BANK COMPETITION, RISK, AND ASSET ALLOCATIONS: NEW THEORY AND NEW EVIDENCE

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This draft: June 22, 2007

Abstract

We study a new banking model in which banks invest in a riskless asset and compete strategically in both loan and deposit markets. The model predicts a negative relationship between competition and banks' risk of failure, the possibility of endogenous credit rationing for high market concentration values, and a positive relationship between competition and loan-to-asset ratios for certain ranges of parameters. We explore these predictions empirically using a cross-sectional sample of about 2,500 U.S. banks in 2003, and a panel data set of about 2600 banks in 134 non-industrialized countries for the period 1993-2004. With both samples, we find that banks' probability of failure is negatively and significantly related to measures of competition, and that loan-to-asset ratios are positively and significantly related to measures of competition, all consistent with the predictions of the theory. There is no evidence of a trade-off between bank competition and stability, and bank competition seems to foster banks' willingness to lend.

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I. INTRODUCTION

This study deals with one of the most important unresolved policy issues in banking. Since the Great Depression at least, it has been widely held by policy makers that more competition in banking results in *ceteris paribus* greater instability (more failures). Since bank failures are frequently associated with negative externalities, this has been seen as a social cost of "too much competition in banking."

> The legislative reforms adopted in most countries as a response to the banking and financial crises of the 1930's shared one basic idea which was that, in order to preserve the stability of the banking and financial industry, competition had to be restrained. This fundamental proposition was at the root of the reforms introduced at that time in the United States, Italy, and most other countries." Padoa-Schioppa (2001).

A number of important and influential studies have provided support for the conventional wisdom, including Keeley (1990), Allen and Gale (2000, 2004), Hellmann, Murdock and Stiglitz (2000), Repullo(2004), and others. All this work carefully modeled banks' strategic interactions in deposit markets but effectively ignored competition in loan markets and did not consider an asset allocation decision. Now, if taking deposits is the *Yin* of banking, making loans is the *Yang;* thus, this literature studied the *Yin,* ignored the *Yang,* and in so doing overlooked the earlier, seminal work of Stiglitz and Weiss (1981). When banks compete for loan customers, they cannot generally take market conditions as given. In the presence of adverse selection or moral hazard, bank strategies will affect the pool of potential loan applicants, the actions of loan customers, or both. Indeed, these are key characteristics that distinguish loan and securities markets.

Recently, we studied a standard model of deposit market competition (Allen and Gale, 2004) modified in just one respect: we allowed, in a rather conventional way, for loan market competition *a la* Stiglitz-Weiss (Boyd and De Nicolo, 2005). The result was to reverse the conventional wisdom: e.g. in the modified model more bank competition was associated with less, not more, risk of failure. What produced this remarkable reversal of model predictions will become clear in the theory analysis of the next section.

In the present study, we generalize Boyd and De Nicolo (2005) in a fundamental way. The new model allows for imperfect deposit market competition, loan market competition a la Stiglitz-Weiss, and for banks' holding of a risk-free government bond. Realistically, we know that banks' asset choices are not limited to just lending in informationally opaque loan markets. They also acquire bonds and other traded securities in competitive markets in which there is no private information and in which they are price takers. Therefore, it is important to consider an environment in which both kinds of activity can occur simultaneously, and that is what is done here for the first time.

Allowing banks to hold risk-free bonds yields a rich new set of predictions. First, when the possibility of investing in risk-free bonds is introduced, banks' investment in bonds can be viewed as a choice of collateral, and when bond holdings are sufficiently large deposits become risk free. Second, the asset allocation between bonds and loans becomes a strategic variable, since changes in the quantity of loans will change the return on loans *relative* to the return on bonds. Third, the new theoretical environments produce an important new prediction that depends on both loan and bond markets being modeled simultaneously. A bank's optimal quantity of loans, bonds and deposits will depend on the degree of competition. Thus, the banking industry's optimal portfolio choice will depend on the degree of competition. Such a relationship is of more than theoretical interest. One of the key economic contributions of banks is believed to be their role in efficiently intermediating between borrowers and lenders in the sense of Diamond (1984) or Boyd and Prescott (1986). But banks play no such role if they simply raise deposit funds and use them to acquire risk-free bonds. Thus, if competition affects banks' choices between loans and risk-free bonds, there are almost sure to be welfare consequences. To our knowledge, this margin has not been recognized or explored elsewhere in the literature.

Model Predictions

First, the new model predicts a *negative* relationship between the number of banks N and banks' risk of failure, at least when the number of banks is "sufficiently large". Thus, generalization of the model does not reverse the earlier Boyd-De Nicolo (*op. cit.*) result, but continues to contradict the conventional wisdom. Second, there is the rather unsurprising prediction that as N increases profits per bank decline, at least when N gets "sufficiently large". Third, the new model predicts that when N increases "enough", banks will allocate relatively larger amounts of their assets to lending. As mentioned above, this implies that a new dimension may have to be considered when evaluating the social costs and benefits of bank competition.

Note, when taken all together, the three model predictions *appear* counter-intuitive and inconsistent with conventional banking lore. One would think that as profit margins become thin, banks would become riskier and more susceptible to the vagaries of the trembling hand. Yet the model predicts the opposite. Moreover, since loans are subject to default risk and government bonds are not, one would expect that as the loan to bond ratio increases banks become riskier. Yet again, the model predicts the opposite. The key reason for this is that in the model banks' risk choices are *endogenous*, whereas the above conjectures are formulated implicitly assuming risk is exogenously given. This will become clear (and our discussion precise) as we proceed through the theoretical analysis. In terms of predictions, however, "The proof of the pudding is in the eating," and for present purposes that must refer to empirical testing of the model predictions.

We explore the predictions of the model empirically using two data sets: a cross-sectional sample of about 2,500 U.S. banks in 2003, and an international panel data set with bank-year observations ranging from 13,000 to 18,000 in 134 non-industrialized countries for the period 1993-2004. We present a set of regressions relating measures of concentration to measures of risk of failure, to profitability, and to loan to asset ratios. The empirical findings are three. First, banks' probability of failure is positively and significantly related to concentration, *ceteris paribus.* Second, bank profits are positively and significantly related to concentration. Third, the loan to asset ratio is negatively and significantly associated with concentration.   All three results are obtained with both samples, and all three conform to the predictions of theory.

The remainder of the paper is composed of three sections. Section II analyzes the model. Section III presents the evidence. Section IV concludes. Proofs of all propositions are in the Appendix.

I. THE MODEL

The economy lasts two dates: 0 and 1. There are three classes of agents: entrepreneurs, depositors and banks, and all agents are risk-neutral.

Enterpreneurs

There are many entrepreneurs who have no resources, but can choose to operate a risky technology indexed by $S \in [0, \overline{S}]$ The risky technology requires a fixed input, normalized to 1. It yields *S* with probability *p(S)* and 0 otherwise at date 1.

As in Allen and Gale (2004), the probability function $p:[0,\overline{S}] \mapsto [0,1]$ satisfies the following conditions**:** $p\left(\underline{S}\right)=1, p\left(\overline{S}\right)=0, p'<0 \ \mathit{and} \ p''\leq 0$ for all $S \in \left(0,\overline{S}\right)$. These conditions imply that $p(S)S$ is a strictly concave function of *S* and reaches a maximum S^* when $p'\left(S^*\right)S^* + p\left(S^*\right)=0$. Increasing *S* from the left of S^* entails increases in both the probability of failure and expected return. To the right of S^*, the higher *S*, the higher is the probability of failure and the lower is the expected return.

The entrepreneur's (date 0) choice of *S* is unobservable to outsiders. At date 1, outsiders can only verify at a cost whether the investment's outcome has been successful (positive output) or unsuccessful (zero output).

Depositors

To observe the outcome of the entrepreneurs' technology, depositors incur a verification cost assumed sufficiently high as to prevent them from lending to entrepreneurs directly. Thus, they deposit all their funds in banks. The deposits of bank *i* are denoted by D_i, and total deposits by $Z \equiv \sum_{i=1}^{N} D_i$. By assumption, deposit contracts are simple debt contracts. In the event that the outcome of lending is unsuccessful, depositors are assumed to have priority of claims on the bank's assets. Deposits are insured, so that their supply does not depend on risk, and for this insurance banks pay a flat rate deposit insurance premium standardized to zero. The inverse supply of deposits is denoted with $r_D = r_D(Z)$ with $r_D' > 0, r_D'' \geq 0$.[1]

Banks

There are N banks that have no initial resources. They collect deposits and can invest the relevant proceeds in bonds and in loans to entrepreneurs. As in Allen and Gale (2004), banks compete à la Cournot. In our two-period context, this assumption is fairly general. As shown by Kreps and Scheinkman (1983), the outcome of this competition is equivalent to a two-stage game where in the first stage banks commit to invest in observable "capacity" (deposit and loan service facilities, such as branches, ATM, etc.), and in the second stage they compete in prices.

When lending to entrepreneurs, banks can verify whether their projects is successful at a verification cost standardized to zero, and implement simple debt-like loan contracts. Banks cannot observe the entrepreneur's choice of risk *S*, but take into account the best response of entrepreneurs to their choice of the loan rate.

[1] If bank deposits provide a set of auxiliary services (e.g. payment services, option to withdraw on demand, etc.) and depositors can invest their wealth at no cost in the risk-free asset, then deposits and "bond" holdings can be viewed as imperfect substitutes and deposits may be held even though bonds dominate deposits in rate of return.

The entrepreneur's problem and the inverse loan demand

Given a loan rate r_L, entrepreneurs choose $S \in \left[0, \bar{S}\right]$ to maximize: $p(S)(S - r_L)$.

