Bank Competition, Asset Allocations and Risk of Failure: An Empirical Investigation

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Abstract

This study is an empirical investigation of theoretical predictions concerning the impact of bank competition on bank risk and asset allocations. Recent work (Boyd, De Nicolò and Jalal, 2009, BDNJ henceforth) predicts that as competition in banking increases, the loan-to-asset ratio will rise (under reasonable assumptions), but the probability of bank failure can either increase or decrease. However, the probability of bank failure will fall if and only if borrowers' response to take on less risk as loan rates decline is sufficiently strong. We test these predictions using two samples with radically different attributes. With both, we find that banks' probability of failure is negatively and significantly related to measures of competition. We also find that as competition intensifies, borrower risk decreases and the loan-to-asset ratio increases. These results are consistent with the predictions of the BDNJ model.

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I. Introduction

This empirical study investigates the relationship between bank competition, asset allocations and risk taking. It presents a sequence of tests of the predictions of the model recently developed in Boyd, De Nicolò and Jalal (2009, BDNJ henceforth). The BDNJ model allows for imperfect deposit and loan market competition, but adds banks' holding of a risk-free asset, which is not done in any existing theoretic literature.

The relationship between bank competition, asset allocation and bank risk is of great interest to policy-makers. One of the key economic contributions of banks is 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 riskless assets. Thus, if competition affects banks' choices between loans and riskless assets, there will be welfare consequences.

The BDNJ model predicts that as competition in banking increases, under reasonable assumptions the loan-to-asset ratio will rise, but the probability of bank failure can either increase or decrease (unlike in Boyd, De Nicolo (2005). However, the BDNJ model reveals an important conditional relationship between bank risk and borrower risk. As competition intensifies, banks lower loan rates and borrowers respond by lowering their own risk of failure *ceteris paribus* (which has come to be known as the "BDN effect" in the literature). However, bank risk will fall if and only if borrower risk decreases sufficiently. In other words, bank risk will decrease if and only if the BDN effect is sufficiently strong.

We explore these predictions using two datasets: a cross-section of 2,500 U.S. banks in 2003, and an international panel dataset with annual individual bank observations of about 100 non-industrialized countries for the period 1993-2004. As will be explained, the two samples have very different attributes. One is chosen for its precision in measurement of competition, the other for its large size, breadth and variety of coverage.

We begin with a review of the recent literature, a literature that has grown substantially since the publication of Boyd and De Nicolo (2005) prompted new interest in this topic. We then turn to the empirical tests. There are three main findings. *First*, banks' probability of failure is positively and significantly related to concentration.[1] *Second*, banks' loan-to-asset ratios are negatively and significantly associated with measures of concentration. This is consistent with the predictions of the BDNJ model when the interest rate elasticity of loan demand is greater (in absolute value) than the interest rate elasticity of deposit supply. To our knowledge, we are the first to empirically investigate the link between competitive conditions and bank asset allocations. As noted, this finding is important for policy because, as will be discussed, it represents another social benefit of competition in banking. Both the *first and second* findings are robustly supported by a variety of specifications with both datasets.

The *third* empirical finding is that when concentration increases, the risk of borrowers increases also. This finding is consistent with the joint-conditional relationship between bank risk of failure and borrower risk of default predicted by the BDNJ model. To test this joint-conditional relationship we employ several loan loss variables as proxy measures for the probability of loan customers' default. In all tests and with both samples, as competition intensifies banks' loan loss ratios deteriorate. Previous empirical work has investigated both bank risk and borrower risk separately, but often the joint-conditional relationship between the two has been ignored.

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[1] Boyd and De Nicolo (2005) predict that when concentration increases bank risk of failure will increase.

The remainder of the paper is composed of four sections. Section II reviews the literature. Section III present the evidence on the relationship between measures of competition and bank risk, while Section IV focuses on such a relationship using measures of borrowers' risk.. Section V concludes.

II. LITERATURE REVIEW

A. Existing Empirical Evidence

In this section, we review the recent empirical literature on competition and risk in banking (One can also find useful literature reviews in Beck (2008), and Noth, (2010)). As reported by Beck *op. cit*., this literature has produced mixed results: "Empirical studies focusing on individual countries provide ….. ambiguous results, while cross-country studies point mostly to a positive relationship between competition and stability in the banking system." (Abstract).

There are two broad classes of risk measures and existing research has examined both: the riskiness of *banks* and the riskiness of *bank loan customers* (the latter usually being proxied by loan loss measures). Some studies have treated loan loss ratios as actual proxies for bank risk of failure (For examples, Dick, 2006; Jimenez et al., 2010). However, such measures actually represent borrower rather than bank risk, since they reflect the fraction of loan customers in (or expected to be in) default. Borrower risk and bank risk are different objects and can move in opposite directions – for example, due to offsetting changes in bank equity ratios. In terms of the relation between bank competition and bank risk, such tests are inconclusive.

