

Received July 27, 1995

In the presence of economies of scale, depositors' expectations are shown to give rise to vertical differentiation and to yield multiple market equilibria, some of which exhibit institutional or systemic collapse. This fragility is due to a coordination problem among depositors and not to bank competition. Nevertheless, failure perceptions do influence rivalry which in turn affects the failure probability in particular equilibria. Deposit insurance improves welfare by preventing collapse, extending the market, and minimizing frictions. However, deposit insurance also may induce fiercer competition for deposits and increase the deadweight losses associated with failing institutions. The welfare impact of deposit insurance is shown to depend on market structure, and is thus ambiguous even in a world of full liability and no moral hazard in bank investments. *Journal of Economic Literature* Classification Numbers: G21, G28. © 1996 Academic Press, Inc.

1. INTRODUCTION

Episodes of widespread failures and runs recur in the history of banking, having influenced heavily successive regulation. In this context, competition for depositors has traditionally been considered a source of instability and excessive risk taking (see Sprague (1910) and Friedman and Schwartz (1965)). Regulatory measures, including interest rate regulation, the lender of last resort, and deposit insurance, have been viewed as attenuating these

* A first version of this paper was circulated in 1991 under the title "Competition for Deposits, Risk of Failure, and Regulation in Banking." We are grateful to Sudipto Battacharya, Patrick Bolton, Ramon Caminal, Pierre-André Chiappori, Hans Degryse, Jean Dermine, Mathias Dewatripont, Kai-Uwe Kühn, Paul Klemperer, Jorge Padilla, Jean-Charles Rochet, and József Sákovics for helpful comments. We are also thankful to the referees and an editor of this journal for their suggestions. Lluís Bru has provided excellent research assistance. The research reported in this paper has been supported by the Fundación Banco Bilbao Vizcaya. Further partial support has been provided by the Spanish Ministry of Education through CICYT Grant PB 93-0679.

1042-9573/96 $18.00

problems (see Baltensperger and Dermine (1987) and Vives (1991)). In the United States, the introduction of the Federal Reserve System in 1914 and deposit insurance in 1934 have provided stability.[1] However, subsequent to deregulation in the 1980s, there has been a substantial increase in bank failures, including the thrift debacle, straining the safety net, and triggering a debate over banking regulation.[2]

We investigate the relationship between banking competition, instability, and failures. We also assess the welfare tradeoffs of establishing deposit insurance. The understanding of the mutual influence of depositors' expectations and rivalry between banks is crucial from both the positive and normative perspectives. From the positive side, it helps to comprehend the contribution of competition to fragility and failure probabilities. From the normative side, it helps to understand the effects of policy interventions such as deposit insurance. We investigate how the impact of deposit insurance depends on market structure, and the extent to which insurance may change market structure.

Our starting point is Diamond's (1984) intermediation theory. We develop a model of banking competition that includes elements of product differentiation and network externalities. This extends recent financial intermediation theory to imperfect competition. We depart from the Diamond model in that we assume that banks cannot fully diversify their portfolios, with the consequence that they bear some risk and can fail. We abstract from limited liability issues.[3] Banks bear the full cost of bankruptcy, and incentives are provided by the existence of nonpecuniary penalties as in Diamond (1984).[4] In this way we can focus on the role played by expectations about failure probabilities in the presence of scale economies (minimum size investments and/or diversification economies). The result of modeling, as in Diamond and Dybvig (1983), will be that banks are subject to confidence crises.[5]

[1] Regulation (contained in the McFadden Act of 1927 and in the Banking Act of 1933 (Glass-Steagall)) prevented bank runs, and limited the number of bank failures between 1940 and 1980. In this period, only 299 insured commercial banks failed, mostly as a result of fraud, as opposed to 9,106 between 1930 and 1933 (Jaffee, 1989). Boyd and Runkle (1993) report much higher failure rates for the period 1981–1991.

[2] The Federal Savings and Loans Insurance Corporation (FSLIC) created in 1934 became insolvent, once the crisis affected commercial banks as well. Between 1985 and 1988 almost twice as many banks (698) as S&L (357) closed because of financial difficulties (Jaffee, 1989). See Boot and Greenbaum (1991) for a summary of reform proposals.

[3] For an analysis of the choice of asset risk and the moral hazard problem associated with taking too much risk under limited liability, see Gennottee and Pyle (1990), Gennotte (1990), Besanko and Thakor (1993a), and Matutes and Vives (1995).

[4] Alternatively, incentives could be provided by monitoring as in Townsend (1979) or Gale and Hellwig (1985).

[5] Apart from the leading contributions of Diamond and Dybvig (1983) and Bryant (1980) to the bank runs/confidence crisis literature, see also Postlewaite and Vives (1987), Jacklin and Bhattacharya (1988), and Aghion *et al.* (1988).

We start by examining free (unregulated) banking competition in a context where banks can fail and then examine the implications of deposit insurance. The analysis shows that the quality of a bank (its probability of success) is endogenously determined by depositors' expectations which create a vertically differentiated structure and may result in multiple equilibria.[6] Possible equilibria include corner or "natural monopoly" equilibria where one bank is out of the market, and even no banking ("systemic confidence crisis"). Quality is endogenous, yet it is fragile because of the self-fulfilling character of expectations. Different possible depositors' expectations become self-fulfilling: a bank perceived to be safer commands a higher margin and market share which makes the bank actually safer because of better diversification.[7] In fact, a bank can be understood as a network: a larger bank with more depositors will be better diversified and will have a lower probability of failure (higher quality). Our model can be understood also as an extension of the standard network externalities model to a situation where margins, as well as market share, influence quality (probability of success).[8]

The multiplicity of equilibria is due to the coordination problem arising from the fact that alternative sets of expectations become self-fulfilling due to scale economies. The problem is not competition; a monopoly bank could suffer from instability. This is consistent with Diamond and Dybvig (1983), although in our case instead of runs we have no-banking equilibria. Our results also are consistent with Yanelle (1989, 1995) who studies endogenous financial intermediation with double-sided competition and finds multiple equilibria in different extensive-form multistage games. Likewise, Winton (1994) finds coordination problems in a dynamic framework where industry structure results from interaction between banking competition, beliefs, and regulation. Finally, Gale (1993) addresses the fragility issue from the asset side instead of the deposit side. In his model, the screening function of banks with limited informational capacity and in the presence of friction leads to multiple equilibria including financial collapse (a coordination failure) and positive lending equilibria.

In our model the degree of rivalry (which decreases with differentiation)

[6] See Gabszewicz and Thisse (1979) and Shaked and Sutton (1983) for an analysis of vertical differentiation. Gehrig (1993) also has studied vertical differentiation aspects of intermediated markets in the presence of search costs for trading partners.

[7] Ideally, the concept of fragility should describe how the economy can move from one equilibrium to another. However, this concept of fragility cannot be developed in a static framework. Instead, in the paper we interpret banking fragility as the coexistence of alternative sets of self-fulfilling expectations, which in turn yield various types of equilibria. Further research should explore this issue in a dynamic setting. For an analysis of the stability of different equilibria in a banking model, see Gale (1993).

[8] See Katz and Shapiro (1985) and Farrell and Saloner (1985, 1989) for examples of network externalities models and Dybvig and Spatt (1983) for an early adoption externalities model.

influences the probability of failure associated with a particular equilibrium. Indeed, in a symmetric interior equilibrium the probability of failure is increasing with the degree of rivalry. Conversely, failure perceptions influence rivalry: a safer bank will command a higher margin and market share, and in a symmetric equilibrium the possibility of failure weakens competition.

Deposit insurance prevents systemic confidence crises, minimizes frictions (transport costs), and tends to extend the market by increasing the incentive to deposit, given interest rates. On the other hand, by ensuring that all banks are active, it may preclude the realization of desirable diversification economies. Finally, deposit insurance may induce heightened competition since depositors will not "discount" the rates offered by banks. This has a direct negative effect, since failure probabilities increase with the deposit interest rates offered. However, insurance may have the positive impact of extending the market. As a result of this, deposit insurance has the potential for changing the market structure from one where banks have local monopoly power to one where they compete. Furthermore, we will see that the way the welfare tradeoffs associated with deposit insurance are resolved will depend on the market structure. Thus, the welfare effects of deposit insurance are ambiguous (cannot be assessed independently of the market structure) even when moral hazard in bank investments—the commonly considered distortion associated with governmental deposit insurance—is absent.

Section 2 introduces the model. Section 3 examines banking rivalry for given perceptions of depositors. Section 4 characterizes the equilibria of the model. Section 5 examines equilibria with deposit insurance and welfare implications. Concluding remarks are in Section 6.

2. THE MODEL

Two risk neutral banks raise money from depositors and invest the proceeds in loans to firms.[9] Depositors cannot invest directly in firms' projects. In this sense, we take the need of financial intermediation for granted.

The features of the model are as follows:

i. Horizontal differentiation. This is introduced via a standard Hotelling model. Depositors are uniformly distributed on a unit segment [0, 1]. There are two banks: bank a is located at 0 and bank b is located at 1.

[9] For an analysis of entry in a spatial context similar to the one developed here, see Gehrig (1992). See also Besanko and Thakor (1996).

Potential depositors are risk neutral, have an inelastic supply of one unit of funds with a reservation value v (the return of a risk-free outside opportunity), and face linear transport costs at rate $t \geq 0$. They have to decide whether to deposit in a bank or not, and in the former case in what bank to deposit.

The "transport costs" need not be interpreted as the cost of time spent "traveling" to the bank. Banks could be differentiated because they provide different combinations of services valued by depositors such as ATM network sizes, consumer credit facilities, availability in foreign countries, etc. We take this level of differentiation as exogenously given to focus on the role of failure perceptions on competition for deposits. Then, comparative static exercises on transportation costs allow us to explore the impact of changes in the degree of differentiation. For example, an increase in t could be associated with an increase in the diversity of the services provided by various banks.

ii. Incentive contracts and price competition. Depositors do not observe the returns of the bank. Bank i offers a fixed (gross) deposit interest rate r_i to its consumers according to a standard debt contract with nonpecuniary bankruptcy penalties as in Diamond (1984). If the bank fails (that is, the revenue obtained by the banks does not cover the face value of debt) it declares bankruptcy. In this case we make the simplifying assumption that depositors do not receive anything and that the funds left are frozen by the government.[10] The bank suffers an endogenous nonpecuniary penalty so that its utility is the same as in the case in which it had to pay the posted rate. If bank i quotes a rate r_i per depositor and intends to pay z, it suffers a nonpecuniary penalty $\delta(z) = \max(r_i - z, 0)$.

iii. Investment. Bank i can invest the proceeds of its deposits in entrepreneurial projects or in cash assets. Let n_i represent the deposit market share (and the total funds at the disposal) of bank i. Denote by $\tilde{R}_i$ the (random) return of a unit of funds invested by bank i when the bank invests n_i. It is assumed that $E\tilde{R}_i = R$, where $R > v$ is a positive constant (independent of n_i). $\tilde{R}_i$ is distributed according to a distribution function $F(\cdot; n_i)$ which is of class C^2 (on both arguments). Notice that to grant a reasonable economic interpretation we should impose the constraint that $\tilde{R}_i \geq 0$. The bank can also invest in cash assets with return v. Bank i, investing n_i, declares bankruptcy when revenues cannot cover payment obligations: $\tilde{R}_i < r_i$.

