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How Does Bank Competition Affect Systemic Stability?

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Abstract

Using bank level measures of competition and co-dependence, the authors show a robust positive relationship between bank competition and systemic stability. Whereas much of the extant literature has focused on the relationship between competition and the absolute level of risk of individual banks, in this paper we examine the *correlation* in the risk taking behavior of banks, hence systemic risk. The analysis finds that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks. Examining the impact of the institutional and regulatory environment on systemic stability shows that banking systems are more fragile in countries with weak supervision and private monitoring, high government ownership of banks, and in countries with public policies that restrict competition. Furthermore, lack of competition has a greater adverse effect on systemic stability in countries with generous safety nets and weak supervision.

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How Does Bank Competition Affect Systemic Stability?

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1. Introduction

The impact of bank competition on financial fragility has always been a subject of active academic and policy debate. However public policy interest in this topic has intensified after the global financial crisis, with both academics and policymakers questioning to what extent the "dark side" of competition and the resulting financial innovations in search of higher margins were responsible for the crisis. While greater competition in the banking sector has no doubt led to greater innovation and efficiency, there is still no academic consensus on whether this competition has also led to greater fragility, with conflicted theoretical predictions and mixed empirical results.

In parallel, the financial crisis also led to a re-examination of risk assessment practices and regulation of the financial system, with a renewed interest in systemic fragility and macro-prudential regulation. This requires a focus not on the risk of individual financial institutions, but on an individual bank's contribution to the risk of the financial system as a whole. Hence, there is a growing consensus that from a regulatory perspective of ensuring systemic stability, the correlation in the risk taking behavior of banks is much more relevant than the absolute level of risk taking in any individual institution.

In this paper we address both sets of issues by re-examining the empirical relationship between competition and systemic stability. Unlike the extant literature which has focused on stand-alone bank risk, our focus in this paper is on systemic stability. Hence instead of looking at the absolute level of risk in individual banks, we examine the *correlation* in the risk taking behavior of banks, measured as the total variation of changes in default risk of a given bank explained by changes in default risk of all other banks in a given country.

We follow Anginer and Demirguc-Kunt (2011) and use Merton's (1974) contingent claim pricing framework to measure bank default risk and its contribution to systemic risk. Using a sample of 1,872 publicly traded banks in 63 countries over the period 1997 to 2009, we investigate the impact of bank concentration and competition, as measured by the Lerner index of bank market power. Our results suggest a positive relationship between competition and systemic stability, consistent with the view that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks. We also examine the impact of the larger institutional and regulatory environment on this relationship. Correlated risk taking behavior is higher in countries with weak supervision and private monitoring, high government ownership of banks, and in countries with public policies that restrict competition.

The competition – systemic fragility relationship is also sensitive to the underlying institutional environment. We find lack of competition has a greater adverse effect on systemic stability in countries with generous safety nets and weak supervision.

Our paper contributes to a large literature on the relationship between competition and stability in the financial system.[2] Economic theory is conflicted on the impact of banking structure on financial stability. On the one hand, the charter value view of competition suggests there could be significant stability costs of competition, since too much competition may lead to excessive risk taking as it reduces margins (Marcus, 1984, Keeley, 1990 and Allen and Gale, 2004). Proponents of this view argue that in an environment with greater competition, the pressure on profits will make banks choose riskier portfolios, leading to greater fragility (Hellman, Murdoch and Stiglitz, 2000). Others argue that in a more competitive environment, banks earn lower rents which also reduces their incentives for monitoring (Boot and Thakor 1993, Allen and Gale 2000).[3] Large banks can also diversify better so that banking systems dominated with a few large banks are likely to be less fragile than banking systems with many small banks (Allen and Gale, 2004). Finally, some hold that a few large banks are easier to monitor and supervise compared to competitive banking systems with a large number of small banks. These arguments are all consistent with competition leading to greater fragility.

On the other hand, lack of competition may also exacerbate bank fragility. Banks with greater market power tend to charge higher interest rates to firms, inducing them to take on greater risk, and hence increasing the fragility of the financial system as well (Boyd and De Nicolo, 2005).[4] Importantly, large banks frequently receive "too-big-to-fail" subsidies from safety net policies, distorting their risk taking incentives and destabilizing the financial system as a whole (Anginer and Warburton 2011, Kane 1989). Finally, as the global financial crisis has

[2] See for example literature reviews by Carletti (2008) and Degryse and Ongena (2008).

[3] Dell'Ariccia and Marquez (2004) show that more intense competition may induce banks to switch to more risky, opaque borrowers; and Hauswald and Marquez (2006) show competition makes banks acquire less information on borrowers.

[4] In extensions of Boyd and de Nicolo model that allow for imperfect correlation in loan defaults, Martinez-Miera and Repullo (2010) and Hakenes and Schnabel (2011) show that the relationship between competition and risk is U shaped. Wagner (2010) allows for risk choices to be made by borrowers as well, which overturns the Boyd and De Nicolo results. Allen and Gale (2004) also show that competition –stability relationship can be complex, where competition can also increase stability.

amply illustrated, large banks also can be more difficult to supervise given their complexity, and their ability to politically capture their supervisors (Johnson and Kwak, 2010).

Most of the theoretical literature on bank competition and stability focuses on individual bank risk, not on correlated risk taking by banks. Modeling correlated risk taking has been the focus of papers after the recent crisis (see for example Brunnermeier 2009, Daneielsson, Shin and Zigrand 2009, Battiston, Gatti, Gallegati, Greenwald, and Stiglitz, 2009 among others) but these papers do not address issues of bank competition.

Given the current policy relevance of the topic and conflicting theoretical predictions, there is also a growing empirical literature on the impact of bank competition on bank fragility. Individual country studies - mostly for the US - have not come up with conclusive findings.[5] Cross-country analyses have shown that more concentrated banking systems are less likely to suffer a systemic banking crisis but so are more competitive banking systems, potentially suggesting a stabilizing effect for having a contestable banking system (Beck, Demirguc-Kunt, and Levine 2006, Schaeck, Cihak, and Wolfe 2009). Others have shown that banks in more competitive banking systems hold more capital, which could explain the positive effect of bank competition on stability (Schaeck and Cihak 2010, Berger, Klapper, and Turk-Ariss, 2009). Beck, De Jonghe, and Schepens (2011) find a positive correlation between accounting measures of bank soundness and market power, and examine the cross-country heterogeneity in this relationship, identifying links with regulatory and institutional features.

Our contribution to this literature is three-fold. First, unlike most of the previous papers using bank level data to investigate the link between competition and bank fragility, we do not look at individual bank risk, but the co-dependence of those risks, hence addressing macro-prudential regulation issues of current policy interest. Second, we compute default risks from the structural credit risk model of Merton (1974) instead of the commonly used accounting based measures of risk such as Z-scores of bank soundness. Using Z-scores in investigating the relationship between bank risk and competition is particularly problematic since Z-scores and Lerner index of market power are both calculated using profitability measures, making their positive correlation potentially spurious. In contrast, we use risk measures developed in Anginer

[5] See for example, Boyd and Runkle (1993) for an analysis of US bank holding companies.

and Demirguc-Kunt (2011), applying the recent advances made in the risk pricing literature[6] to an international sample of publicly traded banks in 63 countries. Finally, the cross-country nature of our dataset allows us to examine the impact of the institutional and regulatory environment on systemic stability as well as the relationship between competition and correlated risk taking behavior of banks, which are of particular interest for policy.

The rest of the paper is organized as follows. Section 2 describes the construction of the sample and variables. Section 3 presents the empirical results and discusses the implications. Section 4 concludes.

2. Data and Empirical Methodology

2.1. Sample

In this section we describe the data sources used in this paper. We obtain bank level financial information from Bankscope. We use stock market information from Compustat Global for international banks and stock market information from CRSP for U.S. banks. The Bankscope database reports detailed balance sheet and income statement information for both public and private banks and covers over 90% of the total banking assets in a given country. The Compustat Global database provides daily stock price information for both active and delisted companies accounting for 98% of the global stock market capitalization. CRSP is the standard source for stock price information of U.S. companies. Our final sample consists of 1,872 unique publicly traded banks in 63 countries from 1997 to 2009. Sample size varies across regression specifications because not all variables are available for all bank year observations.

2.2. Systemic Default Risk Measure

We use the Merton (1974) contingent claim framework to measure bank default risk. This approach treats the equity value of a company as a call option on the company's assets. The probability of default is computed using the "distance-to-default" measure, which is the difference between the asset value of the firm and the face value of its debt, scaled by the standard deviation of the firm's asset value. The Merton (1974) distance-to-default measure has been shown to be good predictor of defaults outperforming accounting-based models (Campbell,

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[6] See Adrian and Brunnermeier (2009), Huang, Zhou, and Zhu (2009), Chan-Lau and Gravelle (2005), Avesani, Pascual, and Li (2006), and Elsinger, Lehar and Summer (2005).