The solution to the above problem, denoted by $\tilde{S}$, satisfies:

$$h(\tilde{S}) \equiv \tilde{S} + \frac{p\left(\tilde{S}\right)}{p'\left(\tilde{S}\right)} = r_L \quad \text{if} \quad r_L < \bar{S}\,, \text{ and } \quad \tilde{S} = \bar{S} \quad \text{if} \quad r_L \geq \bar{S} \tag{1}$$

Let $X = \sum_{i=1}^{N} L_i$ denote the total amount of loans. We assume that the rate of interest on loans is a function of total loans: $r_L = r_L\left(X\right)$, with $r_L' < 0,$. This inverse demand for loans can be generated by a population of potential borrowers whose reservation utility to operate the productive technology differs. Under this assumption, conditions (1) define implicitly the optimal risk choice $\tilde{S}$ as a function of total loans:

$$S(X) = \bar{S} \text{ for all } X \leq \bar{X} \text{ and } S(X) = h^{-1}(r_L(X)) \text{ for all } X > \bar{X} \tag{2}$$

where $\bar{X}$ satisfies $\bar{S} = r_L(\bar{X})$. Thus, if $X \leq \bar{X}$ the total supply of loans is too small (loan rates are too high) and entrepreneurs will choose the maximum level of risk. If $X > \bar{X}$ the total supply of loans is large enough (loan rates are not too high) and enterpreneurs will choose a level of risk lower than the maximum, and their choice of risk is the lower the larger is the supply of loans (the lower is the loan rate), since $\tilde{S}'(X) = h^{-1\prime}(r_L(X))r_L'(X) < 0$ for all $X > \bar{X}$.

Finally, denote with $P(X) \equiv p\left(\tilde{S}(X)\right)$ the probability of a good outcome as a function of total loans. Clearly, $P(X) = 0$ for all $X \leq \bar{X}$, and $P'(X) > 0$ for all $X > \bar{X}$.

The bank problem

Let $L_{-i} \equiv \sum_{j \neq i} L_j$ denote the sum of loans chosen by all banks except bank i. Each bank chooses deposits, loans and bond holdings so as to maximize profits, given similar choices of the other banks and taking into account the entrepreneurs' choice of *S*. Thus, each bank chooses $\left(L, B, D\right) \in R_+^3$ to maximize

$$P\left(L_{-i} + L\right)\left(r_L(L_{-i} + L)L + rB - r_D(D_{-i} + D)D\right) +$$

$$(1 - P(L_{-i} + L)\max\{0, rB - r_D(D_{-i} + D)D\} \tag{3}$$

Subject to condition (2) and,

subject to $\quad L + B = D$. (4)

It is convenient to split the problem above into two sub-problems. The first problem is one in which a bank adopts a no-moral hazard strategy (NMH) ($rB \geq r_D(D_{-i} + D)D$). If no loans are supplied, we term this strategy a *credit rationing* strategy (CR) for the reasons detailed below. The second problem is one in which a bank adopts a moral hazard (MH) strategy ($rB \leq r_D(D_{-i} + D)D$). For ease of exposition, in what follows we substitute constraint (4) into objective (3).

No-moral-hazard (NMH) strategies

If $rB \geq r_D(D_{-i} + D)D$, a bank chooses the pair $\left(L, D\right) \in R_+^2$ to maximize:

$$(P(L_{-i}+L)r_L(L_{-i}+L)-r)L+(r-r_D(D_{-i}+D))D. \quad (5)$$

subject to $\quad rL \le (r-r_D(D_{-i}+D))D. \quad (6)$

Differentiating (5) with respect to D, the optimal choice of deposits, denoted by D^*, satisfies:

$$r-r_D(D_{-i}+D^*)-r_D'(D_{-i}+D^*)D^*=0. \quad (7)$$

Let $\overline{\Pi}(D_{-i}) \equiv (r-r_D(D_{-i}+D^*))D^*$ denote the profits obtained by a bank by rasing deposits and investing in bonds. Thus, a bank chooses $L \ge 0$ to maximize:

$$(P(L_{-i}+L)r_L(L_{-i}+L)-r)L+\overline{\Pi}(D_{-i}), \quad (8)$$

subject to $\quad L \le \overline{\Pi}(D_{-i})/r. \quad (9).$

Let the pair $\{L^*(L_{-i}), D^*(D_{-i})\}$ denote the best-response functions of a bank. Of particular interest is the case in which there is no lending, that is $L^*(L_{-i})$ =0. This occurs when the sum of total lending of a bank's competitors plus the maximum lending a bank can offer under a NMH strategy is lower than the threshold level that forces entrepreneurs to choose the maximum level of risk $\overline{S}$,[2] and under more general circumstances, as detailed below.

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[2] It is straightforward to show that $L^*(L_{-i})=0$ when $L_{-i}+\overline{\Pi}(D_{-i})/r \le \overline{X}$.

We term a NMH strategy that results in banks investing in bonds only a *credit rationing* (CR) strategy. To preview, the intuition for this is as follows. With few competitors in the loan market, it may be that, even though entrepreneurs are willing to demand funds and pay the relevant interest rate, loans will not be supplied. This can happen because the high rent banks wish to extract from entrepreneurs would force them to choose a level of risk so high as to make the probability of a good outcome small. But, importantly, a low probability of a good outcome will also reduce the portion of expected profits deriving from market power rents in the deposit markets. If this probability is small enough, banks' expected profits from lending would be lower than those obtained by holding bonds only. Hence, holding bonds only would be banks' preferred choice. Of course, under this strategy banks are default-risk free.

As we will show momentarily, banks' choice of providing no credit to entrepreneurs may occur as a symmetric equilibrium outcome for values of N not "too large". The occurrence of this case will ultimately depend on the relative slopes of functions $P(.)$, $r_L(.)$ and $r_D(.)$.

Moral-hazard (MH) strategy

Under this strategy, a bank chooses $\left(L,D\right)\in R_+^2$ to maximize:

$$P(L_{-i}+L)[(r_L(L_{-i}+L)-r)L+(r-r_D(D_{-i}+D))D], \tag{10}$$

subject to $$(r-r_D(D_{-i}+D))D\leq rL, \tag{11}$$

and $$L\leq D. \tag{12}$$

Let $\tilde{L}$ and $\tilde{D}$ denote the optimal lending and deposit choices respectively. It is obvious that for this strategy to be adopted , $r_L(L_{-i}+\tilde{L})-r>0$ must hold. If $r_L(L_{-i}+\tilde{L})-r>0$ and constraint (11) is satisfied at equality, then the objective would be $(P(.)r_L-r)L+(r-r_D(D_{-i}+D))D$, which represents the profits achievable under a NMH strategy. Thus, for an MH strategy to be adopted, constraint (11) is never binding.

Let λ denote the Kuhn-Tucker multiplier associated with constraint (12). The necessary conditions for the optimality of choices of L and D are given by:

$$P'(L_{-i}+L)[(r_L(L_{-i}+L)-r)L+(r-r_D(D_{-i}+D))D]$$

$$+P(L_{-i}+L)[r_L(L_{-i}+L)+r_L'(L_{-i}+L)L-r]-\lambda=0 \tag{13}$$

$$P(L_{-i}+L)[r-r_D(D_{-i}+D)-r_D'(D_{-i}+D)D]+\lambda=0 \tag{14}$$

$$\lambda\geq 0\,,\quad \lambda(L-D)=0\,. \tag{15}$$

Recall that an interior solution (constraint (12) is not binding) will entail strictly positive bond holdings ($B>0$, or, equivalently, $L<D$).

We now establish two results which will be used to characterize symmetric Nash equilibria. To this end, denote with $\Pi^{MH}(L_{-i},D_{-i})$ the profits attained under a MH strategy, with $\Pi^{MH}_{B>0}(L_{-i},D_{-i})$ the profits attainable under the same strategy when a bank is constrained to hold some positive amount of bonds, with $\Pi^{NMH}(L_{-i},D_{-i})$ the profits attained under a NMH strategy, and with $\Pi^{CR}(D_{-i})\equiv\bar{\Pi}(D_{-i})$ the profits attainable under a credit rationing (CR) strategy.

The following Lemma establishes that: (a) a CR strategy can dominate a MH strategy when the level of competitors' total *loans* isnot too large, and (b) a MH strategy always dominates a NMH strategy when the level of competitors' total *deposits* is not too small:

Lemma 1

(a) *If* $\Pi^{CR}(0) > \Pi^{MH}(0, D_{-i})$*, then there exists a value* $\tilde{L}_{-i}$ *such that* $\Pi^{CR}(D_{-i}) > \Pi^{MH}(L_{-i}, D_{-i})$ *for all* $L_{-i} < \tilde{L}_{-i}$ *and all* D_{-i}.

(b) *There exists a value* $\tilde{D}_{-i}$ *such that* $\Pi^{MH}(L_{-i}, D_{-i}) > \Pi^{NMH}(L_{-i}, D_{-i})$ *for all* $D_{-i} > \tilde{D}_{-i}$ *and all* L_{-i}.

Proof: See Appendix.

Nash Equilibria

Symmetric Nash equilibria in pure strategies can be of at most of three types: no-moral hazard without lending (i.e. credit rationing, CR), no-moral hazard with positive lending (NMH), or moral hazard (MH) equilibria. The occurrence of one or the other type of equilibrium depends on the shape of the function $P(.)$, the slope of the loan and deposit functions, as well as the number of competitors.

We can state the following proposition:

Proposition 1

(a) *If* $\Pi^{CR}(0) > \Pi^{MH}(0,0)$, *then there exists an* $N_1 \geq 1$ *such that the unique symmetric Nash equilibrium is a credit rationing (CR) equilibrium for all* $N \leq N_1$

(b) *There exists a finite* $N_2 \geq 1$ *such that for all* $N \geq N_2$ *the unique equilibrium is MH.*

Proof : See Appendix

The interpretation of Proposition 1 is straightforward. Part (a) says that if the expected return of a monopolist bank that invests in bonds only is *lower* than the return achievable under a MH strategy, than the CR equilibrium would prevail for a range of low values of N. Thus, this model can generate credit rationing as an equilibrium outcome. Note again that in such equilibria, entrepreneurs are willing to demand funds and pay the relevant interest rate. However, loans are not supplied because the resulting low probability of a good outcome forced on entrepreneurs by high loan rates reduces banks' expected rents extracted in the *deposit* market. Thus, banks prefer to exploit their pricing power in the deposit market only.