Jimenez et. al. (2010) and Berger et. al. (2009) find that as competition increases bank risk of failure increases also, which is the opposite of what we obtain in this study. However, both studies employ several different measures of competition, including the Lerner Index, and empirical approaches that we will critically discuss below. Berger et. al. (op. cit.) employ a sample composed of large, developed nations, and define a country as a banking market when using concentration measures. However, this sample includes many large multinational banks that operate across national borders and therefore blur market definitions. For just that reason, in our work we will intentionally exclude the countries that Berger *et. al.* (op. cit.) studied.

Three recent studies use our theoretical framework (Boyd and De Nicolo, 2005, and BDNJ) to impose discipline on their empirics. Cerqueiro (2008), working with highly disaggregated data, investigates the link between banking competition and loan customer risk. He studies the attributes of both 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 applicant pool and lower quality loans extended. These results clearly indicate endogenous loan customer reaction to the degree of competition in banking (e.g. a BDN effect). This could reflect a moral hazard or adverse selection problem, but either will cause loan risk to decline as bank competition intensifies. Noth (2010) also employs highly disaggregated data and studies the risk of bank borrowers. He finds a nonlinear relationship such that as banking competition increases, borrowers risk first increases and then declines.

Another recent study is Corbea and D'Erasmo (2009). This study is a stochastic-dynamic calibration and simulation of a banking industry that competes a la Cournot-Nash. It is potentially important because it employs a methodology totally different from other existing work in this literature. Early calibrations of their model suggest that increasing competition in banking reduces the risk of bank failure, consistent with our own findings.

B. Measuring Competition in Banking: Conceptual Issues

There have been two important problems in the way that many existing empirical studies measure the degree of competition in banking markets. The measures of competition have often been *ad-hoc* as they have lacked rigorous theoretical underpinnings. Most importantly, as stressed by De Nicolò and Turk Ariss (2010), these measures have been constructed ignoring risk and uncertainty.

Several studies have employed the so-called "H-statistic" introduced by Panzar and Rosse (1987). One problem is due to using the H-statistic as a *continuous* measure of competitive conditions. It is well known that using this statistic as a continuous measure of competition is inappropriate, and may produce competitive rankings opposite to those obtained by other measures (see the discussion in Shaffer, 2004). An additional problem of this measure is that it is derived under the assumption of competitive factor markets. As applied to banking, this assumption has been applied to banks' liability side, with the implication that market power rents on the funding side are ignored. Studies using the H-statistic as a continuous measure of competition and ignoring risk and uncertainty include Bikker and Haaf (2002) Claessens and Laeven (2004, 2005), and Levy-Yeyati and Micco (2007).[2]

Several other studies have employed some proxy measure of a Lerner index as a measure of competition. However, as demonstrated by Vives (2008), 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"

[2] More recently, Shaeck and Cihak (2010) employ an H-type measure of competition and show that this measure exhibits a continuous "ranking" of competition similar to the H measure. Thus, the problems associated with H-type measures persist also in this study. In addition, as in the other studies reviewed, their competition measure ignores rents on the funding side as well as risk and uncertainty.

(Vives, 2008, p.445). Thus, the results obtained using such measures of competition are difficult to evaluate and compare without a specific reference to a model. [3]

Examples of such studies include Jimenez et al. (2010) and Berger et al. (2009). Jimenez et al. (2010) make an attempt to “correct” their Lerner index with a default risk premium obtained under the assumption that the cost of bank funding is determined competitively; thus, their risk-correction ignores market power rents on the liability 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. 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, during 1991Q1-2008Q3 the correlation between delinquencies and charge off rates on all loans for the US commercial banks was 0.86). In addition to concentration measures, Berger et. al. (2009) employ a Lerner index in which marginal costs are estimated assuming that bank funding is provided competitively. Therefore, such a measure ignores market power on the liability side and does not take into account borrower default risk

C. Our Empirical Work: Its Relation to the Literature

Our analysis differs from previous studies in three key respects. First, this is the first empirical study in banking that assesses the *joint* implications of changes in competitive conditions on bank risk *and on asset allocations*. Second, we employ measures of bank competition and risk that are dictated by and derived formally from an explicit theoretical construct, the BDNJ model. Third, we separately examine bank risk of failure and borrower risk of failure, mindful of the theoretical link between the two.

[3] This same point is stressed by Corts (1998).

The relationship between bank competition and asset allocations is important, and to our knowledge has received no previous attention in this literature. The BDNJ model suggests that competition will affect the loan-asset ratio and we believe that policy makers should care about that. Suppose, (hypothetically and, based on our work, counter-factually) that reduced competition resulted in reduced risk of bank failure, but only because it caused banks to substitute risk-free government bonds for risky loans. Assume further that this supposed benefit of reduced competition was correctly identified by the researcher and reported to the policy-maker. The policy-maker would be poorly guided unless the researcher also investigated asset allocations. Without interfering with competition, the regulator could achieve the same desired risk effect by directly requiring banks to hold a higher-than-equilibrium fraction of risk-free assets.

III. EMPIRICAL SPECIFICATIONS AND PROCEDURES

A. Measurement of competition

A standard measure of market structure is the Hirschmann-Hirfendahl Index (HHI). In symmetric Cournot-Nash models, such as the BDNJ model, the HHI index is given by N^{-2}. *Ceteris paribus*, this HHI is positively associated with the price-cost margin (Lerner index). 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.[4]

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 lower prices.