Hilscher and Szilagyi 2008; Hillegeist, Keating, Cram, and Lundstedt 2004; Bharath and Shumway 2008). Although the Merton distance-to-default measure is more commonly used in bankruptcy prediction in the corporate sector, Merton (1977) points out the applicability of the contingent claims approach to pricing deposit insurance in the banking context. Bongini, Laeven and Majnoni (2002), Bartram, Brown and Hund (2007) and others have used the Merton model to measure default risk of commercial banks.

We follow Campbell, Hilscher and Szilagyi (2008) and Hillegeist, Keating, Cram, and Lundstedt (2004) to calculate Merton's distance-to-default measure. Specifically, the market equity value of a company is modeled as a call option on the company's assets:

$$V_E = V_A e^{-dT} N(d_1) - X e^{-rT} N(d_2) + \left(1 - e^{-dT}\right) V_A$$
$$d_1 = \frac{\log\left(\frac{V_A}{X}\right) + \left(r - d + \frac{s_A^2}{2}\right) T}{s_A \sqrt{T}}; d_2 = d_1 - s_A \sqrt{T} \quad (1)$$

In equation (1), V_E is the market value of a bank. V_A is the value of the bank's assets. X is the face value of debt maturing at time T. r is the risk-free rate and d is the dividend rate expressed in terms of V_A. s_A is the volatility of the value of assets, which is related to equity volatility through the following equation:

$$s_E = \frac{V_A e^{-dT} N(d_1) s_A}{V_E} \quad (2)$$

We simultaneously solve the above two equations to find the values of V_A and s_A. We use the market value of equity for V_E and total liabilities to proxy for the face value of debt X. Since the accounting information is on an annual basis, we linearly interpolate the values for all dates over the period, using beginning and end of year values for accounting items. The interpolation method has the advantage of producing a smooth implied asset value process and avoids jumps in the implied default probabilities at year end. s_E is the standard deviation of daily equity returns over the past year. In calculating standard deviation, we require the bank to have at least 90 non-missing daily returns over the previous twelve months. T equals one year. r is the one year US treasury yield, which we take to be the risk free rate. We use the Newton method to simultaneously solve the two equations above. For starting values for the unknown variables, we use $V_A = V_E + X$ and $s_A = s_E V_E/(V_E+X)$. We winsorize s_E and $V_E/(V_E+X)$ at the 5th and 95th percentile levels to reduce the influence of outliers. After we determine asset values V_A, we follow Campbell, Hilscher and Szilagyi (2008) and assign asset return *m* to be equal to the equity premium (6%). Merton's distance-to-default (*dd*) is finally computed as:

$$dd = \frac{log\left(\frac{V_A}{X}\right) + \left(m - d - \frac{s_A^2}{2}\right)T}{s_A\sqrt{T}} \tag{3}$$

The default probability is the normal transform of the distance-to-default measure and is defined as $PD = F\ (-dd)$, where *F* is the cumulative distribution function of a standard normal distribution.

As mentioned earlier, our focus in this paper is on systemic stability. Hence instead of looking at the absolute level of risk in individual banks, we examine the *correlation* in the risk taking behavior of banks, measured as the total variation of changes in default risk of a given bank explained by changes in default risk of all other banks in a given country. We use as our measure of systemic stability the R-squared obtained from regressing changes in bank default risk on changes in average default risk of all banks in a given country. To calculate this measure, for each bank *i* in country *j* in week *w* of year *t*, we first compute a weekly Merton's distance-to-default ($dd_{i,j,t,w}$). Then for each bank *i* in year *t*, we run a time series regression of bank *i*'s weekly change in distance-to-default on country average weekly change in distance-to-default excluding bank *i* itself:

$$\Delta dd_{i,j,t,w} = \alpha_{i,j,t} + \beta_{i,j,t}\frac{1}{n}\sum_{k=1,k\neq i}^{n}\Delta dd_{k,j,t,w} + \varepsilon_{i,j,t,w} \tag{4}$$

We follow Morck, Yeung, and Yu (2000) and Karolyi, Lee, and Van Dijk (2011) and use the logistic transformation of R-squared from the above regression, which is equal to $log(rsq_{i,j,t} / (1-rsq_{i,j,t}))$, to measure systemic risk posed by bank *i*. R-squared is only computed for banks with at least twenty-six weeks of changes in weekly distance-to-default data in a year. In terms of measuring co-dependence, using R-squared has advantages over alternative measures as described in Pukthuanthong and Roll (2009) and Bekaert and Wang (2009). Higher R-squared for a given bank suggests that the bank is exposed to similar sources of credit risk as other banks in a given country. Higher R-squared also suggests that there are channels of inter-dependency between the bank and others in a given country. Both interconnectedness and common exposure to risk makes the banking sector more vulnerable to economic, liquidity and information shocks.

2.3. Competition Measure

In this paper, we use the Lerner index as our main measure of lack of competition. The Lerner index is a proxy for profits that accrue to a bank as a result of its pricing power in the market. It is measured at the bank level and has been utilized in a number of banking studies.[7] We follow the methodology used in Demirguc-Kunt and Martinez-Peria (2010) and first estimate the following log cost function for each country:

$$\begin{aligned} log(C_{it}) = \alpha &+ \beta_1 \times log(Q_{it}) + \beta_2 \times (log(Q_{it}))^2 + \beta_3 \times log(W_{1,it}) + \beta_4 \times log(W_{2,it}) + \beta_5 \times log(W_{3,it}) \\ &+ \beta_6 \times log(Q_{it}) \times log(W_{1,it}) + \beta_7 \times log(Q_{it}) \times log(W_{2,it}) + \beta_8 \times log(Q_{it}) \times log(W_{3,it}) \\ &+ \beta_9 \times (log(W_{1,it}))^2 + \beta_{10} \times (log(W_{2,it}))^2 + \beta_{11} \times (log(W_{3,it}))^2 + \beta_{12} \times log(W_{1,it}) \times log(W_{2,it}) \\ &+ \beta_{13} \times log(W_{1,it}) \times log(W_{3,it}) + \beta_{14} \times log(W_{2,it}) \times log(W_{3,it}) + \Theta \times Year\ Dummies \\ &+ \Omega \times Bank\ Specialization\ Dummies + \varepsilon_{it} \end{aligned} \quad (5)$$

In equation (5) above, C_{it} is total costs and is equal to the sum of interest expenses, commission and fee expenses, trading expenses, personnel expenses, other admin expenses, and other operating expenses, measured in millions of US dollars. Q_{it} is the quantity of output and is measured as total assets in millions of US dollars. $W_{1,it}$ is the ratio of interest expenses to the sum of total deposits and money market funding. $W_{2,it}$ is measured as personnel expenses divided by total assets. $W_{3,it}$ is the ratio of administrative and other operating expenses to total assets. The subscript *i* denotes bank i and the subscript *t* denotes year t. We take natural logarithm of all variables and estimate the regression for each country in our dataset using pooled ordinary least squares (OLS). We include calendar year and bank specialization dummies in the regression. All variables are winsorized at the 1st and 99th percentile levels to reduce the

[7] See for instance, Demirguc-Kunt and Martinez-Peria (2010) and Beck, De Jonghe, and Schepens (2011).

influence of outliers. We further impose the following five restrictions on regression coefficients to ensure homogeneity of degree one in input prices:

$$\beta_3+\beta_4+\beta_5 = 1;\ \beta_6+\beta_7+\beta_8 = 0;\ \beta_9+\beta_{12}+\beta_{13} = 0;\ \beta_{10}+\beta_{12}+\beta_{14} = 0;\ \beta_{11}+\beta_{13}+\beta_{14} = 0 \qquad (6)$$

We then use the coefficient estimates from the previous regression to estimate marginal cost for bank *i* in calendar year *t*:

$$MC_{it} = \partial C_{it}/\partial Q_{it} = C_{it}/Q_{it} \times [\beta_1 + 2\times\beta_2\times log(Q_{it}) + \beta_6\times log(W_{1,it}) + \beta_7\times log(W_{2,it}) + \beta_8\times log(W_{3,it})] \qquad (7)$$

The Lerner index is then computed as:

$$Lerner_{it} = (P_{it} - MC_{it}) / P_{it} \qquad (8)$$

Above, P_{it} is the price of assets and is equal to the ratio of total revenue (sum of interest income, commission and fee income, trading income, and other operating income) to total assets.

In section 3.3, as a robustness check, we use bank asset concentration as an alternative proxy for bank competition.[8] Untabulated results show that country level bank concentration, as measured by the three bank asset concentration ratio, is correlated with the country level average Lerner index with a Pearson correlation coefficient of 0.077 (p-value < 0.0001). The three bank asset concentration ratio is also highly correlated with the Hirschmann-Herfindahl index of bank assets concentration with a Pearson correlation coefficient of 0.798 (p-value < 0.0001).

