Competition, Adverse Selection, and Information Dispersion in the Banking Industry

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Proprietary information generated through the process of lending can impact the structure of the banking industry. With more competing banks, borrower-specific information becomes more disperse, as each bank becomes informed about a smaller pool of borrowers. This reduces banks' screening ability, creating an inefficiency as more low-quality borrowers obtain financing. Incumbent banks' information advantage may also create difficulties for potential entrants, so that entry should be easier in markets with high borrower turnover or where entrants have specific expertise in evaluating credit risks. We draw implications for whether financial deregulation is likely to increase borrowers' surplus, and what patterns of entry might be observed.

One of the primary functions of banks is to gather information about borrowers and screen creditworthy borrowers from noncreditworthy ones. Much of this information is obtained in the process of lending and in the subsequent "monitoring" role that is often seen as a defining characteristic of bank financing.[1] Moreover, most of this information is proprietary to the lending bank, allowing banks to extract rents from their previous customers. However, in competing for borrowers, banks will be faced with an adverse selection problem to the extent that either borrowers or other banks may be better informed about a particular borrower's prospects. This article explores the implications of this information problem for competition and market structure in the banking industry.

To address these issues, we present a simple model of competition in banking where banks are constrained in the number of loans they can grant (they have "lending capacities"). Moreover, we assume that there is some heterogeneity across borrowers, in that some borrowers have profitable investment opportunities, while others do not. While this characteristic of borrowers is ex ante unobservable, we assume that banks may observe, upon the granting

I would like to thank Giovanni Dell'Ariccia, Glenn Ellison, David Genesove, Denis Gromb, Bengt Holmström, David Scharfstein, Jeremy Stein, Jean Tirole, and an anonymous referee for useful discussions and suggestions, as well as seminar participants at New York University, Stanford University, University of Maryland, University of Pennsylvania, Federal Reserve Board, CEMFI, and University of California at Santa Cruz. Financial support from the National Science Foundation Graduate Fellowship program is gratefully acknowledged. All remaining errors are my own. Address correspondence to Robert Marquez, R. H. Smith School of Business, University of Maryland, College Park, MD 20742, or e-mail: rmarquez@rhsmith.umd.edu.

[1] James (1987) provides evidence on the special nature of bank loans over other kinds of finance. Lummer and McConnell (1989) argue that banks may have access to private information during the life of a loan, so that loan renewals provide a signal of the debtor firm's creditworthiness.

The Review of Financial Studies Summer 2002 Vol. 15, No. 3, pp. 901–926

of a loan, whether borrowers have good projects or not. As a final element, we assume that there is some turnover among borrowers, so that banks have an incentive to compete over any new borrowers.

One implication of this setup is that, since banks learn their borrowers' "types" after granting a loan, any profit-maximizing bank would refuse to continue financing borrowers revealed to be bad. Since information is proprietary and not transferable, these borrowers remain as part of the pool of customers that are unknown to all other banks. We are then able to use this intuition to derive a number of interesting results.

One conclusion of this model is that focusing exclusively on the number of banks may not provide a very good indicator of the competitiveness of a market. One of the main results of the model demonstrates that markets composed of many small banks may actually have higher expected interest rates in equilibrium than markets composed of a few large banks. In our model, increased competition among banks leads to an inefficiency: since each small bank has less information about the market than a large bank would, it is less effective in its screening. This kind of "information dispersion" resulting from increasing the number of banks implies that more bad borrowers will be able to obtain financing, and may lead to an increase in interest rates.

Another result is that incumbent banks' informational advantage can create serious difficulties for banks attempting to enter this market. Entrant banks face larger "adverse selection costs" than incumbents, effectively providing existing banks with an incumbency advantage. This implies that new banks may only choose to enter when they are able to compete on a more or less equal footing with incumbent banks, which occurs when there is a high degree of turnover among borrowers. High turnover erodes an incumbent's informational advantage, thus reducing the adverse selection effect and permitting entry.

A specific application of this analysis is to the financial integration taking place in the European Union through the formation of the common market, or to the deregulation on limits to interstate branching that is under way in the United States. Our analysis suggests that, due to the information asymmetries across banks, entry by new banks may be limited following a deregulation. Also, banks will find entry difficult unless they can quickly acquire information about the market, so that most entry should be in the form of a merger with or an acquisition of an incumbent bank. This provides an entrant bank with a customer base and reduces its informational disadvantage. Some recent empirical work finds that, in Europe, foreign banks have found it rather difficult to enter domestic markets even after the dropping of most regulatory barriers [see Hoschka (1993) and Vesala (1995)], and have done so mainly through acquisitions of or mergers with domestic banks, entering predominantly into the commercial or wholesale banking market rather than the retail market. Whether entry will be welfare enhancing for borrowers remains to be seen, but our analysis offers one reason why borrowers may not benefit: increased inefficiencies in lending after entry may translate into higher interest rates, making the benefits of entry ambiguous.

Much of the existing literature has analyzed the monitoring and information gathering role of bank finance [Diamond (1984)]. The theory of banking under asymmetric information shows that private information about borrowers can allow banks to extract positive profits from some borrowers, even when markets are characterized by pure price competition [see, e.g., Broecker (1990), Sharpe (1990), Riordan (1993), and von Thadden (1998)]. Our article extends these results by focusing on the determinants of the industry structure and profitability. In particular, our framework allows us to parameterize a measure of information asymmetry across banks (borrower turnover) and focus on how changes in that measure affect banks' ability to compete. Moreover, our framework also allows us to differentiate between effects on bank profits stemming from their relative size versus those stemming from superior information.

Entry under information asymmetries has been analyzed by Dell'Ariccia, Friedman, and Marquez (1999). In their model of Bertrand competition with asymmetrically informed banks, new banks find entry blockaded as long as there are already two incumbent banks. We use a similar model and extend it by introducing constraints on banks' information base and lending ability. This is done for two main reasons. The first is to explicitly incorporate a feature of banking markets that many authors have identified as important. Kashyap and Stein (1995), for instance, find that the lending behavior of banks seems to be quite sensitive to exogenous changes in monetary policy. A conclusion of that study is that banks must face limits to their pool of loanable funds. Thakor (1996) provides both theory and evidence that increases in capital requirements for banks decrease aggregate lending. A bank's supply of loanable funds may also be limited by the total pool of customer deposits in its market.[2]

The second reason is more pragmatic. It is well known that capacity constraints for firms are a way of introducing market power into models of price competition [e.g., Kreps and Scheinkman (1983)]. Introducing capacity constraints for banks allows us to focus on situations where banks can hold some degree of market power while at the same time retaining the essence of price (or interest rate) competition for borrowers in a market where information asymmetries should be important.

The rest of the article proceeds as follows. Section 1 lays out the basic model and assumptions. Section 2 provides a preliminary analysis of the

[2] Alternatively, informational asymmetries between outside investors and bank managers may limit a bank's ability to raise funds [Stein (1998)], or banks may have a limited ability to process information or monitor loans [see Gale (1993) and Almazan (1996)]. See also Chiappori, Perez-Castrillo, and Verdier (1995), Yanelle (1995), and Matutes and Vives (1996) for additional reasons.

general model. In Section 3 we specialize the model by imposing symmetry across banks and analyze the symmetric N-bank case. Section 4 drops the symmetry assumption and considers the role of lending capacities and information in a two-bank setting. Section 5 concludes with a discussion and some extensions for future research.

1. Model

Our setup is a form of two-period interest rate competition among banks for loans to borrowers.[3] In period 1, there is a continuum of borrowers, which we normalize to be of size 1. Each potential borrower has an investment project that requires a capital inflow of \$1 and generates a cash flow R with probability θ, and 0 with probability $1-\theta$. This cash flow is observable and contractible, but θ is unknown to either borrower or lender. We assume that $\theta \in \{\theta_l, \theta_h\}$, $\theta_l < \theta_h$, that $\Pr(\theta = \theta_h) = q$, and that this distribution of types of borrowers is common knowledge. We also assume that borrowers have no private resources, that the "safe" interest rate is normalized to 1, and that $\theta_l R < 1$ and $\theta_h R > 1$, so that it is efficient to finance good borrowers but not bad borrowers. Moreover, letting $\bar{\theta} = q\theta_h + (1-q)\theta_l$ denote the average success probability, we assume that $\bar{\theta}R > 1$, so that it is ex ante efficient to grant a loan.

There are N banks, each with a limited amount of loanable funds. We denote the constraint on lending capacity for bank i as $\overline{K}_i$, and assume that $\overline{K} = \sum_{i=1}^{N} \overline{K}_i \leq 1$, so that the aggregate lending capacity of the banking sector is (weakly) binding. We assume that, having granted a loan, a bank learns that borrower's type, θ.

We assume that the nature of competition among banks in period 1 is such that each bank lends to a fraction α_i of borrowers. Given the assumption on aggregate capacity, lending in the first period should be at full capacity, so that $\alpha_i = \overline{K}_i$. (This is the sense in which the model is static.[4]) In period 2, a fraction λ of borrowers exits the market and is replaced by an equal number of new borrowers that have the same distribution over types as the original borrowers. This exit from the market is independent of borrower type, so that we maintain both the population size and the distribution of borrowers the same.

In period 2, banks compete in interest rates for the pool of borrowers. We assume that banks are unable to distinguish between new borrowers and

[3] As will be clear below, we really only consider a static model. However, it is useful, for expositional purposes, to divide the description of the model into two periods.