Assuming the bank invests all its funds in risky assets, and given the

[10] Alternatively, we could suppose that the bank keeps the income it has obtained and suffers a larger endogenous nonpecuniary penalty (r_i per unit deposited whenever the bank fails and 0 otherwise) which leaves it again indifferent with respect to the case where it had to pay the posted rate.

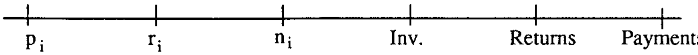

FIG. 1. Time line.

standard debt contract, the expected profits of bank i can be written $\pi_i = (R - r_i)n_i$. This follows since expected revenue equals $E\{\tilde{R}_i n_i\}$, with $E\tilde{R}_i = R$, and expected deposit costs equal $n_i r_i$, given the bankruptcy penalty. Given our assumptions, the bank always invests all deposit proceeds in risky loans.

iv. Diversification and size. A bank needs a minimum size to be viable whenever an investment project needs the funds of a (small but positive) proportion of total funds, s, to be financed. A bank needs then to attract at least a market share of s. Otherwise the bank cannot invest and it is not viable. For simplicity, we adopt the convention that in the presence of minimum size investments bank i setting rate $r_i \leq R$ fails with probability 1 only if $n_i = 0$. Given r_i, the probability of failure of bank i is given by $F(r_i;\, n_i)$ (with $F(r_i;\, 0) = 1$ given a minimum size requirement). It is reasonable to suppose that a bank by investing more can diversify away some of the risk it faces. We say that diversification economies exist when a smaller market size results in a mean-preserving spread of the distribution, that is, when smaller values of n_i are associated with mean-preserving spreads of the distribution of returns F.[11]

v. The extensive form we consider is as follows (see Fig. 1). Depositors are endowed with homogeneous prior beliefs $(p_{\mathrm{a}}, p_{\mathrm{b}})$ about the probabilities of success of banks. Banks, knowing these beliefs, set deposit rates. In turn, depositors, upon observing the rates offered, choose which bank to patronize. Consumers deposit in the bank offering the higher expected return net of transportation costs, provided this is larger than v. Given assessed probabilities of success p_{a} and p_{b}, the market share of bank i is given by $n_i = \frac{1}{2} + (p_i r_i - p_j r_j)/2t$, $j \neq i$, provided $p_i r_i - p_j r_j$ is in the interval $[-t, t]$ and $p_i r_i - t n_i \geq v$, $i =$ a,b. If $p_i r_i - p_j r_j$ is in the interval $[-t, t]$ but $p_i r_i - t n_i < v$, then some depositors do not deposit and banks do not compete directly with one another but have local monopolies. If $p_i r_i - p_j r_j$ is not in the interval $[-t, t]$, then all consumers prefer the bank with higher expected return and the other bank is left out of the market. Banks invest the funds they receive, collect the returns, and, except in case of failure, make deposit payments. In equilibrium, depositors' expectations

[11] Although econometric studies find that economies of scale in banking are exhausted at relatively small sizes, recent work by Boyd and Runkle (1993) finds an inverse relationship between size and the volatility of asset returns.

are fulfilled, that is, $p_i = 1 - F(r_i^*; n_i^*)$ where r_i^* and n_i^* denote equilibrium magnitudes. The model therefore has a rational expectations flavor.[12] An alternative framework, in which banks can influence the expectations of depositors with their choice of deposit interest rates yields similar insights with a less tractable model.[13]

An example satisfying our assumptions is one where $\tilde{R}_i$ follows a symmetric beta distribution. Let $\tilde{R}_i = R + \frac{1}{2} - \tilde{X}_i$, where $\tilde{X}_i$ follows a beta distribution on the interval [0, 1] with parameters $[1 + n_i/k, 1 + n_i/k]$.[14] We have then that the support of $\tilde{R}_i$ is $[R - \frac{1}{2}, R + \frac{1}{2}]$, $E[\tilde{R}] = R$, and $\mathrm{Var}[\tilde{R}_i] = 1/(12 + 8(n_i/k))$. A smaller n_i/k represents a mean-preserving spread of the distribution of returns. Another example we will use has $\tilde{R}_i$ distributed log-normally with mean R and variance k/n_i.

In the next section we examine competition among banks for given fixed perceptions. In Section 4 we close the model by endogenizing perceptions and consider the equilibria of the game.

3. BANK COMPETITION WITH DEPOSITORS' PERCEPTIONS FIXED

In this section we consider fixed perceptions (p_a, p_b) of depositors and examine possible outcomes of deposit interest rate competition among banks. Consider first the case where r_b is such that $p_b r_b + t \geq p_a R \geq p_b r_b - t$. The first inequality ensures that bank a cannot profitably set a rate that drives b out of the market (since to do so would require a rate above R). Likewise, the second inequality ensures that bank a can capture some deposits with a rate below R. For the range of r_b satisfying both inequalities, the optimum response by bank a is similar to the typical Hotelling model. That is, $r_a = B_a(r_b) \equiv (p_a R - t + p_b r_b)/2p_a)$. The higher

[12] The equilibria of our model can be understood also as perfect Bayesian equilibria (PBE) of a game with Bayesian depositors having (degenerate) point prior beliefs $({}^e p_a, {}^e p_b)$ which are constant out of the equilibrium path (and fulfilled in equilibrium, obviously). If depositors expect (equilibrium) rates r^* to obtain and banks set those rates then at a PBE necessarily the point initial expectations are confirmed. Otherwise, if banks set different rates (which is a zero probability event), Bayesian consistency does not impose any restriction on the updating of beliefs. Our model would call then for depositors not to modify their initial beliefs. Two requirements must be fulfilled at a PBE: (i) beliefs must be consistent, that is $({}^e p_a, {}^e p_b)$ must equal the true probabilities of success, and (ii) banks must maximize expected profits taking into accont the updating rule followed by depositors.

[13] See the discussion in Section 4 and Appendix II.

[14] Beta[1, 1] is just an uniform density on [0, 1]; Beta[a, b] is symmetric iff a = b.

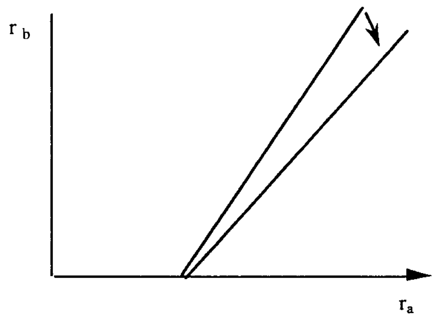

FIG. 2. Effect of increase of p_b on $B_a(r_b)$.

p_b, the larger the deposit interest rate set by firm a (see Fig. 2). This is because the higher p_b, the lower a's market share becomes for a given r_a and hence it is not as costly to attract an additional customer (the increase in r_a must be paid to a smaller customer base). Instead, an increase in p_a has an ambiguous impact; on one hand, a slight increase in r_a attracts a larger number of new customers the larger p_a is and thus a higher p_a provides bank a with an incentive to offer a larger deposit interest rate. On the other hand, a larger p_a means that, for any given r_a, bank a enjoys a larger market share and hence increasing r_a becomes more costly; that is, bank a becomes a "fat-cat" in the terminology of Fudenberg and Tirole (1984) (see Fig. 3). If $p_a = p_b = p$, and given a market of fixed size, the market share fat-cat effect vanishes, and increasing p makes banks more aggressive.

The following proposition gives the equilibria of our modified (because of failure probabilities) Hotelling game according to different regions of

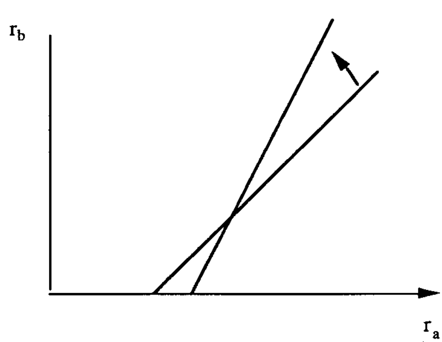

FIG. 3. Effect of increase of p_a on $B_a(r_b)$.

parameters (see Appendix I for a complete statement and proof of Proposition 1).

PROPOSITION 1. *Given* $p_a \geq p_b \geq 0$:

I. *When* $p_iR < v$, $i = \text{a, b}$, *there is no active banking.*

II. *When* $p_bR < v$ *and* $p_aR > v$, *bank* a *is a natural monopoly* (*with blockaded entry*).

III. *When* $p_iR \geq v$, $i = \text{a, b}$.

(i) *If* $(p_a + p_b)R > (2v + 3t)$, *banks compete. If the difference in perceptions of success of banks is small relative to the transport cost* ($3t > R(p_a - p_b)$) *then there is a unique interior equilibrium, with margins* $R - r_i = t/p_i + R(p_i - p_j)/3p_i$, *in which the safer bank* (a) *enjoys a higher margin and market share. Otherwise* ($3t \leq R(p_a - p_b)$), *bank* a *enjoys a natural monopoly* (*with impeded entry*) *with margin* $R - r_a = (R(p_a - p_b) - t)/p_a$.

(ii) *If* $2(t + v) > (p_a + p_b)R$, *banks have local monopolies with margins* $R - r_i = (R/2) - (v/2p_i)$, *and market shares* $n_i = (p_iR - v)/2t$.

(iii) *Otherwise, there are multiple "touching markets" equilibria, with all the markets being served.*

To understand the parameter regions inducing different equilibria, let us focus first on the symmetric case, $p_a = p_b = p$, (see Fig. 4). Suppose that the parameters R and t are such that with $p = 1$ the equilibrium is of the competitive type. Then, when p is very low, both banks are out of the market since they cannot offer an expected return larger than the reservation value v. For larger p's, banks enjoy local monopolies (LM) since their potential market areas do not overlap. Further increases in p make the market areas of the rivals just "touch" (TM) as in Salop's kinked equilibrium (Salop (1979) and Economides (1984)). For still larger p's, banks compete directly (DC). Note that the margin $x \equiv \mathrm{R} - r$ is not monotone in p: the possibility of failure has an ambiguous impact on margins depending on the type of equilibrium. The margin increases over the regions of LM ($x = (R/2) - v/2p$), and also TM ($x = R - (v + t/2)/p$), and decreases in the region of DC ($x = t/p$). A monopoly bank which is considered safer can offer lower rates. This is a fat-cat effect: a bank perceived safer will command a larger market share and be more restrained in pricing. A bank facing competition (of equal perceived soundness) will become more aggressive when the perception of success increases simultaneously for both institutions.[15]

[15] Nevertheless, the margin with DC is always larger than the margin with LM whenever probabilities of success are larger than $\frac{1}{2}$ (this must be the case with symmetric distributions).