This result complements and extends the credit rationing results obtained by Stiglitz and Weiss (1981) and by Williamson (1986). Differing from these authors' set-ups, in our model credit rationing arises as a consequence of bank market structure in an environment where the risk choice of entrepreneurs and banks is endogenous. By contrast, Stiglitz and Weiss' and Williamson's result arises from specific constellations of preference and technology parameters, and there is no risk choice by entrepreneurs and banks.

Part (b) establishes that for all values of N larger than a certain threshold, the unique equilibrium is an MH equilibrium. In such an equilibrium, banks may hold some bonds, or no bonds. The rationale for this result is the mirror image of the previous one. When banks' ability to extract rents is limited because of more intense competition, they will find it optimal to extract rents on *both* the loan and deposit markets by maximizing the option value of limited liability through the adoption of a moral-hazard strategy.

The following proposition establishes the negative relationship between competition (the number of banks N) and the risk of failure in MH equilibria:

Proposition 2 *In any MH equilibrium,* $dX/dN > 0$*,* $dZ/dN > 0$ *and* $dP/dN > 0$.

Proof: See Appendix

With regard to asset allocations, note that an increase in N in a MH equilibrium entails both an increase in total loans and total deposits. Thus, the ratio of loans to assets $\alpha(.) \equiv X/Z = L/D$ will increase (decrease) depending on whether proportional changes in loans are larger (smaller) than proportional changes in deposits.

Note that the model predicts a relationship between asset allocations and the number of banks that can be monotonically increasing beyond certain threshold values of N if the functions describing the demand of loans, the supply of deposits and the probability of a good outcome results in no investment in bonds in a MH equilibrium. In this case, $\alpha(.)$ would jump up to unity when N crosses the threshold value N_2 of Proposition 2(b). However, this will also occur when banks hold bonds *and* the number of banks is not too small, as shown in the following

Proposition 3 *There exists a finite* N_3 *such that for all* $N \geq N_3$, $d\alpha / dN > 0$ *in any interior MH equilibrium.*

Proof: See Appendix.

Our earlier working paper (Boyd, De Nicolò and Jalal, 2006) provides several numerical examples illustrating the foregoing propositions.

Summing up, the key predictions of the model is that banks' risk of failure is strictly *decreasing* in the number of competing firms whenever banks lend some positive amount, and that there can be credit rationing. With regard to asset allocations, the model predicts a loan-to-asset ratio either monotonically increasing in the number of firms, from 0 to a positive value if credit rationing occurs, or for larger values of N if it does not. Next, these predictions are confronted with the data, using measurement consistent with theory.

II. EVIDENCE

We have elsewhere reviewed the existing empirical work on the relationship between competition and risk in banking (Boyd and De Nicolò, 2005), and will not repeat that review here. Very briefly, that body of research has reached mixed conclusions. A serious drawback with most existing work is that it has employed *either* good measures of bank risk *or* good measures of bank competition, but not both. In the present study we attempt to overcome these problems, employing measures of bank risk and competition that are directly derived from the theory just presented.

Our empirical risk measure will be *Z-score* which is defined as $Z = (ROA + EA) / \sigma(ROA)$, where ROA is the rate of return on assets, EA is the ratio of equity to assets, and $\sigma(ROA)$ is an estimate of the standard deviation of the rate of return on assets, all measured with accounting data. This risk measure is monotonically associated with a measure of a bank's probability of failure and has been widely used in the empirical banking and finance literature. It represents the number of standard deviations below the mean by which profits would have to fall so as to just deplete equity capital. It does not require that profits be normally distributed to be a valid probability measure; indeed, all it requires is existence of the first four moments of the return distribution. (Roy, 1952). Of course, in our theory model banks are for simplicity assumed to operate without equity capital. However, in the model the definition of a bank failure is when gross profits are insufficient to pay off depositors. If there *were* equity capital in the theory model, bankruptcy would occur precisely when equity capital was depleted. Thus, the empirical risk measure is identical to the theoretical risk measure, augmented to reflect the reality that banks hold equity.[3]

Also consistent with the theory, we measure the degree of competition using the Hirschmann-Hirfendahl Index (HHI). In Cournot-Nash competition models such as ours, the HHI index is, *ceteris paribus*, positively associated with price-cost margins, a

[3] In a sense equity is already included in the model. That is, the risk choice in our model can be interpreted as embedding a stylized choice of capital to the extent that the amount of capital determines a bank's risk of failure.

standard measure of the degree of competitiveness.[4] As detailed below, in our empirical tests we control for the other key factors that may affect the relationship between the degree of competition and concentration.

Credit Rationing and No Moral Hazard (NMH) Equilbria

Our theory predicts the possible existence of equilibria in which banks hold only risk-free bonds and/or hold a sufficient quantity of risk-free bonds that their deposits are riskless. Although interesting theoretically, such equilibria are not the main focus of this study and therefore we do not feature them in the empirical investigation that follows. However, we conducted some preliminary tests which suggest that those kinds of equlilibria are probably not an important feature of recent US or international data. Recall that in a NMH equilibrium, banks either make no loans at all and hold only risk-free bonds (a credit rationing equilibrium), or they may make some quantity of loans but hold a large (relative) quantity of bonds such their deposits are still fully protected. Either of these occurrences may occur only if N is "sufficiently small." Therefore, we explored the data for evidence of extraordinarily high bond holdings in very concentrated banking markets. In a variety of tests, we found no evidence of such a relationship.[5] In

[4] As remarked by Sutton (2006) with reference to studies of non-financial firms, "that a fall in concentration will lead to a fall in prices and price-cost margins is well-supported both theoretically and empirically". Evidence on a positive relationship between concentration and price-cost margins is reviewed in Berger et al (2003) for U.S. banks, and Corvoisier and Gropp (2002) for European banks.

[5] For example, we estimated non-linear regressions with loans / deposits (bond / deposits) the dependent variable and found no evidence of significant nonlinearities. Similarly, we estimated "break regressions" allowing for discontinuous jumps at high concentration and found no evidence of breaks.

the United States, however, it is clear that we could not reasonably expect to observe credit rationing of the kind predicted by our model, at least not during the last 30 years. Since 1977 the Community Reinvestment Act has required banks to lend a substantial fraction of their assets in the geographic areas in which they raise deposits.

In the empirical tests that follow, therefore, we investigate only simple, monotonic relationships between HHI measures of competition and Z-score, and between HHI measures of competition and the loan to asset ratio.[6] More work on equilibrium credit rationing and NMH equilibria is left for the future.

Samples

We employ two samples with very different characteristics. Each has its advantages and disadvantages and the idea is to search for consistency of results. The first sample is composed of 2500 U.S. banks that operate only in rural non-Metropolitan Statistical Areas, and is a cross-section for one period only, June, 2003. The banks in this sample tend to be small and the mean (median) sample asset size is \$80.8 million (\$50.2 million). For anti-trust purposes, in such market areas the Federal Reserve Board (FRB) defines a competitive market as a county and maintains and updates deposit HHIs for each market. These computations are done at a very high level of dis-aggregation. Within each market area the FRB defines a competitor as a “banking facility,” which

[6] Recall that if NMH equilibria are possible, the risk of failure may exhibit a discrete jump at some interior value of N and thus be non-monotonic in N. We also conducted empirical tests looking for a non-monotic relationship between competition and *Z-score*, but found no evidence of such in either sample.

could be a bank or a bank branch. This U.S. sample, although non-representative in a number of ways, exhibits extreme variation in competitive conditions.[7] The U.S. sample has another important and unique feature. We asked the FRB to delete from the sample all banks that operated in *more than one deposit market area.*[8] By limiting the sample in this way, we are able to directly match up competitive market conditions as represented by deposit HHIs and individual bank asset allocations as represented by balance sheet data. This permits a "clean" test of the link between competitive conditions and asset composition, as predicted by our theory.[9] [10] Obviously, computation of the HHI statistics was done before these deletions, and was based on all competitors (banks and branches) in a market.

The second sample is a panel data set of about 2700 banks in 134 countries *excluding* major developed countries over the period 1993 to 2004, which is from the *Bankscope* (Fitch-IBCA) database. We considered all commercial banks (unconsolidated

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[7] For example, when sorted by HHI, the top sample decile has a median HHI of 5733 while the bottom decile has a median HHI of 1244. The sample includes 32 monopoly banking markets.

[8] The "banking facilities" data set is quite different from the Call Report Data which take a bank as the unit of observation. The banking facilities data are not user-friendly and we thank Allen Berger and Ron Jawarcziski for their assistance in obtaining these data.

[9] These "unit banks" have offices in only one county; however, they may still lend or raise deposits outside that county. To the extent that they do, our method for linking deposit market competition and asset portfolio composition will still be noisy. Still, we think this approach is better than attempting to somehow aggregate HHI's across different markets.

[10] The FRB-provided deposit HHI data allow us to include (or not) savings and loans (S&Ls) as competitors with banks, which could provide a useful robustness test. S&L deposits are near perfect substitutes for bank deposits, whereas S&Ls compete with banks for some classes of loans and not for others.

accounts) for which data are available. The sample is thus unaffected by selection bias, as it includes all banks operating in each period, including those which exited either because they were absorbed by other banks or because they were closed.[11] The number of bank-year observations ranges from more than 13,000 to 18,000, depending on variables' availability.

The advantage of this international data set is its size, its panel dimension, and the fact that it includes a great variety of different countries and economic conditions. The disadvantage is that bank market definitions are necessarily rather imprecise. It is assumed that the market for each bank is defined by its home nation. Thus, the market structure for a bank in a country is represented by an HHI for that country. To reduce possible measurement error from this source, we did not include banks from the U.S., western Europe and Japan. In these cases, defining the nation as a market is problematic, both because of the country's economic size and because of the presence of many international banks.

A. Results for the U.S. Sample

Table 1 defines all variables and sample statistics, while correlations are reported in Table 2. Here, *Z-score* ($Z = (ROA + EA)/\sigma(ROA)$) is constructed setting EA equal to

[11] Coverage of the Bankscope database is incomplete for the earlier years (1993 and 1994), but from 1995 coverage ranges from 60 percent to 95 percent of all banking systems' assets for the remaining years. Data for 2004 are limited to those available at the extraction time.

the ratio of the quarterly average over three years of the book value of equity over total assets*;* ROA equal to the ratio of net accounting profits after taxes to total assets*;* and $\sigma(ROA)$ equal to the quarterly standard deviation of the rate of return on assets computed over the 12 most recent quarters. As shown in Table 1, the mean Z-score is quite high at about 36, reflecting the fact that the sample period is one of profitable and stable operations for U.S. banks. The average deposit HHI is 2856 if savings and loans are not included, and 2655 if they are.[12] Forty six of the fifty states are represented.