[4] This creates a direct link between banks' lending capacities and their information base. We leave unmodeled the first-period competition for borrowers, when no bank possesses any private information regarding firms' success probabilities. Since there is no question of project choice [as in Rajan (1992) or von Thadden (1995)], adding a previous period of competition among banks would only complicate the analysis and notation without contributing to the insight of the problem.

borrowers that have been rejected by a competitor bank or who are simply switching banks to take advantage of lower rates. These borrowers comprise what we call the "free market." The timing in period 2 is as follows. First, all banks simultaneously choose an interest rate for the free market. Then, having observed the other banks' rates, they simultaneously choose interest rates for their old customers. Old borrowers then decide whether to stay with their current bank or leave to try to obtain a loan from a competitor bank (at that bank's free market rate). If an old borrower decides to leave its current bank, we assume that it cannot return if it fails to obtain a loan elsewhere.[5] If an old borrower can get the same interest rate from its old bank as from a competitor, we assume that it stays with its current bank. If all banks offer a different rate, all borrowers apply first to the bank with the lower rate. Banks then make loans to all borrowers that have applied to them for credit, up to their capacity to supply loans. All borrowers not served by the bank with the lowest interest rate apply for loans at the bank with the next lowest interest rate, and so on. We assume that banks give credit to unknown borrowers in proportion to their relative frequency in the population.

If more than one bank offers the same free-market interest rate, all tying banks split the market according to the following simple rule. Suppose that a number of banks M all offer the same rate. We assume that all borrowers apply first for a loan to one randomly chosen bank from this group of M banks. Once this bank exhausts its capacity to serve its applicants, all remaining borrowers then apply to another randomly chosen bank, and so on. Therefore each tying bank has an equal probability of being the first (or second, or third, etc.) bank chosen by all the borrowers.[6]

The assumption that banks learn by lending is meant to capture the stylized notion that a borrower's old bank may know more than what is publicly available on a credit record, either from monitoring or having access to books or by observing the kind of projects being undertaken. Therefore banks are able to charge differential rates to their old customers, with the constraint that borrowers can always switch banks if they are offered a better rate.

[5] This assumption simplifies the calculation of the equilibrium strategies. If we allow borrowers to return to their current bank if they are either unable to obtain a loan elsewhere or cannot obtain one at an attractive rate (due to competitors' lending constraints), then banks will have an incentive to offer very low free-market rates in order to attract at least some old good borrowers, significantly complicating the analysis. Moreover, this assumption is consistent with the timing assumptions of the model: if a borrower chooses to seek a loan elsewhere, it may not have the option of returning to its old bank, as that bank will already have exhausted its lending capacity elsewhere.

[6] In most analyses of capacity-constrained competition, the form of market rationing plays a key role [see Davidson and Deneckere (1986)]. In our model, the form of rationing is less important, as the demand for loans is independent of the interest rate charged for rates below the maximum payoff to the project, R. As will be clear, all that matters is that, given the information asymmetries between banks, perfect redistribution of good risks across banks is impossible. Our rationing rule, along with our tie-breaking rule (as well as most others), satisfies this condition.

2. Equilibrium Analysis: The General Model

Before proceeding with the main part of the analysis, we first describe the equilibrium in the subgame after free-market bids have been submitted. Once borrowers are identified as being of low quality (θ_l), no further loans will be extended to them. This implies that in period 2, each bank will release all of its old low-quality borrowers into the market. Also, an implication of allowing each bank to make a final counteroffer to its old customers is that each bank should be able to retain its old good customers by offering a rate sufficiently low so that these borrowers do not switch banks. The rate a bank has to offer to its high-quality customers to prevent them from switching is simply one that is competitive with competitors' market rates, which are observed by each bank before it has to set its own rate for old customers. A competitor bank that offers a rate low enough to attract high-quality borrowers will also attract all low-quality borrowers, leading to losses for this competitor bank.

From this it is clear that the rate banks charge their old customers depends only on the rates charged by competitors, as this is an old borrower's only alternative, and not on its own free-market rate. Therefore, in the analysis of free-market competition (competition for new borrowers), we can ignore the impact of a bank's own interest rate on its profit from old customers, as this profit does not affect a bank's equilibrium free-market strategy. Since our main focus will be on this part of the market, which represents the portion over which banks effectively compete, we subsequently drop the reference to profit from old borrowers in the analysis of equilibrium in the free market.[7]

We first compute the overall distribution of borrowers in the population. Since every bank offers financing to all its old high-quality borrowers, and since a fraction q of borrowers are of high quality, with a fraction $(1-\lambda)$ of them having survived from period 1, the number of loans made to old borrowers by bank i is $\overline{K}_i q(1-\lambda)$. This leaves an amount $K_i = \overline{K}_i - \overline{K}_i q(1-\lambda) = \overline{K}_i(1-q(1-\lambda))$ for financing new borrowers. The pool of free-market borrowers in period 2 is given by the λ new borrowers with average success probability $\bar{\theta}$, as well as the bad borrowers rejected by each bank in period 2. For bank i, these can be calculated as $\mathcal{A}_i \equiv \overline{K}_i(1-\lambda)(1-q)$, since a fraction $(1-\lambda)$ of bank i's old borrowers survived from period 1 and a fraction $(1-q)$ of them were of low quality.

Suppose that $r_i < r_j$ for all $j \neq i$. If $K_i \geq \lambda + \sum_{j\neq i} \mathcal{A}_j$, bank i lends to *all* the new borrowers and all of its competitors' rejected borrowers. If, however, $K_i < \lambda + \sum_{j\neq i} \mathcal{A}_j$, then bank i finances

$$K_i\left(\frac{\lambda}{\lambda+\sum_{j\neq i}\mathcal{A}_j}\right) \text{ new firms } + K_i\left(\frac{\sum_{j\neq i}\mathcal{A}_j}{\lambda+\sum_{j\neq i}\mathcal{A}_j}\right) \text{ rejects} = K_i \text{ total.}$$

[7] It is nevertheless important to have modeled these old borrowers, as this constitutes a major source of market power for each bank.

The interesting case here is the case where at least the capacity of the lowest-rate bank is binding, so that no single bank has the ability to monopolize the entire market. The condition for this to be the case is

$$\overline{K}_i < \frac{\lambda + \overline{K}(1-\lambda)(1-q)}{1+(1-\lambda)(1-2q)}, \quad i = 1, \dots, N. \tag{1}$$

Under Equation (1), we can now directly calculate the profit for each bank.[8] Let $\pi_i(r_i|W)$ denote the profit on the free market to bank i if r_i is strictly smaller than all other rates (the "winning" rate):

$$\pi_i(r_i|W) = K_i\left[\frac{\lambda}{\lambda + \sum_{j\neq i}\mathcal{A}_j}\right](r_i\bar{\theta}-1) + K_i\left[\frac{\sum_{j\neq i}\mathcal{A}_j}{\lambda+\sum_{j\neq i}\mathcal{A}_j}\right](r_i\theta_l - 1). \tag{2}$$

Similarly, let $\pi_i(r_i|L)$ represent the free-market profit for bank i when it has the strictly highest rate among all N banks, assuming all banks submit a bid: $r_i > r_j$ for all $j \neq i$. This free-market profit for a bank with the strictly highest interest rate (the "losing" bank) depends on the proportion of new borrowers left over, which is a function of its competitors' capacities. For concreteness, here we offer an explicit illustration of this payoff function for a model with only two banks, with capacities $\overline{K}_1$ and $\overline{K}_2$:

$$\begin{aligned}\pi_i(r_i|L) = \min&\left\{\lambda\left(1-\frac{K_j}{\lambda+\mathcal{A}_i}\right), K_i\left[\frac{\lambda\left(1-\frac{K_j}{\lambda+\mathcal{A}_i}\right)}{\lambda\left(1-\frac{K_j}{\lambda+\mathcal{A}_i}\right)+\mathcal{A}_j}\right]\right\}(r_i\bar{\theta}-1)\\ &+\min\left\{\mathcal{A}_j, K_i\left[\frac{\mathcal{A}_j}{\lambda\left(1-\frac{K_j}{\lambda+\mathcal{A}_i}\right)+\mathcal{A}_j}\right]\right\}(r_i\theta_l-1).\end{aligned} \tag{3}$$

A final assumption we need to make is that $\pi_i(R|W) > 0$ for all i. This assumption merely guarantees that it will always be profitable for any one bank to serve the market if it is guaranteed to have the winning interest rate and can charge the highest possible interest rate. We can now establish the existence of an equilibrium and provide a partial characterization.

Proposition 1. *The game of interest rate competition on the free market has no pure strategy equilibrium, but a mixed-strategy equilibrium exists. If* $\pi_i(R|L) > 0$ *for all i, then, in any equilibrium, all banks bid on the free market with probability one and at least one bank makes profits equal to* $\pi_i(R|L)$. *If* $\pi_i(R|L) < 0$ *for all i, then, in any equilibrium, at least one bank assigns a positive probability to not bidding on the free market and makes zero profits.*

[8] With $N > 2$ symmetric banks, this condition will always be satisfied: if $\overline{K}_i = \frac{1}{N}$, then $K_i = \frac{1}{N}(1-q+\lambda q)$. The pool of free-market borrowers applying to bank i is $\lambda + \frac{N-1}{N}(1-\lambda)(1-q) = \frac{1}{N}\lambda + (N-1)K_i > K_i$, and the low-rate bank's capacity is clearly binding.

Proof. See the appendix.

While the interpretation of mixed-strategy equilibria is not always straightforward, it is a standard result in models of Bertrand competition with fixed costs that competitors would have an incentive to undercut the offer of any firm using a predictable strategy, so that it would face certain losses. Therefore banks must randomize their interest rate offers in order to prevent competitors from always cornering the market.[9] One possible interpretation is that the randomization is the result of a process in which banks bargain over interest rate offers separately with each borrower. We should then observe a distribution over interest rates across the population of borrowers, instead of a single interest rate offer drawn from the specified distribution.[10]

The lack of a pure-strategy equilibrium in models of competition with information asymmetries has been found by Broecker (1990) and von Thadden (1998) in the context of banking, and for models of price competition with capacity constraints but symmetric information by Kreps and Scheinkman (1983). However, the literature on capacity constraints suggests that, at least for very small capacities, the game should admit a pure-strategy equilibrium: an already constrained firm has no incentive to lower its price in order to increase its market share. The result above demonstrates that the nonexistence of a pure-strategy equilibrium is purely a result of the adverse selection effect: a bank is able to improve its distribution of applicants by undercutting its opponents and hence obtain a higher expected payoff. Therefore, imposing strictly binding constraints on lending does not drive away the result.