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.

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." 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 time periods indicate that more concentrated markets are associated with significant interest rate margins in both deposit and loan markets.

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[4] 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).

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. It represents the number of standard deviations below the mean by which a bank's profits would have to fall so as to 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).[5]

Our second risk measure is specifically related to the riskiness of banks' loan portfolios. Although explicit borrower default probability measures are not available, we can employ standard measures of loan portfolio losses as proxy measures.

C. Samples

We employ two samples with very different characteristics. The first sample, a single cross-section of US banks, is chosen so as to minimize measurement problems in market definition. In making this choice we give up sample size and representativeness. The second sample, an international panel of banks, has enormous size and is representative of many

[5] In the BDNJ 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 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.

different markets and economic environments. However, measurement issues arise in defining banking markets and measuring competition therein.

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.[6] 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 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.[7] 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 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

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[6] 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.

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

branch level. This means that we cannot compute the loan/asset 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 FRB staff to delete from our sample all banks that operated in more than one deposit market.[8] 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/asset ratios as represented by bank balance sheet data. [9] 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 provides 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.

The second sample is an unbalanced panel data set of about 3,000 banks in about 100 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.[10] The number of bank-year

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[8] 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.

[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 allocations will still be noisy.

[10] Coverage of the Bankscope database is incomplete in some countries for the earlier years (1993 and 1994), but from 1995 coverage in almost all countries is about 95 percent of all banking systems' assets. Therefore, time

(continued)

observations ranges from about 10,000 to 13,000, depending on availability of all variables of interest.

The advantage of this international data set is its size, 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 exclude 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.[11]

D. Results for the U.S. Sample

Table 1 defines all variables and sample statistics. Here, the *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

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variations in statistics such as concentration measures for each country essentially reflect changes in market structure rather than changes in sample coverage. Data for 2004 are limited to those available at the extraction time.

[11] All variables in the Bankscope database were carefully checked for reliability and consistency: outliers due to obvious measurement errors were eliminated, and each variable was winsorized at the 1st and 99th percentiles.

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:

$$X_{ij} = \alpha + \beta HHI_j + \gamma Y_j + \delta Z_{ij} + \varepsilon_{ij} \quad (1)$$

where X_{ij} is *Z-score*, the Z-score components, 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.

The 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.* 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 demand for bank services across markets 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. Finally,

[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.

since the range of the ratio of loans to assets is the unit interval, we use a Cox transformation to turn this into an unbounded variable.[13]

In Table 2 we present regressions in which the dependent variables are the Z-score, the transformed ratio of loans to assets, and the three individual components of Z-score. 2.1 is a regression of Z-score against *HHI0,* the six control variables and state fixed effects (fixed effects, for brevity, are not shown). The coefficient of *HHI0* is negative and statistically significant at usual or higher 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 efficiency may reduce the risk of failure. The coefficient of *LASSET* enters with a negative and highly significant coefficient suggesting that for this sample and time period larger banks were riskier than smaller ones. Regression 2.2 is identical to 2.1 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.

It is possible that bank failure risk, as represented by the Z-score, could feed back and at least partially determine the number and size of competitors in a market as represented by the HHI. This would result in a reverse-causality or "endogeneity" problem. Therefore, column 2.3 employs an IV procedure to instrument for *HHI0*. The instruments used in first stage estimates are median county income in 1989 and rate of poverty in 1989. These are lagged by fourteen years and thus should be sufficiently exogenous to current conditions in banking markets (see Table 2, footnote). The IV procedure seems to have little effect on regression results except to marginally increase the significance of the HHI.

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

Actually, for purely economic reasons we believe that possible endogeneity of the HHI is not a serious issue in the context of our application. Our Z-scores are based on current accounting reports and can change very substantially in a short time frame. The HHI, on the other hand, tends to change very slowly. Entry, exit, mergers and acquisitions do occur in banking to be sure, but at a much lower frequency.[14] Thus, for present purposes, an HHI measure may be considered "*de-facto* exogenous". We will demonstrate that this is the case in results to be presented later, that exploit the time dimension of the international panel data.

Recall that the BDNJ model does not yield unequivocal predictions on the *unconditional* relationship between competition and bank risk. Therefore, we wish to assess whether there is any evidence of non-linearity in this relationship.[15] This finding is reported in column 2.4: there is no evidence of non-linearity.

Regression 2.5 shows that the (log-transformed) ratio of loans to assets is negatively and significantly related to both HHI measures at about the one percent confidence level. The loan to asset ratio is positively and significant related to 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.

In Regressions 2.7 – 2.9, the three components of the Z-score are treated as separate dependent variables. *PA,* the rate of return on assets, is *positively* related to both *HHI0* and *HHI00* at about the 90% confidence level. *EA_cox* is the (Cox transformation of) the equity to

[14] For example, Berger and Dick (2007) show that for a large sample of US banks, the best single predictor of market share in 2002 is market share in 1972, thirty years earlier.

