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Bank risk taking and competition: evidence from regional banking markets

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Non-technical summary

Bank risk taking and its determinants has been a widely discussed topic during recent years. This paper contributes to the empirical literature on the link between bank competition and bank risk taking behavior. The topic is of particular interest since recent theoretical literature casts doubt on the prevailing view that lower competition mitigates risk taking incentives, arguing that higher competition goes along with reduced bank risk.

Empirical studies conducted so far are inconclusive. This study therefore aims at contributing to this puzzle by analyzing the impact of different proxies for competition on bank riskiness. To do so, we employ a unique and comprehensive dataset provided by the Deutsche Bundesbank, comprising bank-level balance-sheet data and risk taking information for all German banks. The key challenge is indeed to define appropriate measures for bank competition. We apply three carefully chosen concepts, corresponding to three dimensions at which competition affects risk taking behavior:

- First, we calculate a bank-specific efficiency-adjusted Learner Index, which accounts for the market power of banks by measuring the degree to which banks can set their prices above marginal costs.
- Second, we compute a measure of market power in terms of bank branches, accounting for the geographical reach of individual banks.
- Third, we use the Boone indicator, which measures competition by the response of profits to changes in marginal costs. The intuition behind this index as a competition measure is that increased competition reallocates output and accordingly profits from (in terms of marginal costs) less-efficient to more-efficient banks.

A further key challenge is the proper identification of bank risk. Previous studies have used rather poor measures, relying on either the non-performing loans ratio or the so-called z-scores, which do not account for actual bank distress or bank default. In contrast, we use outright bank defaults and weaker forms of bank distress as a direct measure of bank risk.

Using logit models we estimate the probability that a bank distress event or an outright bank default occurs, applying the aforementioned measures for bank competition as well as several variables to control for banks' capital adequacy, profitability, and portfolio risks. To confirm the robustness of our results, we also apply standard bank-risk measures (i.e., z-scores which proxy distance to bank default, and the non-performing loans ratio). Further, we account for possible endogeneity of the Lerner Index, using an instrumental variables approach.

Our main results can be summarized as follows: Using the Lerner Index as a proxy for bank-specific market power, our results support the view that market power tends to reduce the default probability, i.e. the riskiness of the banks. In contrast, using the Boone Indicator (derived on the state level) and/or the regional branch share as a measure of competition, we find strong support that increased competition lowers the riskiness of banks. Therefore, political implications derived from empirical banking market studies must also recognize the theoretical properties of the used indicators for market power and competition.

Nicht-technische Zusammenfassung

Die Risiken in den Geschäftsmodellen von Banken und deren Hintergründe wurden in den vergangenen Jahren vielfach diskutiert. Diese Studie ergänzt die bereits bestehende empirische Literatur, welche die Verbindung zwischen Wettbewerb und dem Risikoverhalten von Banken untersucht. Das Thema ist von besonderem Interesse, da die neuere theoretische Literatur die lange vorherrschende Sichtweise in Frage stellt, dass geringerer Wettbewerb den Anreiz zu Risikoübernahme mindert. Es wird stattdessen argumentiert, dass höherer Wettbewerb mit einer Verringerung des Risikos von Bankinstituten einhergeht.

Die bisher veröffentlichten empirischen Studien liefern hierzu kein eindeutiges Ergebnis. Deshalb ist es das Ziel dieser Studie, Erklärungsansätze für gegensätzliche Ergebnisse in der Literatur zu liefern, indem sie den Einfluss verschiedener Wettbewerbsmaße auf das Risiko von Banken misst. Hierzu wird ein einzigartiger, umfassender Datensatz der Deutschen Bundesbank verwendet, welcher auf Bankenebene Bilanzdaten und Risikovariablen für das deutsche Universalbankensystem enthält. Die Definition eines aussagekräftigen Maßes für Wettbewerb stellt bei dieser Untersuchung die zentrale Herausforderung dar. In Anlehnung an drei Dimensionen, in denen Wettbewerb das Risikoverhalten von Banken beeinflusst, verwenden wir die folgenden drei Konzepte:

- Erstens messen wir Marktmacht mittels eines bankspezifischen, Effizienz angepassten Lerner Index (d.h. wir bestimmen, inwieweit Banken dazu in der Lage sind, ihre Preise oberhalb ihrer Grenzkosten zu setzen).
- Zweitens messen wir Marktmacht mittels des Zweigstellenanteils der Institute in den relevanten Bankenmärkten (d.h. unter Berücksichtigung der "geografischen Reichweite" der jeweiligen Institute).
- Drittens verwenden wir den Boone-Indikator, welcher den Einfluss von Gewinnen auf die Veränderung der Grenzkosten misst (d.h. die Intuition hierbei ist, dass steigender Wettbewerb den Output/die Gewinne von weniger effizienten zu effizienteren Banken "umverteilt").

Eine wesentliche Herausforderung stellt die genaue Identifikation des Risikos einer Bank dar. Vorhergehende Studien haben hierfür relativ schwache Indikatoren gewählt, indem sie sich bspw. auf den Anteil notleidender Kredite an den Gesamtkrediten oder sogenannte Z-Scores stützen, welche allerdings weder die eigentliche Notlage von Bankinstituten noch deren Ausfall abbilden. Dagegen berücksichtigt die vorliegende Studie tatsächliche Ausfälle von Banken sowie schwächere Formen von Notlagen bei Bankinstituten als direkte Maße für deren Risiko.

Mittels Logit-Modellen schätzen wir die Wahrscheinlichkeit, dass eine Bank in Schieflage gerät oder gänzlich ausfällt. Dabei stellen wir auf die oben genannten Wettbewerbsmaße ab, kontrollieren aber gleichzeitig auch für die Kapitalisierung, die Ertragskraft und die Risiken in den Portfolien der jeweiligen Bankinstitute; alternative Risikomaße wie bspw. den Z-Score (als Indikator für den Abstand einer Bank zur Insolvenz) sowie den Anteil der notleidenden Kredite an den Gesamtkrediten verwenden wir zur Überprüfung der Robustheit unserer Ergebnisse. Darüber hinaus berücksichtigen wir mögliche Endogenitätsprobleme des Lerner Index mittels eines "Instrumental Variables"-Schätzverfahrens.

Die zentralen Erkenntnisse unserer Studie können wie folgt zusammengefasst werden: Unsere Regressionsergebnisse stützen die Sichtweise, dass Marktmacht die Ausfall-

wahrscheinlichkeit (und somit das Risiko) von Banken verringert, sofern der Lerner Index als bankindividuelles Maß für Marktmacht herangezogen wird. Werden im Gegensatz hierzu der auf Bundeslandebene berechnete Boone-Indikator und/oder der regionale Zweigstellenanteil als ein Maß für Bankenwettbewerb interpretiert, finden sich starke Hinweise darauf, dass schärferer Wettbewerb das (Ausfall-)Risiko von Bankinstituten reduziert. Aus empirischen Untersuchungen des Bankenmarktes abgeleitete politische Empfehlungen müssen sich damit an der Frage orientieren, welche Indikatoren für Marktmacht und Wettbewerb mit welchen theoretischen Eigenschaften den entsprechenden Analysen zugrunde liegen.

Bundesbank Discussion Paper No 30/2013

Bank Risk Taking and Competition: Evidence from Regional Banking Markets*

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Abstract

This study investigates the bank competition-stability nexus using a unique regulatory dataset provided by the Deutsche Bundesbank over the period 1994 to 2010. First, we use outright bank defaults as the most direct measure of bank risk available and contrast the results to weaker forms of bank distress. Second, we control for a wide array of different time-varying characteristics of banks which are likely to influence the competition-risk taking channel. Third, we include different measures of competition, contestability and market power, each corresponding to a different contextual level of a bank's competitive environment. Our results indicate that political implications derived from empirical banking market studies must recognize the theoretical properties of the indicators for market power and competition. Using the Lerner Index as a proxy for bank-specific market power, our results support the view that market power tends to reduce banks' default probability. In contrast, using the Boone Indicator (derived on the state level) and/or the regional branch share as a measure of competition, we find strong support that increased competition lowers the riskiness of banks.