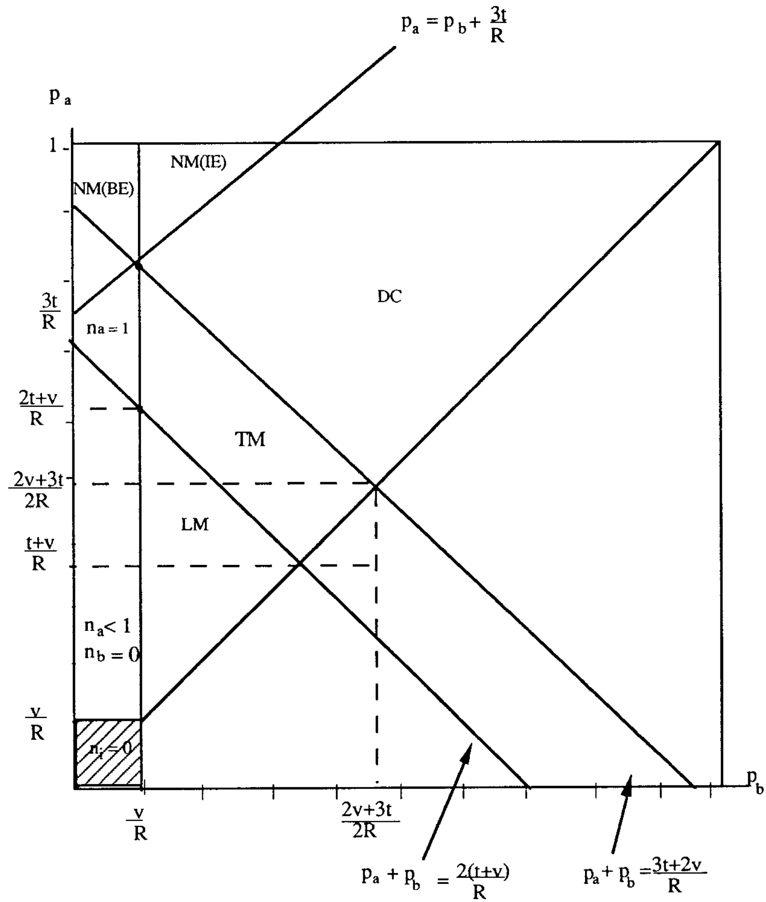

FIG. 4. Competition with fixed perceptions.

Proposition 1 highlights the importance of the perceptions of depositors in banking competition. Suppose that the "reputation" or "quality" of a bank is synonymous with its perceived probability of success. This introduces vertical differentiation in banking competition: if all banks were to offer the same rates, and there were no other differentiation elements, depositors would prefer the safer ones. A natural monopoly structure (a natural oligopoly in a market with *m* banks) may thus emerge. This is a situation where only a few firms can survive despite low fixed costs and free entry. Aggressive price competition among high quality firms may leave no room for lower quality products.

In our duopoly model, two types of natural monopoly situations may emerge. In the first, one bank, say b, is perceived as of sufficiently low quality that it cannot attract depositors, independently of the behavior of bank a (case II, natural monopoly with blockaded entry, NM(BE) region in Fig. 4). The second situation permits bank b to earn positive profits as a monopolist, but the high quality bank drives it out of the market (case III (i), natural monopoly with impeded entry, NM(IE) region in Fig. 4).

Since our model incorporates horizontal differentiation, the possibility of one bank driving its rival out in equilibrium depends on the magnitude of the transport cost. Only when the transport cost is low relative to the difference in the quality of banks may such an equilibrium arise. Indeed, when $3t/R > p_a - p_b$, both firms share the market and compete with one another (case III (i) interior equilibrium; region DC in Fig. 4).

When banks are direct competitors, the safer bank enjoys a higher margin and market share.[16] The safer bank setting a lower deposit rate can attract a larger market share. Interpret the fixed perceptions of depositors as corresponding to a case where banks a and b are entering a new market which is small compared to the set of markets already served. In this case the business in the new market does not affect the overall failure probability of the institutions. A larger, more diversified, and therefore safer bank captures a larger fraction of the new market while offering a lower deposit interest rate than a smaller rival.[17] An initial advantage in one market may therefore snowball, leading to banking industry concentration.

4. EQUILIBRIUM CHARACTERIZATION

Given perceptions $p_i, i =$ a,b, Proposition 1 characterizes possible equilibria in deposit rates. An equilibrium of the game requires depositors' perceptions to be self-fulfilling: the probabilities of success must satisfy $p_i = 1 - F(r_i;\, n_i)$, $i =$ a,b, where n_i is the outcome of price competition among banks taking parametrically the probabilities of success p_i as in Proposition 1. Several types of equilibria may arise.

PROPOSITION 2. *In addition to equilibria of the touching-markets and local-monopolies type, possible equilibria, coexisting for given parameter values, are as follows:*

[16] This need not be the case in the touching markets case.

[17] Further, in this interpretation, the condition stated in the vertical differentiation literature (e.g., Shaked and Sutton, 1983) for the emergence of a natural oligopoly seems to be satisfied: the burden of the increase in quality (increase in the customer base to profit from diversification economies) falls basically on fixed costs (investment in the branch network, ATM systems, and promotion).

(i) *Interior symmetric equilibrium where banks compete with* $R - r^* = t/p^*$.

(ii) *Interior asymmetric equilibria (where the safer bank has a higher margin and market share).*

(iii) *Corner asymmetric equilibria:* $n_i > 0$, $n_j = 0$, $i \neq j$.

(iv) *No banking equilibrium:* $n_i = 0$ *(and* $p_i = 0$*)*, $i =$ a,b. *It is always an equilibrium with minimum size investments.*

Proof. See Appendix I.

Therefore, unlike the typical Hotelling model (even modified as in Proposition 1 with fixed probabilities of failure) where equilibria are unique (except in the touching-markets region), there are multiple equilibria. The source of the multiplicity is the self-fulfilling character of expectations of depositors in the presence of the standard deposit contract coupled with economies of scale. A bank with high perceived quality (probability of success) sets a lower deposit interest rate and commands a larger market share which may sustain (make self-fulfilling) the initial belief.[18] Also, asymmetric equilibria arise from expectations, and not from an ex ante asymmetry across banks.

If a minimum market share is required to invest, the nonbanking equilibrium and corner equilibria (the latter under regularity conditions) always exist. The consequence is that, equilibria of the type (i), (ii), (iii), and (iv) in Proposition 2 typically arise simultaneously. Further, diversification economies are additional driving forces behind the multiplicity of equilibria. Indeed, with diversification economies, an initial advantage in depositors' perception can be made self-fulfilling because the greater margin and market share commanded reinforce the lower failure probability associated with a larger institution.

Multiple equilibria arise here for reasons similar to those encountered in the network externalities literature where the self-fulfilling character of expectations introduces the possibility of multiple equilibria (see Katz and Shapiro (1985), Farrell and Saloner (1985, 1989)). A bank can be understood as a network in which more customers mean that everyone benefits and

[18] This may happen in our model even in the absence of diversification economies and minimum size projects as the following example shows (although it does not arise when depositors obtain the revenue of the bank in case of bankruptcy). Assume that there are no diversification economies or minimum size projects and that $\tilde{R}$ takes the values, R_1, R_2, and R_3 with probabilities α_1, α_2, and α_3, respectively, and has expected value $R > R_2$. There are parameter constellations for which a symmetric interior equilibrium with $p_i = \alpha_3$ coexists with asymmetric interior equilibria of the type $p_{\mathrm{a}} = \alpha_2 + \alpha_3$ and $p_{\mathrm{b}} = \alpha_3$. For instance, both equilibria coexist when $R_3 = 2R_2 = 4R_1$, $\alpha_3 = \frac{1}{4}$ and $\alpha_2 = \frac{1}{2}$, $1.12R_1 < 3t < 1.31R_1$, and $9R_1 > 4v + 2t$.

where the network requires a minimum size to be viable. Indeed, with diversification economies, a larger bank has, ceteris paribus, a lower probability of failure. Our model extends the usual network externalities situation to a case where the quality of the product of a firm depends not only on the size of the network (market share) but also on the margin set by the firm.

Expectations-driven equilibria are not uncommon in the banking literature. The nonbanking equilibrium in our model is reminiscent of the (bad) "confidence crisis" equilibrium, in the bank runs literature. Diamond and Dybvig (1983) show that even an otherwise sound bank may experience a bank run. In the bad equilibrium (0, 0) of our model, depositors anticipate that banks are not viable and do not deposit in either bank. Banking may not get started even when it is the only way of linking lenders and borrowers. Thus, the coordination problem implies a potential nonviability of banks. Further, we also obtain the possibility of an "institution confidence crisis" in which depositors mistrust one of the banks, making it not viable. With minimum size projects, this situation arises because of depositors' mistrust and not because of actions of the rival bank. Equilibria cannot be of the natural-monopoly-with-impeded-entry type (with one bank out of the market because of competition from the rival bank). Indeed, when $n_i = 0$, then $p_i = 0$ and the expected return that bank i can promise depositors is zero, and therefore the bank is left out of the market (as in II(i) in Proposition 1: natural monopoly with blockaded entry).

In summary, coordination problems among depositors result in multiple equilibria where banks have different quality, which makes different levels of confidence possible in equilibrium (self-fulfilling). Nevertheless, quality, endogenously determined in the market, may be fragile because it is based on the expectations of depositors. This fragility is not due to competition since it can arise even with a single bank.

The multiplicity of equilibria would be enhanced if we allowed banks to influence depositors' expectations. Indeed, consider an alternative game where depositors form expectations about banks' failure probabilities after deposit rates have been set. In this game any pair of rates that yields nonnegative expected profits can be sustained in equilibrium. The reason is that, once rates are set, there is a coordination game among depositors which allows them to enforce any pair of rates with the threat of reversion to the no-banking equilibrium. The threat is credible since when each depositor believes that others will not deposit, it is a best response not to deposit either. This is because a single individual cannot deposit as much as the minimum amount required for the banks not to fail with probability 1. (See Appendix II).