Proposition 1 also allows us to partly pin down each bank's reservation interest rate and profit, as $\pi_i(R|L)$ provides a lower bound on its profit when bidding. In any mixed-strategy equilibrium in which banks choose to always participate, each possible interest rate offered must yield the same profit level. However, at the highest interest rate offered, a bank knows that it is sure to be undercut by competitors. Therefore, in equilibrium, at least one bank's expected profit must be equal to this value. Of course, in order for this to be an equilibrium it must be that this profit is positive, as otherwise a bank can opt to not participate in the free market at all, so that its profit is zero.[11]

A comment about one of the assumptions may be useful at this point. The assumption that banks are unable to distinguish between new and old borrowers may seem somewhat extreme given that a firm's credit history

[9] Rajan (1992) analyzes a similar situation where he allows firms to seek competitive bids from many banks. He argues that it is not uncommon to see firms seeking sealed bids from a number of different banks, and that this kind of behavior leads to mixed-strategy equilibria.

[10] I would like to thank Bengt Holmström for suggesting this interpretation.

[11] Note that we can always find parameter values $(\lambda, \theta_h, \underline{\theta_l}, q)$, such that $\pi_i(R|L) > 0$ for all i. Clearly, for λ or q sufficiently large, this will be true. Similarly, for $\overline{K}_i$ sufficiently small, profits should also be positive, even for the bank with the highest interest rate.

is often available.[12] However, we believe that allowing banks to review the credit records of applicant firms before making any loans would not change the results in any qualitative way, as long as this review comes at some per-firm cost. To a borrower's current lender, the review cost is already sunk, so that this bank possesses an informational advantage that translates into a cost advantage over competitor banks. This would be similarly true for entrant banks (analyzed later), who would face larger review costs than all incumbent banks.

Alternatively, similar results are obtained if we assume that some bank-borrower relationships end for exogenous reasons (such as dissatisfaction with services) at a rate λ. Banks will then be unable to distinguish rejected borrowers from those that are changing banks for taste considerations. A further reason for venturing elsewhere for financing might be the constraints on lending capacity of some banks, which may bind when a firm wants to obtain a loan in order to expand output, or which may be subject to exogenous shocks, forcing some banks to curtail their lending.

3. Competition: The Case with $N > 2$ Symmetric Banks

In this section we concentrate exclusively on the case of symmetric banks and investigate the effect of increasing the number of banks. We demonstrate that, in the context of this model, a bank's profitability depends to a large extent on the measure of information asymmetry (λ) in this market. To be explicit, we assume throughout this section that all banks are identical, with $\overline{K}_i = \frac{1}{N}$, so that $\overline{K} = \sum_{i=1}^{N} \overline{K}_i = 1$, and in the aggregate there is no shortage of loanable funds, even though each individual bank's capacity is binding. All results for this section apply to the symmetric mixed-strategy equilibrium of this game.[13] We first provide a version of Proposition 1 that applies to the symmetric game.

Proposition 2. *Assume that $\overline{K}_i = \frac{1}{N}$, $i = 1, \ldots, N$. There exists a symmetric mixed-strategy equilibrium with $F_i = F$ for all $i = 1, \ldots, N$ such that*

- (*i*) *Banks mix over an interval $[\underline{r}, R]$.*
- (*ii*) *F is continuous and strictly increasing.*
- (*iii*) *If $\pi_i(R|L) > 0$ for all i, then equilibrium profits are $\bar{\pi} = \pi_i(R|L)$ for all banks, and all banks always bid on the free market.*

[12] The availability of information concerning borrowers' previous credit arrangements is itself an equilibrium phenomenon [see Padilla and Pagano (1997)]. While banks never have an incentive to share information about their old borrowers in our static model, this incentive may arise in a dynamic framework.

[13] In the two-bank case we analyze later, a restriction to symmetric equilibria would be without loss of generality, since the equilibrium obtained is unique. With $N > 2$ banks, the symmetric equilibrium may not be the unique equilibrium of the game.

(*iv*) *If* $\pi_i(R|L) \leq 0$ *for all* i*, then equilibrium profits are* $\bar{\pi} = 0$ *for all banks. If the inequality is strict, all banks assign a positive probability to not bidding*: $F(R) < 1$.

Proof. See the appendix.

If the profits from all bank's reservation interest rate offer is sufficiently high, then in equilibrium, all banks enter the market and obtain exactly that expected profit. If not, then an equilibrium can only be maintained if banks sometimes refrain from bidding, so that those who do bid have an increased chance of financing some new borrowers.

We now offer one of the main results of the article concerning the equilibrium distribution of borrowers obtaining financing.

Proposition 3. *Let* $\overline{K}_i = \frac{1}{N}$*. If all banks bid, the average quality of borrowers obtaining credit in equilibrium decreases with* N*. Moreover, as* $N \to \infty$*, all borrowers obtain credit.*

Proof. See the appendix.

This result stems from the fact that, even though capacity is sufficient to finance everyone, in equilibrium some borrowers are denied credit since banks need not refinance their own old customers that are known to be poor credit risks. The proposition demonstrates that this rationing is reduced as we increase the number of banks. The intuition comes from noticing that as the number of banks increases, each bank has knowledge of a relatively smaller fraction of the customers. The total pool of free-market borrowers remains unchanged, but the fraction that each bank can "screen" based on its previous knowledge is reduced, so that in effect it faces a worse distribution of borrowers. In equilibrium, this leads to more low-quality borrowers obtaining financing.

A similar result has been found by Broecker (1990) and Riordan (1993) in models of creditworthiness tests. In particular, Broecker finds that, if banks have independent screening technologies, the zero-profit interest rate is an increasing function of the number of banks, since the average success probability of borrowers who obtain financing is decreasing in the number of active banks.[14] There is, however, a subtle difference between those results and ours. In those models, the result is driven by the "winner's curse": as the number of banks increases, the probability that a given bad borrower passes at least one bank's test increases. In our model, the result stems from the fact that, as the number of banks increases, borrower-specific information becomes more dispersed or fragmented, as each bank acquires information

[14] Shaffer (1998) provides evidence consistent with these findings: as the number of banks in a market increases, loan charge-off ratios for each bank increase. This suggests that the average quality of the loan being granted worsens as the number of banks increases.

about a smaller number of borrowers. Each bank becomes less able to distinguish between good and bad credit risks, even though in aggregate the amount of information is unchanged.[15]

This result allows us to state the following proposition concerning equilibrium profits:

Proposition 4. *Let* $\overline{K}_i = \frac{1}{N}$. *There exists some* $\lambda_N^+ < 1$ *such that for* $\lambda > \lambda_N^+$, *free-market profits for all banks are positive* ($\bar{\pi} > 0$), *and are equal to zero for* $\lambda \leq \lambda_N^+$. *Moreover,* λ_N^+ *is increasing in N.*

Proof. See the appendix.

This proposition establishes that if the proportion of new borrowers is large enough, in equilibrium each bank obtains positive profits on the free market. This seems in accordance with our intuition, since if there are enough new borrowers each period (λ is close to 1), so that information asymmetries are low, one possible strategy by a bank is simply to offer the maximum interest rate R on all loans and make a positive profit. However, if the proportion of new borrowers is small, then the bank with the highest interest rate will be left having to finance almost all bad borrowers, and hence cannot expect to make positive profits. The only symmetric equilibrium then is that given in Proposition 2: each bank makes zero expected profits and refrains sometimes from bidding. The reason why λ_N^+ is increasing in N even though aggregate lending capacity is fixed is that as the number of banks increases, the pool of borrowers obtaining credit worsens (Proposition 3).

For completeness, the following limit result highlights the role of adverse selection in determining bank profits and interest rates.

Corollary 1. (*Comparative statics results on the symmetric market equilibrium.*)

(*i*) *Fix aggregate capacity* $\overline{K} \equiv \sum_{i=1}^{N} \overline{K}_i$, *equal to* 1. *For large values of* λ, *banks offer an expected interest rate approaching* R: $\lim_{\lambda \to 1} E[r_i] = R$.

(*ii*) *Fix* $\lambda = 1$. *As aggregate capacity increases, banks' interest rate offers decrease*: $\lim_{\overline{K} \to \infty} E[r_i] = 1/\bar{\theta}$.

As information asymmetries becomes less important, each bank maximizes its profit by charging the highest possible interest rate, since the limit on aggregate lending capacity prevents banks from competing with each other for customers. However, increasing capacity when there are no information asymmetries leads to the usual result of zero profits.

[15] In Broecker (1990), the total amount of *aggregate* information is increasing in the number of banks: one bank administering N independent tests would have better information than just administering one test.

3.1 A comparison across markets

Consider two different banking markets, one a highly concentrated market with few large banks, and another characterized by competition among a large number of small banks. An important question is whether seemingly "more competitive" markets will in fact offer lower rates to borrowers. In this model, the interaction between banks' lending capacities, which determines their information base, and the degree of informational asymmetries determines the expected interest rates, so that the number of banks by itself may not be a sufficiently good proxy for the degree of competition.

Therefore we wish to analyze the effect on expected interest rates of increasing the number of banks, keeping the aggregate lending capacity fixed. In the context of a standard capacity-constrained game, Allen and Hellwig (1986) show that the equilibrium price converges in distribution to the competitive outcome as the number of competitors is increased at the same time as each competitors' capacity is decreased (so that aggregate capacity remains constant). However, in our model there is a countervailing factor that limits the beneficial effects of increased competition: Proposition 3 demonstrates that the average quality of borrowers that obtain credit is decreasing in the number of competing banks. The effect of this is to push interest rates up to compensate for the lower average quality of borrowers, so that whether interest rates decrease because of increased competition or increase because of the worsening of the pool of borrowers is ambiguous.

