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Bank Competition, Risk and Asset Allocations

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Abstract

We study a banking model in which banks invest in a riskless asset and compete in both deposit and risky loan markets. The model predicts that as competition increases, both loans and assets increase; however, the effect on the loans-to-assets ratio is ambiguous. Similarly, as competition increases, the probability of bank failure can either increase or decrease. We explore these predictions empirically using a cross-sectional sample of 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 the loan-to-asset ratio is positively and significantly related to measures of competition. Furthermore, several loan loss measures commonly employed in the literature are negatively and significantly related to measures of bank competition. Thus, 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

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. 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 modeled banks' strategic interactions in deposit markets but ignored competition in loan markets.

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.

Recently, we studied a standard model of deposit market competition (Allen and Gale, 2004) modified in one respect: we allowed for loan market competition *a la* Stiglitz-Weiss (Boyd and De Nicolò, 2005). The result was to reverse the conventional wisdom. In a modified model where risk choices are jointly determined by firms and banks, more bank competition was associated with less, not more, risk of failure.

In the present study, we generalize Boyd and De Nicolò (2005) in a fundamental way. The new model still allows for imperfect deposit market competition and loan market competition a la Stiglitz-Weiss. What is new is that we add banks' holding of a risk-free asset. Realistically, we know that banks' asset choices are not limited to just lending in informationally opaque loan markets. Therefore, it is important to consider an environment in which both kinds of activity can occur simultaneously. That is not done in Allen and Gale *op. cit.* or in Boyd De Nicolò, *op. cit.* or in any other existing literature we have seen.

The new model yields a rich set of results and predictions. First, 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.
Second, bank's optimal asset 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 when they raise deposit funds and use them to acquire risk free assets, such as government bonds. Thus, if competition affects banks' choices between loans and bonds, as we will find it does, there will be welfare consequences. To our knowledge, this margin has not been recognized or explored elsewhere in the theoretical literature on bank competition.

In the new environment, it is shown that increased competition can either increase or decrease the risk of bank failure. This is different from our previous findings (Boyd and De Nicolò, 2005, and Boyd, De Nicolò and Jalal, 2006) and reflects the greater generality of the new model. In addition, we find that increased competition will generally affect the ratio of loans to deposits, but the direction of the effect can be either positive or negative.

In this work we allow for the existence of a moral hazard problem on the part of firms. As banks raise loan rates, firms endogenously respond by increasing their own risk of failure. We call this the "BDN effect," a term that will be made precise in what follows. We then prove that, if no BDN effect is present, an increase in bank competition will always result in an increase in the risk of bank failure. However, this result can be reversed if and only if the BDN effect is present and sufficiently strong,.. Thus, the existence of the BDN effect is a necessary but not sufficient condition to observe decreasing risk of bank failure as competition rises. We provide numerical examples of both cases; i.e. risk rises (falls) as competition increases.

We explore the predictions of the model empirically using two data sets: a cross-sectional sample of 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. Then, we present a set of regressions relating measures of risk of failure and the loan-to-asset ratio to measures of concentration *controlling for all factors that affect concentration independently of the existence of market power rents.* Thus, these measures of concentration are proxy measures of bank's market power rents.

The empirical findings are three. First, banks' probability of failure (measured in two different ways) is positively and significantly related to concentration, *ceteris paribus.* Second, the loan-to-asset ratio is negatively and significantly associated with concentration. Both results are obtained with both samples.

Third, since the data indicate that risk of bank failure falls as competition increases, the model implies that a BDN effect must be present in the data. To investigate this prediction, we employ several standard loan loss variables as proxy measures for the probability of loan customers' default risk. In all tests and with both samples, as competition increases, banks' loan loss ratios deteriorate. These results, as well as other empirical results in the literature, suggest that a BDN effect is present in the data.

The remainder of the paper is composed of three sections. Section II analyzes the model. Sections III and IV present the evidence, and Section V concludes.

II. THE MODEL

The economy lasts two dates: date 0, the investment period, and date 1, the consumption period. There are three classes of agents: entrepreneurs, depositors and banks. All agents are risk-neutral.

Entrepreneurs

There is a continuum of entrepreneurs who have no resources but are endowed with effort. They are uniquely endowed with access to productive activities that require effort as an input. Specifically, they can operate one identical project of fixed size, normalized to 1. The project yields an output $y+z$ at date 1 per unit invested at date 0.

The component of total output y is random, distributed with density function $f(y)$ and cumulative density $F(y)$ on the closed interval $[0, A]$. The component of total output z is deterministic, obtained one-to-one with entrepreneurs' effort. The cost of effort is $c(z)$, where $c(z)$ is a strictly increasing, convex and twice differentiable cost function. As an alternative to operating a project, an entrepreneur can employ effort to obtain a utility level $b \in [0, B]$. Entrepreneurs' utility levels are distributed on $[0, B]$ with cumulative density $G(b)$.

The outcome of the project $y+z$ can be observed by banks only at a (verification) cost, which for simplicity is normalized to zero. Entrepreneurs who decide to undertake a project will borrow only from banks, as depositors are assumed to incur verification costs so large as to make direct lending to entrepreneurs too costly.

Banks offer simple debt contracts. The bank receives R^L if the entrepreneur does not default, which occurs when $y+z \geq R^L$. The entrepreneur defaults when $y+z < R^L$. In this case, the bank verifies the outcome of the project and receives the entire output $y+z$.

The entrepreneur chooses z to maximize expected profits:

$$\int_{R^L-z}^{A} (y+z-R^L) f(y)dy - c(z) = \int_{R^L-z}^{A} yf(y)dy + (z-R^L)(1-F(R^L-z)) - c(z) \quad .$$

Integrating the term $\int_{R^L-z}^{A} yf(y)dy$ by parts, expected profits can be written as:

$$. \ A + z - R^L - \int_{R^L-z}^{A} F(y)dy - c(z) \quad (1).$$

We assume that (1) is strictly concave in *z,* which implies that $F'(R^L-z) - c''(z) < 0$. The optimal z satisfies:

$$1 - F(R^L - z) - c'(z) = 0 \qquad (2).$$

Denote with $z(R^L)$ the function associating each optimal z to a given loan interest rate defined implicitly by (2). Differentiating (2), we get:

$$z'(R^L) = \frac{F'(R^L-z)}{F'(R^L-z) - c''(z)} < 0 \qquad (3).$$

Thus, the higher is the loan rate, the lower is the entrepreneur's effort. As noted, we have called this the BDN effect, which is induced by optimal contracting with entrepreneurial moral hazard. Hence, entrepreneurs choose riskier projects— in the form of a smaller deterministic portion of output—when the loan interest rate is higher

We now derive entrepreneurs' aggregate demand for funds. Let $\pi^e(R^L)$ denote the entrepreneurs' expected profits if they choose to undertake the project. It is straightforward to show that $\pi^e(R^L)$ is strictly decreasing in R^L. Thus, an entrepreneurs will undertake the project if the expected profits $\pi^e(R^L)$ are not lower than her reservation utility:

$$\pi^e(R^L) \geq b \qquad (4).$$

Let b^* denote the value of b that satisfies (4) at equality. The total demand for loans is thus given by $L = G(b^*) = G(\pi^e(R^L))$. This expression defines implicitly a downward-sloping inverse supply of loans, which we denote with $R^L = R^L(L)$, with $R^L(0) > 0$, $R_L^L < 0$ by assumption.

Depositors

There is a continuum of depositors who place all their funds in banks.[2] The deposits of bank *i* are denoted by d_i, and total deposits by $D \equiv \sum_{i=1}^{N} d_i$. By assumption, deposit contracts are simple debt contracts. 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 by $R^D = R^D(D)$ with, by assumption, $R_D^D > 0, R_{DD}^D \geq 0$.

Banks

There are N banks that have no initial resources. They collect deposits and invest the proceeds in a riskless technology *and* in risky loans to entrepreneurs. By investing an amount x of date 0 resources, the riskless technology yields rx output at date 1.