[15] Noth (2010) reports finding a non-linear variable, although with a rather different specification than ours .

assets ratio; this variable is not significantly related to either *HHI0* or *HHI00*. *lnSDPA* is (the log-transformed) standard deviation of earnings and is *positively* and significantly related to both HHI measures. The positive sign on *PA* suggests that higher concentration is associated with higher expected profits. However, as HHI changes the positive effect on *PA* is more than offset by the effect on lnSDPA.[16]

To summarize, results with the U.S. sample suggest that more competitive bank markets are associated with lower risk of bank failure and higher loan to asset ratios. Both findings seem robust and are both are consistent with the predictions of the BDNJ model.[17]

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 in each year* is defined as $Z_t = (ROA_t + EA_t)/\sigma(ROA_t)$. ROA_t is the return on average assets, EA_t is the equity-to-assets ratio, and $\sigma(ROA_t) = | ROA_t - T^{-1}\sum_t ROA_t |$. All are constructed with annual data. When this standard deviation measure is averaged across

[16] Recall that the models with uncertainty and endogenous choice of risk by Boyd and De Nicolò (2005) and BDNJ do not imply an unequivocal relationship between concentration and bank risk, since lower concentration will move up the probability of project success, while market power rents will be lower. The net effect will depend on the relative strength of the BDN effect and the magnitude of the decline in market power rents.

[17] There is a branch of the literature on bank competition in the United States that deserves mention because it is consistent with 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 competition. In our analysis, of course, regulatory restrictions of this nature play no direct role.

time, it generates a cross-sectional series whose correlation with the Z-score as computed previously is 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.

We estimate dynamic panel regressions of the following form:

$$X_{ijt} = \alpha_i + \beta HHI_{jt-1} + \gamma Y_{jt-1} + \delta Z_{ijt-1} + \rho X_{ijt-1} + \varepsilon_{ijt}, \quad (2)$$

where X_{ij} is the Z-score, the (transformed) loan-to-asset ratio of bank i in country j, or the components of the Z-score, α_i is a time-invariant firm fixed effect, HHI_j is a Hirschmann-Herfindahl Index in country j, Y_j is a vector of country-specific controls, and Z_{ij} a vector of bank-specific controls.

We use a dynamic specification since the dependent variables exhibit high persistence: indeed, the coefficient ρ is different from 0 with high significance in all regressions presented below. For this reason, the "static" specifications used in *all* studies using panel data previously reviewed (except Jimenez et al., 2010) may lead to significant estimation biases.

Importantly, 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 variables. This is a standard specification (see, for example, Demsetz and Strahan, 1997). *Economically*, our specification is consistent with the fact (and standard modeling assumptions) that banks' risk and asset allocation choices made in period t will generate observable outcomes in period t+1. *Statistically*, this specification exploits the time dimension to address the potential problem of endogeneity of measures of competition that might arise from contemporaneous specifications.

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} includes 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 estimated (2) applying the GMM estimation procedure developed by Arellano and Bond (1991). The lagged dependent variables and all independent variables are instrumented using their lags at time *t*-2, *t*-3, and so on. Estimates of coefficients are reported for the one-step Arellano-Bond estimator, while, as suggested by Arellano and Bond *(op. cit.)*, autocorrelation tests and Sargan specification tests are based on the relevant two-step estimator.

Table 4 reports the results for the entire sample.[18] For both the *Z-score* (regression 4.1) and the (Cox-transformed) ratio of loans to assets (regression 4.2), the sign associated with the HHI is negative and significant. Note that for both these 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.

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[18] As pointed out in footnote 11, the incompleteness of the coverage of the Bankscope database for the years 1993-1995 and 2004 may induce bias in the estimates of HHIs. For this reason, we run all regressions for the international sample reported below excluding these years, and obtained essentially identical results. For brevity, the results of these regressions are omitted.

Regressions 4.3-4.5 report results with the components of *Z-score* as dependent variables. The return on assets (*ROA*) is *negatively* related to HHI, the (Cox-transformed) ratio of equity capital to assets (*EA_cox*) is also *negatively* related to HHI, while the (log-transformed) volatility of earnings *LnSDROA* is positively related to the HHI. All coefficients are significant at standard confidence levels. Thus, in this international sample all components of the Z-score move in a direction consistent with the negative and significant coefficient that we obtain when Z-score is the dependent variable.

Next, we address two "robustness" issues. First, recall that the BDNJ model does not yield unequivocal predictions on the *unconditional* relationship between competition and bank risk. Therefore, we wish to assess whether there is any evidence of non-linearity in this relationship. Second, as remarked previously, we wish to assess whether changes in the determinants of HHI are slower than changes in the Z-score. An implication of these differential speeds of adjustment is that a bank's Z-score should not predict a bank's market share or, equivalently, a convex function of its market share. In fact, the HHI is the sum of squared market shares.

Table 5 reports these robustness tests. As shown in regressions 5.1 and 5.2, there is no evidence of non-linearity both in the case of a quadratic specification, as well as in the case of a piecewise specification. As shown in regression 5.3, lagged Z-scores have no predictive value for the evolution of the square of market shares. Both these tests appear to confirm the robustness of our results.