We estimate versions of the following cross-sectional regression:

$$X_{ij} = \alpha + \beta HHI_j + \gamma Y_j + \delta Z_{ij} + \varepsilon_{ij}$$

where X_{ij} is *Z-score*, or the loan-to-asset ratio of bank i in county j, HHI_j is a deposit HHI in county j, Y_j is a vector of county-specific controls, and Z_{ij} a vector of bank-specific controls.

In these regressions, variables Z_{ij} control for certain differences between the abstract theoretical model and the real world. First, we need to control for bank heterogeneity. In the theory, all banks are the same size in equilibrium. In reality, that is not so and we need to control for the possible existence of scale (dis)economies. For this purpose our control variable is the natural logarithm of total bank assets, *LASSET.* Second, in reality banks do not employ identical production technologies, as they do in the theory. To control for differences in technical efficiency across banks, we include the

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[12] To put these HHI's in perspective, suppose that a market had four equal sized banks. Then its HHI would be 4 x 25 ** 2 = 2500.

ratio of non-interest operating costs to total income, *CTI.* Thirdly, comparing HHIs across markets requires that we control for market size (see Bresnahan, 1989). An HHI may be mechanically lower in large markets, since a greater number of firms can profitably operate there. Our control variable for economic size of market is the product of median per capita county income and population, *TOTALY,* which is essentially a measure of total household income in county, trimmed for the effect of outliers.

We also need to control for differences in economic conditions across markets, especially differences in the demand for bank services. Three variables, all computed at the county level, are included for this purpose: the percentage growth rate in the labor force, *LABGRO;* the unemployment rate, *UNEM*; and an indicator of agricultural intensity, *FARM,* which is the ratio of rural farm population to total population. This variable is included because many of the counties in our sample are primarily agricultural, but others are not. Thus we need to control for possible systematic differences in agricultural and non-agricultural lending conditions. To further control for regional variations in economic conditions all regressions also include state fixed effects.

For each dependent variable, we present two basic sets of regressions. The first set is robust OLS regressions with state fixed effects, and the second set adds a clustering procedure at the county level to correct significance tests for possible locational correlation of errors.[13]

[13] See Wooldridge (2003).

Finally, whenever the range of a dependent variable is the unit interval (in our case, the ratios of equity to assets and loans to assets), we use a Cox transformation to turn it into an unbounded variable.[14]

Z-score regressions

In Table 3. we present regressions in which Z-score, our risk of failure measure, is the dependent variable. 3.1 is a regression of Z-score against *HHI0,* our six control variables (*LABGRO,UNEM, FARM,TOTALY, LASSET, CTI),* and with state fixed effects. The coefficient of *HHI0* is negative and statistically significant at usual confidence levels. The same is true when HHI100 is employed instead of *HHI0*. (In Table 3. and throughout, results with HHI100 are shown in the last row.) Among the control variables, the coefficient of CTI is negative and highly significant, suggesting that cost inefficiency may adversely affect risk of failure. The coefficient of LASSET enters with a negative and highly significant coefficient.

Regression 3.2 is identical to 3.1 except that it employs clustering at the county level, there being 1280 counties included. This procedure seems to have little effect on estimated standard errors. To summarize, these results suggest that more concentrated bank markets are *ceteris paribus* associated with greater risk of bank failure.

[14] The Cox transformation for x is $ln(x/(1-x))$. Throughout, variables transformed in this way are labeled "*x_cox.*"

Regressions of Z-score components

In this set of regressions, we separately examine each of the three components of *Z-score* (ROA , EA and $\sigma(ROA)$). This is done for three reasons: first, check the model-predicted relationship between concentration and profitability; second, to see if we can determine which is principally driving the observed negative relationship between concentration and *Z-score*; and thirdly as a robustness check.[15]

Table 4. presents regressions with the rate of return on assets, *ROA,* as the dependent variable, and follows our same progression of regression specifications discussed earlier. In all the regressions, *ROA* is positively and significantly related to the HHI index. Also, *ROA* is positively and significantly associated with bank size, *LASSET,* in all specifications, and negatively and significantly associated with *CTI* , as might be expected. In sum, these results suggest that there exists a positive relationship between concentration and bank profitability.

Some related but different regressions are presented in Table 5. These employ a different dependent variable, *LPROFITS*, which is the log of bank profits plus an arbitrary constant (large enough to avoid taking negative logs). This variable is not a component of *Z-score,* and these tests are included for a different reason. As discussed in our working paper (Boyd, DeNicolo, Jalal, 2006), the predictions of theory pertain to profits, not to the ratio of profits/assets. Dividing by profits by assets is not just a benign scaling operation in this case because both assets and profits are endogenous variables.

[15] These tests with components of Z-score must be interpreted cautiously, however, since several of them are significantly correlated (Table 2).

(Both decrease with N, but not necessarily at the same rates). In any case, in Table 5. we obtain U.S. dataset results very similar to to those in 4.1 and 4.2: profits are negatively and significantly related to both measures of the HHI index.

Table 6. presents regressions in which the dependent variable is the (transformed) bank capitalization ratio, *EA_cox*. In no specification do we find a statistically significant relation between measures of an HHI index and *EA_cox*. Table 7. presents regressions in which the dependent variable is the natural logarithm of the standard deviation of the return on bank assets, $Ln(\sigma(ROA))$, (taking logs ensures that the values of the standard deviation predicted by the regression are non-negative). In all four specifications, this variable is positively and significantly associated with the HHI measures.[16]

[16] Note that in all specifications, $Ln(\sigma(ROA))$ is positively and significantly associated with CTI, suggesting that profits are less volatile for banks with more efficient production technologies.

Taken together, these results indicate that the positive association between market concentration and risk of failure is driven primarily by a positive association between concentration and volatility of the rate of return on assets. This relationship is strong enough to overcome a positive and significant relationship between concentration and bank profitability.

Asset Composition Regressions

Table 8 presents regressions in which the dependent variable is the (transformed) ratio of loans to assets, *LA_cox*. In 8.1 we see that this measure is negatively and significantly related to both HHI measures at about the one percent confidence level. Regressions 8.2 adds the county clustering procedure, but this seems to have little effect on confidence intervals. Thus, consistent with the theory, the U.S. data suggest that in more concentrated markets banks are *ceteris paribus* less committed to lending and more committed to holding risk-free bonds.

On Endogeneity

In all these tests, the key explanatory variable is the HHI index and a possible problem empirically is that HHI could be partially an endogenous function of local economic conditions. The latter could also affect the risk of failure resulting in a serious model misspecification. For example, assume hypothetically that bankers in some markets are for some reason characterized by exceptionally low risk-aversion. Over time, this could result in more bank failures leading to exceptionally high HHI measures in those markets. In this (purely hypothetical) example, risk of failure is exogenous, a function of preferences, and the resulting HHI is an endogenous function.

Table 2. shows that the two HHI measures are significantly correlated with bank size (*LASSET)* as expected, and with several of the economic control variables including market size (*TOTALY*), and agricultural intensity (*FARM).* In terms of simple correlations, the HHI index seems to be primarily associated with large banks operating in small, agricultural markets.

To test for a possible specification problem, we employed several different procedures of instrumenting for the HHI index, and we conducted such tests with all the dependent variables including *Z-score*, *LNASSET, PA, EA and* $\sigma(ROA)$. Briefly, we found is that in all cases, with a Hausman test the null hypothesis was not rejected--meaning that ordinary least- squares yielded consistent estimates. To be abundantly cautious, however, we went ahead and did instrumental variables estimates employing a GMM procedure (even though the Hausman test indicated that this was unnecessary). In no case were the results with HHI qualitatively affected, and in almost all cases the coefficient of HHI increased both in absolute value and in significance.[17] In sum, we do not believe that our estimates are significantly affected by endogeneity of the HHI index.

To summarize, results with the U.S. sample suggest that more concentrated bank markets are *ceteris paribus* associated with greater profitability, higher risk of failure, and with lower bank commitment to lending. The empirical findings seem robust, and

[17] However, these instrumental variable results have to be interpreted cautiously. In most cases a Hansen-Sargan test rejected the joint null hypothesis that the instruments are uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation.

are supported by many other regressions using different specifications that, for brevity, are not presented.[18]

B. Results for the International Sample

Table 9 reports definitions of variables and some sample statistics for banks and macroeconomic variables. There is a wide variation across countries in terms of income per capita at PPP (ranging from US$ 440 to US$ 21,460), as well as in terms of bank size.

Here, *Z-score at each date* is defined as $Z_t = (ROA_t + EA_t)/\sigma(ROA_t)$, where ROA_t is the return on average assets, EA_t is the equity-to-assets ratio, and $\sigma(ROA_t) = | ROA_t - T^{-1}\sum_t ROA_t |$. When this measure is averaged across time, it generates a cross-sectional series whose correlation with the Z-score as computed previously is about 0.89. The median *Z-score* is about 19. It exhibits a wide range, indicating the presence of banks that either failed (negative Z) or were close to failure (values of Z close to 0), and banks with minimal variations in their earnings, with very large Z values.

[18] These effects also appear to be of "economically relevant" magnitudes. For example, a one standard deviation increase in the banks-only HHI results in a decrease in the predicted Z-score of __add numbers , which is about _add numbers_% of the sample mean Z-score. A one standard deviation increase in the banks-only HHI results in a decrease in the loan/asset ratio of .0085, which is about 1.7% of sample mean loan/asset ratio.

We computed HHI measures based on total assets, total loans and total deposits. The median asset HHI is about 19, and ranges from 391 to the monopoly value of 10,000. The correlation between the HHIs based on total assets, loans and deposits is very high, ranging from 0.89 to 0.94.