Denote the loans of bank *i* by l_i, with total loans given by $L \equiv \sum_{i=1}^{N} l_i$. Thus, the balance sheet of bank i is $l_i + x_i = d_i$.

[2] 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 a risk-free asset, then deposits and the investment in the risk-free asset can be imperfect substitutes, and deposits may be held even though the investment in the risk-less asset dominates deposits in rate of return. For simplicity, investments in a risk-less asset by depositors are ruled out.

Bank profits for each realization of the random component of output are as follows.

If $y \geq R^L - z$, no entrepreneur defaults and bank profits are

$$(R^L(L) - r)l_i + (r - R^D(D))d_i,$$

where we have used $x_i = d_i - l_i$.

If $y < R^L - z$, then all entrepreneurs financed by a bank default, and a bank's limited liability implies its profits are:

$$\max\{0, (y + z - r)l_i + (r - R^D(D))d_i\}.$$

Denote with Y^* the realization of y for which bank profits equal to zero—that is, $(Y^* + z - r)l_i + (r - R^D(D))d_i = 0$. Then,

$$Y^*(l_i, d_i) \equiv r - \frac{(r - R^D(D))d_i}{l_i} - z \qquad (5)$$

If $y \in [Y^*, R^L - z)$, then all entrepreneurs financed default and fail, but the bank does not. If $y < Y^*$ then a bank fails. Thus, Y^* is the bank failure threshold, hence, $F(Y^*)$ is a bank's probability of failure. By choosing deposits, loans, and the investment in the risk-free asset, a bank also chooses its level of risk-taking Y^* and its probability of failure $F(Y^*)$.

Each bank maximizes expected profits, taking into account the best response of entrepreneurs' choice of effort to their choice of the loan rate, as given by (3). We denote this best response with the function $z(L) = z(R^L(L))$.

Therefore, bank *i* expected profits are given by:

$$\begin{aligned} &\int_{R^L(L)-z(L)}^{A} [(R^L(L) - r)l_i + (r - R^D(D))d_i] f(y)dy + \\ &\int_{Y^*(l_i,d_i)}^{R^L(L)-z(L)} [(y + z - r)l_i + (r - R^D(D))d_i] f(y)dy \end{aligned} \qquad (6).$$

Equation (6) can be re-written as:[3]

$$(R^L(L)-r)l_i+(r-R^D(D))d_i-l_i\int_{Y^*(l_i,d_i)}^{R^L(L)-z(L)}F(y)dy \qquad (7)$$

We focus on unique solutions by assuming that (7) is strictly concave in l_i and d_i.

Equilibrium

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 strategic interaction 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.

In an interior Nash equilibrium, each bank *i* chooses $(l_i,d_i)\in R_{++}$ that is the best response to the strategies of other banks. By the assumed strict concavity of the bank's profit function (7), an interior equilibrium is characterized by:

$$R^L-r-\int_{Y^*}^{R^L-z}F(y)dy-l_i[F(R^L-z)(R_L^L-z_L)-R_L^L-F(Y^*)Y_{l_i}^*]=0 \quad (8),$$

$$r-R^D-R_D^D d_i+l_iF(Y^*)Y_{d_i}^*=0. \qquad (9),$$

$$\text{where } Y_{d_i}^*=-\frac{(r-R^D-R_D^D d_i)}{l_i} \quad (10),$$

$$\text{and } Y_{l_i}^*=\frac{(r-R^D)d_i}{l_i^2}-z_{l_i} \quad (11).$$

Observe that an interior threshold bank failure point satisfies $Y^*\in(0,A)$, which implies $F(Y^*)\in(0,1)$. Assuming and interior solution, and substituting (10) in (9), Equation (9) simplifies to:

$$r-R^D-R_D^D d_i=0. \qquad (12),$$

Thus, total deposits are determined independently of total loans.[4]

[3] Equation (7) is obtained by adding and subtracting $\int_{Y^*}^{R^L(L)-z}[(R^L(L)-r)l_i+(r-R^D(D))d_i]f(y)dy$ to equation (6), integrating by parts the term $\int_{Y^*}^{R^L(L)-z}yf(y)dy$, and substituting (5) in the resulting expression.

An interior *symmetric* Nash equilibrium has $L = Nl$ and $D = Nd$. Substituting these conditions in (8), (10), (11) and (12), yields:

$$G(L,D,N) \equiv R^L - r - \int_{Y^*}^{R^L - z} F(y)dy - \frac{L}{N}[F(R^L - z)(R_L^L - z_L) - R_L^L - F(Y^*)Y_l^*] = 0 \quad (13),$$

$$r - R^D - R_D^D \frac{D}{N} = 0. \qquad (14),$$

$$Y^*(L,D) \equiv r - \frac{(r - R^D)D}{L} - z \qquad (15)$$

where, in (13). $Y_L^* = \dfrac{R_D^D D^2}{NL^2} - z_L$, obtained by substituting $L = Nl$ and $D = Nd$ in (11) and using (14).

Equation (13) says that the lending rate is the sum of the "risk free rate" r, plus two terms. The first of these two terms— $RP \equiv \int_{Y^*}^{R^L - z} F(y)dy$ — is a "risk premium", since it is the probability that the level of realized output is such that all entrepreneurs financed default and fail, and the larger is such probability, the higher is the charged loan rate. The third term— $LR \equiv \frac{L}{N}[F(R^L - z)(R_L^L - z_L) - R_L^L - F(Y^*)Y_l^*]$ —represents "market power rents" on the loan side, since it captures how loan pricing is chosen taking into account the elasticity of loan demand as well as the loan choices of competitors. Similarly, Equation (14) says that the deposit rate is the sum of the risk-free rate plus market power rents on the deposit side, given by the term $DR \equiv -R_D^D \frac{D}{N}$.

Indeed, in this model with uncertainty the classical "Lerner" index of market power, defined as the excess of price over "marginal" costs, includes a "risk premium", and is given by $R^L - R^D = RP + LR + DR$. As N increases, market power rents LR and DR decline, and vanish as $N \to \infty$.

Equation (15) is the equilibrium bank failure threshold. In equilibrium, such threshold increases with total deposits, since $Y_D^* = -\dfrac{r - R^D - R_D^D D}{L}$. By (14), $r - R^D - R_D^D D = R_D^D D(\frac{1}{N} - 1) < 0$ for $N > 1$. Thus, $Y_D^* > 0$.

[4] This result is obtained by Dermine (1986) in a model of a monopolist bank as well as under perfect competition.

However, *ceteris paribus*, the bank failure threshold can either increase or decrease in the amount of loans. Note that, substituting (14) in (11), $Y_L^* = \frac{R_D^D D^2}{NL^2} - z_L$. The first term—$\frac{R_D^D D^2}{NL^2}$—is positive, but the second term—$z_L = z'(R^L) R_L^L$—is also positive, since $R_L^L < 0$ and $z'(R^L) < 0$ by (3). Thus, $Y_L^* > 0$ if the BDN effect is weak, since $z_L < \frac{R_D^D D^2}{NL^2}$, while $Y_L^* < 0$ if the BDN effect is sufficiently strong, since $z_L > \frac{R_D^D D^2}{NL^2}$.

Next, we illustrate the comparative statics with respect to an increase in the number of banks—which can be either the result of a lift of entry restrictions or lower sunk costs of the intermediation technology.

Differentiating (14), we get:

$$\frac{dD}{dN} = \frac{R_D^D D}{N(R_D^D(N+1) + R_{DD}^D D)} > 0 \quad (16).$$

Thus, total deposits increase with *N*.