2.4. Institutional and Regulatory Variables

As mentioned in the introduction we are also interested in the impact of the larger regulatory and institutional framework on the competition and systemic stability relationship. The main regulatory and institutional variables used in this study come from the three surveys conducted by Barth, Caprio, and Levine (2008). The surveys were conducted in the years 1999, 2002, and 2005. Since country level regulations change slowly over time, we use the previously available

[8] We use the three bank asset concentration ratio from the Financial Structure Dataset (Beck, Demirguc-Kunt and Levine 2010) as a measure of bank concentration.

survey data until a new survey becomes available. Specifically, we use the survey data of 1999 for years 1996 to 2001, the survey data of 2002 for years 2002 to 2004, and the survey data of 2005 for years 2005 to 2009.

We consider three groups of bank regulation/institutional variables. The first group of regulatory variables is related to state policies that enable or restrict competition. Entry barrier index, *entry_bar,* measures bank entry requirements, which is constructed based on eight questions in the Barth, Caprio, and Levine surveys regarding legal submissions required to obtain a banking license in a given country. Application denied, *ap_denied*, is the percentage of applications to set up a bank which were denied in the past five years. Government ownership, *gov_own*, measures the fraction of banks that are 50% or more owned by the government. The second group of variables measure bank regulation and supervision. Activity restrictions index, *activity_restriction*, measures the degree to which the national regulatory authorities allow banks to engage in securities, insurance, and real estate businesses. Capital stringency index, *capital_stringency*, measures the amount of capital a bank must maintain. Supervisory power index, *supervisory_power*, indicates whether the supervisory authorities have the power and the authority to take specific preventive and corrective actions. Diversification index, *diversification_index*, captures whether there are explicit, verifiable, quantifiable guidelines for bank asset diversification and whether banks are allowed to make loans outside of national borders. Deposit insurance coverage ratio, *covratio,* is the amount of deposit insurance coverage divided by deposits per capita. It is set to 1 if a country offers full coverage. We obtain this variable from Demirguc-Kunt, Kane, and Laeven (2008). Since the data ends in year 2003 and most countries did not change their deposit insurance coverage till the recent financial crises, we use the deposit insurance coverage in 2003 for years 2003 to 2007.[9]

Finally, we also use data on the investor protection index (*investor_protection*), depth of credit information sharing (*credit_info_depth*), and the existence of a private information bureau (*private_bureau*) from Djankov, McLiesh, and Shleifer (2007) and the World Bank Doing Business Survey.[10] These variables measure the strength of private monitoring and information

[9] See Demirguc-Kunt, Kane, and Laeven (2008) for a detailed analysis of various features of deposit insurance mechanisms.
[10] Details on how these variables are constructed are available on World Bank's Doing Business Survey website at http://www.doingbusiness.org/methodology.

sharing in each country. A full list of variables, definitions and sources are provided in Appendix I.

2.5. Control Variables

In examining the relationship between competition and systemic stability we control for a number of bank and country level variables. Bank level controls come from Bankscope. For each bank, each year, we calculate bank size (natural logarithm of total assets), leverage (liabilities divided by total assets), market-to-book ratio (market value of assets divided by book value of assets), provisions (loan loss provisions divided by total assets), reliance on deposits for funding (deposits divided by total assets) and profitability (net income divided by total assets). We winsorize all financial variables at the 1st and 99th percentile level of their distributions to reduce the influence of outliers and potential data errors.

Country level controls are collected from a number of sources. We obtain economic development measures from the World Bank's World Development Indictor (WDI) database. We use the natural logarithm of GDP per capita to measure the economic development of a country, the variance of GDP growth rate to measure economic stability, the natural logarithm of population to measure country size, and imports plus exports of goods and service divided GDP to measure global integration (Karolyi, Lee, and Van Dijk 2011). In addition, we obtain years in which a country experienced a banking crisis from Laeven and Valencia (2008). We also use stock market capitalization divided by GDP and private credit divided by GDP from the Financial Structure Dataset (Beck, Demirguc-Kunt, and Levine 2010) to control for differences in financial development and structure. As the R-squared measure may be a mechanically linked to the number of cross-sectional observations, we also control for the log of the number of banks in each country.

3. Summary Statistics

In this section we describe our empirical results. Figure 1 shows the evolution of average bank market power, as measured by the average Lerner index, for the years 1996 to 2009. The pattern of time series changes in the Lerner index is consistent with that in Beck, De Jonghe, and Schepens (2011). The Lerner index has been steadily increasing since 1998 but has declined sharply after 2007 after the onset of the global financial crisis. Figure 2 shows the evolution of our measure of systemic stability - the average R-squared. Consistent with Anginer and Demirguc-Kunt (2011), we find an increase in systemic risk leading up to the sub-prime financial crises. The graphs also indicate that there seems to be a positive relation between bank market power and systemic risk, which we will examine further in Section 3.1.

Panel A of Table 1 provides the summary statistics of variables used in this study. An average bank in the sample has log total asset value of 8.22, leverage ratio of 0.90, market-to-book ratio of 1.07, deposits to assets ratio of 0.71, provision to net interest income ratio of 0.17, return on assets of 0.01, and Lerner index of 0.18. These numbers are comparable to those in previous studies such as Beck, De Jonghe, and Schepens (2011).

Panel B of Table 1 shows the sample distribution by calendar year. The number of banks increased markedly in 2001 as Bankscope increased its coverage of banks. In terms of country coverage, we find that U.S. and Japan have the highest number of banks in the sample. While U.S. and Japanese banks account for about 55% of our bank-year observations, our results are robust to the exclusion of these banks. There are a handful of countries with very few bank year observations. Since our measure of systemic risk can be affected by the number of bank observations in each country-year, we also checked that our results are robust to excluding countries with fewer than seven banks in any given year from our analyses and confirmed that they are.

Panel A of Table 2 presents the Pearson correlations for bank level variables. The univariate correlations suggest that larger banks, highly leveraged banks, banks that have higher loan loss provisions to net interest income ratios, and banks that are less competitive (more market power) have higher systemic risk. They also suggest that the Lerner index is positively correlated with bank growth options, as measured by market-to-book ratio, and bank profitability, as measured by return on assets, and is negatively correlated with leverage and loan loss provisions to net interest income ratio.

Panel B of Table 2 presents the Pearson correlations for country level variables. Countries with more concentrated banking industries have higher ratios of applications denied, higher government ownership of banks, and more stringent requirements on bank capital. These countries with more concentrated banking industries are also less likely to have specific guidelines regarding bank diversification, and they tend to have lower entry barriers, lower levels of activity restrictions, supervisory power, investor protection and credit information sharing.

3.1. Competition and Systemic Stability: Baseline Results

In this section we examine how bank competition affects systemic stability after controlling for bank and country level variables. We use the following regression specification for our main analyses:

$$risk_{ijt} = \beta_0 + \Omega \times bank\_controls_{ijt-1} + \Theta \times country\_controls_{jt-1} + \beta_1 \times competition_{ijt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt} \qquad (8)$$

Our dependent variable is bank *i*'s systemic risk (in country *j* in year *t*), $risk_{ijt}$, and is equal to the logistic transformation of R-squared from a regression of bank *i*'s weekly changes in distance to default on country *j*'s average weekly changes in distance to default in year *t* excluding bank *i* itself. Our main explanatory variable of interest is bank competition, measured by the Lerner index. As alternative measures, we also consider bank concentration, state policies that restrict competition and state ownership of banks. We expect government ownership and government policies that inhibit competition to result in correlated risk taking incentives which would increase systemic risk. While the recent literature emphasizes the differences between the competition and concentration (Demirguc-Kunt and Martinez Peria 2010), concentration has been used in a number of previous studies. As alternative measures, we use the bank concentration (*concen*) measured as the percentage of total assets held by top three commercial banks in a given country, bank entry requirements (*entry_bar*), applications to set up a bank which were denied in the past five years (*ap_denied*), and the fraction of banks that are 50% or more owned by the government (*gov_own*). Bank level control variables include bank size (*size*), leverage (*leverage*), market-to-book ratio (*mb*), provisions to net interest income ratio (*provision*), reliance on deposits for funding (*deposits*) and profitability (*roa*). Country level control variables include natural logarithm of GDP per capita (*loggdppca*), variance of GDP growth rate (*vargdpgr*), natural logarithm of population (*logpop*), imports plus exports of goods and service divided GDP (*trade_gdp*), stock market capitalization divided by GDP (*stmktcap*), private credit divided by GDP (*pcrdbofgdp*), crisis year dummy (*crisis*) and the log number of banks in each country and year (log_nbank). All explanatory variables are lagged by one year. In the regression, we also include bank fixed effects, α_i, to control for time invariant bank heterogeneity and use calendar year fixed effects, λ_t, to control for time varying global business cycle effects.