The basic insight of the model does not change with limited liability. In the context of our model, limited liability will not alter the fact that different risk perceptions induce vertical differentiation resulting in multiple equilibria, including the no-banking equilibrium or the corner-monopoly equilibrium whenever there are minimum size requirements. However, limited liability may relax deposit interest rate competition in the presence of diversification-based economies of scale. For example, an increase in size may look less appealing since it reduces the risk of returns of the bank (see Winton (1994)). In another paper (Matutes and Vives, 1995), we assume away diversification-based economies of scale and focus on the consequences of limited liability for risk taking on both the asset and liability side (via rate increases) of the balance sheet. Limited liability may induce excessive risk taking on the asset side, an issue we have not considered, and it can be an additional consideration to undertake further risk by raising deposit rates. We show there that with limited liability, corner equilibria remain when a minimum size is required, and that interior equilibria are such that the bank with an observable riskier asset position sets a higher deposit rate. In this case, depositors require a higher deposit rate when the bank assumes further risk; this offsets the additional profits derived from the higher risk under limited liability. We also show that when investors cannot observe the asset risk position of banks, limited liability induces maximum asset risk so that the only set of rational expectations for depositors is to assume that each bank chooses the riskiest portfolio available.

Our model provides comparative static results.

PROPOSITION 3. *At a symmetric equilibrium in which banks compete, whenever the return distribution of* $\tilde{R}_i - R$ *can be written in the form* $G(\cdot; n_i)$ (*with* G *independent of* R), *then the margin* $R - r^*$ *and the probability of success* p^* *are independent of* R, *and provided that* $p^* < 1$, *they both increase with the degree of friction* t.

Proof. See Appendix I.

Remark. The assumption in Proposition 3 holds for symmetric distributions around R, as in our beta example, but not for the log-normal distribution. In the latter case, simulations show that as R increases, the equilibrium margin and the probability of failure decrease.

Remark. Under the assumption in Proposition 3, when banks compete, both the expected margin and probability of failure depend on the diversity of the services offered by banks (the degree of differentiation or the level of market friction), and are independent of the expected return of the distribution. It is competition that leads to the banks' expected profit being unaffected by the expected return of investments: financial institutions fight for the marginal depositor to the point that the margin remains constant and only depositors benefit from the higher expected return. On the other hand, to the extent that banks offer a better mix of services from the

TABLE I
BETA DISTRIBUTION UNREGULATED MARKET

A. Competitive market structure

(i) Impact of R ($t = 0.175$, $v = 1$, $k = 0.1$)

R	r^*	n^*	p^*	π^*
1.4	1.208	0.5	0.912	0.095
1.42	1.228	0.5	0.912	0.095
1.44	1.248	0.5	0.912	0.095
1.46	1.268	0.5	0.912	0.095
1.48	1.288	0.5	0.912	0.095
1.5	1.308	0.5	0.912	0.095

(ii) Impact of k ($R = 1.4$, $v = 1$, $t = 0.175$)

k	r^*	n	p^*	π^*
0.01	1.224	0.5	0.999	0.087
0.03	1.222	0.5	0.984	0.088
0.05	1.217	0.5	0.960	0.091
0.07	1.213	0.5	0.938	0.093
0.09	1.209	0.5	0.919	0.095
0.11	1.206	0.5	0.905	0.096

(iii) Impact of t ($R = 1.4$, $v = 1$, $k = 0.1$)

t	r^*	n^*	p^*	π^*
0.15	1.23	0.5	0.88	0.08
0.175	1.20	0.5	0.91	0.09
0.02	1.18	0.5	0.93	0.10
0.225	1.16	0.5	0.95	0.11

B. Local monopolies: low-risk equilibrium

(i) Impact of R ($t = 0.4$, $v = 1$, $k = 0.01$)

R	r^*	n^*	p^*	π^*
1.28	1.14	0.3296	0.98725	0.044
1.3	1.15	0.3679	0.99560	0.054
1.32	1.16	0.3973	0.99836	0.063
1.34	1.17	0.4240	0.99942	0.071
1.36	1.18	0.4497	0.99981	0.080
1.38	1.19	0.4749	0.99994	0.090
1.4	1.20	0.500	0.99998	0.099

(ii) Impact of k ($t = 0.4$, $v = 1$, $R = 1.41$)

k	r^*	n^*	p^*	π^*
0.01	1.200	0.5	0.999	0.0999
0.02	1.200	0.497	0.998	0.0991
0.03	1.204	0.48	0.991	0.0946
0.04	1.216	0.44	0.967	0.0814

TABLE I—*Continued*

B. Local monopolies: low-risk equilibrium

(iii) Impact of t ($R = 1.4$, $v = 1$, $k = 0.01$)

t	r^*	n^*	p^*	π^*
0.4	1.2	0.5	0.999	0.09
0.5	1.2	0.39	0.999	0.07
0.6	1.2	0.33	0.999	0.06
0.7	1.2	0.28	0.999	0.05
0.8	1.2	0.24	0.998	0.049

C. Local monopolies: high-risk equilibrium

(i) Impact of R ($t = 0.3$, $v = 1$, $k = 0.05$)

R	r^*	$R - r^*$	n^*	p^*	π^*
1.38814	1.227	0.160	0.5	0.9365	0.0800
1.39558	1.247	0.148	0.45	0.9100	0.0667
1.41203	1.275	0.136	0.4	0.8781	0.0546
1.43853	1.313	0.124	0.35	0.8411	0.0436
1.47651	1.363	0.112	0.3	0.7991	0.0337

(ii) Impact of k ($t = 0.3$, $v = 1$, $R = 11.4$)

k	r^*	$R - r^*$	n^*	p^*	π^*
0.05567	1.238	0.161	0.5	0.9285	0.0807
0.05182	1.251	0.148	0.45	0.9071	0.0669
0.04571	1.264	0.135	0.4	0.8857	0.541
0.03811	1.278	0.121	0.35	0.8642	0.0425
0.02973	1.293	0.106	0.3	0.8428	0.0320

(iii) Impact of t ($R = 1.4$, $v = 1$, $k = 0.4$)

t	r^*	$R - r^*$	n^*	p^*	π^*
0.36971	1.211	0.188	0.5	0.97836	0.0944
0.39676	1.215	0.184	0.45	0.96934	0.0828
0.4198	1.224	0.175	0.4	0.95416	0.0703
0.40168	1.246	0.153	0.35	0.91512	0.0537

point of view of some depositors, incentives to exploit the captive clientele increase, and incentives to compete for other institutions' customers diminish. The outcome is an increased expected margin and higher probability of success.

Simulations yield other interesting comparative static results:

(i) At a symmetric equilibrium in which banks compete and returns follow a beta distribution, riskier returns (larger k) lead to increases in the probability of failure and the margin (see Table IA).

(ii) When banks have local monopolies and beta-distributed returns, there is an equilibrium where the market served, probability of success, and expected profit increase with the expected return, and decrease with the transport cost and the risk of the returns (see Table IB). This will be a "low-risk" equilibrium. There may also be a "high-risk" equilibrium where the market area served, probability of success, and expected profit decrease as the expected return of investment increases, or the risk of the return decreases (see Table IC).[19]

Thus, our results indicate that competitive banks become more profitable when they face riskier returns. The reason is that the probability of failure (which increases with risk) softens competition, as pointed out in the previous section. On the other hand, at the low-risk local-monopoly equilibrium, the supply of funds for local monopolies diminishes when the variability of their returns increases. Banks pay higher deposit rates, but they attract fewer deposits and earn lower expected profits due to the higher associated probability of failure.

There also may exist a high-risk local-monopoly equilibrium (for the same parameter values as the low-risk one) in which an increase in the expected return on investment leads to increases in the equilibrium rate and the probability of failure, and decreases in market area served and expected profits. The idea is that in this equilibrium the probability of bankruptcy is rather high, and as a result the only way to attract depositors is by offering a high deposit rate, which makes the high probability of bankruptcy self-fulfilling. Banks are trapped in a high-risk equilibrium.

5. DEPOSIT INSURANCE AND WELFARE

In this section we study deposit insurance and the implied welfare tradeoffs.

Suppose there is a deposit insurance fund (DIF) run by the government which fully insures deposits. The DIF guarantees that the banks' posted rates will be honored and it finances the deposit insurance via an insurance premium, β, i.e., the banks deposit in the DIF a percentage β of the deposits they obtain. The DIF covers the difference with posted rates in case of bankruptcy, and invests the funds collected. Otherwise, the incentive contract between the bank and depositors remains the same. That is, since neither the DIF nor the depositors have monitoring capabilities, the bank

[19] Except for the existence of a high-risk equilibrium with local monopolies, the same results as in (i) and (ii) were obtained with simulations assuming a log-normal distribution of returns.

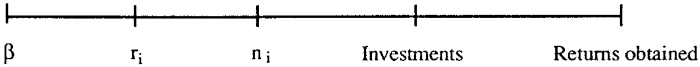

FIG. 5. Time line with deposit insurance.

incurs appropriate nonpecuniary penalties and hence it pays the posted rate whenever feasible.[20] Consequently, insurance does not introduce limited liability in the model and we can isolate the impact of insurance on competition for deposits.

The sequence of events is as follows. First the DIF quotes a premium β (any number between 0 and 1). Next, bank i sets rate r_i, obtains a market share n_i, pays βn_i to the DIF, and invests the rest. Returns from investments are obtained. If the bank declares bankruptcy, then the DIF pays $(r_i - (1-\beta)\tilde{R}_i)n_i$ while the bank pays $(1-\beta)n_i\tilde{R}_i$. Otherwise, the bank pays the posted rate to depositors.[21] (see Fig. 5.)

The nonpecuniary penalties now depend not only on the posted rate but also on the insurance premium since the total returns to the bank depend on how much it was able to invest. That is, in case bank i cannot honor its commitment to pay the rate r_i (this happens when $(1-\beta)\tilde{R}_i < r_i$), the bank suffers a nonpecuniary penalty equal to $r_i - (1-\beta)\tilde{R}_i$. The expected deadweight loss (DWL) associated with nonpecuniary penalties for bank i is therefore $(1-p_i)E[r_i - (1-\beta)\tilde{R}_i | \tilde{R}_i < (r_i/1-\beta)]n_i$. This loss increases with the insurance premium β for a given deposit rate and market size. This is so since a higher β makes it more likely that the bank fails, and the difference between the posted rate and the return becomes larger.[22]

The bank's expected profit is

$$\pi_i = (R(1-\beta) - r_i)n_i.$$

Depositors now are repaid with certainty, i.e., they view $p_i = 1$, $i = $ a,b. This means that the equilibrium is similar to that in the classical Hotelling

[20] If a minimum size investment is required and for given deposit rates a bank does not obtain the minimum market share to operate, the DIF has the power to uniformly tax the agents in the economy in order to inject the minimum required by the bank to invest and operate. This can be interpreted as a lender-of-last-resort facility.