Substituting the total deposit function defined implicitly by (14) in (13), and differentiating, we get:

$$\frac{dL}{dN} = \frac{-G_N}{G_L} \qquad (17).$$

By the assumed concavity of bank's profits in loans, $G_L < 0$. Thus,

$$sign(\frac{dL}{dN}) = sign(G_N) \quad (18)$$

Recall that we defined $LR \equiv \frac{L}{N}[F(R^L - z)(R_L^L - z_L) - R_L^L - F(Y^*)Y_l^*]$. Then, differentiating $G(L, D(N), N)$ with respect to N (keeping L fixed at the equilibrium level), we obtain:

$$G_N \equiv \frac{LR}{N} + \frac{dD}{dN}\left(F(Y^*)Y_D{}^* + \frac{dLR}{dD}\right) = \frac{LR}{N} + \frac{dD}{dN} F(Y^*)Y_D{}^* + \frac{dLR}{dN}. \qquad (19)$$

The term $\frac{LR}{N}$ is positive, as the rents on the loan side cannot be negative, otherwise profits due to loans would be negative and a solution with $L > 0$ could not be an equilibrium. The term $F(Y^*)Y_D{}^*$ is positive, since we have shown that $Y_D^* > 0$ for $N > 1$. The last term is: $\frac{dLR}{dN} = -\frac{LR}{N}$, which cancels out with the first term.

Thus, total loans also increase with *N*.

Next, we discuss the *joint* empirical implications for risk taking and asset allocation of an increase in competition. In this model, the asset allocation is summarized by the ratio of loans to deposits L/D, as deposits are the only source of banks' funding..

The change in Y^*—hence, the change in the risk of failure $F(Y^*)$—resulting from a change in the number of banks is given by:

$$Y_N^* = Y_D^* \frac{dD}{dN} + Y_L^* \frac{dL}{dN} \qquad (20)$$

The term $Y_D^* \frac{dD}{dN}$ is positive, so that, *ceteris paribus,* an increase in total deposits will result in a larger set of output realizations for which a bank failure occurs. As we have seen, total loans increase with N ($\frac{dL}{dN} > 0$). It is clear that if $Y_L^* > 0$, that is, if the BDN effect is weak, then risk unambiguously increases, since $Y_N^* > 0$. Note that this, in principle, may occur under any asset allocation, that is, whether L/D increases or declines with N. Thus, *if the BDN effect is weak, then risk will increase independently of the asset allocation.* Conversely, if $Y_L^* < 0$, that is, *if the BDN effect is strong, then the change in risk will generally depend on both the strength of the BDN effect as well as on the asset allocation.*

However, note that for any economy, $Y_L^* \to -z_L$ as $N \to \infty$. Thus, there exists a threshold value of N such that for all numbers of banks greater than such threshold, the BDN effect becomes strong. In other words, the BDN effect becomes more important as competition increases.

In all cases, though, the magnitude of the change in total loans relative to total deposits will depend on all the parameters of the model, such as the elasticity of the demand for loans and supply of deposits, moral hazard costs and the assumptions regarding the distribution of the random component of the return on the risky investment.

This can be seen by the numerical examples reported in the Table below for a simple economy with linear demand and supply schedules and a uniform distribution of the return of the risky technology. Panel A reports the case where there is no BDN effect: risk increases as N goes up, while L/D first declines and then increases with N. Panel B reports the same economy, but with a strong BDN effect: here risk monotonically declines with N, while, similarly to the previous case, L/D exhibits a U-shaped relationship with the number of banks.[5]

[5] The sensitivity of the behavior of risk to the underlying parameters of the model is also underscored by other special versions of our model with no asset allocation choice. Boyd and De Nicolò (2003) in an Allen and Gale (2000) model with bankruptcy costs show that there can be a non-linear U-shaped relationship between the number of banks and bank risk. On the other hand, Martinez-Miera and Repullo (2008)

(continued…)

Table

Number of banks	profits per bank	total loans	total deposits	loans/deposits	Probability of bank failure [F(Y*)]
	Panel A: No BDN effect				
2	3.953	5.36	7.00	0.766	0.059
3	2.255	5.97	7.88	0.758	0.070
5	1.023	6.59	8.75	0.753	0.082
10	0.315	7.16	9.55	0.750	0.092
20	0.090	7.49	10.00	0.749	0.098
30	0.043	7.61	10.16	0.749	0.100
50	0.016	7.72	10.29	0.750	0.102
100	0.003	7.84	10.40	0.754	0.104
	Panel B: Strong BDN effect				
2	4.181	5.66	7.00	0.808	0.077
3	2.503	5.95	7.88	0.755	0.067
5	1.515	5.50	8.75	0.629	0.062
10	0.672	5.66	9.55	0.593	0.050
20	0.293	5.94	10.00	0.594	0.041
30	0.142	6.66	10.16	0.655	0.034
50	0.011	7.81	10.29	0.759	0.027
100	0.003	7.86	10.40	0.756	0.025

In sum, as N increases, risk increases if the BDN effect is weak, but can decrease if such effect is strong. Moreover, any economy will exhibit a strong BDN effect for a sufficiently large number of banks. As our numerical examples illustrate, when the BDN effect is strong (weak), there exists economies where beyond a certain level of N, risk decreases (increases) as the loan to asset ratio increases. Next, these predictions are confronted with the data.

III. Evidence

In a recent survey of the empirical literature, Beck (2008) points out that studies of banks in individual countries have reached mixed conclusions on the relationship between competition and risk in banking, while cross-country studies tend to indicate a positive relationship between competition and the stability of banking systems.

We should note two important drawbacks of many existing empirical studies: 1. the measures of competition used have been either "ad-hoc"; or 2. they have lacked a clear theoretical underpinning.

Examples of the former are studies that have used the so-called "H-statistics" introduced by Panzar and Rosse (1987) as a *continuous* measure of competitive conditions. It is well known in the literature that using this statistic as a continuous measure of competitive conditions is inappropriate, and that it produces competitive rankings

consider a special modification of our previous model (Boyd and De Nicolò, 2005) with no competition in the deposit market, and where our assumption of perfectly correlated loans returns à la Allen and Gale (2000) is replaced with imperfect correlation. A non-linear inverted-U shaped relationship between the number of banks and bank risk can be obtained under some assumptions, in contrast to Boyd and De Nicolò (2003).

opposite to those obtained by other measures proposed in the so-called "New Industrial Organization" (NIO) literature (see the discussion in Shaffer, 2004). Importantly, this and other NIO competition measures are constructed ignoring key features of banking, such as risk and uncertainty. [6]

Examples of the second group are studies that have considered some proxy measure of a Lerner index as a measure of competition. The endogeneity of such measures is typically tackled empirically by using instrumental variables. Yet, in many studies the choice of instruments seems often to be dictated more by data availability than by an explicit theoretical derivation. Most importantly, as demonstrated by Vives (2008) in the context of workhorse models of firm competition under certainty, even measures such as the Lerner index are not model-independent, so that "….. it cannot be taken for granted that a good proxy for the degree of product substitutability, as an indicator of competitive pressure, is the Lerner index" (Vives, 2008, p.445). Thus, the results obtained using measures of competition not supported by some explicit theoretical construct are difficult to evaluate and compare, and, as known since Cort (1999) , estimates of measures of competition can be significantly biased. [7]

Our empirical analysis differs from previous studies in three key respects. To our knowledge, this is the first empirical study in banking that assesses the *joint* implications of changes in competitive conditions on both bank risk and asset allocations with the guidance of an explicit theoretical model. Second, we employ measures of bank competition and risk that are dictated by our theory. Third, we consider two very different samples, a U.S. sample and an international sample, to assess whether country-specific and cross-country evidence differ in key respects. Next, we explain these features of the empirical work in detail.

A. Measurement of competition

A standard measure of market structure is the Hirschmann-Hirfendahl Index (HHI). In symmetric Cournot-Nash competition models such as ours, the HHI index is given

[6] Recent published studies using the H-statistics as a continuous measure of competition and ignoring risk include Bikker and Haaf (2002) Claessens and Laeven (2004, 2005), and Levy-Yeyati and Micco (2007).