Table 3 presents the coefficient estimates for the bank fixed effect regressions. Column (1) of Table 3 shows that larger banks pose greater systemic risk. Banks with higher market-to-book ratios have lower systemic risk, suggesting that the availability of growth options reduces systemic risk. Greater profitability also tends to be associated with higher systemic risk. For country level variables, we find that openness to trade is associated with lower systemic risk. Similarly financial depth as captured by private credit to GDP is associated with lower systemic risk, suggesting that banks take more diversified risks in these countries. Log number of banks is positively correlated with systemic risk, which is consistent with more accurate estimation of systemic risk in countries with a larger number of banks.

In Column (2) of Table 3, we include the Lerner index as an additional explanatory variable for bank systemic risk. We find that the relationship between Lerner index and bank systemic risk is both positive and statistically significant at the 1% level. The coefficient estimate indicates that a one standard deviation increase in competition (i.e., a 0.2 unit decrease in the Lerner index) is associated with a 0.1 standard deviation reduction in systemic risk. If we were to rank all banks according Lerner and systemic risk, after all controls, a bank that moves up a quintile in Lerner rankings, would move up one decile in systemic risk rankings. We find a similar result using bank concentration reported Column (3). In contrast to some of the earlier work that has examined the incidence of banking crises (Beck, DemirgucKunt, and Levine 2006), we find that higher concentration is associated with greater systemic fragility. Both greater government ownership (Column 6) and applications denied (Column 5) are also associated with greater systemic fragility. The coefficient on entry barriers (Column 4) is positive but statistically insignificant. Overall, the evidence in Table 3 suggests that competition enhances stability.

3.2. Competition, Regulation, and Systemic Stability

As we have shown in the previous section, competition has a positive impact on systemic stability consistent with the notion that competition incentivizes banks to take on more diverse risks. The impact of lack of competition may depend on the larger institutional environment anc can potentially be mitigated through regulation. For instance, greater capital requirements and activity restrictions may limit the extent to which banks can or will engage in correlated risk taking activities in the absence of competition. Similarly, better investor protection and greater information availability would facilitate better monitoring even in the absence of competition. In this section, we examine how each country's regulatory and institutional environment affect bank systemic stability and whether it exacerbates or mitigates the positive relationship between competition and systemic stability. We use the following regression specification:

$$risk_{ijt} = \beta_0 + \Omega \times bank\ controls_{ijt-1} + \Theta \times country\ controls_{jt-1} + \beta_1 \times competition_{ijt-1} + \beta_2 \times regulation_{jt-1} + \beta_3 \times competition_{ijt-1} \times regulation_{jt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt} \quad (9)$$

As before, our dependent variable is bank i's systemic risk (in country j in year t), $risk_{ijt}$. We use the same controls as described in the previous section. The regression specification is similar to what we used in equation (8) except that we now add in country level bank regulation variables (*regulation*) and the interactions between country level regulation variables and the Lerner index as additional explanatory variables. First we examine the impact of the regulation variables without interaction terms. These baseline results are provided in Table 4. The results with the competition interactions are provided in Table 5.

3.2.1. Bank Regulation, Supervision and Systemic Stability

Tables 4 and 5 present the coefficient estimates for bank fixed effects regressions with bank regulation and supervision variables included as additional explanatory variables. The variables we consider are deposit insurance coverage, activity restrictions, capital stringency, supervisory power and explicit asset diversification guidelines provided by regulators. How deposit insurance affects systemic stability is not immediately clear. While deposit insurance may prevent bank runs (Matutes and Vives 1996) and ensure systemic stability, it may also lead to moral hazard and excessive bank risk taking (Demirguc-Kunt and Kane 2002, and Demirguc-Kunt and Huizinga 2004). Furthermore, generous safety nets tend to be correlated with other implicit state guarantees. If there is an implicit guarantee provided by the State to cover losses stemming from a systemic crisis, banks will have incentives to take on correlated risks (Acharya 2005). Guaranteed banks will not have incentives to diversify their operations, since the guarantee takes effect only if other banks fail as well. In Column (1) of Table 4, we include a deposit insurance coverage ratio as an additional explanatory variable. In Column (1) of Table 5, we include both the deposit insurance coverage ratio and the interaction between the Lerner index and deposit insurance coverage ratio as additional explanatory variables. When included with the competition variable, the main effect of deposit insurance on systemic stability is positive and significant. The interaction term is positive and significant, suggesting the effect of deposit insurance on incentives is more pronounced in less competitive markets.

Activity restrictions can reduce potential channels of credit risk contagion (Anginer and Demirguc-Kunt 2011). However activity restrictions may also result in herding behavior and greater correlated risk taking if the banks are unable to venture into new markets, or seek new lines of businesses or clients. Stringent capital requirements would help minimize contagion and may also incentivize bank investors to control systemic risk taking. Investors tend to prefer well capitalized banks as these banks have a relatively higher incentive to monitor (Repullo 2004, Allen, Carletti, and Marquez 2011). We would also expect greater supervisory power and explicit guidelines for diversification to have a positive impact on systemic stability by incentivizing banks to take on diverse risks.

The baseline results reported in columns (2), (3), (4), and (5) suggest that this is indeed the case. Except for activity restrictions all variables are negative and significant. As before, we interact these supervision variables with the Lerner index. The regression results are reported in Table 5. The coefficient on the interaction variable for the diversification guidelines is negative (column 5), suggesting that the benefit in reducing systemic risk with diversification guidelines is greater in less competitive markets. The interaction variable for activity restrictions is also negative (column 2). The coefficient on the interaction variable between supervisory power and the Lerner index is positive (column 4). That is, the benefit from having strong supervisory powers is less pronounced in less competitive markets. This is consistent with the notion of regulatory capture in highly concentrated industries. The other interaction terms are insignificant.

3.2.2. Private Monitoring and Systemic Risk

Next we examine the impact of private monitoring on systemic stability and on the competition-stability relationship. The variables we consider are investor protection, depth of credit information and the existence of private information collection agency. We expect greater monitoring and lower asymmetry in information to be associated with lower systemic risk. First, better investor protection and greater information availability facilitates better monitoring. Second, information asymmetry provides a potential channel in which shocks can be propagated through the banking system (a number of papers have used constrained information asymmetry framework to explain risk contagion and crises; see for instanceGenotte and Leland 1990, Kodres and Pritsker 2002, Hong and Stein 2003, and Barlevy and Veronesi 2003, Yuan 2005). If greater information availability provides a substitute to competition in reducing systemic fragility, then we would expect the impact of greater information to be stronger in less competitive markets. However, it is also possible that information asymmetry affects stability through different channels than competition. For instance, competition may incentivize banks to take on more diversified risks, while greater information availability may help reduce contagion of a macro shock to the banking system.

The baseline results are provided in columns (6), (7) and (8) in Table 4. Consistent with our expectations, both depth of credit information and the existence of private information collection agency significantly reduce systemic risk after controls. In columns (6), (7) and (8) of Table 5, we present results from regressions including the interaction between private monitoring variables and the Lerner index. The results indicate that the effect of investor protection and depth of credit information in reducing systemic risk is lower in less competitive markets.

3.3. Robustness Checks

In this section we show that our results are robust to alternative regression specifications as well as alternative definitions of competition and systemic stability. A number of previous studies have used concentration, measured as the percentage of total assets held by top three or five bank in a given country, as a proxy for competition. While concentration is correlated with bank competition, the recent literature also emphasizes the differences between the two, suggesting concentration is a less reliable indicator of competition (Beck, Demirguc-Kunt, and Levine, 2006; Demirguc-Kunt and Martinez Peria, 2010). Nevertheless, as an alternative measure of competition, we use the three bank asset concentration ratio from the Financial Structure Dataset to measure banking concentration. We run the same regressions specified in equation and (9) replacing the Lerner index with bank concentration. Unlike the Lerner index, bank concentration is measured at the country level each year. All other control variables are the same as those used in Sections 3.2. The regression results are provided in Table 6. Although our bank systemic risk variable is measured at the bank level while our concentration variable is measured at the country-year level, our regression results using bank concentration are largely consistent with what we find using the Lerner index.

We also used a number of alternative measures for systemic stability as a robustness check. We computed R-squared using equity returns instead of changes in distance-to-default. In unreported results, when we repeat the regression specified in equations (8) and (9) above using the R-squared computed from equity returns, we obtain similar results. We also computed variance ratios for each country as explained in Anginer and Demirguc-Kunt (2011). These results are also qualitatively similar but not as significant.