[21] Note that we do not require the premium β to be fair (see Chan *et al.* (1992)). A fair premium for bank i would satisfy

$$\beta = (1-p_i)E\left[r_i - (1-\beta)\tilde{R}_i | \tilde{R}_i < \frac{r_i}{1-\beta}\right].$$

[22] Recall that the DIF invests the collected premium. Therefore, the increase in the DWL is not artificially due to βn_i being dissipated.

model, with firms maximizing $\pi_i = (R(1-\beta) - r_i)n_i$, and the multiplicity of equilibria is eliminated. Hence:

PROPOSITION 4. *With deposit insurance, equilibria are as follows:*

(i) *If* $R(1-\beta) > v + 3t/2$, *then there is a unique symmetric equilibrium* $R(1-\beta) - r^{\mathrm{DI}} = t$.

(ii) *If* $R(1-\beta) < t + v$, *then there is a symmetric local monopoly equilibrium with margin* $R(1-\beta) - r^{\mathrm{DI}} = (R(1-\beta) - v)/2$, *and* $n_i = (R(1-\beta) - v)/2t$.

(iii) *If* $v + t < R(1-\beta) < v + 3t/2$, *then there is a symmetric touching markets equilibrium with margin* $R(1-\beta) - r^{\mathrm{DI}} = R(1-\beta) - (v + t/2)$. (*Asymmetric TM equilibria also exist.*)

Proof. Follows directly from Proposition 1 setting $p_i = 1$ and replacing R by $R(1-\beta)$. ■

Remark. With deposit insurance, banks are indifferent as to the level of risk they take when they compete directly. Indeed, note that the net margin is given by the degree of friction in the market and the unique equilibrium is symmetric. Expected profits of a bank are thus $t/2$. Also, with local monopolies, the risk assumed by banks is reflected in the expected profits only to the extent that it translates into higher premiums. With fair premiums, one would expect the premium to increase with the variability (mean-preserving spread) of returns and hence to decrease expected profits. Table III shows that this is indeed the case with beta-distributed returns.[23]

Deregulation during the 1970s and 1980s most likely reduced differentiation among financial institutions by allowing different types of institutions to perform similar operations, and increased the risk of returns they faced by lifting restrictions on the asset side of the balance sheet. All this was done with deposit insurance. Comparative statics derived from Proposition 4 in the competitive regime indicate that, for given insurance premiums, a decrease in t raises the probability of failure $1 - p = \Pr(\tilde{R}_i < R - t/(1-\beta))$. The same is true for a mean-preserving spread of the distribution of returns provided it is symmetric (since $r = R - t/(1-\beta) < R$). This is consistent with the increase in failure probabilities observed during the 1980s.

Deposit insurance rules out the possibility of vertical differentiation across banks. That is, depositors perceive the quality of both banks to be the same because the DIF guarantees that posted rates will be honored.

[23] Simulations show that the same result holds with returns distributed as a log-normal, i.e., expected profits also decrease when risk increases if premiums are fair. With log-normal returns an increase in k represents an increase in the variance of returns.

As a result, insurance eliminates the multiplicity of equilibria associated with the market solution cutting through the multiple self-fulfilling expectations, but what welfare tradeoffs does it present?

First, it is clear that deposit insurance improves upon the situations where the market fails and both banks are not viable in the presence of minimum size investments (stabilization effect). This is reminiscent of Diamond and Dybvig (1983) where governmental deposit insurance eliminates the bad equilibrium. Second, (except possibly in the TM region) the DIF implies that a symmetric equilibrium prevails and hence, given the number of customers who deposit, total transport cost is minimized (uniformity effect). However, there may be costs associated with uniformity in terms of lost diversification economies. Indeed, welfare may decrease when deposit insurance is imposed if the market outcome was a corner equilibrium; this case may arise when diversification economies are so important in reducing bankruptcy costs and relative to the unit transport cost that concentration of depositors in a single bank may outweigh the benefits of reduced total transport costs implied by deposit insurance.

Next, insurance has a market-extension effect: the certainty of being repaid induces consumers to deposit, given posted rates. On the other hand, as we have seen, given posted rates and market size, the deadweight loss (DWL) increases with insurance. That is, insurance increases the nonpecuniary cost, and the insurance premium increases the cost of making contracts incentive compatible (DWL effect). Finally, deposit insurance changes the equilibrium rates (rate effect) and thus the residual probability of failure, and this may modify the market expansion effect and/or the DWL effect. Indeed, given that insurance makes the supply of funds more elastic, a deposit rate increase attracts more depositors when there is insurance. Thus, insurance encourages banks to compete more for deposits by setting higher rates. This happens when banks compete directly in a symmetric situation, since from Proposition 1 with unregulated competition the deposit rate increases with the common perception of success of the banks. However, when banks have local monopolies, the situation is the opposite: rates decrease with the perception of success of the banks.

Table II shows the welfare magnitudes both with and without a DIF and Propositions 5 and 6 explore the market-extension effect, DWL effect, and rate effect more formally by focusing on symmetric equilibria. Notice that with insurance the equilibrium magnitudes depend on the side of the premium, while without insurance they depend directly on the probability of bankruptcy. As a result, an analysis of the effects of insurance necessarily involves comparing the premium with the probability of bankruptcy of the uninsured market equilibrium.

We now compare equilibrium magnitudes in an insured context with an uninsured one with symmetric competitive or local monopoly equilibria.

TABLE II
WELFARE

Expected total surplus:

$$\mathrm{ETS} = (R - v)(n_a + n_b) - t\left(\frac{n_a^2 + n_b^2}{2}\right) - \mathrm{DWL}$$

Deadweight loss:

$$\mathrm{DWL} = (1 - p_a)E\left[r_a - (1-\beta)\tilde{R}_a \middle| \tilde{R}_a < \frac{r_a}{1-\beta}\right] n_a + (1 - p_b)E\left[r_b - (1-\beta)\tilde{R}_b \middle| \tilde{R}_b < \frac{r_b}{1-\beta}\right] n_b$$

with $\beta = 0$ without DIF, and $\beta > 0$ with DIF.

Let r^* and r^{DI} be the equilibrium deposit interest rates in an uninsured and an insured market, respectively, and $1 - p^*$ and $1 - p^{\mathrm{DI}}$ be the corresponding probabilities of bankruptcy.

PROPOSITION 5. *When banks are direct competitors:*

(i) *Insurance increases the expected payment to depositors* (*and the probability of bankruptcy*) *if and only if* $\beta < 1 - p^*$.

(ii) Insurance enhances rate competition and decreases expected profits and expected total surplus when $\beta < (1 - p^*)(t/Rp^*)$.

Proof. See Appendix I.

PROPOSITION 6. *When banks have local monopolies:*

(i) *Insurance increases the expected payment to depositors and extends the market if and only if* $\beta < 1 - p^*$.

(ii) *A necessary condition for insurance to increase expected profits is that it extends the market. When insurance extends the market, it increases welfare provided the insurance fund makes no losses.*

Proof. See Appendix I.

Propositions 5 and 6 indicate that when premiums are relatively small, the impact of insurance on welfare may be positive when banks have local monopoly power, and negative when banks compete. To better understand the intuition behind this result, let us consider what happens when the premium decreases.

For a given set of parameters, as the premium decreases, the equilibrium rate increases more when there is competition (R per unit of decrease of β) than when banks have a monopoly ($R/2$ per unit of decrease of β). The net margin remains constant with competition ($R(1 - \beta) - r = t$). As a result, only when there is local monopoly power is a smaller premium translated into a significantly smaller probability of bankruptcy, yielding a welfare benefit. When banks have local monopoly power, competition does not entirely erode the incremental margin that a lower premium allows. Furthermore, only with local monopolies will the increase in rates associated with a lower premium translate into more deposits. This is so since each depositor supplies \$1 inelastically and, when banks are direct competitors, all of the market is served.

How reasonable are the conditions stated in Proposition 5 and 6? We report below results of simulations that assume that premiums are always fair.[24] Our simulations reveal that the conditions in these propositions are reasonable.

More specifically, using the beta distribution for returns, we have examined whether $\beta < 1 - p^*$ and/or $\beta < (1 - p^*)(t/Rp^*)$ when premiums are fair and banks are direct competitors both with and without insurance. Table IIIA reports the competitive equilibrium outcome when banks compete in the presence of insurance. Comparing Tables I and III, it can be checked that both inequalities hold.[25] That is, when banks are direct competitors, insurance with fair premiums enhances rate competition, increases the probability of bankruptcy, and lowers both expected profits and welfare.

On the other hand, when banks have local monopolies and with the beta distribution we find that in the equilibrium, $\beta < 1 - p^*$, as can be checked comparing Tables I and III. Furthermore, in the example considered, when insurance enlarges the market, it also increases expected profit. That is, with local monopolies and with the beta distribution, fair insurance expands the market and increases expected profits and welfare.

Thus, when banks compete directly, the rate and DWL effects (and the nonexistence of the market extension effect) imply that fair insurance is

[24] Chan *et al.* (1992) show that in the presence of private information and moral hazard, perfect competition and fair deposit insurance may be incompatible with one another. The reason is that riskier banks do not have incentives to reveal that they are high risk so as to pay a lower premium and earn positive (rather than zero) expected profits. In our model, there is imperfect competition and banks make positive expected profits so that fair insurance is possible.

[25] The range of values of fair premiums generated by our simulations with the beta distribution (see Table III) are not inconsistent with insurane premiums used in various countries or, for that matter, with the risk-adjusted deposit premiums calculated in Ronn and Verma (1986). The estimates of those authors range from 0.72 to 0.0001%. Similarly, failure probabilities are in line with observed failure rates: from 1940 to 1980 the failure rate of insured commercial banks in the United States was 299/13500 = 0.0221, and hence the implied probability of success $p = 0.9779$; Boyd and Runkle (1993) report failure rates for the period 1981–1991 of 0.0991 for small banks and 0.1045 for large banks, yielding lower success rates (of 0.9009 and 0.8955, respectively).