[7] Recent examples of this kind of studies are Jimenez, Lopez and Saurina (2007) and Berger, Klapper and Turk-Ariss (2009). Jimenez, Lopez and Saurina (2007) correct their Lerner index with a risk premium, which is assumed to be determined under the assumption that the bank cost of funding is determined competitively, thus ignoring market power rents on the funding side. In addition, this premium is proxied by the probability of default of their loan categories, given by the ratio of defaulted loans to total loans, while their dependent variable is the ratio of non-performing loans to total loans: thus, the dependent variable is regressed on a highly correlated independent variable (to give a perspective, the correlation between delinquencies and charge off rates on all loans for the US commercial banks during 1991Q1-2008Q3 is 0.86). Berger, Klapper and Turk-Ariss (2009) employ a Lerner index in which marginal costs are estimated assuming that the cost of bank funding is provided competitively, thereby missing by construction any market power on the deposit side. Further they ignore any measure of a risk premium.

by N^{-2}. *Ceteris paribus*, this HHI is positively associated with price-cost margins (Lerner index), a standard measure of the degree of competitiveness, as we have shown. However, in reality both banks and markets are heterogeneous. Thus, the relationship between concentration measures and the degree of competition needs to be conditional on certain factors that are not directly connected with the ability of firms to extract market power rents, but may affect the level of concentration.[8]

Banks differ both with respect to scale (dis)economies and with respect to their cost structures. In theory, it has been well known since Desmetz (1973) that, *ceteris paribus*, a high HHI may reflect differences in banks' technologies, since more efficient banks will be able to gain larger market shares due to their ability to set prices lower than their competitors.

Likewise, markets differ with respect to size and the demand for banking services. Comparing HHIs across markets requires that we take into account differences in market size (see Bresnahan, 1989), since an HHI may be lower in a larger market, in which a greater number of firms can profitably operate. Differences in the demand for banking services across markets can also result in differences in HHIs not necessarily directly related to the ability of banks to extract market power rents.

Thus, our proxy measure of the degree of competition is the HHI index *conditional* on measures of banks' size and costs, size of market and proxy measures of the demand for banking services. As remarked by Sutton (2007) with reference to studies of non-financial firms in which firm and market heterogeneity is accounted for, "…..that a fall in concentration will lead to a fall in prices and price-cost margins is well-supported both theoretically and empirically."[9] Similarly, Degryse and Ongena (2008), in their recent comprehensive survey of the empirical banking literature, show that the results of studies conducted in many countries and different time periods indicate that more concentrated markets are associated with significant interest rate margins in both deposit and loan markets.

B. Measurement of risk

Our first empirical measure of bank risk is the *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 bank's probability of failure and has been widely used in the empirical banking and finance literature. Specifically, it represents the number of standard deviations below the mean by which a bank's profits would have to fall so as to deplete

[8] It is well known that in the context of Cournot-Nash competition, the direct relationship between concentration and the degree of market power holds only for specific forms of firm heterogeneity (see for example Tirole, 1988).

[9] Recent evidence of a significant positive relationship between concentration and price-cost margins is in Ali, Klasa and Yeung (2008).

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).[10]

Our second risk measure is specifically related to the riskiness of banks' loan portfolios. Recall that in the theoretical model, there are two distinct failure probabilities: the probability that loan customers default (represented by $F(R^L - z)$), and the probability that the bank fails (represented by $F(Y^*)$). As discussed earlier, loan customers' default risk is partly determined by a moral hazard problem in which, as loan rates rise they supply less effort which causes their risk of failure to rise. We have referred to this as the BDN effect. We investigate the size of the BDN effect by looking at the risk associated with bank loan portfolios. Although explicit loan default probability measures are not available, we can employ standard measures of loan portfolio losses as proxy measures. These procedures and the attendant caveats are discussed in the next section.

Our third risk measure is an indicator of actual bank failures, or near-failures, and we can only use this measure with the international sample. Unfortunately, we cannot employ such a measure with the US cross-section of banks, since 1993 was a benign year and none of the 2500 sample banks was even close to failure or under regulatory supervision. In the international panel, observing actual bank failures is difficult because the authorities frequently intervene with problem banks, re-organize, and recapitalize, making it difficult to identify the timing of actual failures. What we do as an alternative is to look at the accounting sum of capital plus current profits standardized by assets and define extremely low (outlier) observations as "failed or near –failed banks". This procedure is discussed in detail below.

C. Samples

We employ two samples with very different characteristics, each with its own advantages and disadvantages. The first sample, a single cross-section of US banks, is specifically chosen so as to reduce measurement problems in market definition to the absolute minimum. In making this choice we admittedly give up sample size and representativeness of the sample. The second sample, an international panel of banks in many countries, has enormous size and is representative of many different markets and economic environments. However, measurement issues arise in defining banking markets and measuring competition therein.

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[10] In our 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 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.

The first sample is composed of 2500 U.S. banks that operated only in rural non-Metropolitan Statistical Areas, and is a cross-section for one period, 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). They exhibit extreme variation in competitive conditions.[11] By limiting ourselves to these banks we are able to use the Federal Reserve's "Facilities" dataset. For anti-trust purposes, in these rural market areas the Federal Reserve Board (FRB) defines a competitive market as a county and maintains deposit HHIs for each market. These computations are done at a very high level of disaggregation. Within each market the FRB defines a competitor as a "banking facility," which could be a bank or a bank branch.

There is a substantial literature on the topic of competition in rural US banking markets, one that is too large to be adequately reviewed here.[12] However, two measurement problems are commonly recognized in this research. One is that the FRB only reports HHI indices for deposits, not for loans. It is entirely possible that the loan market is different from the deposit market in many cases so that the deposit market HHI is not the appropriate measure for loan market conditions. Another widely-recognized problem is that many banks operate in more than one deposit and/or loan market. When that occurs, the researcher must somehow aggregate HHI measures across markets and there is no unanimity on how that should be done. A related problem, important for our purposes, is that banks do not publicly report balance sheets at the branch level. This means that we cannot compute the loan/deposit ratio at the county level, and that is a key variable for our investigation.

In an attempt to mitigate all these problems simultaneously, we asked the FRB staff to delete from our sample all banks that operated in more than one deposit market.[13] By limiting our sample to such "unit banks," we neatly avoid the problem of having to aggregate HHI indices. In addition, with these unit banks we are able to match up competitive market conditions as represented by deposit HHIs and loan/deposit ratios as represented by bank balance sheet data.[14] Obviously, computation of the HHI statistics was done before these deletions, and was based on all competitors (banks and branches) in each market. Finally, this dataset allows us to include (or not) savings and loans as competitors with banks, which could provide a useful robustness test. S&L deposits are

[11] 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.

[12] Some recent studies include Adams *et al .(*2007), Rosen (2007), Berger, Rosen and Udell (2007), and Hannan and Prager (2004, 2006).

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

[14] 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 allocations will still be noisy.

near perfect substitutes for bank deposits, whereas S&Ls compete with banks for some classes of loans and not for others.

The second sample is a panel data set of about 3,000+ 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 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.[15] The number of bank-year observations ranges from about 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 banking systems and economic conditions. The disadvantage is that bank market definitions are necessarily imprecise, since 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 excluded banks from the U.S., the European Union, Switzerland, the Nordic countries, and Japan. In these cases, defining the nation as a market is especially problematic, both because of the country's economic size and because of the presence of many international banks.[16]

D. 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 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 was 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.[17] Forty six of the fifty states are represented.

[15] 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.

[16] This problem mars the significance and interpretation of the results obtained by Berger, Klapper and Turk-Ariss (2009), who consider HHI indexes as measures of competition precisely for the countries we exclude.

[17] 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.

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.

Our control variable for bank size is the natural logarithm of total bank assets, *LASSET*. Differences in technical efficiency across banks are accounted for by the ratio of non-interest operating costs to total income, *CTI*. In addition, as noted, comparing HHIs across markets requires that we control for market size. 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 a measure of total household income in county.