In our main analyses in Section 3.2, we use bank fixed effect regression to control for the impact of time invariant bank heterogeneity on bank systemic risk. In this section, we consider two alternative regression specifications. First, we use country fixed effect regression to control for country heterogeneity while also controlling for year fixed effects. The regression results are presented in Column (1) of Table 7. The relationship between Lerner index and bank systemic risk is still positive and statistically significant. Second, we follow Beck, De Jonghe, and Schepens (2011) and use a time varying country fixed effect to capture time varying country-specific regulation or business cycle effects on systemic risk taking by banks. The coefficient estimates in Column (2) of Table 7 show a statistically significant positive relationship between the Lerner index and systemic risk. Our results on bank competition and systemic risk are robust to these alternative specifications.[11]

In addition, we conduct a battery of robustness checks using different sample selection criteria such as excluding banks in USA and Japan, including bank observations in 2010, excluding bank-year observations prior to 2001, and dropping countries with fewer than seven banks. The regression results are presented in Columns (3) – (6) of Table 7. Our results are robust to these alternative sample selection criteria.

[11] Regulatory and institutional variables are more sensitive to including country fixed effects as opposed to bank fixed effects. Nevertheless, the main results on entry (applications denied), generosity of deposit insurance, and private monitoring (investor protection and credit information depth) remain robust.

4. Conclusion

Competition in the financial sector has a long list of obvious benefits: greater efficiency in the production of financial services, higher quality financial products and more innovation. When financial systems become more open and contestable, generally this results in greater product differentiation, a lowering of the cost of financial intermediation and more access to financial services. But when we turn to the issue of financial stability, it is no longer so obvious whether competition is beneficial or not, with a continuing debate among academics and policymakers alike.

In this paper we investigate the relationship between bank competition and systemic stability, and using bank level measures of competition and co-dependence, we show a robust positive relationship between the two. Whereas much of the extant literature has focused on the relationship between competition and the absolute level of risk of individual banks, we examine the correlation in the risk taking behavior of banks to capture systemic fragility. Our results indicate that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks.

We also examine the impact of the institutional and regulatory environment on systemic stability and find that banking systems are more fragile in countries with weak supervision and private monitoring, greater government ownership of banks, and in countries with public policies that restrict competition. Furthermore, lack of competition has a greater adverse effect on systemic stability in countries with generous safety nets and where the authorities restrict fewer bank activities and provide limited guidance for bank asset diversification.

Our paper has important policy implications. Unlike most of the earlier literature, our findings suggest that concentration, as well as market power, are associated with greater systemic fragility. Hence when competition and systemic stability are concerned, we do not observe a trade-off, which emphasizes the importance of ensuring a competitive environment in banking. However, our results also stress the importance of the underlying regulatory and institutional framework. Allowing entry (by rejecting fewer applications) reduces systemic fragility, but so do activity restrictions and diversification guidelines, particularly in less competitive banking environments. Our results also suggest that government ownership is directly associated with higher systemic fragility.

Overall, our results lend support to the view that fostering the appropriate incentive framework is very important for ensuring systemic stability. These incentives are shaped by the design of entry and exit policies, existence and generosity of deposit insurance and safety net policies, good prudential regulation, and availability of information. The fact that entry barriers, activity restrictions, supervisory power and private monitoring are all associated with lower systemic fragility is also consistent with the important role of both prudential regulation and market discipline in ensuring stability. Importantly, the effectiveness of some of these policies in controlling systemic fragility is reduced in less competitive banking environments where there is likely to be greater regulatory capture.

In conclusion, it is important for the regulatory framework to strike the right balance between curbing excesses while avoiding potential anti-competitive effects. Our results suggest information availability, prudent capital requirements for entry as well as operation, and better credit monitoring are the types of actions that would improve systemic stability without impairing competition. In contrast, increases in regulatory costs that raise entry barriers into the financial sector make markets less contestable, depriving countries of many of the benefits of an efficient and innovative banking system, as well as leading to greater fragility.

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Figure 1: Time series change in Lerner index
This figure shows the evolution of Lerner index over time.

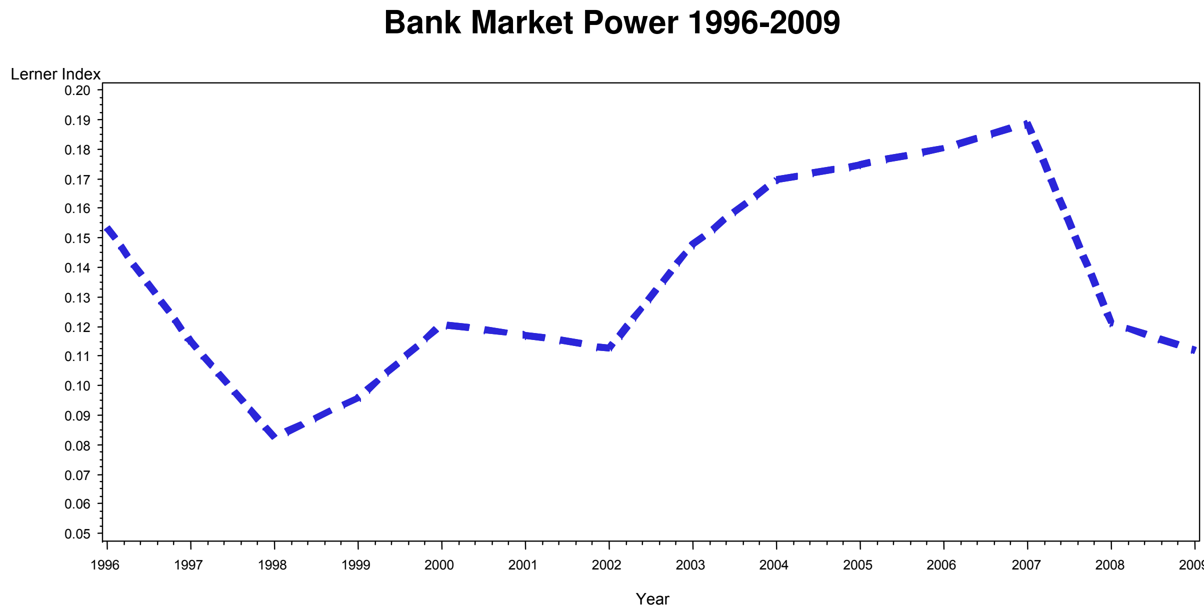

Figure 2: Time series change in R-squared
This figure shows the evolution of R-squared from a regression of a bank's weekly change in distance to default on country average weekly change in distance to default (excluding the bank itself).

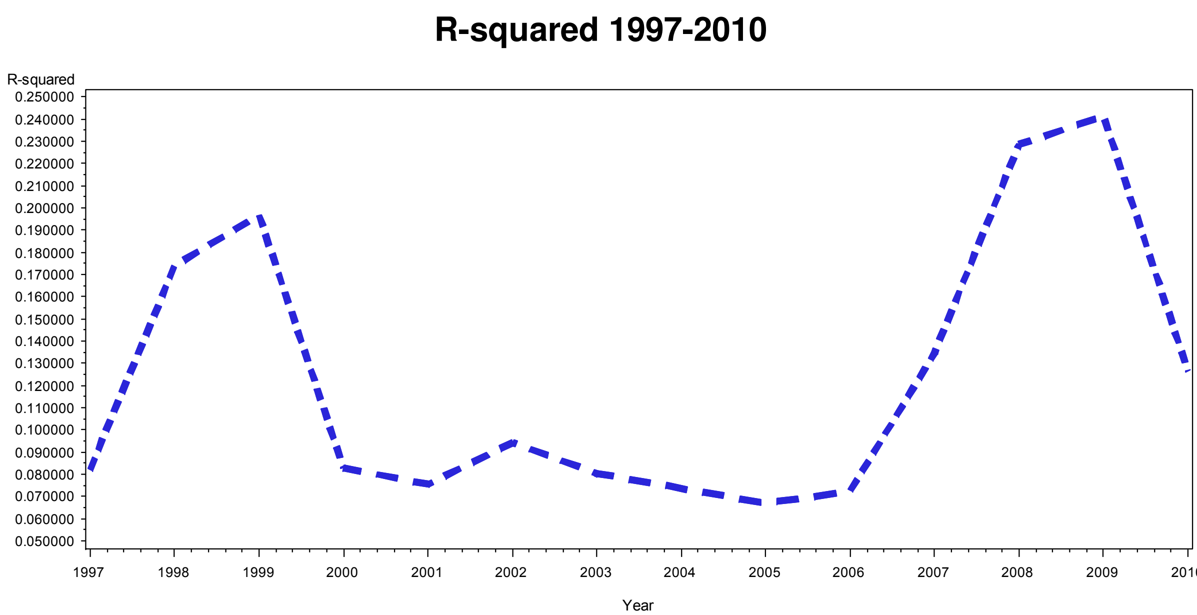

Table 1: Summary statistics

To be included in the sample, we require a bank to have stock price information from Compustat Global/CRSP and financial information from Bankscope. Definitions of variables are in Appendix I. Panel A presents the summary statistics of all variables used in this study. Panel B reports the sample distribution by calendar year.