TABLE III
BETA DISTRIBUTION DEPOSIT INSURANCE

A. Competitive market structure

(i) Impact of R ($t = 1.75$, $v = 1$, $k = 0.1$)

R	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
1.3	1.118	0.5	0.89076	0.0049	0.0875
1.34	1.158	0.5	0.89074	0.0047	0.0875
1.38	1.198	0.5	0.89072	0.0046	0.0875
1.42	1.238	0.5	0.89070	0.0045	0.0875
1.46	1.278	0.5	0.89068	0.0044	0.0875
1.5	1.310	0.5	0.89067	0.0004	0.0875

(ii) Impact of k ($R = 1.4$, $v = 1$, $t = 0.175$)

k	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
0.01	1.225	0.5	0.999	0	0.087
0.03	1.224	0.5	0.983	0.0003	0.087
0.05	1.223	0.5	0.953	0.0012	0.087
0.07	1.221	0.5	0.924	0.0025	0.087
0.09	1.219	0.5	0.901	0.0039	0.087
0.11	1.217	0.5	0.881	0.0052	0.087
0.13	1.215	0.5	0.864	0.0065	0.087

(iii) Impact of t ($R = 1.4$, $v = 1$, $k = 0.1$)

t	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
0.1	1.28	0.5	0.75	0.013	0.05
0.125	1.26	0.5	0.80	0.009	0.06
0.15	1.24	0.5	0.85	0.006	0.07
0.175	1.21	0.5	0.89	0.004	0.08
0.2	1.19	0.5	0.92	0.002	0.1
0.225	1.17	0.5	0.94	0.001	0.11
0.25	1.14	0.5	0.96	0.001	0.12

B. Market structure with local monopolies

(i) Impact of R ($t = 0.4$, $v = 1$, $k = 0.01$)

R	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
1.1	1.03	0.09	0.62779	0.02501	0.00328
1.15	1.07	0.177	0.80732	0.007291	0.01253
1.2	1.09	0.247	0.92312	0.001917	0.02443
1.25	1.12	0.311	0.97867	0.000369	0.03892
1.3	1.14	0.374	0.99637	0.000044	0.05623
1.35	1.17	0.437	0.99967	3.00×10^{-6}	0.07656
1.4	1.20	0.50	0.99998	0	0.1

(ii) Impact of k ($t = 0.4$, $v = 1$, $R = 1.4$)

k	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
0.01	1.2	0.5	0.999	0	0.1
0.03	1.19992	0.4998	0.993	0.000115	0.09992
0.05	1.19954	0.4989	0.973	0.000654	0.09954
0.07	1.9893	0.4973	0.950	0.001528	0.09893
0.09	1.1982	0.4955	0.928	0.002576	0.09821

(iii) Impact of t ($R = 1.4$, $v = 1$, $k = 0.01$)

t	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
0.4	1.2	0.5	0.999987	0	0.1
0.7	1.19999	0.2857	0.991307	0	0.05714
0.8	1.19999	0.25	0.999307	1.65×10^{-5}	0.04999
0.9	1.19998	0.2222	0.997673	3.09×10^{-5}	0.04443
1	1.19996	0.2	0.996422	5.17×10^{-5}	0.03999

TABLE IV
BETA DISTRIBUTION UNREGULATED MARKET

A. Local monopolies ($t = 0.3$, $v = 1$, $k = 0.5$)

R	r^*	n^*	p^*	π^*
1.45	1.33	0.08	0.824	0.11
1.47	1.35	0.06	0.808	0.08
1.48	1.37	0.04	0.790	0.05
1.50	1.40	0.02	0.771	0.02

With deposit insurance

B. Direct competition ($t = 0.3$, $v = 1$, $k = 0.5$)

R	r^{DI}	n^{DI}	p^{DI}	β	π^{DI}
1.45	1.15	0.5	0.999	1.32×10^{-5}	0.15
1.47	1.17	0.5	0.999	1.30×10^{-5}	0.15
1.48	1.18	0.5	0.999	1.29×10^{-5}	0.15
1.50	1.20	0.5	0.999	1.27×10^{-5}	0.15

dominated by the symmetric interior uninsured equilibrium. However, when banks have local monopolies, the market extension effect and the rate effect of fair insurance outweigh the DWL effect, and welfare increases.[26] Finally, the market-extension effect implies that insurance has the potential for changing the market structure from local monopolies to direct competition. Table IV provides parameter constellations where deposit insurance changes the market structure. In the example in the table, the local monopoly equilibrium without insurance is of the high risk type, and it is transformed into a direct competition situation by insurance. In this case, insurance reduces the rate paid to depositors but increases the expected payment, as well as practically eliminating the probability of failure of banks. The result is that insurance increases welfare. This is so since, as seen in Table IV, the insurance premium is very small, and hence so is the deadweight loss per unit of deposit. It follows that expected surplus, given the amount deposited, increases (see Table II). Furthermore, total deposits increases with insurance, and hence, expected total surplus increases, given that it was positive without insurance.

6. CONCLUDING REMARKS

We have developed a framework that links incentive and competition theories to study rivalry among financial intermediaries in an imperfect competition context as well as the policy implications of deposit insurance.

[26] Once again, the same results were obtained with returns distributed as a log-normal.

We have found that the possibility of failure allows the emergence of vertical differentiation through the formation of expectations by depositors, and that this is an important determinant of competition. As is well known, vertical differentiation may entail natural monopoly or oligopoly structures. A bank resembles a network and many different outcomes of the competitive process are possible depending on the expectations of depositors, which become key to the explanation of the fragility of banking. Nevertheless, this fragility cannot be attributed to competition since it is based on a coordination problem of depositors and could arise even with a monopoly bank.

Our analysis provides a better understanding of the relationship between depositors' expectations and rivalry among competing banks. For example, a bank perceived to be safe has incentives to be less aggressive in pricing and enjoys a large market share, which makes the expectation self-fulfilling. The understanding of the interaction between depositors' expectations and rivalry proves to be crucial when analyzing the effects of deposit insurance. With insurance all banks are perceived to be safe and, with direct competition, rivalry is enhanced since it increases the elasticity of supply of deposits. On the other hand, when banks have local monopolies, they set lower rates with insurance. Yet, insurance results in greater deposits because it increases the expected payment to depositors. This market-expansion effect may be sufficiently important to transform the market structure from local monopolies into one of direct competition.

We have shown that, even in a world of full liability and in the absence of moral hazard problems on the investment side, deposit insurance (which can be fairly priced) presents welfare tradeoffs. Its benefit is that it helps to avoid systemic confidence crises by eliminating the multiplicity of equilibria linked to different self-fulfilling depositors' expectations. Further, it minimizes frictions (transport costs) and it may extend the market. Its disadvantage is that is may preclude desirable concentrations of deposits and may make banks more aggressive in bidding for deposits, thereby increasing failure probabilities and generating a larger deadweight loss in the economy. Simulations with the model, assuming fair insurance premiums, reveal that this tradeoff favors deposit insurance when banks have local monopolies but argues against deposit insurance when they are direct competitors.

APPENDIX I

PROPOSITION 1. *Given* $p_{\mathrm{a}} \geq p_{\mathrm{b}} \geq 0$:

I. *When* $p_i R < v$, $i = \mathrm{a,b}$, *then both banks are out of the market.*

II. *When* $p_{\mathrm{b}} R < v$ and $\mathrm{p_a} R > v$ *then bank* b *is out of the market and* *bank* a *has a positive market share. If* $p_{\mathrm{a}}R \leq 2t + v$ *then bank* a *sets* $r_{\mathrm{a}} = (p_{\mathrm{a}}R + v)/2p_{\mathrm{a}}$ *and* $n_{\mathrm{a}} = (p_{\mathrm{a}}R - v)/2t$. *Otherwise,* $r_{\mathrm{a}} = (v + t)/p_{\mathrm{a}}$ *and* $n_{\mathrm{a}} = 1$.

III. *When* $p_i R \geq v$, $i =$ a,b:

(i) *If* $(p_{\mathrm{a}} + p_{\mathrm{b}})R > (2v + 3t)$ *then banks compete. If* $3t > R(p_{\mathrm{a}} - p_{\mathrm{b}})$ *there is a unique interior equilibrium:* $R - r_i = t/p_i + R(p_i - p_j)/3p_i$, *and both banks have a positive market share* $n_i = \frac{1}{2} + (p_i - p_j)R/6t$, $n_{\mathrm{a}} \geq n_{\mathrm{b}}) > 0$, $i =$ a,b. *Otherwise* $(3t \leq R(p_{\mathrm{a}} - p_{\mathrm{b}}))$, $n_{\mathrm{a}} = 1$ and $n_{\mathrm{b}} = 0$, with $r_{\mathrm{a}} = (p_{\mathrm{b}}R + t)/p_{\mathrm{a}}$.

(ii) *If* $2(t + v) > (p_{\mathrm{a}} + p_{\mathrm{b}})R$ *banks have local monopolies and* $r_i = (R/2) + (v/2p_i)$, $n_i = (p_i R - v)/2t$.

(iii) *If* $2(t + v) \leq (p_{\mathrm{a}} + p_{\mathrm{b}})R \leq (2v + 3t)$ *then there are multiple touching markets equilibria, all with* $n_{\mathrm{a}} + n_{\mathrm{b}} = 1$, *of the form* $p_{\mathrm{a}}r_{\mathrm{a}} = \gamma(v + t/2)$ *and* $p_{\mathrm{b}}r_{\mathrm{b}} = 2v + t - \gamma(2v + t)/2$, *where* γ *is an appropriate constant. If* $p_{\mathrm{a}} = p_{\mathrm{b}}$ *then the symmetric equilibrium is given by* $\gamma = 1$.

Proof I. If $p_i < v/R$, firm i cannot attract depositors and earn positive expected profits. Thus when $p_i < v/R$, bank i is out of the market.

II. The expected profits of firm i are $\pi_i = n_i(R - r_i)$, where

$$n_i = (p_i r_i - v)/t, \qquad \text{if } (p_i r_i - v)/t < (v - p_j r_j + t)/t, \tag{1}$$

$$(p_i r_i - p_j r_j + t)/2t, \qquad \text{otherwise.} \tag{2}$$

From (1) and (2) it is clear that when $p_{\mathrm{b}} < v/R$, then n_{a} is defined as in (1), since by setting $r_{\mathrm{a}} = (v + t)/p_{\mathrm{a}}$ firm a can attract all depositors. Maximizing a's profits when n_{a} is given by (1) we obtain

$$r_{\mathrm{a}}^* = (p_{\mathrm{a}}R + v)/2p_{\mathrm{a}} \quad \text{and} \quad n_{\mathrm{a}}^* = ((p_{\mathrm{a}}R - v)/2t, \quad \text{when } p_{\mathrm{a}}R < 2t + v,$$

$$r_{\mathrm{a}}^* = (t + v)/p_{\mathrm{a}} \quad \text{and} \quad n_{\mathrm{a}}^* = 1, \quad \text{otherwise}$$

III. Next, let both p_{a} and p_{b} exceed v/R. If both firms maximize the profit function and market shares are defined by (1), they set rates equal to

$$r_{\mathrm{a}}^* = (p_{\mathrm{a}}R + v)/2p_{\mathrm{a}},$$

$$r_{\mathrm{b}}^* = (p_{\mathrm{b}}R + v)/2p_{\mathrm{b}}.$$

As a result, $n_i^* = (p_i R - v)/2t$. Notice that $n_{\mathrm{a}} + n_{\mathrm{b}} < 1$ when $(p_{\mathrm{a}} + p_{\mathrm{b}})R < 2(t + v)$. Hence, when $(p_{\mathrm{a}} + p_{\mathrm{b}}) < 2(t + v)/R$, the equilibrium rates and market shares are as in (ii).