Differences in economic conditions across markets—especially differences in the demand for bank services—are controlled by three variables computed at the county level: 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. To further control for regional variations in economic conditions all regressions 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 location-specific correlation of errors. Finally, since the range of the ratio of loans to deposits is the unit interval, we use a Cox transformation to turn this into an unbounded variable.[18]

In Table 3 we present regressions in which the dependent variables are the Z-score and the transformed ratio of loans to assets, *LA_cox*. 3.1 is a regression of Z-score against *HHI0,* the six control variables discussed above, and with state fixed effects (which, for brevity, are not shown in the tables). The coefficient of *HHI0* is negative and statistically significant at usual confidence levels. The same is true when HHI100 is employed instead of *HHI0*. (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 suggesting that in this sample larger banks are riskier than small ones. Regression 2.2 is identical to 2.1 except that it employs

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

clustering at the county level, there being 1280 counties included. This procedure seems to have little effect on estimated standard errors.

2.3 shows that the (transformed) ratio of loans to deposits is negatively and significantly related to both HHI measures at about the one percent confidence level. The loan to deposit ratio is positively and significant related to growth rate in county labor force *LABGRO*, the size of the market *TOTALLY*, and to bank size *LASSET*; it is negatively and significantly related to bank operating costs *CTI*. Regression 2.4 adds the county clustering procedure, but this seems to have little effect on confidence intervals.

To summarize, results with the U.S. sample suggest that more competitive bank markets are associated with greater risk of failure and a higher ratio of loans to assets. Both findings seem robust, and are consistent with the predictions of the theoretical model when the BDN effect is present and is sufficiently strong.[19] We return to this issue in the next section.

E. Results for the International Sample

Table 3 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), and in terms of bank size.

Here, the *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. We computed HHI measures based on total assets. The median HHI is about 1900, and ranges from 391 to the monopoly value of 10,000. Some of the correlations between banking and macroeconomic variables (not shown) are noteworthy.[20]. The highest correlation is found between the HHI and GDP per capita.

[19] There is a branch of the literature on bank competition in the United States that deserves mention because it supports, or at least seems to support, our finding that more competition is associated with greater banking stability. Carlson and Mitchener (2006) find that increased competition brought about by branch banking increased financial stability during the Great Depression. A similar conclusion was reached by Jayaratne and Strahan (1996, 1998) who studied the effect of bank deregulation in the 1980's and 1990's. In all this work, cross-sectional and inter-temporal variations in measures of bank competition are primarily due to variations in regulatory restrictions on the location of banks and branches. As banks were permitted to expand geographically, this directly affected their ability to diversify. Therefore, it is difficult to separate the effects of improved diversification and increased completion. In our analysis, of course, regulatory restrictions of this nature play no direct role.

[20] Correlations tables for both sample are reported in our previous working paper (Boyd, De Nicolò and Jalal, 2006)

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. [21] The second highest correlation is between the HHI index and asset size which is negative (-0.26) and significant. Because of this high value, as detailed below, we will use regressions specifications with and without firm specific variables so as to check the possible impact of multicollinearity between the HHI and asset size.

We estimate panel regressions of the following form:

$$X_{ijt} = \alpha_i + \beta HHI_{jt-1} + \gamma Y_{jt-1} + \delta Z_{ijt-1} + \rho X_{ijt-1} + \varepsilon_{ijt}$$

where X_{ij} is the Z-score or the (transformed) loan-to-deposit ratio of bank i in country j, α_i is a time-invariant firm fixed effect, 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. The HHI, the macro variables 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 independent variable.[22]

The vector of country-specific variables Y_{jt} includes: real GDP growth and inflation, which control for cross-country differences in the economic environment; GDP per capita and the logarithm of population, which control for differences in relative and absolute size of markets (countries); and the exchange rate of domestic currency to the US dollar, since bank balance sheet values are all expressed in dollar terms. For the reasons mentioned earlier, the vector of firm variables Z_{ij} may include the natural logarithm of total bank assets, *LASSET* and the ratio of non-interest operating costs to total income *CTI* to control for differences in banks' technologies and cost structures.

We present two basic types of regressions with the Z-score and the transformed loan-to-asset ratio as dependent variables. The first type of regression is a standard fixed effect "static" panel regression ($\rho = 0$), with standard errors clustered by country. We report two specifications: one without firm specific variables, and one with all variables included.

The second type is a dynamic panel regression (all variables are included) with one lag of the dependent variable. We apply the GMM estimation procedure developed by Arellano and Bond (1991). The lagged dependent variables and all independent variables are treated as pre-determined, and we instrument these variables using their lags at time *t*-

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

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

2, *t*-3, and so on. Estimates of coefficients are reported for the one-step Arellano-Bond estimator, while Sargan specification tests are based on the relevant two-step estimator**.** Table 4 reports the results. For both the *Z-score* and the (Cox-transformed) ratio of loans to assets, the sign associated with the HHI is negative and significant in the fixed effects panel regressions as well as in the dynamic panel regressions.[23]

Remarkably, in the dynamic panel regressions with the Z-score as dependent variable (4.3), the sign of the HHI coefficient is not only negative and significant, but doubles its size (in absolute value). By contrast, the size of the HHI coefficient in the regressions with the loans-to-assets ratio as the dependent variable (4.6) declines. This indicates the importance of taking into account the dynamics of risk and asset allocation measures in these regressions, as witnessed by the significance of the coefficients associated with the lagged values of the dependent variables.

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

In sum, similar to the U.S. sample, we find that more concentrated bank markets are *ceteris paribus* associated with higher risk of bank failure and lower loan-to-asset ratios. Again, these results are consistent with the predictions of our model but only if the BDN effect is sufficiently strong.

IV. ALTERNATIVE RISK MEASURES

In the empirical literature on bank risk, it has been quite common to use measures of loan losses as proxy measures for risk in loan portfolios. Two *caveats* must be emphasized. First, such risk does not necessarily imply a higher risk of bank failure if the asset allocation tilts towards a larger holding of risk free assets. Our theoretical analysis shows that borrower failure and bank failure are different events and that the probability of bank failure can increase (decrease) at the same time that the probability of borrower failure decreases (increases). Second, such measures at best capture the default risk associated with the loan portfolio; the default risk associated with other bank assets (risky investments) is not captured by these measures. For our purposes, however, indicators of loan quality have independent interest, at least to the extent that they are correlated with the probability of borrower failure. We have obtained evidence that, as competition,

[23] In both dynamic panel regressions, the autocorrelation tests indicate that coefficient estimates are unbiased, and the Sargan tests do not reject the null hypothesis that the over-identifying restrictions are valid.

measured by the HHI increases, risk of bank failure decreases. The model requires that a necessary condition for observing both at same time is that there exist a strong BDN effect.

A. Loan Loss Measures of Risk

For the U.S. sample, we use two measures of loan losses, both of which have been commonly used in the literature. One is "loan loss provisions", which is an expense item on the income statement and reflects managerial judgment concerning future loan loss write-offs. The other is the "loan loss allowance", which is supposed to summarize historical loan loss experience. Both these variables are scaled by net loans and leases. Results with both variables are presented in Table 5, where the first two columns show robust OLS regressions, and the second two columns have robust OLS regressions with county clustering. We include all the controls discussed previously.

In all four regressions, the coefficient of the HHI index is positive and significant at usual confidence levels. This suggests that more concentration in US unit banking markets is *ceteris paribus* associated with greater loan losses as a percentage of total loans. To the extent that loan losses are a proxy for the default risk of loan customers, these results suggest that there is a BDN effect in our sample of unit banks in the United States. Specifically, as concentration increases and banks raise loan rates, the risk of loan default systematically increases. [24]

With the international data, the comparability of accounting definitions or standards across countries is uncertain, although the compilers of the database spend substantial effort to classify accounting items into homogenous categories. Keeping in mind this caveat, we estimated fixed effects regressions using the ratio of impaired loans to gross loans as defined in the Bankscope database. As shown in Table 6, the sign associated with the HHI is positive and significant in both regressions without and with firm controls. Thus, for the international sample more concentration is *ceteris paribus* associated with greater loan losses, consistent with the findings of the previous regressions with the U.S. sample.