Keywords: bank risk, bank competition, instrumental variables models

JEL classification: C35 , G21 , G32 , L50.

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1 Introduction

The effect of bank competition on the risk taking behavior of banks has been at the center of a discussion among regulators, policy makers and researchers for a long time. Until recently, the general consensus among policy makers and researchers has been that market power gives banks proper incentives to behave prudently. The central aim of prudential bank regulation to reduce banks' risk taking incentives therefore often coincides with restricting competition among banks. Accordingly, the banking industry has been exempted from competition law for a long time (Carletti and Vives (2008)). In recent years, however, several theoretical and empirical studies have challenged the view that monopoly power mitigates bank risk taking, instead arguing that higher competition among banks leads to lower levels of bank risk. The recent financial crisis, which has also been triggered by excessive bank risk taking, has again heightened interest in the relationship between competition among banks, bank market structure and banking stability. The competition-bank risk taking nexus has been extensively analyzed in the theoretical banking literature. The predictions emerging from the theoretical models are ambiguous, however. Models such as those of Keeley (1990), Allen and Gale (2004), Matutes and Vives (2000), Hellmann, Murdock, and Stiglitz (2000) and Wagner (2010) all predict that fiercer competition among banks will result in higher bank risk taking. The intuition behind the result is straightforward: High market power at the bank level is associated with high monopoly rents which the bank manager wants to protect by investing in safe assets. By reversing the line of argument of the above models, Boyd and De Nicolo (2005) show how higher competition among banks might lead to a reduction in the overall level of bank risk taking: Higher competition reduces interest rate costs at the level of the borrowing firm, leading the firm to choose a safer project which ultimately generates safer banks. Martinez-Miera and Repullo (2010) build a model which predicts that the effect of bank competition on bank risk taking is non-linear. Their model shows that under specific circumstances higher bank competition first increases bank risk taking and then reduces bank risk taking. Their model thus predicts a reversed u-shaped relationship between bank competition and bank risk taking. Besides the theoretical literature, there is abundant empirical work examining the effect of bank competition on stability and bank risk. One strand of empirical research uses large aggregated cross-country datasets. Beck, Demirguc-Kunt, and Levine (2006), using a logit probability model, find that more concentrated banking systems are less likely to experience a banking crisis. At the same time, however, more competition also reduces bank risk. In a similar model, employing the Panzar and Rosse H-statistic as a measure of competition, Schaeck, Cihak, and Wolfe (2009) also find a negative relationship between the likelihood of a systemic banking crisis and the competitiveness of the banking system. Another set of research uses (cross-country) bank-level data to examine the relationship between competition and individual bank risk. Boyd, De Nicolo, and Jalal (2007) find that less-concentrated banking markets are characterized by lower z-scores, an inverse measure of bank risk. Jiménez, Lopez, and Saurina (2007) find no relationship between credit risk and market concentration but a positive effect of competition on credit risk, supporting the competition-fragility hypothesis. Schaeck and Cihak (2012) find a positive relationship between higher competition and bank capital ratios. Inasmuch as better capitalized banks can be considered less risky, these results confirm the competition-stability hypothesis. Berger, Klapper, and Turk-