Panel A: Summary statistics

Variable	**n**	**p5**	**p25**	**mean**	**median**	**p75**	**p95**	**sd**
risk	12,530	-7.211	-3.863	-2.550	-2.189	-0.883	0.609	2.557
lerner	11,332	-0.089	0.125	0.179	0.202	0.272	0.413	0.200
concen	12,493	0.212	0.231	0.437	0.352	0.574	0.875	0.216
size	12,530	5.495	6.685	8.221	7.915	9.577	11.998	1.986
leverage	12,530	0.795	0.891	0.901	0.914	0.936	0.963	0.073
mb	12,530	0.951	1.001	1.071	1.042	1.103	1.274	0.123
deposits	12,530	0.312	0.636	0.709	0.756	0.835	0.909	0.184
provision	12,530	-0.004	0.036	0.169	0.085	0.189	0.615	0.289
roa	12,530	-0.005	0.005	0.010	0.009	0.013	0.028	0.013
loggdppca	12,530	6.533	9.685	9.762	10.436	10.517	10.564	1.258
vargdpgr	12,530	0.402	0.813	1.489	1.256	1.627	3.757	1.267
logpop	12,530	15.494	17.684	18.408	18.991	19.487	19.534	1.438
trade_gdp	12,530	22.393	24.347	53.189	28.849	60.671	138.461	54.731
stmktcap	12,530	0.181	0.614	1.084	1.202	1.427	1.732	0.597
pcrdbofgdp	12,530	0.241	0.884	1.328	1.539	1.826	2.024	0.592
crisis	12,530	0.000	0.000	0.146	0.000	0.000	1.000	0.353
log_nbank	12,530	1.684	2.813	4.489	4.827	6.232	6.413	1.755
entry_bar	12,374	6.000	7.000	7.411	8.000	8.000	8.000	0.849
ap_denied	11,695	0.000	0.000	0.077	0.004	0.014	0.600	0.198
gov_own	12,316	0.000	0.000	0.076	0.000	0.042	0.440	0.161
covratio	10,966	1.000	2.319	9.266	8.363	8.699	11.703	67.173
activity_restriction	12,374	5.000	8.000	8.251	8.000	9.000	11.000	1.825
capital_stringency	12,374	3.000	5.000	5.169	5.000	5.000	7.000	1.015
supervisory_power	12,374	7.000	11.000	11.938	13.000	14.000	14.000	2.326
diversification_index	12,374	1.000	1.000	1.356	1.000	2.000	2.000	0.558
invest_protection	3,489	4.000	5.700	6.952	7.700	8.300	8.300	1.590
credit_info_depth	4,727	2.000	4.000	5.053	6.000	6.000	6.000	1.469
private_bureau	12,506	0.000	1.000	0.892	1.000	1.000	1.000	0.310

Panel B: Sample distribution

Year	Freq.	Percent
1997	541	4.32
1998	596	4.76
1999	652	5.2
2000	693	5.53
2001	914	7.29
2002	932	7.44
2003	1,101	8.79
2004	1,175	9.38
2005	1,184	9.45
2006	1,245	9.94
2007	1,210	9.66
2008	1,180	9.42
2009	1,107	8.83
Total	12,530	100

Table 2: Correlation tables

To be included in the sample, we require a bank to have stock price information from Compustat Global/CRSP and financial information from Bankscope. Definitions of variables are in Appendix I. Panel A presents the correlation matrix of bank level variables. Panel B presents the correlation matrix of country level variables. * indicates significance at the 5% level.

Panel A: Correlation matrix of bank level variables

	risk	size	leverage	mb	deposits	provision	roa	lerner
risk	1							
size	0.3737*	1						
leverage	0.1038*	0.3643*	1					
mb	-0.0478*	-0.0700*	-0.2669*	1				
deposits	0.0099	-0.1504*	0.4039*	-0.1112*	1			
provision	0.0354*	0.1513*	0.0678*	-0.1186*	-0.0215*	1		
roa	0.0096	-0.1263*	-0.4982*	0.4508*	-0.2375*	-0.3623*	1	
lerner	0.0705*	0.0269*	-0.1379*	0.2715*	-0.0131	-0.4611*	0.6919*	1

Panel B: Correlation matrix of country level variables

		1	2	3	4	5	6	7	8	9	10	11
1	concen	1										
2	entry_bar	-0.0497*	1									
3	ap_denied	0.2669*	-0.0422*	1								
4	gov_own	0.2153*	-0.2700*	0.5135*	1							
5	covratio	0.0111	0.0377*	-0.0526*	-0.0243*	1						
6	activity_restriction	-0.5104*	-0.1699*	-0.1172*	-0.0561*	-0.0407*	1					
7	capital_stringency	0.1214*	-0.0689*	0.0503*	0.0463*	-0.0401*	-0.0732*	1				
8	supervisory_power	-0.5820*	0.1109*	-0.1684*	-0.2174*	-0.0213*	0.3304*	-0.0320*	1			
9	diversification_index	-0.0250*	-0.0034	0.0088	-0.1048*	0.0284*	-0.3238*	0.0559*	0.0538*	1		
10	invest_protection	-0.5967*	0.2304*	-0.3752*	-0.5091*	-0.0326	0.0993*	-0.1246*	0.3716*	-0.1134*	1	
11	credit_info_depth	-0.4004*	0.2234*	-0.4862*	-0.5488*	0.0312*	-0.1615*	-0.2335*	0.2006*	-0.0163	0.6229*	1
12	private_bureau	-0.2069*	0.1143*	-0.3545*	-0.3800*	0.0116	0.0859*	-0.0686*	0.1880*	0.0592*	0.4016*	0.7088*

Table 3: Competition and systemic risk: baseline results

Regression results of model $risk_{ijt} = \beta_0 + \Omega\times bank\_controls_{ijt-1} + \Theta\times country\_controls_{jt-1} + \beta_1\times competition_{ijt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt}$, Definitions of all variables are listed in Appendix I. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. *** (**) (*) indicates significance at 1% (5%) (10%) two tailed level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	risk	risk	risk	risk	risk	risk
size	0.274**	0.235**	0.341***	0.292***	0.333***	0.302***
	(0.111)	(0.112)	(0.110)	(0.113)	(0.119)	(0.113)
leverage	-0.960	-1.693	-1.194	-0.903	-1.508	-1.143
	(1.173)	(1.261)	(1.146)	(1.183)	(1.416)	(1.190)
mb	-0.618*	-0.543	-0.515	-0.617*	-0.571	-0.705**
	(0.348)	(0.374)	(0.336)	(0.348)	(0.365)	(0.352)
deposits	-0.054	-0.114	0.056	-0.079	-0.354	-0.060
	(0.437)	(0.470)	(0.430)	(0.441)	(0.491)	(0.437)
provision	-0.218*	-0.144	-0.191*	-0.204*	-0.239**	-0.187*
	(0.111)	(0.132)	(0.111)	(0.113)	(0.120)	(0.112)
roa	12.301***	0.877	12.451***	12.386***	12.924***	11.787***
	(2.975)	(3.677)	(2.968)	(2.992)	(3.290)	(2.895)
loggdppca	-1.241	0.232	-0.590	-1.482	-1.582	-0.784
	(1.050)	(1.138)	(1.029)	(1.073)	(1.153)	(1.066)
vargdpgr	-0.049	-0.061*	-0.048	-0.041	-0.114***	-0.037
	(0.033)	(0.035)	(0.033)	(0.034)	(0.039)	(0.034)
logpop	-2.340	1.045	-1.792	-1.810	1.335	-3.753**
	(1.551)	(1.959)	(1.552)	(1.594)	(1.980)	(1.515)
trade_gdp	-0.011***	-0.003	-0.013***	-0.010***	-0.006	-0.011***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)
stmktcap	0.266*	-0.041	0.159	0.384**	0.181	0.361**
	(0.155)	(0.165)	(0.156)	(0.165)	(0.194)	(0.163)
pcrdbofgdp	-0.775***	0.326	-0.787***	-0.807***	-0.988***	-0.870***
	(0.196)	(0.260)	(0.203)	(0.198)	(0.216)	(0.200)
crisis	0.104	0.214*	0.026	0.117	0.111	0.132
	(0.104)	(0.115)	(0.105)	(0.106)	(0.109)	(0.105)
log_nbank	1.374***	1.393***	1.407***	1.418***	1.402***	1.489***
	(0.196)	(0.213)	(0.194)	(0.196)	(0.207)	(0.198)
lerner		**1.533*** **				
		(0.287)				
concen			**2.889*** **			
			(0.442)			
entry_bar				**0.052**		
				(0.084)		
ap_denied					**1.281*** **	
					(0.255)	
gov_own						**1.429** **
						(0.610)
Constant	48.009*	-30.141	29.673	39.679	-16.500	69.018**
	(28.717)	(39.105)	(28.956)	(29.345)	(36.948)	(28.505)
Observations	12,530	11,332	12,493	12,374	11,695	12,316
R-squared	0.435	0.424	0.439	0.436	0.443	0.439