[24] On this issue, a recent study by Cerqueiro (2008) is extremely useful. Working with highly disaggregated data, he investigates both the attributes of bank loans extended, and of the pool of applicants from which loan customers are drawn. He finds robust evidence that more concentration is associated with significantly higher loan rates. In turn higher loan rates are associated with a lower quality loan applicant pool and lower quality loans extended. His results clearly indicate endogenous customer reaction in response to terms of bank lending. This could reflect a moral hazard problem such as the one we modeled, or an adverse selection problem in which the pool of loan applicants changes. But either of these mechanisms will produce a BDN effect.

B. Actual Failures (or near failures) as the Dependent Variable

Ideally, the best empirical measure of risk of failure in banking is a (0,1) indicator of whether a sample bank "survived" or "failed" (Boyd and Runkle, 1993). For a variety of reasons, however, such data are difficult to obtain and can be hard to interpret. For one thing, actual bank failures are quite uncommon occurrences, meaning that the (0,1) measure produces something close to a vector of zeros. For another, in modern times failing banks are usually rescued by government and when that occurs they rarely end up on an official failure list (Boyd and Runkle, *op. cit.*).

For our sample of US banks, such tests are not possible due to the uniform good health of these banks in 2003.[25] With the international sample, things are more promising given the time series dimension, as well as the diversity of nations and economic conditions included.. With the international sample, we defined two proxy measures of bank failures according to the overall distribution of the sum of profits and equity capital standardized by assets: FAIL5 and FAIL10, corresponding to the 5th and 10th percentile of the entire distribution of this sum across time and countries.

Table 7 reports the results of two Logit regressions: the first is a pooled regression, while the second is a random effects version. The set of explanatory variables is the same one used previously. In all regressions, the coefficient associated with the HHI is positive and significant, as well as those associated with bank size and costs. In sum, consistent with all previous results, more concentration is *ceteris paribus* associated with a greater incidence of bank failures.

V. Conclusion

Our theoretical analysis considered a model that allows for competition in both deposit and risky loan markets, and for holding a risk-free asset. We have shown that increased competition can either increase or decrease the risk of bank failure. Further, we have shown that increased competition will generally affect the ratio of loans to assets, but that the direction of the effect is ambiguous. We allow for the existence of a moral hazard problem on the part of firms, called the BDN effect; as banks raise loan rates firms endogenously respond by increasing their risk of failure. It is proved that, when no BDN effect is present, an increase in bank competition will always result in an increase in risk of bank failure. That result are reversed if and only if the BDN effect is present and sufficiently strong. Thus, the existence of the BDN effect is a necessary but not sufficient condition to observe decreasing risk of bank failure as competition increases. Numerical examples have been provided illustrating that either result is possible.

Our empirical tests employed two different samples with very different attributes. First, we examined the relationship between competition and bank risk of failure. We found that the relationship is negative, meaning that more competition (lower HHI) is *ceteris*

[25] Out of 2500 banks, only five had a ratio of (equity + current profits)/ assets that was less than five percent. No sample bank had negative equity.

paribus associated with a lower probability of bank failure (higher *Z-score*). With the international sample we obtained similar results when the dependent variable was a (0,1) indicator of bank (near) failure. In all specifications, the incidence of bank (near) failure was negatively and significantly related to measures of competition.

We also conducted alternative tests employing loan loss measures as the dependant variable. With both samples, loan losses were found to be positively and significantly related to the HHI. These findings can be interpreted in two distinct ways. First, it has been common in the banking literature to interpret such loan loss measures as indicators of overall bank risk. Under that interpretation, our findings are entirely consistent: increasing competition is associated with lower risk of bank failure. Second, one may interpret the loan loss measures as indicators of borrower default probability. If loan losses are reasonable proxy measures for risk of default by bank borrowers, these findings are consistent with the existence of the BDN effect. That finding, in turn, would be consistent with the joint predictions of the theory.

In addition, we examined the relationship between measures of competition and asset composition represented by the loans-to-assets ratio. The empirical tests with both samples found a positive and highly significant relationship suggesting that increased competition increases banks' willingness to lend.

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 model specification and can easily be reversed by adopting a different specification. Moreover, our empirical work, based on two data sets and a variety of specifications, suggests that as banking markets become more competitive risk of bank failure declines.

Second, we have shown theoretically and by example that, as competition increase, the loan/deposit ratio can either increase or decrease. However, in all our tests the data suggest a positive and significant *ceteris paribus* relationship between bank competition and the loan/deposit ratio. This is potentially important because it adds a dimension that policy makers might consider when evaluating the costs and benefits of competition in banking. There has been little previous work on this relation and obviously more work needs to be done. If our results hold up to further examination, however, the policy implication is obvious and would appear to favor more competition in banking.

REFERENCES

Adams, R., Brevoort, K. and Kiser, E. 2007, "Who Competes with Whom? The Case of Depository Institutions," *Journal of Industrial Economics,* 55, 141-167.

Ali, Ashiq, Sandy Klasa and Eric Yeung, 2008, "The Limitations of Industry Concentration Measures Constructed with Compustat Data: Implications for Finance Research," Forthcoming in the *Review of Financial Studies*.

Allen, Franklin, and Douglas Gale, 2000, *Comparing Financial Systems* (MIT Press, Cambridge, Massachusetts)

Allen, Franklin, and Douglas Gale, 2004, "Competition and Financial Stability", *Journal of Money, Credit and Banking* 36(2), 453-480.

Arellano, M., Bond, S., 1991. "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies,* 58, 277-297.

Beck, Thorsten, 2008, "Bank Competition and Financial Stability: Friends or Foes?", in: *Competition in the Financial Sector*, Bank Indonesia and Banco de Mexico (eds), forthcoming.

Berger, A.N., Rosen, R.J., and Udell, G.F. 2007, "Does Market Size Structure Affect competition? The Case of Small Business Lending." *Journal of Banking and Finance,* 31, 11-33.

Berger, Allen, Leora F. Klapper and Rima Turk-Ariss, 2009, "Bank Competition and Financial Stability", *Journal of Financial Services Research,* Volume 35, 99-118.

Bikker, Jacob and Katharina Haaf, 2002, Competition, concentration and their relationship: an empirical analysis of the banking industry, *Journal of Banking and Finance* 26, 2191–2214.

Bresnahan, Timothy, 1989, "Empirical Studies of Industries with Market Power", Chapter 17 in *Handbook of Industrial Organization*, Vol. II, edited by Schmalensee and Willig, Elsevier, Amsterdam.

Boyd, John H., and Gianni De Nicolò, 2005, "The Theory of Bank Risk Taking and Competition Revisited", *Journal of Finance*, Volume 60, Issue 3, 1329-1343.

Boyd, John H., Gianni De Nicolò and Abu M. Jalal, 2006, "Bank Risk and Competition: New Theory and New Evidence", IMF Working Paper # 06/297, International Monetary Fund, Washington D.C.

Boyd, John H. and Edward Prescott, 1986, “Financial Intermediary Coalitions”, *Journal of Economic Theory*, 38, 211-232.

Boyd, John H. and David Runkle, 1993, “Size and Performance of Banking Firms”, *Journal of Monetary Economics*, 31, 47-67.

Carlson, M.A. and K. Mitchner, 2006, “Branch Banking, Bank Competition, and Financial Stability, *Journal of Money, Credit and Banking, 38, 1293-1328.*

Cerquero, Geraldo, 2008, “Bank Concentration, Credit Quality and Loan Rates”, Working Paper, Center, Tilburg University.

Claessens, Stijn, and Luc Laeven, 2004, “What drives bank competition? Some international evidence”, *Journal of Money, Credit and Banking* 36(2), 563–584.

Claessens, Stijn, and Luc Laeven, 2005, “Financial Dependence, Banking Sector Competition, and Economic Growth”, *Journal of the European Economic Association,* 3(1), 179-207.

Corts, K.S (1999). Conduct parameters and the measurement of market power. *Journal of Econometrics* 88, pp. 227-250.