Ariss (2009) find that competition in the loan market has a mitigating effect on credit risk. They also analyze the effect of competition on overall bank risk and banks' capital ratios where they find competition to increase overall bank risk and decrease capital ratios. Finally, Schaeck and Cihak (2013) find in general a negative effect of competition on bank risk for European countries. In this study we aim at adding to the empirical literature analyzing the competition-bank risk nexus by using bank-level data for all German banks. One of the key challenges in the attempt to identify the effect of competition and concentration on bank risk empirically lies in defining the relevant market for each group of banks. Existing empirical evidence generally assumes that the relevant market for a particular bank in a given country is the country itself. This implies that each bank in a given country stands in direct competition to all other banks in the country. While true for large, multinational banks which compete directly with one another in many markets, this assumption seems unrealistic for the majority of banks which operate in regional banking markets. We improve on the existing literature by allowing competition to affect banks operating in different markets in distinct ways. We use a total of three concepts to measure competition, corresponding to three different dimensions at which competition might affect the risk-taking behavior of banks. First, to approximate the ability of banks to generate rents by pricing its products over their marginal costs, we compute bank-specific efficiency-adjusted Lerner indexes. Second, the vast majority of banks in Germany belong either to the cooperative banks sector or to the savings banks sector. These banks are by law geographically limited in their scope of activities.[1] Our dataset provides us with detailed locational information for all German banks ("three-pillar system") so that we can exploit this special characteristic of the German banking industry to clearly define the relevant market for each specific bank in our sample.[2] For each banking market we compute measures of concentration and contestability of the banking market. It is already a stylized fact that measures of concentration and competition are distinct features affecting banks in different ways. Third, we compute Boone indicators for the next contextual level above the relevant market for banks (see also Schaeck and Cihak 2010). Although most German banks do not run branches outside their home county, there is nothing stopping a business customer or a depositor from choosing a bank outside that particular county. The Boone indicator measured at the federal state level captures exactly this characteristic of bank market competition. Another important issue in empirical studies analyzing the relation between risk taking and bank competition is identifying the correct measure of bank risk. Most bank-level studies proxy bank risk with either some sort of credit risk (i.e., the ratio of non-performing loans over loans), or by the z-score introduced by Boyd and Runkle (1993). While the z-score can be interpreted as the number of standard deviations by which a bank is removed from insolvency, the non-performing loans ratio focuses on credit risk only. However, neither of these risk indicators considers actual bank distress and bank failure events, which are without doubt the most appropriate concepts to define bank risk. Our measurement of bank risk is comprised from the distress database collected by the German central bank. This dataset contains information on bank-level distress events that range from weak incidences to forced exit by means of restructuring mergers or bank moratoria. Hence, our measurement of bank risk directly captures the

[1] This special structure of the German banking sector is known as *regional principle, "Regionalprinzip"*.

[2] Besides information on bank distress and bank balance sheet data, our dataset contains the location of bank headquarters and their branches for all institutions in the German universal system.

possibility of outright bank defaults. We are not aware of any study employing actual failure events as dependent variable to investigate the competition-bank risk nexus and we believe this is an important step forward toward a better understanding of the underlying mechanisms. Our paper is structured as follows: in Section 2 we present the data and the methodological approaches to measuring bank competition at different contextual levels and to analyzing the bank risk taking-competition nexus. In Section 3 we present the main results of our empirical model before concluding in Section 4.

2 Methodology and Data

2.1 Data

Our analysis covers the German economy and its banking system over the period 1994 to 2010.[3] Bank balance sheet data are collected from the unconsolidated balance sheet and income statement reports which all banks report to the Bundesbank annually. Our measure of bank risk is constructed from the confidential distress database. We complement the bank-level data with macroeconomic data at the county level obtained from the German Federal Statistical Office. We apply a very thorough merger treatment to the dataset: After the merger of two banks we artificially create a third bank (for the time after the merger) in the dataset.[4]

Measuring Bank Risk

Most existing empirical studies investigating the relationship between bank competition and financial stability at the microeconomic level focus either on credit risk alone, using some form of credit risk measure such as non-performing loans, or resort to bank risk measures constructed from balance sheet information, such as a z-score. Bank risk measures constructed from balance sheet information, however, have the disadvantage that they do not provide information on actual distress events, or even outright failures of banks. Our measure of bank risk is comprised from the distress database collected by the Bundesbank. This dataset contains information on bank-level distress events that range from weaker incidences such as capital support measures by the deposit insurance schemes to outright bank defaults (i.e., bank moratoria or takeovers in the banking market which are classified by supervisors as "distressed mergers").[5] Hence, our measurement of bank risk directly captures the possibility of banks exiting the market because of distress events. According to Aspachs, Goodhart, Tsomocos, and Zicchino (2007), the probability of bank distress events is a much more appealing bank risk statistic because, by covering all types of risk, it provides a more exhaustive picture of risk borne by the banking system. We consider two different concepts for defining bank distress: first we construct an indicator

[3]Note that we lose one year of data by setting the analysis in a forward-looking perspective, that is by forwarding bank distress and bank default events by one year with respect to the explanatory variables.