Table 10 reports correlations among some of the banking and macroeconomic variables. The highest correlation is between the asset-based HHI and GDP per capita. This correlation is negative (-0.30) and significant at usual confidence levels, indicating that relatively richer countries have less concentrated banking systems. This is unsurprising, since GDP per capita can be viewed as a proxy for the size of the banking market. [19]

As before, we present regressions in which *Z-score,* its components, and the loan to asset ratio are the dependent variables. We estimate versions of the following panel regression:

$$X_{ijt} = \sum \alpha_i^1 I_i + \sum \alpha_j^2 I_j + \beta HHI_{jt-1} + \gamma Y_{jt-1} + \delta Z_{ijt-1} + \varepsilon_{ijt}$$

where X_{ij} is the Z-score, the Z-score components, or the loan-to-asset ratio of bank i in country j, I_i and I_j are bank i dummy and country j dummy respectively, HHI_j is a Hirschmann-Hirfendahl Index in country j, Y_j is a vector of country-specific controls, and Z_{ij} a vector of bank-specific controls. Two specifications are used. The first is with country fixed effects, the second is with firm fixed effects. The HHI, the macro variables

[19] Interestingly, the U.S. sample exhibits an identical negative and significant correlation (-0.30) between median county per-capita income and *HHI0* (Table 2).

and bank specific variables are all lagged one year so as to capture variations in the dependent variable as a function of pre-determined past values of the dependent variable.[20]

In these regressions, the vector of country-specific variables Y_{jt} includes GDP growth and inflation, which control for cross-country differences in the economic environment, and GDP per capita and the logarithm of population, which control for differences in relative and absolute size of markets (countries) as well as supply and demand conditions for banking services, and the exchange rate of domestic currency to the US dollar, since bank balance sheet values are all expressed in dollar terms. Firm variables Z_{ij} include the logarithm of total assets, which controls for the possible existence of scale (dis)economies, and the ratio of non-interest operating costs to total income, which controls for differences in banks' cost efficiency.

Z-score **regressions**

In Table 11 we present a set of regressions in which *Z-score* is the dependent variable. Regressions 11.1 and 11.2 regress *Z-score* against the HHI based on total assets. In both cases, the coefficient of the HHI index is negative and highly significant. Regressions 11.3 and 11.4 are the same as 11.1. and 11.2 except that they include country specific macroeconomic variables. The addition of these variables does not change the relationship between *Z-score* and the HHI index, which remains negative and highly significant.

[20] This is a fairly standard specification consistent with our two-periods models. See, for example, Demsetz and Strahan (1997).

Regressions 11.5 and 11.6 are the same as 11.3 and 11.4, except that they add bank size and the cost-to-income ratio as additional control variables. Again, the coefficient of HHI based on total assets remains negative and highly significant. The bottom panel of Table 11 reports the estimated coefficients of loan and deposit HHI's for each of the regressions described. While results are similar to those using the asset HHI, the negative effect on the Z-score of changes in HHI are stronger when concentration is measured on deposits rather than on loans. The fact that the coefficient of asset HHI is the largest and always highly significant suggests such a measure may better capture competitive effects related to *all* bank activities, rather than those related to deposit-taking or loan-making activities only.[21]

In sum, as in the U.S. sample these results clearly suggest that more concentrated bank markets are *ceteris paribus* associated with greater risk of bank failure.

Regressions of Z-score components

Similarly to what was done previously, Table 12 reports regressions of the components of *Z-score* at each date as dependent variables: returns on assets (*ROA*), the

[21] It is peripheral to this study but noteworthy that in these tests larger banks exhibit *higher* insolvency risk*,* as the coefficient associated with bank size is negative and highly significant. (Recall, a similar result was obtained with the U.S. sample). Comparable results have been obtained for samples of U.S. and other industrialized country large banks obtained by De Nicolò (2000) for the 1988-1998 period, and with international regressions in De Nicolò et al. (2004). Thus, a *positive* relationship between bank size and risk of failure seems to have been a feature common to both developed and developing economies in the past two decades.

(transformed) ratio of equity capital to assets (*EA_cox*) and the (log-transformed) volatility of earnings, Ln(σ(ROA)).

In 12.1 and 12.2 *ROA* is not significantly related to the asset-based HHI, but is p*ositively* and significantly related to the loan-based HHI's in both specifications 12.1 and 12.2 and to the deposit-based HHIs in specification 12.2.[22] In 12.3 and 12.4. the Capitalization is *negatively* and significantly associated with the HHI measures in all six specificatons. In 12.5 the volatility of ROA, $ln\,\sigma(ROA)$ is positively and significantly correlated with the HHI in two of the three specifications. Finally in specification 12.6, the relationship between HHI and $ln\,\sigma(ROA)$ is insignificant in two specifications, and negative and marginally significant in the third.

As discussed in the last section, the profits prediction of theory pertains to profit levels, not to the ratio of profits/assets. So, for testing the predictions of theory we again employ the dependent variable *LPROFIT,* which is the log of bank profits plus an arbitrary constant (large enough to avoid taking negative logs). These results are shown in Table 13, and they are much stronger than those in Table 12. In all specifications the relationship between the HHI index and *LPROFIT* is positive and statistically significant.

Taken at face value, these results suggest that in the international data it is primarily differences in capitalization that produce the negative relationship between concentration and the Z-score measure of banks' risk of failure. That is, in more

[22] Recall that with the U.S. sample, ROA is *positively* and significantly related to HHI in all specifications, consistent with the theory. Here, the results seem weaker, but where the relationship is statistically significant it is also positive. (Also, see footnote 17.)

concentrated markets banks tend to be less well capitalized and thus riskier. This conclusion is somewhat different from that with the U.S. sample, where the primary driver of the negative relationship between concentration and *Z-score is* variations in $ln\,\sigma(ROA)$. However, these conclusion deserve to be taken with a grain of salt, given the significant simple correlations among the three components of *Z-score* (Tables 2 and 10). As in the U.S. data, there is a positive and significant partial correlation between the HHI and bank profits, consistent with the predictions of theory.

Asset Composition Regressions

The relationship between concentration and asset composition is summarized in Table 14, which reports regressions with the (Cox-transformed) ratio of loans to assets as the dependent variable. The coefficients associated with each measure of HHI are negative and highly significant in all six specifications. Consistent with the prediction of theory and with results for the U.S. sample, loan-to-asset ratios tend to be lower in more concentrated markets.

To summarize results with the international data set, we find that more concentrated bank markets are *ceteris paribus* associated with higher profitability, higher risk of failure, and lower bank commitment to lending. These empirical findings seem robust, and are supported by many other regressions using different specifications that, for brevity, are not presented. Of course, they are also fully consistent with the predictions of theory, and with results obtained with the U.S. sample.[23]

III. CONCLUSION

Our theoretical analysis considered a model which allows for competition in both deposit and loans markets, and for holding risk-free government bonds. The prediction of the model is that risk of failure is *decreasing* in the number of firms, at least beyond some threshold N. With regard to asset allocations the model predicts that the equilibrium loan-to-asset ratio will be weakly increasing in the number of firms N. Of course, profits are predicted to be declining in N.

Our empirical tests employ two different samples with very different attributes. Our risk measure is *Z-score*, our asset allocation measure is the ratio of loans to assets, and our measure of competition is the HHI computed in several ways. First, we examined the relationship between competition and risk-taking. Here, we found that the relationship is negative, meaning that more competition (lower HHI) is *ceteris paribus* associated with a lower probability of failure (higher *Z-score*). This finding is consistent

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23 These effects also appear to be of "economically relevant" magnitudes. For example, a one standard deviation increase in the asset-based HHI results in a decrease in the predicted Z-score of 3.48, which is about 7.9% of the sample mean Z-score. A one standard deviation increase in the asset-based HHI results in a decrease in the loan/asset ratio of .54, which is about 114% of sample median loan/asset ratio. If anything, this elasticity seems unreasonably large, undoubtedly reflecting the effect of the Cox Transformation.

with the predictions of the model. Next, we examined the relationship between competition and asset composition, represented by the loan-to-assets ratio. The theoretical models predicts that this relationship will be weakly positive, and the empirical tests with both samples found a positive and significant relationship. Finally, the theoretically predicted positive relation between HHI and profitability is supported in tests with both datasets.

We draw two main conclusions. First**,** there exist neither compelling theoretical arguments nor robust empirical evidence that banking stability decreases with the degree of competition. Theoretically, that result depends on a particular model specification, and can easily be reversed by adopting a different specification as is done here. Nor do the data support such a conclusion. To us this suggests that positive or normative analyses that depend on models that ignore the loan market and the relevant contracting problem between borrowers and banks should be re-examined.

Second, both the theory and the data suggest a positive *ceteris paribus* relationship between bank competition and willingness to lend. This is potentially important because it means there is another dimension that policy makers might consider when evaluating the costs and benefits of competition in banking. We know of no previous work on this relation and obviously more work needs to be done. If our results hold up to further testing, however, the policy implication is obvious and favors more as opposed to less competition in banking.

APPENDIX

Lemma 1

(a) *If* $\Pi^{CR}(0) > \Pi^{MH}(0, D_{-i})$*, then there exists a value* $\tilde{L}_{-i}$ *such that*

$\Pi^{CR}(D_{-i}) > \Pi^{MH}(L_{-i}, D_{-i})$ *for all* $L_{-i} < \tilde{L}_{-i}$ *and all* D_{-i}.

Proof: If $\Pi^{CR}(0) > \Pi^{MH}(0, D_{-i})$,then a monopolist finds it optimal not to lend. Suppose $\Pi^{MH}(L_{-i}, D_{-i}) > \Pi^{CR}(D_{-i})$ for some $L_{-i} > 0$ (If $\Pi^{MH}(L_{-i}, D_{-i}) < \Pi^{CR}(D_{-i})$ for all $L_{-i} > 0$ a MH strategy would never be chosen). Then $\Pi^{MH}(L_{-i}, D_{-i})$ is monotonically increasing in L_{-i} and, by continuity, there exists a value $\tilde{L}_{-i}$ that satisfies $\Pi^{CR}(D_{-i}) = \Pi^{MH}(\tilde{L}_{-i}, D_{-i})$. Thus, for all $L_{-i} < \tilde{L}_{-i}$ and all D_{-i} $\Pi^{CR}(D_{-i}) > \Pi^{MH}(L_{-i}, D_{-i})$ holds. Q.E.D.