Table 4: Relationship between systemic risk and regulation, supervision and private monitoring

Regression results of model $risk_{ijt} = \beta_0 + \Omega \times bank\ controls_{ijt-1} + \Theta \times country\ controls_{jt-1} + \beta_1 \times \times regulation_{jt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt}$. Definitions of all variables are listed in Appendix I. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. *** (**) (*) indicates significance at 1% (5%) (10%) two tailed level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	risk	risk	risk	risk	risk	risk	risk	risk
size	0.335***	0.269**	0.255**	0.265**	0.259**	0.601	0.791***	0.261**
	(0.122)	(0.109)	(0.109)	(0.109)	(0.109)	(0.369)	(0.304)	(0.108)
leverage	-1.476	-0.903	-0.786	-0.805	-0.723	0.903	1.029	-0.959
	(1.439)	(1.144)	(1.142)	(1.143)	(1.142)	(2.882)	(2.726)	(1.126)
mb	-1.182***	-1.136***	-1.222***	-1.112***	-1.133***	-0.830	-1.048	-1.174***
	(0.452)	(0.409)	(0.407)	(0.406)	(0.407)	(1.103)	(0.822)	(0.404)
deposits	-0.217	-0.018	-0.036	-0.056	-0.133	-1.216	-1.285	0.006
	(0.508)	(0.430)	(0.429)	(0.428)	(0.430)	(0.962)	(0.871)	(0.430)
provision	-0.225	-0.162	-0.166	-0.166	-0.179	-1.226***	-0.698**	-0.190
	(0.145)	(0.129)	(0.128)	(0.129)	(0.130)	(0.362)	(0.299)	(0.127)
roa	24.630***	21.706***	21.858***	21.533***	21.479***	28.578***	32.666***	21.504***
	(4.693)	(3.999)	(3.993)	(3.998)	(4.007)	(10.029)	(7.788)	(3.970)
loggdppca	-2.114*	-1.342	-1.291	-1.377	-1.454	6.018	1.681	-0.686
	(1.182)	(1.081)	(1.074)	(1.078)	(1.099)	(4.259)	(2.844)	(1.092)
vargdpgr	-0.027	-0.036	-0.040	-0.036	-0.023	-0.209	-0.105	-0.041
	(0.040)	(0.034)	(0.034)	(0.034)	(0.034)	(0.129)	(0.101)	(0.033)
logpop	5.120**	-1.543	-0.860	-0.995	-1.456	-15.252*	4.860	-1.652
	(2.178)	(1.620)	(1.684)	(1.690)	(1.600)	(7.998)	(6.016)	(1.605)
trade_gdp	0.003	-0.010***	-0.010***	-0.010**	-0.009**	-0.010	0.002	-0.009***
	(0.007)	(0.004)	(0.004)	(0.004)	(0.004)	(0.014)	(0.011)	(0.003)
stmktcap	-0.138	0.375**	0.306*	0.358**	0.344**	0.164	0.668***	0.171
	(0.233)	(0.163)	(0.162)	(0.165)	(0.164)	(0.307)	(0.257)	(0.159)
pcrdbofgdp	-1.043***	-0.848***	-0.834***	-0.758***	-0.862***	-1.046	-0.469	-0.817***
	(0.228)	(0.204)	(0.197)	(0.202)	(0.194)	(1.084)	(0.734)	(0.201)
crisis	0.029	0.124	0.146	0.121	0.128	0.006	0.110	0.117
	(0.115)	(0.107)	(0.106)	(0.107)	(0.106)	(0.193)	(0.166)	(0.106)
log_nbank	1.358***	1.407***	1.438***	1.397***	1.577***	2.342***	0.075	1.358***
	(0.224)	(0.196)	(0.197)	(0.197)	(0.206)	(0.762)	(0.568)	(0.196)

				Regulation and Supervision				
covratio	-0.000							
	(0.001)							
activity_restriction		-0.028						
		(0.026)						
capital_stringency			-0.090**					
			(0.044)					
supervisory_power				-0.055**				
				(0.028)				
diversification_index					-0.257***			
					(0.081)			
				Private Monitoring				
invest_protection						-0.496**		
						(0.228)		
credit_info_depth							-0.195*	
							(0.100)	
private_bureau								-0.440***
								(0.151)
Constant	-81.238**	34.718	21.871	25.231	33.497	212.350	-113.085	30.968
	(40.068)	(29.743)	(30.925)	(30.934)	(28.869)	(152.776)	(116.194)	(30.380)
Observations	10,966	12,374	12,374	12,374	12,374	3,489	4,727	12,506
R-squared	0.436	0.438	0.438	0.438	0.439	0.677	0.604	0.437

Table 5: Competition and regulation interactions

Regression results of model $risk_{ijt} = \beta_0 + \Omega \times bank\ controls_{ijt-1} + \Theta \times country\ controls_{jt-1} + \beta_1 \times competition_{ijt-1} + \beta_2 \times regulation_{jt-1} + \beta_3 \times competition_{ijt-1} \times regulation_{jt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt}$. Definitions of all variables are listed in Appendix I. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. *** (**) (*) indicates significance at 1% (5%) (10%) two tailed level, respectively. The coefficients for control variables are suppressed for brevity.

VARIABLES	(1) risk	(2) risk	(3) risk	(4) risk	(5) risk	(6) risk	(7) risk	(8) risk
lerner	0.280	2.294***	1.229	-0.555	2.253***	-7.768***	-4.462***	1.279**
	(0.467)	(0.669)	(0.983)	(1.088)	(0.594)	(1.779)	(1.381)	(0.500)
Regulation and Supervision								
covratio	0.072***							
	(0.025)							
lerner_x_covratio	0.155***							
	(0.054)							
activity_restriction		-0.033						
		(0.030)						
lerner_x_activity_restriction		-0.151*						
		(0.086)						
capital_stringency			-0.025					
			(0.055)					
lerner_x_capital_stringency			-0.014					
			(0.179)					
supervisory_power				-0.077**				
				(0.034)				
lerner_x_supervisory_power				0.154*				
				(0.089)				
diversification_index					-0.014			
					(0.107)			
lerner_x_diversification_index					-0.875**			
					(0.384)			
Private Monitoring								
invest_protection						-0.359		
						(0.427)		
lerner_x_invest_protection						1.073***		
						(0.244)		

credit_info_depth							-0.480***	
							(0.139)	
lerner_x_credit_info_depth							0.916***	
							(0.243)	
private_bureau								-0.281
								(0.183)
lerner_x_private_bureau								-0.112
								(0.478)
Constant	-191.737***	-48.691	-40.004	-54.733	-33.212	59.929	41.547	-45.427
	(54.311)	(40.671)	(41.312)	(42.711)	(40.623)	(178.070)	(166.765)	(39.745)
Observations	9,907	11,178	11,178	11,178	11,178	3,126	4,243	11,308
R-squared	0.421	0.425	0.424	0.425	0.426	0.668	0.591	0.424

Table 6: Concentration, regulation and systemic risk

Regression results of model $risk_{ijt} = \beta_0 + \Omega \times bank\ controls_{ijt-1} + \Theta \times country\ controls_{jt-1} + \beta_1 \times concentration_{jt-1} + \beta_2 \times regulation_{jt-1} + \beta_3 \times concentration_{jt-1} \times regulation_{jt-1} + \alpha_i + \lambda_t + \varepsilon_{ijt}$. Definitions of all variables are listed in Appendix I. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. *** (**) (*) indicates significance at 1% (5%) (10%) two tailed level, respectively. The coefficients for control variables are suppressed for brevity.