If both firms maximize profits when market shares are defined by (2), from the first order conditions the unique solution is

$$R - r_i = t/p_i + R(p_i - p_j)/3p_i,$$

which implies $n_i = \frac{1}{2} + (p_i - p_j)R/6t$, $i =$ a,b.
It can be easily checked that these rates are global best responses. Thus they define an equilibrium when

(a) $0 < n_i < 1$ and $n_{\mathrm{a}} + n_{\mathrm{b}} = 1$,

(b) the marginal consumer derives a nonnegative surplus.

It can be easily checked that (a) holds when $p_{\mathrm{a}} - p_{\mathrm{b}} < 3t/R$, and (b) when $(3t + 2v)/R < (p_{\mathrm{a}} + p_{\mathrm{b}})$. Thus, when both conditions hold, firms are direct competitors and the equilibrium is uniquely defined.

If, on the other hand, $3t/R < p_{\mathrm{a}} - p_{\mathrm{b}}$, then firm a can attract all depositors. Since firm b has zero fixed cost it will increase the rate it offers up to R. If we maximize a's profits as in (2) given that firm b sets a rate R, we obtain that a's best response is $((p_{\mathrm{a}} + p_{\mathrm{b}})R - t)/2p_{\mathrm{a}}$. However, at this rate n_{a} exceeds 1; thus, a's best response is $(p_{\mathrm{b}}R + t)/p_{\mathrm{a}}$. This completes the proof of case (i).

Finally, in case (iii) when $2(t + v)/R < p_{\mathrm{a}} + p_{\mathrm{b}} < (2v + 3t)/R$ and $v/R < p_{\mathrm{b}}$, firms cannot be direct competitors since the marginal consumer would derive a negative surplus at the candidate equilibrium rates. On the other hand, if they both maximize the profit function defined as if they had a local monopoly, the sum of the market shares which obtains exceeds 1. Thus, at least one of the firms maximizes its profits at the kink of the supply curve for deposits it faces, and all market is served. The symmetric equilibrium when $p_{\mathrm{a}} = p_{\mathrm{b}}$ is given by $\gamma = 1$. ■

Proof of Proposition 2. (i) From Proposition 1, we know that if there is a symmetric equilibrium then $R - r^* = t/p^*$. Furthermore, p^* must be the true probability of success. That is, $p^* = 1 - F(r^*; \frac{1}{2})$. A unique symmetric interior equilibrium exists when the system of equations, (1) $p = 1 - F(r; \frac{1}{2})$ and (2) $R = r = t/p$, has a unique solution, r^*, p^*. Notice that, since the probability of failure increases with the equilibrium rate, (1) defines p as a decreasing function of r. On the other hand, from (2) r is an increasing function of p; furthermore, from (2), when $p = 0$, r is minus infinity. Hence, (1) and (2) intersect only once. The equilibrium exists and it is unique provided that consumers derive nonnegative surplus; from Proposition 1, we know that this requires $2p^*R > 3t + 2v$.

(ii) With the returns being distributed according to a beta distribution, asymmetric interior equilibria exist, for instance, when $v = 1$, $t = 0.18$, $R = 1.4$, and $k = 0.05$. Market shares are $n_{\mathrm{a}} = 0.589$ and $n_{\mathrm{b}} = 1 - n_{\mathrm{a}}$ for the safer and smaller bank, respectively. The corresponding rates of interest and probabilities of success are ($r_a = 1.18$, $r_b = 1.23$) and ($p_a = 0.988$, $p_b = 0.919$), respectively. Furthermore, when an interior asymmetric equilibrium exists, it must satisfy Proposition 1 (i), and therefore the safer bank has a higher margin and market share, as is the case in the example.

(iii) Suppose that a minimum investment requirement is needed. If the monopoly (rational expectations) equilirium exists then $p_a = 0$ is self-fulfilling and there is a positive p_b which is also self-fulfilling. Indeed, assume that depositors expect $p_a = 0$, then they do not deposit $n_a = 0$. It follows that the true probability of success is 0 since the bank needs a positive market share to invest. Once again, when such equilibria exist, they must satisfy Proposition 1. That they may indeed exist can be shown using the example of the beta distribution. For example, when $v = 1$, $t = 0.18$, $R = 1.4$, and $k = 0.05$, then $n_a = 0$, $p_a = 0$, and $n_b = 0.502$, $p_b = 0.8435$, $r_b = 1.29$ constitute an equilibrium. That is, $p_a = 0$ and $p_b = 0.8435$ are self-fulfilling (obviously, the permutation of bank labels, $p_b = 0$, and $p_a = 0.8435$, is also self-fulfilling). If $v = 1$, $t = 0.3$, $R = 1.476$, and $k = 0.05$, then both $\{n_a = 0, p_a = 0$, and $n_b = 0.3, p_b = 0.799, r_b = 1.36\}$, its permutation, and $\{n_i = 0.3, p_i = 0.799, r_i = 1.36, i = \text{a,b}\}$ constitute equilibria. Note that the latter is just a symmetric local-monopoly equilibrium.

(iv) Let depositors expect $p_i = 0$, $i = \text{a,b}$. Then banks have no customers for any interest rates offered. In consequence, $n_i = 0$, $i = \text{a,b}$, and the probability of failure of any bank is 1 provided a minimum investment is needed.

The four types of equilibria coexist with returns distributed according to a beta distribution and there is a minimum investment requirement for banks when, for example, $v = 1$, $t = 0.18$, $R = 1.4$, and $k = 0.05$. In this case the interior symmetric equilibrium where banks compete is given by $\{n_i = 0.5\ r_i = 1.21, p_i = 0.96\}$. The other types are given as in (ii), (iii), and (iv). ■

Proof of Proposition 3. From the proof of Proposition 2, rewriting the system (1) and (2) as (1) $p = 1 - F(-x; \frac{1}{2})$ and (2) $x = t/p$, where $x = R - r$, it is immediate that, under the assumption of the proposition, $x^* = R - r^*$ and p^* are independent of R. It follows that $dr^*/dR = 1$. Total differentiation yields $dp^*/dt = (pG_1)/(p^2 + G_1 t) > 0$ and $dx^*/dt = p/(p^2 + G_1 t) > 0$. It follows that $dr^*/dt < 0$. ■

Proof of Proposition 5. (i) It is immediate from the equilibrium magnitudes with ($r^{DI} = R(1 - \beta) - t$) and without ($r^* = R - t/p^*$) insurance (in Propositions 1 and 4) that $r^{DI} > r^* p^*$ if and only if $\beta < 1 - p^*$. Likewise, $r^{DI}/(1 - \beta) - r^* > 0$ if and only if $\beta < 1 - p^*$. This is a necessary and sufficient condition for insurance to increase the probability of failure; recall that in both situations, every bank has half the market and therefore banks are in both cases equally diversified.

(ii) It is easy to show that $r^{\mathrm{DI}} > r^*$ when $\beta < (1 - p^*)(t/Rp^*)$. When $r^{\mathrm{DI}} > r^*$, expected profits fall with insurance since banks pay more for deposits and they can only invest a percentage $(1 - \beta)$ of deposits. Furthermore, the DWL increases with β and, obviously, with the deposit rate paid. With direct competition, the deposit supply to each bank is $\frac{1}{2}$ but banks invest only a percentage $(1 - \beta)$ of deposits with insurance. Diversification-based economies of scale will imply then a mean-preserving spread of the distribution of returns of banks (the size of investment going from $\frac{1}{2}$ to $(1 - \beta)/2$). The deadweight loss associated with a bank is a convex function of the return $(\max(r_i - (1 - \beta)\tilde{R}_i, 0))$ and hence it will increase with a mean-preserving spread of the returns. The result is that the DWL is higher and ETS lower with deposit insurance. ■

Proof of Proposition 6. (i) As before, it is immediate from the equilibrium magnitudes with $(r^{\mathrm{DI}} = (R(1 - \beta) + v)/2)$ and without $(r^* = (Rp^* + v)/2p^*)$ insurance (in Propositions 1 and 4) that $r^{\mathrm{DI}} > r^*p^*$ if and only if $\beta < 1 - p^*$. It follows then that $n^{\mathrm{DI}} > n^*$.

(ii) From Propositions 1 and 4, it follows that in the equilibrium with local monopolies, $\pi^* = t(n^*)^2/p$, $\pi^{\mathrm{DI}} = t(n^{\mathrm{DI}})^2$. Hence, a necessary condition for expected profits to increase with insurance is that insurance extends the market. Next, from Propositions 1 and 4, it is easy to see that $r^{\mathrm{DI}}/(1 - \beta) < r^*$ if and only if $\beta < 1 - p^*$ (exactly the opposite of the competitive case). Furthermore, the unit deadweight loss for a bank in the deposit insurance regime is $(1 - \beta) \int^{r^{\mathrm{DI}}/(1-\beta)} (r^{\mathrm{DI}}/(1 - \beta) - \tilde{R})\, dF$ meanwhile without insurance is $\int^{r^*} (r^* - \tilde{R})\, dF$ and $r^{\mathrm{DI}}/(1 - \beta) < r^*$. As a result, for given n, insurance increases welfare. Next, from (i), when $\beta < 1 - p^*$, insurance extends the market. Thus, we need to show that in an insured world, expected total surplus increases with the size of deposits. We next show that this is so, provided the insurance fund makes nonnegative profits. From Table II, it is clear that total expected surplus with insurance can be written as

$$\mathrm{ETS} = 2\left((R(1 - \beta) - r^{\mathrm{DI}}) + \left(r^{\mathrm{DI}} - v - \frac{t}{2}n\right) + \left(\beta R - (1 - p^{\mathrm{DI}})E\left(r^{\mathrm{DI}} - \tilde{R}(1 - \beta) \middle| \tilde{R} < \frac{r^{\mathrm{DI}}}{1 - \beta}\right)\right)\right)n.$$

That is, expected total surplus equals the sum of expected profits, consumer surplus, and profits of the deposit insurance fund. For given r^{DI}, each of these terms is increasing in n, given that expected profits are nonnegative, that the marginal consumer earns positive surplus, and that, by assumption, the DIF makes no losses. ■

APPENDIX II

We explore market equilibria when banks can influence depositors' perceptions. The timing of the game that we consider is as follows. Banks set rates; depositors, having observed the rates offered, form rational perceptions about the probability of failure, or the market share of each bank, and choose whether to deposit and in which bank. That is, given (r_a, r_b), depositors expect $p_i = 1 - F(r_i; n_i)$, where n_i is the outcome of the expectations game induced on depositors. Once deposits are made, banks make their investments. Returns are realized and interest is paid if the bank does not fail.