Table 1 presents expected interest rates for different values of λ and q for a market with either three or four banks, with $\overline{K}_i = \frac{1}{3}$ or $\frac{1}{4}$, respectively. We assume that $\theta_h = .75$, $\theta_l = .25$, and $R = 3$. For the most part, we find

Table 1
Expected interest rates across markets

q	λ	Three banks $E[r]$	Four banks $E[r]$	q	λ	Three banks $E[r]$	Four banks $E[r]$
.2	.9	2.9795	**2.9770**	.6	.4	2.7917	2.8029
.3	.6	2.8995	**2.8955**		.5	2.8276	2.8367
	.7	2.9193	**2.9167**		.6	2.8655	2.8722
	.8	2.9436	**2.9429**		.7	2.9026	2.9071
	.9	2.9709	**2.9701**		.8	2.9376	2.9402
.4	.4	2.8386	**2.8371**		.9	2.9701	2.9712
	.5	2.8520	2.8530	.9	.2	2.7792	2.7958
	.6	2.8750	2.8766		.3	2.8453	2.8559
	.7	2.9035	2.9047		.4	2.8903	2.8974
	.8	2.9348	2.9355		.5	2.9222	2.9269
	.9	2.9673	2.9676		.6	2.9459	2.9491
.6	.2	2.7640	2.7695		.7	2.9642	2.9662
	.3	2.7649	2.7763		.8	2.9786	2.9798
					.9	2.9903	2.9909

$\overline{K}_i = \frac{1}{3}$ or $\frac{1}{4}$, $\alpha_i = \frac{1}{3}$ or $\frac{1}{4}$, respectively. $\theta_h = .75$, $\theta_l = .25$, $R = 3$. Values reported only for equilibria that yielded positive profits. Bold values represent those for which interest rates are lower with four banks.

that expected interest rates are higher with four banks than with three,[16] suggesting that the negative effect of the worsening pool dominates any gain from increased competition.[17] Only for very low values of q, the fraction of high-quality borrowers in the market, do interest rates drop when we increase the number of banks. This occurs because when there are very few high-quality borrowers, the only way to avoid losing money is to offer credit to some of these borrowers, and only the bank with the lowest rate will be able to do so. Increasing N, while keeping the aggregate lending capacity fixed, increases the competition for these few borrowers. (A number of different parameterizations of the model yielded similar results.)

These results have an interpretation in light of the recent consolidation of the banking industry. To the extent that mergers lead to a consolidation of *information* as well as assets, merging banks should be able to reduce the degree of inefficient lending, which may push in the direction of lower interest rates. There has been much debate as to whether the wave of recent mergers and acquisitions in the United States has had a negative impact on the volume of small business loans [Berger Kashyap, and Scalise (1995), Peek and Rosengren (1997)]. Our analysis suggests that perhaps at least a part of this decreased volume may be attributed to more efficient screening of borrowers when information becomes more consolidated.[18]

3.2 Conditions for entry

As alluded to in the introduction, we expect banks to find it easier to enter a market when they are able to compete on a more equal footing with incumbent banks. Incumbent banks' lending constraints may allow for entry by a bank with unused lending capacity as long as incumbents' information advantages are limited.

Proposition 5. *Entry is more difficult the more banks participate in a market. Specifically, let $\overline{K}_i = \frac{1}{N}$ for each of N incumbent banks. There exists some value $\underline{\lambda}_{N+1} < 1$ such that an $N+1$ bank with no previous market presence enters the free market only if $\lambda > \underline{\lambda}_{N+1}$. This cutoff value $\underline{\lambda}_{N+1}$ is increasing in N, the number of incumbent banks.*

[16] While the differences are small, it should be remembered that the model is set up so that $\overline{K}$ remains fixed, even as the number of banks changes, so that at the margin we pick up purely the effects of changes in banks' screening ability.

[17] Two recent articles have demonstrated a similar result. Riordan (1993) uses an application of auction theory to show that interest rates may either rise or fall as the number of lending banks increases. Hoff and Stiglitz (1997) demonstrate that interest rates may rise as the number of banks increases due to the difficulty of enforcing repayment. Since the incentive to renege on debt payments increases with the number of banks, enforcement costs also increase, leading to higher interest rates.

[18] There are reasons to think, however, that larger institutions may be *worse* at monitoring small, regional loans. These loans often require either specialized or local knowledge, and as such may be better monitored by small local banks with strong ties to the community [see Stein (2000) for a model along these lines]. This suggests that postmerger, the new, larger bank may fail to renew many of these small loans. The analysis of this aspect of consolidation is outside the scope of this article. See Peek and Rosengren (1997) and Berger et al. (1997) for a discussion of this issue.

Proof. See the appendix.

The proposition implies that banks should have an easier time entering a market where a large number of new borrowers are seeking financing. When λ is sufficiently large, entrant banks are less disadvantaged relative to incumbent banks and so may find entry profitable. As N increases, the average quality of borrowers obtaining financing decreases (Proposition 3), and incumbents' expected profits decrease, making entry more difficult for fixed values of λ. In the limit, if all borrowers in the market were new or untested ($\lambda = 1$), entry by an equal-sized $N+1$ bank would always occur (independently of N), and no further entry beyond that would be profitable.[19] In this situation, any informational advantage of incumbents would be completely diluted, leaving them at a par with potential entrants.

We should emphasize that in the proposition we keep the total mass of borrowers in the economy fixed, and only change the level of turnover. The result stems from low information asymmetries (high turnover among borrowers) rather than market growth. It should also be noted that, while entry is primarily a dynamic issue and deserves a formal treatment, we believe that the result of limited entry under information asymmetries would continue to hold in a dynamic setting. Dell'Ariccia, Friedman, and Marquez (1999) analyze a related issue and show that the intuition of the static model translates to a dynamic framework. In other words, the adverse selection problem described above, by imposing a larger cost to entrants than to incumbents, should continue to have a similar effect in a multiperiod model.

Finally, it is worth pointing out that this result relies on potential entrants being completely uninformed about all the borrowers in the market. If entrants are able to sort borrowers to some extent, such as if they have specific expertise in evaluating borrowers in certain markets, or if incumbent banks are forced to share borrower-specific information, these conditions for entry should be loosened. Specifically we would expect the threshold values for entry, $\underline{\lambda}_{N+1}$, to be lowered, making entry easier in those situations.

4. The Role of Capacities: A Two-Bank Model

While the previous section analyzed the impact of information on the number of banks and how changes in the number of banks affect competition in the market, we now turn to the analysis of the role of the capacity constraints themselves by focusing on banks' profitability. In order to do so, we specialize the model by assuming that $N = 2$, but drop the assumption of symmetry.

[19] It should be noted that once an equal-sized $N+1^{st}$ bank enters, equilibrium profits for all banks should be zero, since capacity is sufficient to serve the entire market with just any N of the $N+1$ banks. Therefore there should no longer be any incentive for a new bank to enter.

Proposition 6. *Let $\overline{K}_1 + \overline{K}_2 \leq 1$, and assume that $\overline{K}_1 > \overline{K}_2$. Denote the mixed-strategy equilibrium by the distribution functions $\{F_1, F_2\}$ for banks 1 and 2, and let $\mu_i(r)$ represent the mass that bank i puts on r, if any. In this equilibrium, F_1 and F_2 are continuous and strictly increasing over an interval $[\underline{r}, R)$, and equilibrium profits for bank 1 are higher than for bank 2: $\overline{\pi}_1 > \overline{\pi}_2$. Moreover,*

- (i) *If $\pi_2(R|L) > 0$, bank 1 obtains expected profit of $\overline{\pi}_1 = \pi_1(R|L)$, and the lower bound of the support, $\underline{r}$, is given by $\pi_1(\underline{r}|W) = \pi_1(R|L)$. Bank 1 offers interest rate R with probability $\mu_1(R) > 0$, where $\mu_1(R)$ is given by $\pi_2(\underline{r}|W) = (F_1(R) - \mu_1(R))\pi_2(R|L) + \mu_1(R)\pi_2(R|W)$.*
- (ii) *If $\pi_1(R|L) \leq 0$, bank 2 obtains profit $\overline{\pi}_2 = 0$, and $\underline{r}$ is given by $\pi_2(\underline{r}|W) = 0$. Bank 1 obtains profit $\overline{\pi}_1 = \pi_1(\underline{r}|W) > 0$. Bank 2 offers no bid with probability $1 - F_2(R) \geq 0$, which satisfies $\pi_1(\underline{r}|W) = F_2(R)\pi_1(R|L) + (1 - F_2(R))\pi_1(R|W)$.*

Proof. See the appendix.

This kind of result is standard from the literature on capacity-constrained competition. Bank 1, because of its larger capacity, makes greater profit than bank 2, but offers the highest interest rate with positive probability. In effect, bank 2's smaller capacity serves to make bank 1 less aggressive.[20] Bank 2, on the other hand, must ensure that bank 1 does not lose by this strategy, and so must sometimes refrain from bidding whenever bank 1 would otherwise face losses from bidding the highest rate (i.e., if $\pi_1(R|L) \leq 0$). In essence, bank 1's size and information advantage gives it a strategic advantage on the free market.

Some interesting results can be obtained by performing comparative statics on banks' capacities. As the following discussion will show, a change in a bank's capacity has two distinct effects: one stemming from the change in its share of the free market, and the other from the change in its information base. This second effect we believe is new, and reflects how changes in a bank's informational advantage affect its profitability.

In this model, a bank's total lending capacity, $\overline{K}_i$, can be allocated across two segments: a portion is used in granting loans to old good borrowers, and the remainder is allocated to serve free-market borrowers. A bank with larger total capacity should not only have a larger existing market share, but should also compete for a larger fraction of the free market. Therefore we can distinguish between an increase in total capacity, $\overline{K}_i$, that occurs in the initial (unmodeled) period 1, versus an increase that affects only loans to free-market borrowers, K_i, and so can be thought of as occurring at the beginning of period 2.