VARIABLES	(1) risk	(2) risk	(3) risk	(4) risk	(5) risk	(6) risk	(7) risk	(8) risk
concen	3.871***	3.080***	0.291	-1.626	3.430***	9.068***	5.275**	-0.050
	(0.536)	(0.945)	(1.291)	(1.447)	(0.638)	(3.020)	(2.437)	(1.011)
Regulation and Supervision								
covratio	0.004**							
	(0.001)							
concen_x_covratio	-0.006***							
	(0.002)							
activity_restriction		-0.009						
		(0.061)						
concen_x_activity_restriction		-0.024						
		(0.095)						
capital_stringency			-0.404***					
			(0.151)					
concen_x_capital_stringency			0.505**					
			(0.227)					
supervisory_power				-0.308***				
				(0.095)				
concen_x_supervisory_power				0.412***				
				(0.130)				
diversification_index					0.011			
					(0.162)			
concen_x_diversification_index					-0.459			
					(0.283)			
Private Monitoring								
invest_protection						0.382		
						(0.527)		
concen_x_invest_protection						-1.156**		

						(0.568)		
credit_info_depth							-0.346	
							(0.283)	
concen_x_credit_info_depth							0.206	
							(0.525)	
private_bureau								-2.123***
								(0.550)
concen_x_private_bureau								3.185***
								(0.976)
Constant	-109.637***	21.321	1.542	5.112	27.345	199.160	-148.357	22.333
	(38.634)	(29.412)	(30.862)	(31.150)	(29.688)	(151.803)	(120.212)	(30.352)
Observations	10,929	12,337	12,337	12,337	12,337	3,484	4,719	12,474
R-squared	0.441	0.441	0.442	0.442	0.442	0.680	0.614	0.442

Table 7: Alternative regression specifications

Regression results of model $risk_{ijt} = \beta_0 + \Omega \times bank\_controls_{ijt-1} + \Theta \times country\_controls_{jt-1} + \beta_1 \times competition_{ijt-1} + \varepsilon_{ijt}$, Definitions of all variables are listed in Appendix I. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the country level in columns (1), at the country-year level in column (2), and at the bank level in columns (3)-(6). Column (3) excludes banks in USA and Japan. Column (4) includes bank observations in 2010. Column (5) excludes bank-year observations prior to 2001. Column (6) drops countries with fewer than seven banks. *** (**) (*) indicates significance at 1% (5%) (10%) two tailed level, respectively.

VARIABLES	(1) risk	(2) risk	(3) risk	(4) risk	(5) risk	(6) risk
size	0.486***	0.496***	0.077	0.212**	0.365***	0.215*
	(0.062)	(0.044)	(0.163)	(0.103)	(0.132)	(0.116)
leverage	-1.947**	-2.203***	-1.127	-1.763	-1.716	-1.250
	(0.893)	(0.716)	(1.588)	(1.135)	(1.451)	(1.214)
mb	-0.666*	-0.378	-0.608	-0.977**	-0.691	-1.122**
	(0.377)	(0.344)	(0.505)	(0.434)	(0.540)	(0.476)
deposits	0.591***	0.552***	0.538	-0.084	-0.495	-0.223
	(0.184)	(0.193)	(0.595)	(0.436)	(0.525)	(0.482)
provision	-0.274	-0.366	0.103	-0.078	-0.391*	-0.289*
	(0.315)	(0.246)	(0.114)	(0.142)	(0.204)	(0.159)
roa	8.009*	5.419	7.748	10.956**	6.160	8.657
	(4.254)	(3.711)	(4.928)	(5.176)	(6.107)	(5.905)
loggdppca	-0.211		1.924	0.449	1.183	-1.302
	(1.729)		(1.174)	(0.987)	(1.610)	(1.150)
vargdpgr	-0.048		-0.079**	-0.051	0.021	-0.047
	(0.071)		(0.035)	(0.034)	(0.044)	(0.041)
logpop	2.146		2.210	1.956	0.668	0.683
	(3.170)		(2.042)	(1.892)	(2.583)	(2.098)
trade_gdp	-0.002		0.001	-0.001	0.006	-0.003
	(0.005)		(0.003)	(0.003)	(0.004)	(0.003)
stmktcap	-0.052		0.042	-0.063	-0.069	0.113
	(0.304)		(0.165)	(0.120)	(0.222)	(0.154)
pcrdbofgdp	0.164		0.564*	0.675***	0.826**	0.382
	(0.436)		(0.295)	(0.240)	(0.411)	(0.274)
crisis	0.260		0.074	0.203*	0.008	0.218*
	(0.225)		(0.181)	(0.113)	(0.138)	(0.120)
log_nbank	1.236**	-2.071	1.234***	1.248***	0.118	1.499***

	(0.503)	(1.729)	(0.232)	(0.192)	(0.238)	(0.244)
lerner	**0.994*****	**0.809****	**0.740****	**0.924*****	**1.181*****	**1.303*****
	(0.222)	**(0.389)**	**(0.375)**	**(0.268)**	**(0.345)**	**(0.319)**
Constant	-47.620	4.564	-60.258	-48.726	-28.664	-9.127
	(63.372)	(7.877)	(37.965)	(36.981)	(50.358)	(42.235)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Country fixed effects	Yes	No	No	No	No	No
Country x year fixed effects	No	Yes	No	No	No	No
Observations	11,332	11,332	5,238	12,131	9,020	10,510
R-squared	0.277	0.418	0.447	0.419	0.450	0.430

Appendix I. Variable definitions

Variables	Definitions	Source	Time period
<u>Dependent variables</u>			
risk	Logistic transformation of rsq (i.e.. log(rsq/(1-rsq))) , where rsq is r-squared from a regression of weekly change in distance to default on country average weekly change in distance to default (excluding the bank in question) by year.	Authors' calculation using bank data from Bankscope and stock return information from Compustat Global	1997-2010
<u>Bank level control variables</u>			
size	Log value of total assets in millions of US dollars.	Authors' calculation using bank data from Bankscope	1996-2010
leverage	Total liabilities divided by total assets.	Authors' calculation using bank data from Bankscope	1996-2010
mb	Market value of equity plus book value of debt, divided by book value of total assets.	Authors' calculation using bank data from Bankscope and stock return information from Compustat Global	1996-2010
provision	Loan loss provisions divided by net interest income.	Authors' calculation using bank data from Bankscope	1996-2010
deposits	Total deposits divided by total assets.	Authors' calculation using bank data from Bankscope	1996-2010
roa	Net income divided by total assets.	Authors' calculation using bank data from Bankscope	1996-2010
<u>Competition variables</u>			
concen	Assets of three largest banks as a share of assets of all commercial banks.	Financial Structure Dataset, Beck, Demirguc-Kunt and Levine (2010)	1960-2009
lerner	Lerner index is equal to the difference between asset price and marginal cost, normalized by asset price.	Authors' calculation using bank data from Bankscope	1996-2010
<u>Country level variables</u>			
<u>Competition</u>			
entry_bar	Requirement on entry into banking, which is a variable constructed based on eight questions regarding required submission to obtain a banking license. The variable ranges from zero (low entry barrier) to eight (high entry barrier).	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
ap_denied	The percentage of applications to enter banking denied in the past five years.	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005

gov_own	The fraction of banks that are 50% or more owned by the government.	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
Deposit insurance			1999 ,2002, 2005
covratio	Deposit insurance coverage ratio, which is deposit insurance coverage divided by deposits per capita. Set to 1 if a country offers full coverage.	Demirguc-Kunt, Kane, and Laeven (2008)	1960-2003
Supervision			
activity_restriction	A variable that ranges from zero to twelve, with twelve indicating the highest restrictions on bank activities. (Unrestricted=1, Permitted=2, Restricted=3, and Prohibited=4).	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
capital_stringency	A variable that captures both the overall capital stringency and the initial capital stringency. It ranges from zero to eight, with a higher value indicating higher capital stringency.	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
supervisory_power	A variable that ranges from zero to fourteen, with fourteen indicating the highest power of the supervisory authorities.	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
diversification_index	A variable that ranges from zero to two, with higher values indicating more diversification.	Barth, Caprio, and Levine (2000, 2003, 2008)	1999 ,2002, 2005
Private monitoring			
invest_protection	A variables that ranges from zero to ten, with higher values indicating stronger investor protection.	World Banking Doing Business Survey	2004-2011
credit_info_depth	A variable that ranges from zero to six, with higher values indicating deeper credit information.	World Banking Doing Business Survey	2004-2011
private_bureau	An indicator variable that is equal to 1 if a private bureau operates in the country and 0 otherwise.	Djankov, McLiesh, and Shleifer (2007) and World Banking Doing Business Survey	1978-2011
Country level control variables			
log_nbank	Log number of banks used to calculate country average weekly change in distance to default.	Authors' calculation using bank data from Bankscope and stock return information from Compustat Global	1996-2010
crisis	A dummy variable that equals 1 if a country is experiencing a crisis in the year and 0 otherwise.	Laeven Banking Crisis Database	1976-2010
loggdppca	Log value of GDP per capital in nominal constant US 2000 dollars.	WDI	1960-2010
vargdpgr	Variance of GDP growth for the previous five years.	Author's calculation using WDI	1960-2010

		data.	
logpop	Log value of population in millions.	WDI	1960-2010
trade_gdp	Imports plus exports of goods and services as a percentage of GDP.	WDI	1960-2010
stmktcap	Stock market capitalization divided by GDP.	Financial Structure Dataset, Beck, Demirguc-Kunt, and Levine (2010)	1960-2009
pcrdbofgdp	Private credit by deposit money banks and other financial institutions to GDP.	Financial Structure Dataset, Beck, Demirguc-Kunt, and Levine (2010)	1960-2009