(a) *There exists a value* $\tilde{D}_{-i}$ *such that* $\Pi^{MH}(L_{-i}, D_{-i}) > \Pi^{NMH}(L_{-i}, D_{-i})$ *for all* $D_{-i} > \tilde{D}_{-i}$ *and all* L_{-i}.

Proof: Under NMH, , $\Pi^{NMH}(L_{-i}, D_{-i}) = R^{NMH}(L^*, L_{-i}) + \overline{\Pi}(D_{-i})$, where .
$R^{NMH}(L, L_{-i}) \equiv P(L_{-i} + L^*) r_L(L_{-i} + L^*) - r$. Under a MH strategy with a positive amount of bond holdings, $\Pi^{MH}_{B>0}(L_{-i}, D_{-i}) = R^{MH}(\tilde{L}, L_{-i}) + P(L_{-1} + \tilde{L})\overline{\Pi}(D_{-i})$, where
$R^{MH}(\tilde{L}, L_{-i}) \equiv P(L_{-i} + \tilde{L})(r_L(L_{-i} + \tilde{L}) - r)\tilde{L}$. Since $R^{MH}(L, L_{-i}) > R^{NMH}(L, L_{-i})$ for all $L > 0$, $R^{MH}(\tilde{L}, L_{-i}) > R^{NMH}(L^*, L_{-i})$. Thus,
$\Pi^{MH}_{B>0}(L_{-i}, D_{-i}) - \Pi^{NMH}(L_{-i}, D_{-i}) = R^{MH}(\tilde{L}, L_{-i}) - R^{NMH}(L^*, L_{-i}) + (P(L_{-1} + \tilde{L}) - 1)\overline{\Pi}(D_{-i})$.
Since $\overline{\Pi}(D_{-i})$ is strictly decreasing in D_{-i}, there exists a value $\tilde{D}_{-i}$ such that $\overline{\Pi}(\tilde{D}_{-i})$=0.

Thus, for all $D_{-i} > \tilde{D}_{-i}$ and all L_{-i}, $\Pi^{MH}_{B>0}(L_{-i}, D_{-i}) - \Pi^{NMH}(L_{-i}, D_{-i}) > 0$. Since $\Pi^{MH}(L_{-i}, D_{-i}) \geq \Pi^{MH}_{B>0}(L_{-i}, D_{-i})$, it follows that $\Pi^{MH}(L_{-i}, D_{-i}) > \Pi^{NMH}(L_{-i}, D_{-i})$. *Q.E.D.*

Proposition 1

(a) *If* $\Pi^{CR}(0) > \Pi^{MH}(0,0)$, *then there exists an* $N_1 \geq 1$ *such that the unique symmetric Nash equilibrium is a credit rationing (CR) equilibrium for all* $N \leq N_1$

(b) *There exists a finite* $N_2 \geq 1$ *such that for all* $N \geq N_2$ *the unique equilibrium is MH.*

Proof: Setting $D_{-i} = (N-1)\tilde{D}$ and $L_{-i} = (N-1)\tilde{L}$, where the right-hand-side terms are the total deposits and loans of all competitors of a bank in a symmetric Nash equilibrium respectively, both results obtain by applying Lemma 1. Q.E.D.

Proposition 2 *In any MH equilibrium,* $dX/dN > 0$, $dZ/dN > 0$ *and* $dP/dN > 0$.

Proof: Using conditions (13)-(15) at an interior solution ($L < D$), we get

$r_L(X) - r - F(X,Z,N) = 0$ (16); and $r - r_D(Z) - r_D'(Z)\dfrac{Z}{N} = 0$ (17), where

$F(X,Z,N) \equiv -\dfrac{P'(X)r_D'(Z)Z^2/N + P(X)r_L'(X)X}{P'(X)X + P(X)N}$. In equilibrium, $F(X,Z,N) \geq 0$ has to hold, since if $F(X,Z,N) < 0$, (16) would imply $r_L(X) - r < 0$, which contradicts the optimality of strictly positive lending. By simple differentiation, $F_N < 0$ and $F_Z < 0$.

Differentiating (16) and (17) totally yields: $dX = \dfrac{F_Z H + F_N}{(r_L'(X) - F_X)H} dN$ (18); and

$dZ = HdN$ (19), where $H \equiv \dfrac{r_D'(Z)Z}{N(r_D'(Z)(N+1)+r_D''(Z))} > 0$. By the second order necessary condition for an optimum, $r_L'(X) - F_X < 0$. Thus, $dX/dN > 0$, $dZ/dN > 0$. Since function $P(.)$ is increasing in total loans X, $dP/dN > 0$ follows. If banks hold no bonds, the result follows by Proposition 2 in Boyd and De Nicolò (2005). Q.E.D.

Proposition 3 *There exists a finite* N_3 *such that for all* $N \geq N_3$, $d\alpha/dN > 0$ *in any interior MH equilibrium.*

Proof: Using (18) and (19), $\dfrac{d\alpha}{dN} = \dfrac{1}{Z^2}\left(\dfrac{dX}{dN}Z - \dfrac{dZ}{dN}X\right) > 0$ if $\dfrac{F_Z H + F_N}{(r_L'(X) - F_X)H} > \dfrac{X}{Z}$ (20).

Note that $F_Z + F_N/H > r_L'(X) - F_X$ is sufficient for (20) to hold, since $X < Z$. As $N \to \infty$, $F_X \to 0$, $F_Z + F_N/H \to 0$, since $F_Z \to 0$ and

$\dfrac{F_N}{H} = \dfrac{-(P'(X))^2 X}{(P'(X)X + P(X)N)^2 N}(r_D'(Z)(N+1) + r_D''(Z)) \to 0$. Thus, by continuity, there exists a finite value N_3 such that for all $N \geq N_3$ $\dfrac{F_Z H + F_N}{(r_L'(X) - F_X)H} > 1 > \dfrac{X}{Z}$ holds.

Therefore, for all $N \geq N_3$, $d\alpha/dN > 0$. Q.E.D.

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Table 1. U.S. Sample

All balance sheet and income statement data are from the FDIC's *Call Reports* which are available at the FDIC website. Control variables are from various sources, mostly the Census Bureau website. All control variables are at the county level.

Panel A. Definition of Variables

	Bank Variables
Z-score	(rate of return on assets + ratio of equity to assets) ÷ standard deviation of the rate of return on assets
LA	Total loans ÷ total assets, quarterly average over 3 years
ROA	Total profits ÷ total assets, quarterly average over 3 years
EA	Equity (book value) ÷ total Assets, quarterly average over 3 years
σ(ROA)	Standard deviation of ROA, quarterly data
LASSET	Natural logarithm of bank assets
CTI	Ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years
	Market structure
HHI0	Hirschmann-Herfindahl Index computed with banks only
HHI100	Hirschmann-Herfindahl Index computed with banks and savings and loan associations
HHI_dif	HHI0 – HHI100
	County controls
LABGRO	Percentage growth in labor force 1999 – 2003
UNEM	Unemployment rate, 2003
FARM	Ratio of agricultural population ÷ total population in 2003
TOTALLY	Median income in 1999 * number of households. $million.

Panel B. Sample Statistics

Variable	Mean	Std. Dev.	Min	Max
LABGR	0.0062	0.0671	-0.2420	0.2718
UNEM	5.8261	2.4747	1.4000	21.8000
FARM	0.0706	0.0563	0.0000	0.4086
LASSET	10.8132	0.8095	7.6917	16.7759
CTI	0.4630	0.9072	0.0247	29.1276
TOTALY	3740.0	4100.0	611.7	6780.0
HHI0	2855.67	1577.69	881.67	10000.00
HHI100	2655.90	1540.73	719.65	10000.00
HHI_dif	199.77	406.80	-980.13	7131.91

Z-score	35.5870	16.7554	3.0910	261.8150
LA	0.5715	0.1465	0.0000	0.9556
PA	0.0070	0.0047	-0.0262	0.0718
EA	0.1171	0.0422	0.0090	0.7468
Lnσ(ROA	0.0042	0.0029	0.0000	0.0449

Table 2.
Simple Correlations – U.S. Sample

Coefficients significant at 5% confidence level or lower are reported in **boldface**.

	LABGRO	*UNEM*	*FARM*	*LASSET*	*CTI*	*TOTALY*	*HHI0*	*HHI100*	*Z-score*	*LA*	*PA*	*EA*	$ln \sigma(ROA)$
LABGRO	1												
UNEM	**-0.1746**	1											
FARM	**-0.0903**	**-0.3727**	1										
LASSET	**0.0609**	**0.0941**	**-0.3147**	1									
CTI	**0.0724**	-0.0036	**-0.0855**	**-0.0900**	1								
TOTALLY	**0.1629**	0.0177	**-0.4091**	**0.2457**	**0.1284**	1							
HHI0	**-0.0450**	0.0204	**0.1174**	**0.0642**	-0.0274	**-0.3000**	1						
HHI100	**-0.0602**	0.0242	**0.1511**	**0.0458**	-0.0324	**-0.3261**	**0.9662**	1					
Z-score	**-0.1032**	-0.0336	**0.0919**	**-0.2001**	**-0.0827**	**-0.0406**	**-0.0686**	**-0.0607**	1				
LA	**0.0789**	**-0.0566**	**0.0522**	**0.1602**	**-0.0830**	**0.0909**	**-0.0952**	**-0.0965**	**-0.3018**	1			
PA	-0.0265	**-0.0659**	**0.0728**	**0.1670**	**-0.2945**	**-0.1102**	**0.0814**	**0.0799**	**-0.1219**	-0.0242	1		
EA	**-0.0713**	-0.0188	0.0310	**-0.1838**	-0.0057	-0.0332	0.0019	0.0090	**0.4617**	**-0.4194**	**0.1733**	1	
$Ln \sigma(ROA)$	**0.0684**	0.0290	**-0.0839**	0.0014	**0.2465**	**0.0703**	0.0237	0.0221	**-0.5013**	0.0103	0.0143	**0.2100**	1
ROA	0.0265	0.0024	**-0.1614**	**0.7342**	**-0.2090**	**0.1484**	**0.1112**	**0.0976**	**-0.1663**	**0.0853**	**0.5326**	-0.0103	0.0295

Table 3. Dependent Variable: *Z-Score*

Z-score = (rate of return on assets + ratio of equity to assets) ÷ standard deviation of the rate of return on assets. *HHI0* is the Hirschmann-Herfindahl Index computed with banks only. *HHI100* is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. . *LABGRO* is the percentage growth in labor force 1999 – 2003. *UNEM* is the unemployment rate, 2003. *FARM* is the ratio agricultural population / total population in 2003. *LASSET* = natural logarithm of bank assets. *CTI* = ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years. totally = median income in 1999 * number of households. Column 3.1 is robust OLS regressions. Column 3.2 is robust OLS regressions with clustering on counties.