Degryse, Hans, and Steven Ongena, 2008, “Competition and Regulation in the Banking Sector: A Review of the Empirical Evidence on the Sources of Bank Rents”, in *Handbook of Financial Intermediation in Banking* , Anjan V. Thakor and W. A. Boot, Editors, North-Holland, Amsterdam.

De Nicolò, Gianni, 2000, “Size, Charter Value and Risk in Banking: An International Perspective”, International Finance Discussion Paper # 689, Board of Governors of the Federal Reserve System.

De Nicolò, Gianni, Phillip Bartholomew, Jhanara Zaman and Mary Zephirin, 2004, “Bank Consolidation, Internationalization and Conglomeration: Trends and Implications for Financial Risk,” *Financial Markets, Institutions & Instruments*, Vol. 13, No. 4, 173-217.

Demsetz, Harold, 1973, “Industry Structure, Market Rivalry and Public Policy”, *Journal of Law and Economics,* Vol. 16,1, 1-9.

Demsetz, Rebecca, and Philip Strahan, 1997, “Diversification, Size, and Risk at Bank Holding Companies”, *Journal of Money, Credit and Banking,* Vol. 29, 3, 300-313.

Dermine, Jean, 1986, “Deposit Rates, Credit Rates and Bank Capital”, *Journal of Banking and Finance*, Vol.10, 99-114.

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

Gorton, Gary, and Andrew Winton, 2003, "Financial intermediation", Chapter 8 in *Handbook of the Economics of Finance*, edited by G.M.Constantinides, M. Harris and R., Stulz, Helsevier (Amsterdam).

Hannan, Timothy and R. Prager, 2006, "Multimarket Bank Pricing: An Empirical Investigation of Deposit Interest Rates," *Journal of Economics and Business,* 3, 256-272.

Hannan, Timothy and R. Prager, 2004, "The Competitive Implications of Multimarket Bank Branching," *Journal of Banking and Finance,* 28, 1889-1914.

Hellmann, Thomas, Kevin Murdock and Joseph Stiglitz, 2000, Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough?, *American Economic Review* 90(1), 147–165.

Jayaratne, J and Phillip Strahan, 1996, "The Finance-Growth Nexus: Evidence from Branch Bank Deregulation," *Quarterly Journal of Economics,* 111, 639-670.

Jayaratne, J. and Phillip Strahan, 1998, Entry Restrictions, Industry Evolution and Dynamic Efficiency: Evidence from Commercial Banking, *Journal of Law and Economics,* 41, 239-273.

Keeley, Michael, 1990, "Deposit insurance, risk and market power in banking", *American Economic Review* 80, 1183–1200.

Kreps, David and José Scheinkman, 1983, "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes", *Bell Journal of Economics,* 14, 326-337.

Martinez-Miera, David and Rafael Repullo, 2008, "Does Competition Reduce the Risk of Bank Failure?", CEPR Discussion Paper #6669, January.

Panzar, John and James Ross, 1987, "Testing for 'Monopoly' Equilibrium", *Journal of Industrial Economics*, Vol. 35, no.4, 443-456.

Repullo, Raphael, 2004, "Capital requirements, market power, and risk-taking in banking", *Journal of Financial Intermediation*, Vol. 13, 156-182.

Rosen, Richard, 2007, "Banking Market Conditions and Deposit Interest Rates," *Journal of Banking and Finance,* vol 31, 12, 3862-3884.

Roy, A , 1952, "Safety First and the Holding of Assets", *Econometrica,* 20, Vol.3, 431-449.

Shaffer, Sherrill, 2004, "Comments on What Drives Bank Competition: Some International Evidence, by Stijn Claessens and Luc Laeven", *Journal of Money, Credit and Banking* 36(2), pp. 585-592.

Stiglitz, Joseph E. and Andrew Weiss, 1981, "Credit Rationing in Markets with Imperfect Information", American Economic Review, Vol. 71, no.3, June, 393-410.

Sutton, John, 2007, "Market Structure: Theory and Evidence", Chapter 35 in Volume 3 of the *Handbook of Industrial Organization*, edited by Robert Porter and Mark Armstrong, 2301-2368.

Tirole, Jean, 1998, *The Theory of Industrial Organization*, MIT Press, Cambridge, Massachusetts.

Vives, Xavier, 2008, "Innovation and Competitive Pressure", *Journal of Industrial Economics*, Vol. LVI, September, 419-469.

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, quarterly data
LA	Total loans ÷ total assets, quarterly average over 3 years
	ROA
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
	County controls
LABGRO	Percentage growth in labor force 1999 – 2003
UNEM	Unemployment rate, 2003
FARM	Ratio of agricultural population ÷ total population in 2003
TOTALY	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
Z-score	35.5870	16.7554	3.0910	261.8150
LA	0.5715	0.1465	0.0000	0.9556

Table 2. U.S. Sample Regressions

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. LA_cox is the Cox transform of LA. *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. Columns 2.1 and 2.3 are robust OLS regressions. Columns 2.2 and 2.4 are robust OLS regressions with clustering on counties.

	DEPENDENT VARIABLES			
	Z-score	Z-score	LA_cox	LA_cox
	2.1	2.2	2.3	2.4
HHI0	**-0.000425****	**-0.000425****	**-0.0000220****	**-0.0000220****
	[0.047]	**[0.044]**	**[0.014]**	**[0.017]**
LASSET	-4.272***	-4.272***	0.125***	0.125***
	[0]	[5.77e-11]	[9.65e-09]	[0.000000017]
LABGRO	-11.75**	-11.75**	0.395*	0.395*
	[0.025]	[0.021]	[0.054]	[0.052]
UNEM	-0.397***	-0.397**	-0.00303	-0.00303
	[0.0094]	[0.011]	[0.63]	[0.63]
FARM	5.495	5.495	0.444	0.444
	[0.51]	[0.54]	[0.17]	[0.18]
CTI	-1.853***	-1.853***	-0.0686***	-0.0686***
	[0.00060]	[0.00070]	[0.0033]	[0.0031]
TOTALLY	-9.63E-10	-9.63E-10	1.06e-10***	1.06e-10***
	[0.40]	[0.41]	[0.0016]	[0.0022]
Constant	86.20***	86.20***	-1.007***	-1.007***
	[0]	[0]	[0.000052]	[0.000053]
Observations	2496	2496	2498	2498
R-squared	0.099	0.099	0.182	0.182
Regressions with:				
HHI100	**-0.000418***	**-0.000418***	**-0.0000234****	**-0.0000234****
	[0.059]	**[0.053]**	**[0.012]**	**[0.017]**

Table 3. International Sample

This panel data set includes bank/year observations for about 3,000+ banks in 134 countries *excluding* major developed countries over the period 1993 to 2004.

Panel A. Description of Variables

Bank Variables	
Z-score(t)	Z-score, $Z_t = \left(ROA_t + EQTA_t\right) / \sigma\left(ROA_t\right)$
LA(t)/ LA.cox(t)	Gross loan-to-asset ratio/ $= Ln(LA_t /(1 - LA_t))$
LASSET(t)	Log of total assets (in US $)
CTI(t)	Operating cost to income ratio
Market Structure	
HHIA(t)	Hirschmann-Hirfendahl Indexes based on accounting assets
Macroeconomic Variables	
GDPPC(t)	Per-capita GDP at PPP
LPOP(t)	Log Population
GROWTH(t)	Real GDP Growth
INFL(t)	Average CPI Inflation Rate
ER(t)	Domestic currency/US$ 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
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 4. International Sample Regressions

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 $\sigma\left(ROA_t\right) = \left|ROA_t - T^{-1}\sum_t ROA_t\right|$. *LA.cox* is the Cox transformation of the ratio of gross loans to assets. HHIA is the asset-HHI; *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. LASSET is the log of total assets; CTI is the cost-to-income ratio. The L. prefix indicates the relevant variable lagged one period. FFE are firm fixed effects regressions, with standard errors clustered by country. AB are estimates obtained by the GMM one-step estimator of Arellano and Bond (1991), where the lagged HHIA is treated as pre-determined. M1 and M2 is the p-value of the Arellano Bond statistics for first and second order correlation of residuals respectively; Sargan test is the p-value obtained by estimates of the two-step version of the model. Robust p-values are reported in brackets: * denotes significant at 10%; ** significant at 5%; *** significant at 1%.