[20] This stems from the usual equilibrium logic: since the bank whose capacity is larger mixes so as to keep the other bank indifferent, it must shift its distribution up in order to lower its probability of winning. Kreps and Scheinkman (1983) offer the following intuition: since bank 1 now has a relatively larger capacity, it must be less aggressive in its bidding so as to lower the otherwise increased "risk" of losing faced by bank 2.

Corollary 2. *Assume that $\pi_i(R|L) > 0$ for $i = 1, 2$. Then*

- *Bank 1's free-market profit is increasing in its total capacity ($\frac{\partial \overline{\pi}_1}{\partial \overline{K}_1} > 0$) as well as its free-market capacity ($\frac{\partial \overline{\pi}_1}{\partial K_1} \geq 0$). Moreover, $\frac{\partial \overline{\pi}_1}{\partial \overline{K}_1} > \frac{\partial \overline{\pi}_1}{\partial K_1}$.*
- *Bank 1's free-market profit is decreasing in bank 2's total and free-market capacities ($\frac{\partial \overline{\pi}_1}{\partial \overline{K}_2} < \frac{\partial \overline{\pi}_1}{\partial K_2} < 0$).*

Proof. See the appendix.

Increasing bank 1's free-market capacity (K_1) increases its ability to serve new borrowers. As profits are expected to be positive in equilibrium, bank 1 would be better off if it could finance a larger pool of applicants. However, this effect is larger for increases to capacity that also increase bank 1's existing market share. This effect is what we refer to as the "adverse selection" effect. As bank 1's existing market share increases, its informational advantage relative to bank 2 increases. This is equivalent to saying that bank 2 faces a larger adverse selection problem, so that a larger fraction of its applicant borrowers will be bank 1's rejected borrowers. This leaves a larger number of new borrowers for bank 1, so that the expected distribution of borrowers applying to bank 1 is improved. Therefore a bank with a larger total capacity is not only able to increase its profit by serving more borrowers, but also has a greater informational advantage, which translates into a further increase in profits.

When a competitor's capacity increases, two effects operate: less applicant firms are left for the bank with the high rate, and the pool of applicants it faces worsens. Therefore profits must decrease. If, in addition, bank 2's previous market share increases, bank 1 faces an even worse distribution of borrowers, so profits must decrease.

Finally, the corollary is silent on the impact of changes in bank 2's capacity on its own profit. This is consistent with other standard results in models of price competition. Increasing its capacity allows bank 2 to increase its share of the market conditional on winning. However, it also makes bank 1 more aggressive in its bidding, reducing bank 2's probability of winning. The overall impact is therefore ambiguous.[21]

4.1 Implications

The analysis of the previous sections suggests that shocks to the banking industry can have permanent (or long-lasting) effects on its composition. For example, recent studies have argued that shocks that reduce bank capital affect a bank's ability to grant loans [Kashyap and Stein (1995)]. In our

[21] This ambiguity stems from our assumption of exogenously chosen capacities. If increases in capacity have a negative impact on bank 2's profit, free disposal of capacity suggests that bank 2 should reduce its capacity. Alternatively, if banks have a usage of funds other than just granting loans, we should not expect the above derivative to be negative. What can be unambiguously demonstrated is that, as $\overline{K}_2$ increases, the *difference* between the profits of the two banks decreases. In other words, reducing the information disadvantage of bank 2 reduces its competitive disadvantage, even if it leads to lower profits for both banks.

model, banks that reduce their lending activity would also lose information about the borrowers in the market, making competition for future market share more difficult. Therefore banks that are better able to weather these shocks should find themselves in a significantly improved position thanks to their relatively larger information base. Furthermore, to the extent that macroeconomic or monetary policy shocks hit banks across the board, this may allow other competitors (other nonbank intermediaries) to enter these markets and permanently establish a presence.

In a related vein, Berger, Kashyap, and Scalise (1995) find that in the period 1989–1992, the so-called credit crunch, banks curtailed their small business lending, without a significant rebound in the early years after 1992, even though overall growth in commercial and industrial lending seemed to have recovered. Bernanke, Gertler, and Gilchrist (1996) have suggested that this might be consistent with the "flight to quality" phenomenon, although they do not explain the lack of a rebound in this sector. Our analysis offers one possible explanation: the rebound failed to occur precisely because of the information loss concerning small business loans, which can be expected to be most subject to information problems.

4.2 Entry patterns and bank acquisitions

The emerging pattern, particularly in the European market, is for foreign banks entering a domestic market to do so either via acquisitions or via mergers, with very little direct entry. The analysis presented here suggests that, because of informational asymmetries that create difficulties for entry, the most effective way to enter a market may be to buy out an incumbent bank. This provides an entrant not only with an established network, but, more importantly, with information about the market,[22] enabling it to avoid some of the adverse selection problems that a de novo entrant would face.

An argument similar to that used in Section 3.2 can be applied to the two-bank model to demonstrate that, for $\overline{K} \leq 1$, there is always some value of $\lambda < 1$, call it $\underline{\lambda}_3$, such that a third entrant bank could profitably compete in this market only if $\lambda > \underline{\lambda}_3$. However, $\underline{\lambda}_3$ is greater than the minimum value of borrower turnover required for the smaller incumbent bank to make positive profits ($\overline{\pi}_2 > 0$).[23] Along with Corollary 2, this implies that a bank that can come in by buying out bank 1 and, by increasing its free-market capacity, may be able to increase its profit as well.

[22] Vesala (1995) argues that, by acquiring a domestic bank, a foreign bank gets direct access to a customer base and local information. He also suggests that actual foreign rivalry is still fairly limited in many European countries, as the market shares of foreign-owned banks are quite small, and that foreign-owned banks have mostly positioned themselves in the wholesale and corporate banking markets.

[23] The overall pool of borrowers that incumbent bank i faces is $\lambda + \overline{K}_j(1-\lambda)(1-q)$, whereas an entrant faces a pool of size $\lambda + (\overline{K}_1 + \overline{K}_2)(1-\lambda)(1-q)$. The average quality of these borrower is worse than that for an incumbent if $\overline{K}_1, \overline{K}_2 > 0$. Therefore the value of λ that would be required for even a third bank (with no previous market share) to make a nonnegative profit upon entry must be greater than the value that gives a positive profit to both incumbents.

While much work remains to be done to properly address this issue, a model of this kind may be used to develop a theory of bank expansion through acquisitions, leading to a possible consolidation in the industry: consolidation can be viewed as a rational way to tap into new markets. Hoschka (1993) provides some evidence that is consistent with this view. He shows that only the biggest European banks are involved in cross-border operations, with smaller banks operating almost exclusively in domestic markets.

4.3 Comparison to the unrestricted case

It is useful at this point to briefly contrast the results from this section with those of a model where lending constraints are not binding. With unlimited capacities, the bank with the strictly lowest rate would lend to all new borrowers, and the higher-rate bank would finance only all of its competitor's rejected borrowers. Dell'Ariccia, Friedman, and Marquez (1999) provide an analysis of this case. They find that without a constraint to the more informed bank's lending, the less informed bank will never be able to realize a profit on new customers. This occurs because the lack of a capacity constraint leads to unrestricted price competition, which erodes all profits for the more disadvantaged bank. As in our model, however, the more informed bank is able to attain a premium as a result of its superior information.

Dell'Ariccia, Friedman, and Marquez (1999) also find that the intensity of competition implies that an entrant, who faces a worse distribution of applicant borrowers than either incumbent, could not expect to obtain nonnegative profit. Therefore a new bank would never find it profitable to enter this market once there are already two active banks. This occurs independently of the amount of superior information held by the incumbent banks (even if λ is very close to 1). This illustrates one of the usual limitations of models of pure price competition. Capacity constraints provide each bank with a measure of market power and limit the extent to which banks compete with each other, allowing us to analyze how changes in the information structure affect the organization of the industry.

5. Conclusion

We have argued that the presence of information asymmetries among banks regarding the quality of borrowers can affect the competition for their business. Our analysis illustrates that these information asymmetries help determine a bank's profits and its ability to enter new markets, and that these effects are compounded as competition among banks intensifies. In particular, we find that as information asymmetries are reduced, both the possibility of realizing positive profits on new loans and of entering an existing market are increased. We also find that, if entrants do not add significant aggregate capacity to the market, increasing the number of competing banks may actually push interest rates up, as it leads to less efficient screening by banks.

There is some casual evidence that lends support to our theory. Vives (1991) has argued that most trade in banking services in Europe remains limited, even after deregulation. Most of the trade is intraindustry, and varies substantially across different countries, suggesting hidden and persistent economic barriers to entry. This is consistent with our theory that banks find it easier to enter a market when they are either specialized in an industry or when they are on a more equal footing with incumbent banks. Similarly, Hoschka (1993) presents evidence that the small amount of entry that has been observed has been by the largest banks, and that it has mostly taken place in the commercial banking sector rather than the retail sector, where we expect information problems to be greater.

However, there remain a few unresolved issues. While we have taken the lending capacity of banks to be exogenous, it would be useful to analyze the determinants of these limits to lending. For example, competition for deposits imposes another cost that needs to be borne under increased competition, and its role should be analyzed in a dynamic framework that allows for the development of customer relationships. Also, a bank's ability to raise funds may be correlated with depositors'/investors' expectations concerning profitability, so that banks that are perceived as being successful should have an easier time raising funds [Matutes and Vives (1996)], as well as entering new markets.

Another interesting extension is to focus on the ex ante competition for customers. A bank, knowing that in future periods it will have some trapped customers from which it can extract surplus (an issue not analyzed in the text), has an incentive to raise a large pool of funds in order to control a large share of the market. However, raising capacity also lowers future expected interest rates, leading to less surplus extraction from old customers, and hence lowering the incentive to raise lending capacity. The optimum should represent a trade-off between these two effects. Similarly a model of this kind can be useful in analyzing the impact of competition on relationship lending, and may shed some light on the evolution of banking relationships, as well as on their future [see Boot and Thakor (2000) for an analysis of this issue]. These extensions must await further research.