Equation:	3.1		3.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	86.1979	***11.61	86.1979	***11.43
HHI0	**-0.0004254**	****-1.98**	**-0.0004254**	****-2.0**
TOTALY	-9.63E-10	-0.85	-9.63E-10	-0.82
LABGRO	-11.75061	**-2.24	-11.75061	**-2.3
UNEM	-0.3970404	***-2.6	-0.3970404	**-2.52
FARM	5.495381	0.65	5.495381	0.61
LASSET	-4.271885	***-6.7	-4.271885	***-6.55
CTI	-1.853256	***-3.44	-1.853256	***-3.37
R-squared / NOBS	0.0994	2496	0.0994	2496
F-test / p-value	F(7, 2443)	***14.17	F(7, 2443)	***13.18
RMSE / Categories	16.069	46	16.069	46
Regression With:				
HHI100	**-0.0004176**	***-1.89**	**-0.0004176**	***-1.92**

Table 4. Dependent Variables: *ROA*

Pa = total profits ÷ total assets, quarterly average over 3 years. *HHI0* is the Hirschmann-Herfindahl Index computed with banks only. *HHI100* is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. *LABGRO* is the percentage growth in labor force 1999 – 2003. unem is the unemployment rate, 2003. FARM is the ratio, agricultural population / total population in 2003. *LASSET* = natural logarithm of bank assets. *CTI* = ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years. *TOTALY* = median income in 1999 * number of households. Column 4.1 is robust OLS regressions. Column 4.2 is robust OLS regressions with clustering on counties.

Equation:	4.1		4.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	-0.0047537	***-2.77	-0.0047537	***-2.72
HHI0	**1.14E-07**	****1.96**	**1.14E-07**	****1.93**
LASSET	0.0011648	***8.1	0.0011648	***7.95
LABGRO	-0.0028384	**-2.13	-0.0028384	**-2.03
UEM	-0.0000486	-1.06	-0.0000486	-1.03
FARM	0.0004837	0.22	0.0004837	0.22
CTI	-0.001137	***-2.64	-0.001137	***-2.63
TOTALLY	-1.08E-12	**-2.44	-1.08E-12	**-2.35
R-squared / NOBS	0.1704	2500	0.1704	2500
F-test / p-value	F(6, 2447)	***12.37	F(6, 2447)	***19.67
RMSE / Categories	0.00429	46	0.00429	46
Regression With:				
HHI100	**1.09E-07**	***1.82**	**1.09E-07**	***1.79**

Table 5. Dependent Variable: LPROFIT

LPROFIT = Ln (PROFIT + A), where A is 1+ the minimum of PROFIT. All regressions include the full set of control variables detailed in Table 3. HHI0 is the Hirschmann-Herfindahl Index computed with banks only. HHI100 is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations.

Equation:	5.1		5.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	4.851033	***32.27	4.851033	***27.71
HHI0	**5.90E-06**	****1.98**	**5.90E-06**	****2.06**
R-squared / NOBS	0.6211	2500	0.6211	2500
F-test / p-value	F(6, 2447)	***72.81	F(6, 2447)	***54.93
RMSE / Categories	0.17267	46	0.17267	46
Hansen J Statistic / Chi-sq p-value				
Regression With:				
HHI100	**6.20E-06**	***1.82**	**6.20E-06**	****1.96**

Table 6. Dependent Variables: EA_cox

EA = equity (book value) ÷ total Assets, quarterly average over 3 years. *HHI0* is the Hirschmann-Herfindahl Index computed with banks only. *HHI100* is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. *LABGRO* is the percentage growth in labor force 1999 – 2003. *UNEM* is the unemployment rate, 2003. farm is the ratio, agricultural population / potal population in 2003. LASSET = Natural logarithm of bank assets. *CTI* = ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years. *TOTALY* = median income in 1999 * number of households. Column 5.1 is robust OLS regressions. Column 5.2 is robust OLS regressions with clustering on counties.

Equation:	6.1		6.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	-1.133522	***-7.59	-1.133522	***-7.44
HHI0	**2.54E-06**	**0.5**	**2.54E-06**	**0.5**
LASSET	-0.0779583	***-5.95	-0.0779583	***-5.78
LABGRO	-0.4275504	***-3.76	-0.4275504	***-3.93
UNEM	-0.0104683	***-2.87	-0.0104683	***-2.87
FARM	-0.1889034	-1.04	-0.1889034	-1.1
CTI	-0.0166356	**-2.11	-0.0166356	**-2.04
TOTALLY	-3.93E-11	*-1.64	-3.93E-11	*-1.68
R-squared / NOBS	0.0884	2500	0.0884	2500
F-test / p-value	F(6, 2447)	***10.32	F(6, 2447)	***9.9
RMSE / Categories	0.34204	46	0.34204	46
Regression With:				
HHI100	**2.93E-06**	**0.55**	**2.93E-06**	**0.56**

Table 7. Dependent Variables: ***Ln(σ(ROA))***

Ln(σ(ROA)) = logged standard deviation of Pa, 3 years of quarterly data. *HHI0* is the Hirschmann-Herfindahl Index computed with banks only. *HHI100* is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. *LABGRO* is the percentage growth in labor force 1999 – 2003. *UNEM* is the unemployment rate, 2003. *FARM* is the ratio, agricultural population / total population in 2003. *LASSET* = natural logarithm of bank assets. *CTI* = ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years. *TOTALY* = median income in 1999 * number of households. Column 6.1 is robust OLS regressions. Column 6.2 is robust OLS regressions with clustering on counties.

Equation:	7.1		7.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	-5.965511	***-39.59	-5.965511	***-39.55
HHI0	**0.000014**	****2.28**	**0.000014**	****2.29**
LASSET	0.027445	**2.12	0.027445	**2.12
LABGRO	0.058077	0.41	0.058077	0.42
UNEM	0.003591	0.81	0.003591	0.82
FARM	-0.413164	*-1.90	-0.413164	*1.93
CTI	0.073592	**2.35	0.073592	**2.33
TOTALY	1.20e-11	0.38	1.20e-11	0.37
R-squared / NOBS	0.0884	2496	0.0858	2496
F-test / p-value	F(6, 2443)	***2.876	F(6, 2443)	***3.795
RMSE / Categories	0.42817	46	0.42817	46
Regression With:				
HHI100	**0.000014**	****2.32**	**0.000014**	****2.35**

Table 8. Dependent Variables: *LA.cox*

LA = total loans ÷ total assets, quarterly average over 3 years. *HHI0* is the Hirschmann-Herfindahl Index computed with banks only. *HHI100* is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. *LABGRO* is the percentage growth in labor force 1999 – 2003. *UNEM* is the unemployment rate, 2003. *FARM* is the ratio, agricultural population / potal population in 2003. *LASSET* = Natural logarithm of bank assets. *CTI* = ratio of non-interest expense to interest income + non-interest income of banks, quarterly average over 3 years. *TOTALY* = median income in 1999 * number of households. Column 7.1 is robust OLS regressions. Column 7.2 is robust OLS regressions with clustering on counties.

Equation:	8.1		8.2	
Variable	Coeff.	t-Stat	Coeff.	t-Stat
Constant	-1.00652	***-4.05	-1.00652	***-4.02
HHI0	**-0.000022**	****-2.46**	**-0.000022**	****-2.38**
LASSET	0.1251959	***5.76	0.1251959	***5.62
LABGRO	0.3951624	*1.93	0.3951624	*1.93
UNEM	-0.0030314	-0.48	-0.0030314	-0.48
FARM	0.4441235	*1.37	0.4441235	1.34
CTI	-0.0685574	***-2.94	-0.0685574	***-2.93
TOTALY	1.06E-10	***3.17	1.06E-10	***3.04
R-squared / NOBS	0.1643	2498	0.1818	2498
F-test / p-value	F(6, 2445)	***9.64	F(6, 2445)	***9.17
RMSE / Categories	0.60314	46	0.60314	46
Regression With:				
HHI100	**-0.0000234**	****-2.51**	**-0.0000234**	****-2.36**

Table 9. International Sample

Panel A. Description of Variables

Bank Variables	
Z-score(t)	Z-score, $Z_t = \left(ROA_t + EQTA_t\right) / \sigma\left(ROA_t\right)$
ROA(t)	Return on average assets
Ln[σ(ROA(t))]	$\sigma\left(ROA_t\right) = \left\lvert ROA_t - T^{-1}\sum_t ROA_t \right\rvert$
EA(t)/ EA.cox(t)	Equity-to-asset ratio / EA.cox(t) $= Ln(EA_t/(1-EA_t))$
LA(t)/ LA.cox(t)	Gross loan-to-asset ratio/ $= Ln(LA_t/(1-LA_t))$
LASSET(t)	Log of total assets (in US $)
CTI(t)	Cost to income ratio
Market Structure	
HHIA(t)/ HHIL(t)/ HHID(t)	Hirschmann-Hirfendahl Indexes (Asset, Loans.Deposits)
Macroeconomic Variables	
GDPPC(t)	Per-capita GDP at PPP
LPOP(t)	Log Population
GROWTH(t)	Real GDP Growth
INFL(t)	Average CPI Inflation Rate
ER(t)	Domestic currency/US$ exchange rate