	DEPENDENT VARIABLES					
	Zscore	Zscore	Zscore	LAcox	LAcox	LAcox
Estimation Method	FFE	FFE	AB	FFE	FFE	AB
	4.1	4.2	4.3	4.4	4.5	4.6
L.HHIA	**-12.245*** **	**-14.078***	**-24.868** **	**-0.294*** **	**-0.311***	**-0.189** **
	[0.00329]	**[0.0583]**	**[0.0233]**	**[0.00557]**	**[0.0635]**	**[0.0376]**
L.GDPPC	-0.001	-0.002	-0.006***	0	0	-0.000***
	[0.296]	[0.140]	[0.00243]	[0.353]	[0.663]	[0.000170]
L.LPOP	12.561	-12.638	-15.946	-1.147***	-1.774***	-1.259***
	[0.500]	[0.542]	[0.665]	[0.00553]	[0.0000802]	[6.50e-08]
L.GROWTH	-0.099	0.007	0.143	0.022***	0.020***	0.005***
	[0.420]	[0.962]	[0.506]	[0.0000108]	[0.00000410]	[0.00534]
L.INFL	0	-0.001	-0.004	0	0	0
	[0.856]	[0.586]	[0.385]	[0.425]	[0.424]	[0.618]
L.ER	-0.000***	-0.000***	0	-0.000***	-0.000***	0
	[0.000198]	[3.89e-09]	[0.784]	[0.000125]	[0]	[0.478]
L.LASSET		-3.558**	-0.988		0.161***	0.177***
		[0.0119]	[0.669]		[0.000132]	[0.0000882]
L.CTI		0.011	0.028**		-0.001***	0
		[0.138]	[0.0180]		[0.000169]	[0.180]
L.Zscore			0.061***			
			[0.00152]			
L.LAcox						0.573***
						[0]
Constant	9.92	143.353**	143.574	3.420**	3.829***	2.396***
	[0.871]	[0.0372]	[0.238]	[0.0111]	[0.00779]	[0.00560]
Observations	15574	12182	8486	17113	12925	9615
Number of banks	3098	2966	2417	3326	3037	2593
M1 (p-value)			0.00			0.00
M2 (p-value)			0.27			0.73
Sargan Test (p-value)			0.39			0.43

Table 5. U.S. Sample Loan Loss Measures

Dependent variables: LLM1 = Provision for loan and lease losses / Net loans and leases in June 2003; LLM2 = Loan loss allowance / Net loans and leases in June 2003. Independent variables: HHI0 is the Hirschmann-Herfindahl Index computed with banks only. HHI100 is the Hirschmann-Herfindahl Index computed with banks and savings and loan associations. LASSET= natural logarithm of bank assets. 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. CTI is the 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. Columns .1 and .3 are robust OLS regressions. Columns .2 and .4 are robust OLS regressions with clustering on counties.

	DEPENDENT VARIABLES			
	LLM1	LLM2	LLM1	LLM2
	5.1	5.2	5.3	5.4
HHI0	**0.000000198****	**0.000000805*****	**0.000000198****	**0.000000805*****
	[0.021]	**[0.0094]**	**[0.014]**	**[0.0094]**
LASSET	0.000659**	-0.00131*	0.000659**	-0.00131*
	[0.016]	[0.064]	[0.016]	[0.065]
LABGRO	0.00156	-0.00365	0.00156	-0.00365
	[0.12]	[0.31]	[0.11]	[0.35]
UNEM	0.0000298	-0.0000973	0.0000298	-0.0000973
	[0.41]	[0.43]	[0.41]	[0.44]
FARM	0.0000489	-0.00206	0.0000489	-0.00206
	[0.98]	[0.77]	[0.98]	[0.77]
CTI	0.000744***	-0.000249	0.000744***	-0.000249
	[0.000017]	[0.10]	[0.000018]	[0.11]
TOTALLY	0	-0***	0	-0***
	[0.37]	[0.00069]	[0.32]	[0.00098]
Constant	-0.00645**	0.0305***	-0.00645**	0.0305***
	[0.038]	[0.00021]	[0.038]	[0.00023]
Observations	2498	2498	2498	2498
R-squared	0.032	0.025	0.032	0.025
Regressions with:				
HHI100	**0.000000225****	**0.000000902*****	**0.000000225*****	**0.000000902*****
	[0.012]	**[0.0069]**	**[0.0070]**	**[0.0073]**

Table 6. International Sample Loan Loss Measures

NPL is the ratio of impaired (non-performing) loans to gross loans. HHIA is the asset-HHI; *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. LA is the loan to asset ratio; CTI is the cost-to-income ratio. The L. prefix indicates the relevant variable lagged one period. The regressions are firm fixed effects regressions, with standard errors clustered by country. Robust p-values are reported in brackets: * denotes significant at 10%; ** significant at 5%; *** significant at 1%

	DEPENDENT VARIABLES	
	NPL	NPL
	6.1	6.2
L.HHIA	**0.042****	**0.057***
	[0.0431]	**[0.0995]**
L.GDPPC	0	0
	[0.987]	[0.861]
L.LPOP	0.291***	0.233***
	[0.000996]	[0.00532]
L.GROWTH	-0.004***	-0.004***
	[0.00289]	[0.00256]
L.INFL	0	0
	[0.358]	[0.742]
L.ER	-0.000***	0.000***
	[0]	[0.0000114]
L.LA		0.027
		[0.554]
L.CTI		0.000***
		[0.00818]
Constant	-0.837***	-0.694***
	[0.00262]	[0.00762]
Observations	7396	6171
Number of firms	1847	1731

Table 7. International Sample: Proxy Measures of (near) Failure

FAIL5 and FAIL10 are the 5th and 10th percentile of the entire distribution of the sum of profits and equity capital across time and countries respectively. HHIA is the asset-HHI; *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. LASSET is the log of total assets; CTI is the cost-to-income ratio. The L. prefix indicates the relevant variable lagged one period. Estimates are standard Logits and random effects Logits. Standard estimation is a pooled Logit. Random effects estimation is a random effects Logit. Robust p-values are reported in brackets: * denotes significant at 10%; ** significant at 5%; *** significant at 1%

	DEPENDENT VARIABLES			
	FAIL5	FAIL5	FAIL10	FAIL10
Estimation Method	pooled	random effeects	pooled	random effeects
	7.1	7.2	7.3	7.4
L.HHIA	**1.366*** **	**1.500*** **	**1.072*** **	**1.829*** **
	[0.00000259]	**[0.000439]**	**[0.00000385]**	**[0.00000125]**
L.GDPPC	-0.000***	-0.000*	-0.000***	-0.000***
	[0.00160]	[0.0674]	[0.00000410]	[0.00118]
L.LPOP	-0.087***	-0.083	0.01	0.012
	[0.00969]	[0.108]	[0.683]	[0.797]
L.GROWTH	-0.030***	-0.041***	-0.004	-0.020*
	[0.01000]	[0.000651]	[0.699]	[0.0535]
L.INFL	0	0	0	0
	[0.147]	[0.249]	[0.755]	[0.760]
L.ER	-0.000*	0	-0.000**	-0.000**
	[0.0998]	[0.312]	[0.0212]	[0.0436]
L.LASSET	0.454***	0.546***	0.464***	0.668***
	[0]	[0]	[0]	[0]
L.CTI	0.004***	0.003***	0.004***	0.002***
	[0]	[0.000000308]	[0]	[0.0000133]
Constant	-9.068***	-11.787***	-8.747***	-12.900***
	[0]	[0]	[0]	[0]
Observations	14703	14703	14703	14703
Number of firms	3230	3230	3230	3230