Appendix

Proof of Proposition 1. The proof that no pure strategy equilibrium exists is standard in these kinds of models. Given the rationing and tie-breaking rules, each bank can always improve the distribution of borrowers it finances by undercutting its opponents. This occurs because, by undercutting, each bank improves its access to new borrowers relative to rejected borrowers, so that its expected profits jump up discretely. As there is no interest rate that would guarantee zero profits to all banks playing it, no equilibrium in pure strategies can exist.

To prove the existence of an equilibrium, we follow closely the approach in Allen and Hellwig [1986, proposition 2.4 (which is itself an extension of a result found in Dasgupta and Maskin

(1986) hereafter DM)]. Define $P_i(r_1, \ldots, r_N)$ to be the payoff to bank i as a function of the set of interest rate offers (i.e., if $r_i < r_j\ \forall j \neq i$, $P_i(r_1, \ldots, r_N) = \pi_i(r_i|W)$). First, for $i = 1, \ldots, N$, the payoff P_i is continuous at all $(r_1, \ldots, r_N) \in [0, R]^N$ except where, for some $j \neq i$, $r_i = r_j$. Call the set of all possible interest rate constellations such that P_i is not continuous C_i^{**}, and notice that this is a subset of the set $C_i^* = \bigcup_{j\neq i} C^*(i, j)$, where $C^*(i, j) = \{(r_1, \ldots, r_N)|r_j = r_i\}$. This set is of Lebesgue measure zero in $[0, R]^N$ and of the form required in DM.

Second, we require that $\sum_{i=1}^N P_i(r_1, \ldots, r_N)$ be continuous (which it is), and that P_i be weakly lower semicontinuous and bounded in r_i. But this is clear since $\liminf_{r\nearrow r_i} P_i(r, r_{-i}) \geq P_i(r_i, r_{-i})$, and moreover the profit from undercutting is bounded above by $(R\theta_h - 1)\overline{K}_i$. This demonstrates that all the conditions for an equilibrium to exist from DM are satisfied.

If $\pi_i(R|L) > 0\ \forall i$, it will always be optimal for all banks to offer some bid rather than not bid at all. Let $\{F_i\}_{i=1}^N$ define an equilibrium, where F_i represents the mixing distribution over interest rate offers by bank i. Let $\mu_i(r)$ represent the mass F_i puts on interest rate r, if any, and let $\overline{\pi_i}$ represent the equilibrium expected profit of bank i under the proposed strategies $\{F_i\}_{i=1}^N$. We then know that $\overline{\pi_i} \geq \pi_i(R|L)$, since we require that, $\forall\ r \in supp(F_i)$, $\pi_i(r) \geq \pi_i(R|L)$, where $\pi_i(r)$ is the expected profit of bank i of offering the rate r under the proposed equilibrium. Let $\bar{r}_i = \max supp(F_i)$, and assume, without loss of generality, that $\bar{r}_1 \geq \bar{r}_2 \geq \cdots \geq \bar{r}_N$. (Note that the assumption that $\pi_i(R|L) > 0$ implies that $F_i(\bar{r}_i) = 1$ for all i.) Suppose that $\bar{r}_1 > \bar{r}_2$. Then $\Pr(r_j > \bar{r}_1|j \neq 1) = 0\ \forall\ j$, so that $\pi_1(\bar{r}_1) = \pi_1(\bar{r}_1|L)$. But then, since $R = \text{argmax}_{r_1} \pi_1(r_1|L)$, we must have that $\bar{r}_1 = R$. Since $\bar{r}_1$ is in the support of bank 1's mixing distribution, $\pi_1(R|L)$ will be the equilibrium profit for bank 1.

Suppose instead that $\bar{r}_1 = \bar{r}_2 = \cdots = \bar{r}_k = \bar{r}$ (k need not be different from 2). If $\mu_j(\bar{r}) = 0\ \forall j \neq 1$ (so that no other bank has an atom at $\bar{r}$), then again $\Pr(r_j > \bar{r}_1|j \neq 1) = 0$, and $\pi_1(\bar{r}) = \pi_1(\bar{r}|L) = \pi_1(R|L)$. If $\mu_j(\bar{r}) > 0$ for some $j \neq 1$, $j \leq k$, so that bank j puts positive mass on an interest of $\bar{r}$, it is then clear that no other bank (including bank 1) will put positive mass on $\bar{r}$: $\mu_i(\bar{r}) = 0\ \forall i \neq j$. But then a symmetric argument gives us that $\pi_j(\bar{r}) = \pi_j(\bar{r}|L) = \pi_j(R|L)$, as desired. Therefore, in equilibrium, at least one bank has payoff $\pi_i(R|L)$.

The last part of the proposition is obvious. Assume that $\bar{r}_i = \max\{\bar{r}_1, \ldots, \bar{r}_N\}$. If all N banks were to offer a bid with probability 1, then $\overline{\pi_i} = \pi_i(\bar{r}_i|L) \leq \pi_i(R|L) < 0$. But this bank would be better off not bidding, contradicting the assumption that $\bar{r}_i = \max supp(F_i)$. Therefore equilibrium profits must be zero for this bank. ■

Proof of Proposition 2. The existence of a symmetric equilibrium involves checking that the conditions from DM for a symmetric equilibrium are satisfied (as in Proposition 1), and is omitted.

To show part (i), suppose that the highest rate offered is $\bar{r} < R$. Then any bank would have an incentive to raise its rate to R, which would win with the exact same probability as $\bar{r}$, but would yield strictly higher profits.

The proof that the distribution is atomless and strictly increasing is fairly standard. If some interest rate r^* were charged with positive probability, there would be a positive probability of a tie. Then it would be profitable for some bank j to take mass off of r^* and offer a rate of $r^* - \epsilon$, which would yield higher profits for small enough ϵ, since avoiding the tie has a first-order effect on the average quality of borrowers financed, while the interest rate cut is only a second-order effect. But this contradicts the assumption of an atom at r^* in the symmetric distribution function. Similarly, F not being strictly increasing implies that $\exists$ some interval (r', r'') such that $f(r) = 0$ for $r \in (r', r'')$ (where $f = F'$). But then some bank j would strictly prefer to offer a rate $\frac{r'+r''}{2}$ instead of r', since $\Pr(\frac{r'+r''}{2} < r_i|\forall\ i \neq j) = \Pr(r' < r_i|\forall\ i \neq j)$, but yields a higher profit. This contradicts the assumption that $f(r) = 0$ for $r \in (r', r'')$.

Finally, parts (iii) and (iv) are direct consequences of Proposition 1 and the assumption of a symmetric equilibrium. ■

The proofs of Propositions 3, 4, and 5 make use of the following preliminary result:

Lemma A1. *Let $\overline{K}_i = \frac{1}{N}$, and let γ_i denote the ratio of new to bad applicant borrowers for bank i, where we order banks by their interest rate offer. Then $\gamma_i > \gamma_{i+1}$: the distribution of applicant borrowers for each bank gets worse in i.*

Proof. Assume that $r_1 < r_2 < \cdots < r_N$. First, define G_i as the mass of new borrowers applying to bank i, and B_i as the mass of bad (rejected) borrowers applying to bank i. Also, let H_i denote the number of new borrowers that a bank finances if it has the ith lowest interest rate, and let L_i be the number of low-quality borrowers: if bank i's capacity constraint is binding, $H_i = K_i[\frac{G_i}{G_i+B_i}]$ and $L_i = K_i[\frac{B_i}{G_i+B_i}] = K_i - H_i$. Finally, define b_i^j as the mass of rejected borrowers from bank j that have so far not obtained financing and are applying to bank i for a loan (for $j \neq i$, these borrowers are part of B_i). We can now refer to b_i^i as the mass of rejected borrowers from bank i that have so far not secured financing. These borrowers are not a part of B_i, since bank i need not refinance its own rejected borrowers.

With this notation, the proof now follows directly. Of the L_i rejected borrowers that will be financed by bank i, some portion of them must be borrowers from bank $i+1$. Let this portion of bank $i+1$'s borrowers that are financed by bank i be denoted by ρ, implying that there will be $(1-\rho)b_i^{i+1}$ of bank $i+1$'s borrowers left in the market after bank i allocates its capacity. This implies that the mass of rejected borrowers that will apply to bank $i+1$ will be $B_{i+1} = B_i + b_i^i - L_i - (1-\rho)b_i^{i+1} = B_i - L_i + \rho b_i^{i+1}$, since banks i and $i+1$ are consecutive in their interest rate ordering, so that $b_i^i = b_i^{i+1}$.

Now the ratio of new to old borrowers financed by bank $i+1$, γ_{i+1}, is given by

$$\gamma_{i+1} = \frac{H_{i+1}}{L_{i+1}} = \frac{G_{i+1}}{B_{i+1}} = \frac{G_i - H_i}{B_i - L_i + \rho b_i}.$$

We want to show that γ_{i+1} can never be greater than $\gamma_i = \frac{H_i}{L_i} = \frac{G_i}{B_i}$. Since $L_i = (\frac{B_i}{G_i+B_i})K_i$, we can rewrite this as

$$\frac{G_i}{B_i} > \frac{G_i - H_i}{B_i - L_i + \rho b_i} \Leftrightarrow B_i > B_i - \frac{G_i + B_i}{K_i}\rho b_i.$$

Therefore the ratio of new to old borrowers is decreasing over $i = 1, \ldots, N$. ■

Proof of Proposition 3. Since $\sum_{i=1}^N \overline{K}_i = 1$, it is clear that the only borrowers who in equilibrium fail to obtain financing are those remaining rejected borrowers from the bank with the strictly highest interest rate. Assume, without loss of generality, that $r_1 < r_2 < \cdots < r_N$. Using the notation from the proof of the previous lemma, b_N^N is the number of borrowers from bank N who do not obtain financing. We need only show that b_N^N decreases with N.