In sum, similarly 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. These results are consistent with the predictions of the BDNJ model.

IV. MEASURES OF BORROWER RISK

Borrower failure and bank failure are different objects, as the probability of bank failure can increase (decrease) at the same time that the probability of borrower failure decreases (increases). For our purposes, however, indicators of loan quality have independent interest since they should be highly correlated with the probability of borrower default.

We have presented empirical evidence that, as competition increases, risk of bank failure decreases. The BDNJ model requires that a necessary condition for such a relationship is that there exists a sufficiently strong BDN effect. Therefore, given our empirical results with bank risk of failure, it is important to test if increasing competition also reduces borrower risk of failure. This is, essentially, a test of the consistency between the theoretical predictions and empirical findings.

A. Results for the U.S. Sample

For the U.S. sample, we use two measures of loan losses, both of which have been used in the literature. One is "loan loss provisions" *LLM1,* which is an expense item and reflects managerial judgment concerning future loan loss write-offs. The other is the "loan loss allowance" *LLM2*, which summarizes historical loan loss experience. Both variables are scaled by net loans and leases. Results with both variables in levels and log-transformed levels, are presented in Table 6., where the first four columns show results with *LLM1* , and the second four columns with *LLM2*. We include all the controls discussed previously. In 6.1, 6.2, 6..4 and 6.5, the coefficient of the HHI index is positive and significant at usual confidence levels. These results suggest that there is a sufficiently strong BDN effect in our sample of unit banks in the United States. Columns 6.3-6.4 and 6.6-6.7 look for evidence of a non-linear relationship and find none.

B. Results for the International Sample

With the international data, we also use two measures widely used in the literature: "loan loss provisions", *LLP,* and "impaired (non-performing) loans", *NPL*, measuring loans that are delinquent for more than 60 or 90 days. Here, both variables are scaled by gross loans.

Table 7 reports the results with both variables in levels and log-transformed levels, with linear and quadratic specifications for the HHI, and all the controls discussed previously included. In the linear specifications 7.1, 7.3, 7.5 and 7.7 : the coefficient of the HHI index is not significant, except in 7.5, where it is positive and significant,

By contrast, *all* quadratic specifications (7.2, 7.4, 7.6 and 7.8) exhibit a positive and significant coefficient of the HHI index and a negative and significant coefficient of the *squared* HHI index. Thus, the relationship between proxy measures of borrower risk and competition in this sample exhibits a non-linear inverted U-shape: as competition rises from low levels (high concentration) borrower risk first increases and then declines. As measured by the regressions in Table 7, the inversion of the borrower risk-competition relationship from positive to negative occurs at fairly high levels of concentration, since the level of HHI beyond which borrower risk declines includes between 90 and 95 percent of the whole sample. This result is consistent with the BDNJ model, which predicts that the BDN effect is likely to become stronger as competition intensifies. [19]

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[19] As noted, our results are exactly the opposite of what Jimenez et al (2010) find and at variance with the implications of the theoretical model of Martinez-Meira and Repullo (2008). Our result are also at variance with those obtained by Berger et al. (2009), who do not find a significant inverted U-shaped relationship. However, we have already remarked that our results and theirs are not necessarily comparable owing to differences in measurement and specifications of the empirical models used.

V. Conclusions

We draw two main conclusions. First, 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. So does the risk of bank loan customers. Second, in all our tests the data suggest a positive and significant *ceteris paribus* relationship between bank competition and the loan-to-asset ratio, as predicted by the BDNJ model. This is potentially important because it adds a dimension that policy makers should consider when evaluating the costs and benefits of competition in banking. There has been no 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.

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, Allen and Astrid Dick, 2007, "Entry into Banking Markets and The Early Mover Advantage," *Journal of Money, Credit and Bank*ing, 39-4, 775-807.

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, 2009, "Bank Competition, Risk and Asset Allocations", IMF Working Paper 09/143, July.

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

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

Cerqueiro, 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.

Corbea, Dean and Pablo D'Erasmo, 2009, "A Quantitative Model of Banking Industry Dynamics," working paper, University of Texas at Austin.

Corts, K.S (1998). 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, and Rima Turk Ariss, 2009, "Bank Market Power Rents and Risk: Theory and Measurement", Paolo Baffi Centre Working Paper 2009-73.

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.

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

Dick, A., 2006. "Nationwide Branching and its Impact on Market Structure, Quality and Bank Performance," *Journal of Business*, 79:2 567-92.

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.

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

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

Jiménez, Gabriel, Jose A. Lopez and Jesús Saurina, 2010, "How Does Competition Impact Bank Risk-Taking?", Bank of Spain Working Paper No. 1005.

Levy-Yeyati, Eduardo and Alejandro Micco, 2007, "Concentration and Foreign Penetration in Latin American Banking Sectors: Impact on Competition and Risk", *Journal of Banking and Finance*, v. 31, 6, 1633-47

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

Noth, Felix, 2010, Bank Competition and Corporate Risk: Does the Risk-Shifting Channel Exist?”, Goethe University Working Paper.