Panel B.   Sample Statistics

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Z-score (time series)	44.2	19.1	68.73	-40.5	497.6
ROA (in percent)	1.36	1.21	3.55	-24.5	15.9
σ(ROA)	1.41	0.66	2.07	.01	28.9
EA	0.14	0.11	11.60	0.01	0.65
LA	0.47	0.48	0.22	0.05	0.92
LASSET	12.9	12.5	2.03	3.8	20.4
CTI	69.9	61.7	60.68	6.7	96.3
HHIA	2651	1918	2354	391	10,000
GDPPC	6021	5930	3727	440	21,460
GROWTH	3.85	2.97	5.79	-12.6	12.8
INFL	33.1	8.4	413.7	-11.5	527.2

Table 10. Correlations – International Sample

Coefficients significant at 5% confidence level or lower are reported in **boldface**

	HHIA	GDPPC	LPOP	GROWTH	INFL	Z-score (time series)	ROA	EA	σ (ROA)	LA	LASSET
HHI (Assets)	1.00										
GDPPC	**-0.30**	1.00									
LPOP	**-0.25**	**-0.24**	1.00								
GROWTH	-0.01	-0.07	0.07	1.00							
INFL	0.07	-0.03	0.05	-0.08	1.00						
Z-score	-0.04	0.02	-0.01	0.08	-0.04	1.00					
ROA	**-0.14**	0.07	-0.02	-0.08	-0.08	0.07	1.00				
EA	0.01	0.09	-0.06	-0.07	0.01	**0.11**	**0.16**	1.00			
σ (ROA)	0.03	0.03	-0.01	**-0.18**	0.01	**-0.33**	**-0.26**	**0.19**	1.00		
LA	**-0.14**	0.07	-0.06	0.07	-0.08	0.04	-0.09	-0.05	-0.08	1.00	
LASSET	**-0.26**	**0.27**	**0.28**	0.07	-0.01	-0.01	-0.06	**-0.44**	**-0.19**	0.04	1.00
CTI	-0.03	0.06	-0.02	-0.04	-0.01	**-0.09**	**-0.42**	0.02	**0.23**	-0.08	-0.08

Table 11. Dependent Variable: *Z-score(t)*
International Sample

Z-score(t) $= \left(ROA_t + EA_t\right) / \sigma\left(ROA_t\right)$, where ROA_t is the return on assets, EA_t is the ratio of equity to assets, and $\sigma\left(ROA_t\right) = \left|ROA_t - T^{-1}\sum_t ROA_t\right|$ HHIA, *HHIL* and *HHID* are the HHIs computed with assets, loans and deposits respectively; *GDPCC* is per-capita GDP at PPP; *LPOP* is Ln(Population); *GROWTH* is real GDP growth, *INFL* is the annual inflation rate; *ER* is the domestic currency/US$ exchange rate. CFE are country-fixed effects regressions.
FFE are firm fixed effects regressions. t-Stat are robust t-statistics. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Equation:	11.1	CFE	11.2	FFE	11.3	CFE	11.4	FFE	11.5	CFE	11.6	FFE
Independent Variables (t-1)	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
HHIA	**-14.73**	*****-4.4**	**-11.17**	*****-3.0**	**-10.75**	*****-2.8**	**-13.36**	*****-3.2**	**-14.80**	*****-2.5**	**-15.39**	****-2.1**
GDPPC					0.001	0.8	-0.001	-1.1	0.001	0.9	-0.001	-1.4
LPOP					30.11	**2.3	13.50	1.0	7.877	0.5	-11.86	-0.6
GROWTH					0.334	**2.4	-0.04	-0.3	0.354	**2.1	0.049	0.26
INFL					-0.005	-1.3	-0.007	-0.3	-0.006	-1.3	-0.002	-0.4
ER					-0.0001	-1.0	-0.0001	-0.4	0.0001	0.4	-0.0001	-0.5
LASSET									-1.444	***-3.3	-3.536	**-2.1
CTI									-0.061	***6.8	0.016	1.2
R2/ number of observations	0.056	17334	0.405	17334	0.056	15567	0.406	15567	0.060	12195	0.416	12195
Regressions with:												
HHIL	**-11.17**	**-3.6*****	**-5.665**	**-1.5**	**-5.350**	**-1.5**	**-6.077**	**-1.4**	**-0.142**	**-0.3**	**-0.228**	**-0.2**
HHID	**-11.80**	**-3.5*****	**-9.102**	****-2.4**	**-7.632**	****-2.0**	**-10.87**	*****-2.6**	**-10.19**	***-1.7**	**-8.525**	**-1.1**

Table 12. Dependent Variables: Components of the *Z-score*
International Sample

Components of the *Z-score* are ROA_t, the return on assets, *EA.cox* is the Cox transformation of the ratio of equity to assets, and $Ln(\sigma(ROA_t))$, the log transformation of ROA's absolute mean deviations. *HHIA, HHIL* and *HHID* are the HHIs computed with assets, loans and deposits respectively; *GDPCC* is per-capita GDP at PPP; *LPOP* is Ln(Population); *GROWTH* is real GDP growth, *INFL* is the annual inflation rate; *ER* is the domestic currency/US$ exchange rate. CFE are country-fixed effects regressions. FFE are firm fixed effects regressions. t-Stat are robust t-statistics. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Equation:	12.1	CFE	12.2	FFE	12.3	CFE	12.4	FFE	12.5	CFE	12.6	FFE
Dependent Variable (t)	*ROA*		*ROA*		*EA.cox*		*EA.cox*		*Ln(σ(ROA)*		*Lnσ(ROA)*	
Independent Variables (t-1)	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
HHIA	**-0.200**	**-0.6**	**-0.03**	**-0.1**	**-0.224**	*****-3.7**	**-0.174**	*****-4.1**	**0.396**	*****3.2**	**0.11**	**1.1**
GDPPC	0.001	***3.6	0.001	***3.8	0.0001	***3.5	-0.001	-1.5	-0.001	-0.3	0.002	*1.7
LPOP	0.354	0.6	-1.71	**-2.3	0.921	***7.0	0.674	***6.6	0.636	**2.3	0.939	***3.4
GROWTH	-0.006	-0.6	0.008	1.1	-0.001	-0.5	0.002	0.2	-0.018	***-4.7	-0.0013	***-3.8
INFL	0.001	***2.6	0.001	***2.6	0.0001	0.4	-.0004	-1.4	0.0001	1.2	-0.0019	-1.5
ER	-0.0001	-1.3	-0.0001	-0.2	0.0002	***4.3	0.005	***4.1	0.0001	1.0	0.0005	*1.7
LASSET	-0.127	***5.8	-0.466	***-6.8	-0.233	-54.5	-0.202	***-20.8	-0.135	***17.5	-0.115	***-4.4
CTI	-0.013	***11.9	-0.041	**-7.2	-0.012	***-6.9	-1.207	-1.6	0.001	***5.0	-0.008	***-3.5
R2/ number of observations	0.180	13069	0.563	13069	0.396	12673	0.848	12673	0.176	13069	0.623	13069
Regressions with:												
HHIL	**0.674**	***1.9**	**1.073**	*****3.4**	**-0.271**	*****-4.3**	**-0.247**	*****-5.6**	**0.127**	**1.0**	**-0.207**	***-1.7**
HHID	**0.264**	**0.8**	**0.617**	****2.0**	**-0.218**	*****-3.5**	**-0.192**	*****-4.5**	**0.215**	***1.8**	**-0.06**	**-0.5**

Table 13. Dependent Variable: LPROFIT

LPROFIT = Ln (PROFIT + A), where A is 1+ the minimum of PROFIT. All regressions are with firm fixed effects, and include the full set of control variables detailed in Table 10. HHIA,HHIL and HHID are HHIs computed using total assets, total loans and total deposits respectively.

Equation:	13.1		13.2		13.3	
Independent Variables (t-1)	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
HHIA	**2.659**	****2.07**				
HHIL			**2.711**	****2.0**		
HHID					**2.955**	****2.22**
R2/ number of observations	0.492	13069	0.492	13069	0.491	13069

Table 14. Dependent Variable: *LA.cox(t)*

LA.cox (t) is the Cox transformation of the ratio of gross loans to assets. *HHIA, HHIL* and HHID are the HHIs computed with assets, loans and deposits respectively; *GDPCC* is per-capita GDP at PPP; *LPOP* is Ln(Population); *GROWTH* is real GDP growth, *INFL* is the annual inflation rate; *ER* is the domestic currency/US$ exchange rate. CFE are country-fixed effects regressions. FFE are firm fixed effects regressions. t-Stat are robust t-statistics. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Equation:	14.1	CFE	14.2	FFE	14.3	CFE	14.4	FFE	14.5	CFE	14.6	FFE
Independent Variables (t-1)	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat	Coeff.	t-Stat
HHIA	**-0.327**	*****-5.8**	**-0.291**	*****-8.2**	**-0.385**	*****-5.9**	**-0.287**	*****-7.2**	**-0.620**	*****-6.3**	**-0.323**	*****5.4**
GDPPC					-0.001	-0.1	0.001	***3.0	0.001	0.1	-0.001	-0.8
LPOP					-1.438	***-7.1	-1.124	***-8.7	-1.924	****-78.8	-1.763	***-12.0
GROWTH					0.024	***9.3	0.020	***14.3	0.023	***7.5	0.018	***11.9
INFL					-0.001	-1.5	0.0001	0.8	0.001	-0.3	0.0001	1.1
ER					-0.0001	*-1.8	-0.0001	-0.1	-0.001	-1.2	-0.0001	-1.5
LASSET									-0.013	*-1.8	0.155	***11.3
CTI									-0.001	***5.5	-0.001	***-5.3
R2/ number of observations	0.168	18952	0.808	18952	0.187	16972	0.808	16972	0.211	12841	0.849	12841
Regressions with:												
HHIL	**-0.298**	*****-5.1**	**-0.259**	*****-7.1**	**-0.383**	*****-5.8**	**-0.269**	*****-6.1**	**-0.610**	*****-6.0**	**-0.382**	*****6.1**
HHID	**-01.98**	*****-3.4**	**-0.177**	*****-4.9**	**-0.302**	*****-4.6**	**-0.195**	*****-4.8**	**-0.449**	*****-4.5**	**-0.145**	****-2.3**