Again, using the same definitions from the previous lemma, (G_i, H_i, B_i, L_i), we have $G_i = G_{i-1} - H_{i-1}$ and $B_i = B_{i-1} - L_{i-1} + b_{i-1}^{i-1} - b_i^i$. We can establish two sets of relationships between the borrowers from banks i and $i-1$. At bank $i-1$'s turn, its own remaining rejected borrowers, b_{i-1}^{i-1}, are equal in number to those applying to it from bank i, b_{i-1}^i. Moreover, since bank $i-1$ does not refinance its own borrowers, it is also true that $b_{i-1}^{i-1} = b_i^{i-1}$.

Now, of the L_{i-1} loans to rejected borrowers made by bank $i-1$, a fraction $\frac{b_{i-1}^i}{B_{i-1}}$ of them are made to borrowers from bank i. This implies that $b_i^i = b_{i-1}^i - L_{i-1}\frac{b_{i-1}^i}{B_{i-1}} = b_{i-1}^i[1 - \frac{L_{i-1}}{B_{i-1}}]$. Using the fact that $b_{i-1}^{i-1} = b_i^{i-1} = b_{i-1}^i$, we can substitute this expression into the above and simplify,

$$B_i = B_{i-1} - L_{i-1}\left[1 - \frac{b_{i-1}^{i-1}}{B_{i-1}}\right].$$

We can now define b_N^N recursively. As above, $b_N^N = b_{N-1}^N[1 - \frac{L_{N-1}}{B_{N-1}}]$. Since $b_{i-1}^i = b_{i-1}^{i-1}$, we can write this as $b_N^N = b_{N-1}^{N-1}[1 - \frac{L_{N-1}}{B_{N-1}}]$. But we also know that $b_{N-1}^{N-1} = b_{N-2}^{N-1}[1 - \frac{L_{N-2}}{B_{N-2}}]$, so that

$$\begin{aligned} b_N^N &= b_{N-2}^{N-1}\left[1-\frac{L_{N-2}}{B_{N-2}}\right]\left[1-\frac{L_{N-1}}{B_{N-1}}\right] \\ &= b_{N-2}^{N-2}\left[1-\frac{L_{N-2}}{B_{N-2}}\right]\left[1-\frac{L_{N-1}}{B_{N-1}}\right] \\ &\ \ \vdots \\ &= b_1^1\prod_{i=1}^{N-1}\left[1-\frac{L_i}{B_i}\right]. \end{aligned}$$

Finally, using our definitions for $L_i = K_i[\frac{B_i}{G_i+B_i}]$ and $H_i = K_i[\frac{G_i}{G_i+B_i}]$, we have

$$b_N^N = b_1^1\prod_{i=1}^{N-1}\left[1-\frac{K_i}{G_i+B_i}\right],$$

which, with the initial conditions that $G_1=\lambda$, $B_1=\frac{N-1}{N}(1-\lambda)(1-q)$, and $b_1^1=\frac{1}{N}(1-\lambda)(1-q)$, defines b_N^N. Working backward, one can show that the number of these borrowers that are rationed credit is decreasing in N when all banks bid. From this, we see that as $N\to\infty$, $b_N^N\to 0$, since the b_1^1 goes to zero, while each term in the product is bounded above by one. ■

Proof of Proposition 4. By Proposition 2, in order for all N banks to make a positive profit (in the symmetric equilibrium), it must be that $\pi_i(R|L)>0$. Using again the definition of H_i and L_i as the number of new and bad borrowers financed by the bank with the ith lowest interest rate, the expected payoff for any bank is

$$\pi_i(r)=\sum_{i=1}^{N}\binom{N-1}{i-1}F(r)^{i-1}(1-F(r))^{N-i}\{H_i(r\overline{\theta}-1)+L_i(r\theta_l-1)\}.$$

(This equation again makes use of Proposition 2, where we showed that the mixing distributions of a symmetric equilibrium are atomless, so that we can effectively ignore the ties.) Evaluated at the highest possible interest rate, $r=R$, and assuming all banks bid, we need that

$$\pi_i(R)=\pi_i(R|L)=\left\{H_N(R\bar{\theta}-1)+L_N(R\theta_l-1)\right\}>0, \tag{A.1}$$

which will be true for $\gamma_N=\frac{H_N}{L_N}$ large enough. Note that γ_i is an increasing function of λ, and that as $\lambda\to 1$, $\gamma_i\to\infty$ for all i, since there are essentially no old borrowers. This shows that there must be some λ_N^+ such that for $\lambda>\lambda_N^+$, $\pi_i(R|L)>0$, and the bank with the highest rate makes a positive profit. Since equilibrium profits are $\pi_i(R|L)$ in this case, $\bar{\pi}>0$. For $\lambda<\lambda_N^+$, $\pi_i(R|L)<0$, and so $\bar{\pi}=0$ (again, applying Proposition 2). That $\lambda_N^+<\lambda_{N+1}^+$ follows from Proposition 3, since the pool of rationed borrowers is smaller when there are $N+1$ competing banks. Therefore a higher λ is required to generate positive profits with $N+1$ banks. ■

Proof of Proposition 5. Let the equilibrium strategies be given by $\{F_i\}_1^N$, and profits by $\pi_i(R|\,L)>0$. For an entrant bank, $\pi_{N+1}(R|L)<0$ under this equilibrium, since $\Pr(R<\max_j\{r_j\})=0$ if all banks participate, so that the $N+1$ bank finances the remaining rejected borrowers from the bank with the strictly highest rate among the N incumbents (b_N^N). For $\underline{r}$, the minimum of the support of F_i, we have

$$\begin{aligned}\pi_{N+1}(\underline{r}) &= \pi_{N+1}(\underline{r}|W)\\ &= \frac{\lambda}{\lambda+\sum_i \mathcal{A}_i} K_{N+1}(\underline{r}\bar{\theta}-1) + \frac{\sum_i \mathcal{A}_i}{\lambda+\sum_i \mathcal{A}_i} K_{N+1}(\underline{r}\theta_l-1)\\ &= K_{N+1}\left\{\frac{\lambda}{\lambda+(1-\lambda)(1-q)}(\underline{r}\bar{\theta}-1) + \frac{(1-\lambda)(1-q)}{\lambda+(1-\lambda)(1-q)}(\underline{r}\theta_l-1)\right\},\end{aligned}$$

since $\sum_{i=1}^{N} \overline{K}_i = 1$. For any incumbent bank i,

$$\pi_i(\underline{r}|W)=K_i\left\{\frac{\lambda}{\lambda+\frac{N-1}{N}(1-\lambda)(1-q)}(\underline{r}\bar{\theta}-1)+\frac{\frac{N-1}{N}(1-\lambda)(1-q)}{\lambda+\frac{N-1}{N}(1-\lambda)(1-q)}(\underline{r}\theta_l-1)\right\}.$$

For simplicity, let $K_{N+1} = \lambda + (1-\lambda)(1-q)$. Comparing these last two equations, we see that we can express profits for the $N+1$ bank as

$$\pi_{N+1}(\underline{r}) = \left[\frac{\lambda + \frac{N-1}{N}(1-\lambda)(1-q)}{K_i}\right]\pi_i(\underline{r}|W) + \frac{1}{N}(1-\lambda)(1-q)(\underline{r}\theta_l - 1).$$

As $\lambda \to 1$, $\pi_{N+1} \to \frac{1}{K_i}\lim_{\lambda\to 1}\pi_i(\underline{r}|W)$. However, from Corollary 1, we know that $\underline{r} \to R$ as $\lambda \to 1$, and so $\lim_{\lambda\to 1}\pi_i(\underline{r}|W) = K_i(R\bar{\theta}-1)$. This implies that $\lim_{\lambda\to 1}\pi_{N+1}(\underline{r}) = \frac{1}{K_i}K_i(R\bar{\theta}-1) = (R\bar{\theta}-1)$, which is greater than zero by assumption. Therefore $\exists\ \underline{\lambda}_{N+1}$ such that for $\lambda > \underline{\lambda}_{N+1}$, $\pi_{N+1}(\underline{r}) > 0$, and entry by an $N+1$ bank is profitable. Therefore $(\{F_i\}, F_{N+1}(R) = 0)$ cannot be an equilibrium.

Conversely, suppose that, in the N-bank equilibrium, $\overline{\pi}_i = 0$ ($\pi_i(R|L) \leq 0$). Since for any interest rate offer, $\pi_{N+1}(r) < \pi_i(r)$, no entry would place. Moreover, for $\lambda < \underline{\lambda}_{N+1}$, $\pi_{N+1}(r) < 0$ (even if $\overline{\pi}_i \geq 0$), so that entry is not profitable and $(\{F_i\}, F_{N+1}(R) = 0)$ constitutes an equilibrium. That $\underline{\lambda}_{N+1}$ is increasing in N follows from the fact that the profits of the entrant bank are some constant fraction lower than for incumbent banks, and that λ_N^+ is increasing in N. ■

Proof of Proposition 6. First we need to show that $\nexists$ mass points in the mixing distributions of both banks. Suppose that F_i has an atom at some interest rate r': $\mu_i(r') > 0$. We can compare the payoff for bank j when offering the rate r' versus a rate close to r'. By our tie-breaking rule, this is $\lim_{r\nearrow r'} E[\pi_j(r)] - E[\pi_j(r')] = \mu_i(r')[\frac{1}{2}\pi_j(r'|W) - \frac{1}{2}\pi_j(r'|L)] > 0$. Moreover, $\exists\, \epsilon > 0$ such that bidding $r'-\epsilon$ dominates $r'+\epsilon$ for bank j, so that j would not bid on some interval $[r', r'+\epsilon)$. But then bank i could raise its interest rate above r' and not lose customers, so that r' cannot be optimal for bank i, contradicting the assumption of an atom in F_i. Suppose then that F_i is not strictly increasing: for some interval $(r', r'') \subseteq [\underline{r}, R)$, $f_i(r) = 0$ if $r \in (r', r'')$. As in the proof of Proposition 1, in this case bank j would never offer a rate $r_j \in (r', r'')$. But then bank i can increase its profit by offering a rate $r_i = r'' - \delta$ with positive probability, since this will lead to strictly higher profit than any interest rate offer in a neighborhood or r'. This contradicts the assumption that $f_i(r) = 0$ if $r \in (r', r'')$.