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

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

Shaeck, Klaus and Martin Chiak, 2010, Competition, Efficiency, and Soundness in Banking: An Industrial Organization Perspective”, European Banking Center Discussion Paper No. 2010-68S, July.

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.

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
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
TOTALLY	Median income in 1999 * number of households. $million.

Panel B. Sample Statistics

Variable	Mean	Std. Dev.	Min	Max
LABGRO	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
TOTALLY	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. *HHI0^2* is the squared value of *HHI0*. *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 2.5 are robust OLS regressions. Columns 2.2, 2.4, 2.6, 2.7, 2.8 and 2.9 are robust OLS regressions with clustering on counties. Column 2.3 is an Instrumental variables regression.

	DEPENDENT VARIABLES								
	Z	Z	Z	Z	LA_cox	LA_cox	PA	EA_cox	lnSDPA
	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
HHI0	-0.000425**	-0.000425**	-0.000616***	-0.000603	-2.20e-05**	-2.20e-05**	1.14e-07*	2.54E-06	1.36e-05**
	[0.0474]	[0.0461]	[0.000760]	[0.417]	[0.0139]	[0.0177]	[0.0544]	[0.616]	[0.0234]
HHI0^2				1.90E-08					
				[0.792]					
LASSET	-4.272***	-4.272***	-4.060***	-4.266***	0.125***	0.125***	0.00116***	-0.0780***	0.0274**
	[0]	[8.52e-11]	[9.00e-07]	[8.65e-11]	[9.65e-09]	[2.30e-08]	[0]	[9.13e-09]	[0.0355]
LABGRO	-11.75**	-11.75**	-22.72***	-11.79**	0.395*	0.395*	-0.00284**	-0.428***	0.0581
	[0.0251]	[0.0218]	[0.000146]	[0.0212]	[0.0537]	[0.0538]	[0.0428]	[8.94e-05]	[0.678]
UNEM	-0.397***	-0.397**	-0.149	-0.399**	-0.00303	-0.00303	-4.86E-05	-0.0105***	0.00359
	[0.00937]	[0.0117]	[0.194]	[0.0115]	[0.629]	[0.631]	[0.303]	[0.00414]	[0.416]
FARM	5.495	5.495	6.385	5.264	0.444	0.444	0.000484	-0.189	-0.413*
	[0.513]	[0.539]	[0.388]	[0.559]	[0.172]	[0.179]	[0.829]	[0.272]	[0.0563]
CTI	-1.853***	-1.853***	-1.836***	-1.854***	-0.0686***	-0.0686***	-0.00114***	-0.0166**	0.0736**
	[0.000599]	[0.000786]	[0.00208]	[0.000770]	[0.00332]	[0.00343]	[0.00857]	[0.0420]	[0.0211]
TOTALLY	-9.63E-10	-9.63E-10	1.02E-09	-1.04E-09	1.06e-10***	1.06e-10***	-0**	-0*	0
	[0.396]	[0.411]	[0.314]	[0.393]	[0.00155]	[0.00239]	[0.0191]	[0.0933]	[0.712]
Constant	86.20***	86.20***	82.04***	86.50***	-1.007***	-1.007***	-0.00475***	-1.134***	-5.966***
	[0]	[0]	[0]	[0]	[5.22e-05]	[6.17e-05]	[0.00661]	[0]	[0]
Observations	2,496	2,496	2,489	2,496	2,498	2,498	2,500	2,500	2,496
R-squared	0.099	0.099	0.062	0.099	0.182	0.182	0.17	0.088	0.088
Hansen J-Stat (p-value)			2.003 (0.3674)						
Regressions with:									
HHI100	-0.000418*	-0.000418*	-0.000591***	-0.000622	-2.34e-05**	-2.34e-05**	1.09e-07*	2.93E-06	1.43e-05**
	[0.0588]	[0.0555]	[0.000355]	[0.416]	[0.0122]	[0.0182]	[0.0735]	[0.578]	[0.0200]

Robust p values in brackets, *** p<0.01, ** p<0.05, * p<0.1

Footnote: The first-step regression estimate for equation 2.3 is HHI0 = 16125 (0.000***) – 1384.622 (0.000***) * Ln(Median County Income in 1989) + 37.12506 (0.000***) * County Poverty Rate in 1989 .