This expectations game may have multiple equilibria. In particular, notice that if a positive probability of success requires a minimum size, then no banking or one of the banks left with no clients are always possible: if a depositor believes that nobody will deposit in one bank, the best she can do is not to deposit in this bank either. If she were the only one to deposit, the expected return would be zero. Proposition A.1 characterizes the set of *depositors' equilibria* (n_a, n_b) given (r_a, r_b).

PROPOSITION A.1. *Given $R > r_a \geq r_b > 0$, an expectations subgame with multiple equilibria is induced on depositors:*

(i) *With minimum size investments,* (0, 0) *is always an equilibrium.*

(ii) *With minimum size investments,* (1, 0) *is an equilibrium if $p_a(r_a - R; 1)r_a - t \geq v$. Similarly for* (0, 1).

(iii) *When interior equilibria $(n_a, 1 - n_a)$ exist, they are characterized by $\phi(n_a) = p_b(r_b - R; 1 - n_a)r_b - p_a(r_a - R; n_a)r_a + t(2n_a - 1) = 0$ and $p_a r_a - tn_a = p_b r_b - t(1 - n_a) \geq v$. (A sufficient condition for existence is that both* (1, 0) *and* (0, 1) *are equilibria and that the marginal consumer be willing to deposit.*)

(iv) *There may be equilibria where not all the market is served. The configuration $(n_a, 0)$ with $n_a < 1$ is an equilibrium if $p_a(r_a - R; n_a)r_a - tn_a = v$. Similarly for $(0, n_b)$. The configuration (n_a, n_b) with $n_a + n_b <$ is an equilibrium if both $(n_a, 0)$ and $(0, n_b)$ are equilibria.*

Proof. (i) Suppose that all consumers but one believe that neither bank is able to attract depositors; this consumer does not deposit either, because she would obtain a negative expected surplus since the bank will fail for sure (a positive probability of success can only obtain with a positive mass of consumers).

(ii) (1, 0) is an equilibrium if and only if $p_a(r_a - R; 1)r_a \geq v + t$: if all depositors are with bank a, then a single customer never deposits in bank b; all depositors are willing to deposit in bank a if they obtain a positive expected surplus: $p_a(r_a - R; 1)r_a \geq v + t$.

(iii) If interior equilibria exist, market shares are determined by the modified Hotelling supplies (that is, $\phi(n_a) = 0$) and the marginal depositor has to obtain an expected return larger than v. If both (1, 0) and (0, 1) are equilibria then $\phi(0) \geq v$ and $\phi(1) \leq -v$. Interior equilibria exist provided that the individual rationality condition of the marginal consumer is satisfied.

(iv) Obvious. ■

The fact that a no-banking equilibrium is always possible induces a very large multiplicity of equilibria: any rates which give banks nonnegative profits can be supported as a subgame-perfect equilibrium with the depositors "threat" of reversion to the nonbanking (depositors) equilibrium. Proposition A.2 states the result.

PROPOSITION A.2. *Any pair of deposit rates* (r_a, r_b) *such that* $R \geq r_i$, $i =$ a,b, *can be sustained as a subgame-perfect equilibrium.*

Obviously, it may be argued that the complete set of subgame-perfect equilibria is unreasonable because not all equilibria are renegotiation-proof. Indeed, one might expect that when posted rates diverge from expected rates (i.e., the candidate equilibrium rates), depositors may try to coordinate at equilibria better than the no-banking equilibrium. In other words, there is an argument to focus on renegotiation-proof equilibria.[27] The depositors' equilibria cannot in general be Pareto-ranked,[28] due to the transport cost of depositors. Nevertheless, they can be surplus-ranked. Consumers could thus coordinate on the surplus-maximal equilibria, provided side payments are feasible. We will not pursue this analysis further here but it can be shown that, with respect to the parametric perceptions game considered in the text, competition may be enhanced or attenuated in the present game depending on the extent of diversification economies.

In the absence of scale economies the depositors expectations game is degenerate in the sense that for given rates there is a unique depositors'

[27] Yanelle (1995) considers a similar but enlarged extensive form. She finds a multiplicity of equilibria, and explores several selection criteria including payoff-dominant and risk-dominant equilibria.

[28] Obviously, sometimes equilibria can be ranked. For example, if $p_a(r_a - R; 1)r_a - t \geq p_b(r_b - R; 1)r_b \geq v$, then (1, 0) dominates (0, 1).

equilibrium given by the modified Hotelling demands. This turns out to imply that interior asymmetric equilibria of the whole game cannot exist. The reason is that at an asymmetric equilibrium either firm could mimic its rival and obtain a market share of $\frac{1}{2}$; thus, either one firm or the other would increase profits by setting the same deposit rate as its rival.[29]

[29] We thank Paul Klemperer for this observation and the proof. The argument is as follows: an interior equilibrium requires that $n_a x_a \geq x_b/2$, otherwise a will offer x_b and will get a market share of $\frac{1}{2}$. Similarly, $n_b x_b \geq x_a/2$. This implies that $n_b \geq \frac{1}{4}n_a$. We have then that $1 = n_a + n_b \geq n_a + \frac{1}{4}n_a \geq 1$, from which it follows that $n_a = \frac{1}{2}$ since $n_a + \frac{1}{4}n_a$ is minimized at $n_a = \frac{1}{2}$.

REFERENCES

Aghion, P., Bolton, P., and Dewatripont, M. (1988). "Interbank Lending, Bank Runs and Competition," mimeo, Université Libre de Bruxelles.

Baltensperger, E., and Dermine, J. (1987). Banking deregulation, *Econ. Policy* **April,** 63–109.

Besanko, D., and Thakor, A. (1992). Banking deregulation: Allocational consequences of relaxing entry barriers, *J. Bank Finance* **16,** 909–932.

Besanko, D., and Thakor, A. (1992). Relationship banking, deposit insurance, and bank portfolio choice, *in* "Capital Markets and Financial Intermediation" (C. Mayer and X. Vives, Eds.), pp. 292–319. Cambridge Univ. Press, Cambridge, UK.

Boot, A. W. A., and Greenbaum, S. I. (1991). "Deposit Insurance Reform," Banking Research Center working paper 176, Northwestern University.

Boyd, J. H., and Runkle, D. E. (1993). Size and performance of banking firms, *J. Monet. Econ.* **31,** 47–67.

Bryant, J. (1980). A model of Reserves, bank runs, and deposit insurance, *J. Bank Finance* **43,** 749–761.

Chan, Y., Greenbaum, S. I., and Thakor, A. V. (1992). Is fairly priced deposit insurance possible?, *J. Finance* **47,** 227–245.

Diamond, D. (1984). Financial intermediation and delegated monitoring, *Rev. Econ. Stud.* **51,** 393–414.

Diamond, D., and Dybvig, P. (1983). Bank runs, deposit insurance, and liquidity, *J. Polit. Econ.* **91,** 401–419.

Dybvig, P. H., and Spatt, S. (1983). Adoption of externalities as public goods, *J. Public Econ.* **20,** 231–247.

Economides, N. (1984). The principle of minimum differentiation revisited, *Europ. Econ. Rev.* **24,** 345–368.

Farrell, J., and Saloner, G. (1985). Standardization, compatibility, and innovation, *Rand J. Econ.* **16,** 70–83.

Farrell, J., and Saloner, G. (1989). "Converters, Compatibility, and the Control of Interfaces," working paper, U.C. Berkeley.

Friedman, M., and Schwart, A. (1965). "A Monetary History of the United States, 1867–1960," Princeton Univ. Press, Princeton, NJ.

Fudenberg, D., and Tirole, J. (1984). The fat-cat effect, the puppy dog ploy and the lean and hungry look, *Amer. Econ. Rev. P&P* **74,** 361–368.

Gabszewicz, J., and Thisse, J. F. (1979). Price competition, quality, and income disparities, *J. Econ. Theory* **20,** 340–359.

Gale, D. (1993). Informational capacity and financial collapse, *in* "Capital Markets and Financial Intermediation" (C. Mayer and X. Vives, Eds.), pp. 117–151. Cambridge Univ. Press, Cambridge, UK.

Gale, D., and Hellwig, M. (1985). Incentive-compatible debt contracts: The one-period problem, *Rev. Econ. Stud.* October **52,** 647–664.

Gehrig, T. (1993). "Natural Oligopoly in Intermediated Markets." Discussion Paper 1027, Northwestern University Center for Mathematical Studies in Economics and Management Science.

Gehrig, T. (1992). "Excessive Risk and Banking Regulation: An Example," working paper, University of Basel.

Gennotte, G. (1990). "Deposit Insurance and Bank Competition," working paper, Haas School of Business Administration, U.C. Berkeley.

Gennotte, G., and Pyle, D. (1991). Capital controls and bank risk, *J. Bank. Finance* **15,** 805–824.

Jacklin, C. J., and Bhattacharya S. (1988). Distinguishing panics and information-based bank runs: Welfare and policy implications, *J. Polit. Econ.* **96,** 568–592.

Jaffee, D. (1989). Simposium on federal deposit insurance for S&L institutions, *J. Econ. Perspectives* **3,** 3–9.

Katz, M., and Shapiro, C. (1985). Network externalities, competition, and compatibility, *Amer. Econ. Rev.* **75,** 424–440.

Matutes, C., and Vives, X. (1995). "Imperfect Competition and Risk Taking in Banking, CEPR," working paper 1177, London.

Postelwaite, A., and Vives, X. (1987). Bank runs as an equilibrium phenomenon, *J. Polit. Econ.* **95,** 485–491.

Ronn, E. I., and Verma, A. K. (1986). Pricing risk-adjusted deposit insurance: An option-based model, *J. Finance* **41,** 871–895.

Salop, S. (1979). Monopolistic competition with outside goods, *Bell J. Econ.* **10,** 141–156.

Shaked, A., and Sutton, J. (1983). Natural oligopolies, *Econometrica* **51,** 1469–1484.

Sprague, O. M. W. (1910). "History of Crises under the National Banking System," Government Printing Office, Washington, D.C.

Townsend R. M. (1979). Optimal contracts and competitive markets with costly state verification, *J. Econ. Theory* **21,** 265–293.

Vives, X. (1991). Banking competition and european integration. *in* "European Financial Integration" (A. Giovannini and C. Mayer, Eds.), pp. 9–31. Cambridge Univ. Press, Cambridge, UK.

Winton, A. (1994). "Competition among Financial Intermediaries when Diversification Matters," working paper No. 185, Finance Department, Northwestern University.

Winton, A. (1995). Delegated monitoring and bank structure in an finite economy. *J. Finan. Interm.* **4,** 158–187.

Yanelle, M. O. (1989). The strategic analysis of intermediation, *Europ. Econ. Rev.* **33,** 294–304.

Yanelle, M. O. (1995). "Banking Competition and Market Efficiency," mimeo, CNRS and DELTA-ENS, Paris.