To show that the supports of F_i and F_j are the same, notice that it would never make sense for $\underline{r}_i < \underline{r}_j$, as bank i could raise its rate above $\underline{r}_i$ and win with the same probability but make higher profit. Also, suppose that $\bar{r}_i < \bar{r}_j$ and that $\bar{r}_j < R$. Then bank j could offer a rate of R and win with the same probability as at $\bar{r}_j$. Therefore it would never be optimal for bank j to offer a rate between $\bar{r}_i$ and R. But then bank i would be strictly better off offering a rate close to $R-\epsilon$ instead of $\bar{r}_i$, contradicting that $\bar{r}_i < \bar{r}_j$.

Since both banks mix over the same interval, and since $\overline{K}_1 > \overline{K}_2$, it is immediate that $\pi_1(\underline{r}|W) > \pi_2(\underline{r}|W)$, which demonstrates that $\overline{\pi}_1 > \overline{\pi}_2$.

The rest of the proof is an application of the results from Kreps and Scheinkman (1983) (henceforth KS). If $\pi_2(R|L) > 0$, this implies that $\pi_1\ (R|L) > 0$. From Proposition 1 we know that at least one bank must make profits of $\pi_i(R|L)$, which, following a similar argument to that in KS, must be bank 1, the one with the larger capacity. Since in any mixed-strategy equilibrium every bank must make the same profit on every action played, and since at $\underline{r}$ bank 1 has the lowest bid with probability 1, we can use the condition in the proposition to find the value of $\underline{r}$. Once this is obtained, the results concerning bank 2's strategy and profits follow directly. If $\pi_1(R|L) \leq 0$, the only way to maintain higher equilibrium profit for bank 1 than for bank 2 is if bank 2 does not bid with some probability, which implies that bank 2 must make zero profit. Again, this allows us to find $\underline{r}$, so that the rest of the proposition follows directly from this. ■

Proof of Corollary 2. If bank 1's capacity, conditional on having the strictly higher rate, is not binding, increasing K_1 has no effect on its profit, since $\overline{\pi_1} = \pi_1(R|L) > 0$. If it is binding, then we must check that the average quality of the marginal borrower, $\tilde{\theta}_1$, is greater than $\frac{1}{R}$ in order for bank 1's profit to be increasing in K_1. From Equation (3) we note that we need to check that the first term (after the first "min") does not become binding before the second term (after the second "min"), as otherwise the marginal borrower for bank 1 could be a bad borrower with probability one. However, in order for $\lambda(1 - \frac{K_j}{\lambda + \mathcal{A}_i}) < K_i\left[\frac{\lambda(1-\frac{K_j}{\lambda+\mathcal{A}_i})}{\lambda(1-\frac{K_j}{\lambda+\mathcal{A}_i})+\mathcal{A}_j}\right]$, it must be that $K_i > \lambda(1 - \frac{K_j}{\lambda+\mathcal{A}_i}) + \mathcal{A}_j$. But this would imply that $\mathcal{A}_j < K_i\left[\frac{\mathcal{A}_j}{\lambda(1-\frac{K_j}{\lambda+\mathcal{A}_i})+\mathcal{A}_j}\right]$ as well, so that the first term will never be binding before the second term. Therefore, from Equation (3) we see that the average quality of the marginal borrower is greater than $\frac{1}{R}$, so that increasing K_1 leads to an increase in profit.

The rest of the corollary is more direct. An increase in $\overline{K}_1$ corresponds to an increase in $\mathcal{A}_1$. Again from Equation (3), we see that an increase in $\mathcal{A}_1$ increases the pool of rejected borrowers that bank 2 faces, reducing bank 2's take of new borrowers. This leaves a better distribution of borrowers for bank 1, and so increases bank 1's equilibrium profit beyond what it would obtain from just the increase in K_1.

Conversely, an increase in K_2 increases the share of new borrowers obtained by bank 2, and therefore lowers the equilibrium profit for bank 1 by lowering the average quality of borrower it obtains. Similarly, increasing $\overline{K}_2$ increases $\mathcal{A}_2$, which increases the pool of rejected borrowers faced by bank 1, lowering the average quality of borrower financed by bank 1. ■

References

Allen, B., and M. Hellwig, 1986, "Bertrand-Edgeworth Oligopoly in Large Markets," *Review of Economic Studies*, 53, 175–204.

Almazan, A., 1996, "A Model of Competition in Banking: Bank Capital vs. Expertise," working paper, MIT.

Berger, A., A. Kashyap, and J. Scalise, 1995, "The Transformation of the U.S. Banking Industry: What a Long, Strange Trip It's Been," *Brookings Papers on Economic Activity,* 1995(2), 55–218.

Berger, A., A. Saunders, J. Scalise, and G. Udell, 1997, "The Effects of Bank Mergers and Acquisitions on Small Business Lending," working paper, Board of Governors of the Federal Reserve System.

Bernanke, B., M. Gertler, and S. Gilchrist, 1996, "The Financial Accelerator and the Flight to Quality," *Review of Economics and Statistics,* 78, 1–15.

Boot, A., and A. Thakor, 2000, "Can Relationship Banking Survive Competition?," *Journal of Finance*, 55, 679–713.

Broecker, T., 1990, "Credit-Worthiness Tests and Interbank Competition," *Econometrica*, 58, 429–452.

Chiappori, P.-A., D. Perez-Castrillo, and T. Verdier, 1995, "Spatial Competition in the Banking System: Localization, Cross Subsidies and the Regulation of Deposit Rates," *European Economic Review*, 39, 889–918.

Dasgupta, P., and E. Maskin, 1986, "The Existence of Equilibrium in Discontinuous Economic Games, 1: Theory," *Review of Economic Studies*, 53, 1–26.

Davidson, C., and R. Deneckere, 1986, "Long-Run Competition in Capacity, Short-Run Competition in Price, and the Cournot Model," *RAND Journal of Economics*, 17, 404–415.

Dell'Ariccia, G., E. Friedman, and R. Marquez, 1999, "Adverse Selection as a Barrier to Entry in the Banking Industry," *RAND Journal of Economics*, 30, 515–534.

Diamond, D., 1984, "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies*, 51, 393–414.

Gale, D., 1993, "Informational Capacity and Financial Collapse," in C. Mayer and X. Vives (eds.), *Capital Markets and Financial Intermediation*, Cambridge University Press, Cambridge.

Hoff, K., and J. Stiglitz, 1997, "Moneylenders and Bankers: Price Increasing Subsidies in a Monopolistically Competitive Market," *Journal of Development Economics*, 52, 429–462.

Hoschka, T., 1993, *Cross-Border Entry in European Retail Financial Services*, St. Martin's Press, New York.

James, C., 1987, "Some Evidence on the Uniqueness of Bank Loans," *Journal of Financial Economics*, 19, 217–235.

Kashyap, A., and J. Stein, 1995, "The Impact of Monetary Policy on Bank Balance Sheets," *Carnegie-Rochester Series on Public Policy*, 42, 151–195.

Kreps, D., and J. Scheinkman, 1983, "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes," *Bell Journal of Economics*, 14, 326–337.

Lummer, S., and J. McConnell, 1989, "Further Evidence on the Bank Lending Process and the Capital Market Response to Bank Loan Agreements," *Journal of Financial Economics*, 25, 99–122.

Matutes, C., and X. Vives, 1996, "Competition for Deposits, Fragility, and Insurance," *Journal of Financial Intermediation*, 5, 184–216.

Padilla, A. J., and M. Pagano, 1997, "Endogenous Communication Among Lenders and Entrepreneurial Incentives," *Review of Financial Studies*, 10, 205–236.

Peek, J., and E. Rosengren, 1997, "Bank Consolidation and Small Business Lending: It's Not Just Bank Size that Matters," working paper, Federal Reserve Bank of Boston.

Rajan, R., 1992, "Insiders and Outsiders: The Choice Between Informed and Arm's-Length Debt," *Journal of Finance,* 47, 1367–1400.

Riordan, M., 1993, "Competition and Bank Performance: A Theoretical Perspective," in C. Mayer and X. Vives (eds.), *Capital Markets and Financial Intermediation*, Cambridge University Press, Cambridge.

Shaffer, S., 1998, "The Winner's Curse in Banking," *Journal of Financial Intermediation*, 7, 359–392.

Sharpe, S. A., 1990, "Asymmetric Information, Bank Lending, and Implicit Contracts: A Stylized Model of Customer Relationships," *Journal of Finance*, 45, 1069–1087.

Stein, J., 1998, "An Adverse Selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy," *RAND Journal of Economics,* 29, 466–486.

Stein, J., 2000, "Information Production and Capital Allocation: Decentralized vs. Hierarchical Firms," forthcoming, *Journal of Finance*.

Thakor, A., 1996, "Capital Requirements, Monetary Policy, and Aggregate Bank Lending: Theory and Empirical Evidence," *Journal of Finance*, 51, 279–324.

Vesala, J., 1995, "Testing for Competition in Banking: Behavioral Evidence from Finland," Studies E:1, Bank of Finland.

Vives, X., 1991, "Banking Competition and European Integration," in A. Giovannini and C. Mayer (eds.), *European Financial Integration*, Cambridge University Press, Cambridge.

von Thadden, E.-L., 1995, "Long-Term Contracts, Short-Term Investment, and Monitoring," *Review of Economic Studies*, 62, 557–575.

von Thadden, E.-L., 1998, "Asymmetric Information, Bank Lending and Implicit Contracts: The Winner's Curse," working paper, Universite de Lausanne.

Yanelle, M.-O., 1995, "Price Competition Among Intermediaries: The Role of the Strategy Space," Document No. 95-03, DELTA.