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 and its components are defined as in the text. 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 obtained by the GMM one-step estimator of Arellano and Bond (1991). 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	**LAcox**	**ROA**	**EAcox**	**lnSDROA**
	4.1	4.2	4.3	4.4	4.5
L.HHIA	**-24.868****	**-0.189****	**-0.866***	**-0.208****	**0.483*****
	[0.02]	**[0.03]**	**[0.07]**	**[0.05]**	**[0.01]**
L.GDPPC	-0.006***	-0.000***	0.000***	0.000***	0.000***
	[0.00]	[0.00]	[0.68]	[0.00]	[0.00]
L.LPOP	-15.946	-1.259***	-2.803***	0.229	1.315**
	[0.66]	[0.00]	[0.01]	[0.320]	[0.0151]
L.GROWTH	0.143	0.005***	-0.034***	-0.001	-0.001
	[0.51]	[0.00]	[0.00]	[0.532]	[0.856]
L.INFL	-0.004	0	0	0.000**	0
	[0.38]	[0.62]	[0.32]	[0.0207]	[0.208]
L.ER	0.0002	0.001	0	0	0
	[0.78]	[0.48]	[0.44]	[0.599]	[0.993]
L.LASSET	-0.988	0.177***	-0.658***	0.303***	-0.03
	[0.67]	[0.00]	[0.00]	[0.00]	[0.488]
L.CTI	0.028**	0.004	0.009***	0.001***	-0.001***
	[0.02]	[0.18]	[0.00]	[0.00]	[0.00]
L.Zscore	0.061***				
	[0.00]				
L.LAcox		0.573***			
		[0.00]			
L..ROA			0.362***		
			[0.00]		
L.EAcox				0.583***	
				[0.00]	
L.lnSDROA					0.050***
					[0.00]
Constant	143.574	2.396***	18.345***	-4.873***	-5.227***
	[0.24]	[0.00]	[0.00]	[0.00]	[0.00]
Observations	8486	9615	9643	9684	9631
Number of banks	2417	2593	2625	2633	2622
M1 (p-value)	0.00	0.00	0.00	0.00	0.00
M2 (p-value)	0.27	0.73	0.83	0.77	0.31
Sargan Test (p-value)	0.39	0.43	0.38	0.06	0.02

Table 5. International Sample: Two Robustness Tests

Z-score and its components are defined as in the text. HHIA is the asset-HHI; HHIA2 is the square of HHIA; HHIAlow and HHIAhih are the HHIA lower median and higher median respectively. MSHARE2 is the square of the market share of a bank relative to total assets. All other variables are defined as in Table 4. Estimates are obtained by the GMM one-step estimator of Arellano and Bond (1991). 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**	**MSHARE2**
	5.1	5.2	5.3
L.HHIA	**-30.75**		
	[0.23]		
L.HHIA2	**7.37**		
	[0.79]		
L.HHIAlow	**-15.946**	**-70.777*** **	
	[0.66]	**[0.00]**	
L.HHIAhigh	**0.143**	**-33.728*** **	
	[0.51]	**[0.00]**	
L.GDPPC	-0.006***	-0.006***	0.004
	[0.00]	[0.00]	[0.46]
L.LPOP	-15.589	-13.204	0.047
	[0.67]	[0.72]	[0.17]
L.GROWTH	0.146	0.131	0.0004
	[0.49]	[0.54]	[0.64]
L.INFL	-0.004	-0.004	-0.000*
	[0.39]	[0.45]	[0.07]
L.ER	0.000	0.000	0.000
	[0.77]	[0.95]	[0.97]
L.LASSET	-0.98	-1.177	-0.004**
	[0.67]	[0.61]	[0.01]
L.CTI	0.028**	0.028**	0
	[0.02]	[0.02]	[0.80]
L.Zscore	0.061***	0.060***	**0.0003**
	[0.00]	[0.00]	**[0.741]**
L.MSHARE2			0.481***
			[0.00]
Constant	143.217	141.322	-0.137
	[0.24]	[0.25]	[0.20]
Observations	8486	8486	9684
Number of banks	2417	2417	2633
M1 (p-value)	0.00	0.00	0.00
M2 (p-value)	0.27	0.26	0.16
Sargan Test (p-value)	0.39	0.40	0.12

Table 6. 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. LLM1_cox = Ln(1 + (LLM1/(1 – LLM1))) and LLM2_cox = Ln(1 + (LLM2/(1 – LLM2))). 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 6.1 - 6.8 are robust OLS regressions with clustering on counties.

	DEPENDENT VARIABLES							
	LLM1	LLM1_cox	LLM1	LLM1_cox	LLM2	LLM2_cox	LLM2	LLM2_cox
	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8
HHI0	1.98e-07**	2.04e-07**	2.91e-07	3.05e-07	8.05e-07***	8.73e-07**	3.59e-07	3.48e-07
	[0.0137]	[0.0142]	[0.280]	[0.280]	[0.00942]	[0.0113]	[0.709]	[0.747]
HHI0^2			-0	-0			0	5.76e-11
			[0.751]	[0.741]			[0.702]	[0.686]
LASSET	0.000659**	0.000680**	0.000655**	0.000675**	-0.00131*	-0.00144*	-0.00129*	-0.00141*
	[0.0165]	[0.0178]	[0.0200]	[0.0214]	[0.0655]	[0.0742]	[0.0754]	[0.0853]
LABGRO	0.00156	0.00160	0.00159	0.00163	-0.00365	-0.00337	-0.00379	-0.00353
	[0.113]	[0.113]	[0.122]	[0.122]	[0.348]	[0.422]	[0.335]	[0.406]
UNEM	2.98e-05	2.81e-05	3.05e-05	2.88e-05	-9.73e-05	-0.000113	-0.000100	-0.000117
	[0.407]	[0.446]	[0.401]	[0.438]	[0.436]	[0.394]	[0.433]	[0.391]
FARM	4.89e-05	0.000164	0.000199	0.000327	-0.00206	-0.00351	-0.00278	-0.00436
	[0.979]	[0.931]	[0.919]	[0.873]	[0.773]	[0.670]	[0.710]	[0.610]
CTI	0.000744***	0.000749***	0.000742***	0.000748***	-0.000249	-0.000278	-0.000242	-0.000270
	[1.83e-05]	[1.92e-05]	[1.91e-05]	[2.00e-05]	[0.107]	[0.110]	[0.122]	[0.127]
TOTALLY	-0	-0	-0	-0	-0***	-0***	-0***	-0***
	[0.318]	[0.321]	[0.365]	[0.371]	[0.000980]	[0.00114]	[0.00178]	[0.00214]
Constant	-0.00645**	-0.00667**	-0.00658**	-0.00682**	0.0305***	0.0322***	0.0311***	0.0330***
	[0.0383]	[0.0396]	[0.0265]	[0.0280]	[0.000234]	[0.000638]	[0.000103]	[0.000293]
Observations	2,498	2,498	2,498	2,498	2,498	2,498	2,498	2,498
R-squared	0.032	0.030	0.032	0.030	0.025	0.023	0.026	0.023
Regressions with:								
HHI100	2.25e-07***	2.31e-07***	4.20e-07*	4.39e-07*	9.02e-07***	9.79e-07***	3.99e-07	4.01e-07
	[0.00705]	[0.00738]	[0.0847]	[0.0881]	[0.00725]	[0.00899]	[0.697]	[0.729]
HHI100^2			-0	-0			5.70e-11	6.56e-11
			[0.425]	[0.420]			[0.683]	[0.677]

Robust p values in brackets, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7. International Sample Loan Loss Measures

LLP is the ratio of loan loss provisions to gross loans, *NPL* is the ratio of impaired (non-performing) loans to gross loans. HHIA is the asset-HHI; HHIA^2 is HHI squared. *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 obtained by the GMM one-step estimator of Arellano and Bond (1991). 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%. HHImax is the maximum of the quadratic terms, and the last row denotes the percentile of HHImax.

	DEPENDENT VARIABLES							
	LLP	LLP	LLPcox	LLPcox	NPL	NPL	NPLcox	NPLcox
	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8
L.HHIA	**0.015**	**0.121*** **	**-0.115**	**1.416*** **	**4.070***	**17.182*** *	**0.143**	**0.895***
	[0.23]	**[0.00]**	**[0.530]**	**[0.00]**	**[0.07]**	**[0.01]**	**[0.44]**	**[0.08]**
L.HHIA^2		**-0.134*** **		**-1.954*** **		**-18.085*** *		**-1.058***
		[0.00]		**[0.00]**		**[0.02]**		**[0.08]**
L.GDPPC	0	0	0	0	0	0.001	-0.000*	0
	[0.95]	[0.84]	[0.38]	[0.28]	[0.28]	[0.21]	[0.09]	[0.13]
L.LPOP	0.106**	0.101**	1.228**	1.066*	5.923	5.155	1.009**	0.840*
	[0.01]	[0.02]	[0.03]	[0.06]	[0.32]	[0.39]	[0.02]	[0.06]
L.GROWTH	0.001***	0.001***	0.006	0.006	-0.001	0.003	0.005	0.007*
	[0.00]	[0.00]	[0.24]	[0.25]	[0.98]	[0.96]	[0.23]	[0.08]
L.INFL	0.0003	0.0001	0.0002	0.0005	-0.045**	-0.046**	-0.002	-0.003
	[0.760]	[0.67]	[0.38]	[0.41]	[0.04]	[0.03]	[0.19]	[0.86]
L.ER	-0.000*	0	0	0	0	0	0	0
	[0.08]	[0.11]	[0.33]	[0.37]	[0.91]	[0.89]	[0.32]	[0.72]
L.LASSET	0.016***	0.016***	0.227***	0.225***	1.757**	1.791**	0.214***	0.290***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.03]	[0.03]	[0.00]	[0.00]
L.CTI	0	0	0.001*	0.001*	-0.01	-0.01	-0.001	
	[0.957]	[0.91]	[0.05]	[0.06]	[0.28]	[0.27]	[0.32]	
L.LLP	0.248***	0.263***						
	[0.00]	[0.00]						
L.LLPcox			0.129***	0.133***				
			[0.00]	[0.00]				
L.NPL					0.471***	0.501***		
					[0.00]	[0.00]		
L.NPLcox							0.401***	0.393***
							[0.00]	[0.00]
Constant	-0.541***	-0.540***	-14.788***	-14.417***	-38.337**	-38.715**	-7.127***	-7.778***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Observations	6480	6480	6128	6128	3471	3471	3471	3615
Number of banks	2022	2022	1943	1943	1185	1185	1185	1216
M1 (p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M2 (p-value)	0.58	0.53	0.80	0.76	0.15	0.21	0.44	0.48
Sargan Test	0.19	0.16	0.00	0.00	0.02	0.02	0.00	0.00
(p-value)								
HHI max		4508		3623		4750		4368
Percentile		92		90		96		95
of HHImax								

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