[4]Note that the merger treatment causes the total number of banks in the dataset to exceed the maximum number of banks in a given time period.

[5]Note that the Bundesbank distress database is only available until 2006. Hence, from 2007-2010 we define a restructuring merger in a way that the bank being taken over experienced a severe distress event within the three years before the merger (i.e., a low capital ratio, a capital support measure, or a moratorium).

for broader bank distress events (BANK DISTRESS),[6] as well as one more narrowly defined indicator for banks exiting the market in a distressed merger or in a moratorium (BANK DEFAULT). In order to give the analyses a forward-looking perspective, we forward bank distress and bank default events by one year with respect to the explanatory variables.

Table 1: **Distribution of Bank Distress and Bank Default Events**

This table presents descriptive statistics for bank default and bank distress events obtained from the distress database of the Deutsche Bundesbank. The dummy variable BANK DISTRESS refers to a broad definition of distress (including banks exiting the market in a distressed merger or in a moratorium, but also capital support measures from the deposit insurance funds), while the dummy variable BANK DEFAULT is an indicator for bank default (only comprising banks exiting the market in a distressed merger or in a moratorium). The variable z-score is calculated as the ln of the ratio of Tier 1 capital and operating profits of bank i to the standard deviation of operating profits where each position is measured relative to total assets. Tier 1 capital and total assets are averaged over two years ("mid-point values"); to account for changes in the volatility of profits over time the standard deviation of operating profits is calculated over a window of five years. The sample comprises 37,529 bank-year observations on up to 5,035 banks over the period 1994–2010. Note that the z-score can only be calculated for a sub-sample of bank-years (because of the "mid-point" calculation and the five-year time window).

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**
BANK DISTRESS	0.043	0.204	0	1	37,529
BANK DEFAULT	0.013	0.114	0	1	37,529
$z-$score	3.035	0.703	-3.397	7.359	29,680

Table 1 presents descriptive statistics on the occurrence of bank distress, bank default events and the z-score for our sample of German banks ("three-pillar system") over the period 1994 to 2010.

Measuring Market Power

Lerner Index

We use the Lerner Index to approximate competition at the bank level. The Lerner Index represents the markup of prices over marginal cost; as such, the Lerner Index is a direct indicator of the degree of market power. A general definition of the Lerner index is

$$L_{it} = \frac{ar_{it} - mc_{it}}{ar_{it}}, \tag{1}$$

[6]The indicator comprises (*i*) capital support measures by the deposit insurance schemes in Germany, (*ii*) takeovers classified by the Bundesbank as restructuring mergers, as well as (*iii*) bank moratoria. Therefore, the bank distress indicator applied in this study is more narrow (i.e., focusing on more severe distress events) than, for example, the indicators applied in Kick and Koetter (2007) and Jahn and Kick (2012).

where ar_{it} and mc_{it} represent the average revenues and marginal costs of bank i at time t. Marginal costs are derived from a translog cost function of the following form:

$$\begin{aligned}\ln(C_{it}) = \alpha + \sum_m \beta_m \ln(y_{mit}) + \frac{1}{2}\sum_m\sum_n \beta_{mn} \ln(y_{mit}) \ln(y_{nit}) + \frac{1}{2}\sum_k\sum_j \gamma_{kj} \ln(w_{kit}) \ln(w_{jit}) \\ + \sum_m\sum_k \delta_{mk} \ln(y_{mit}) \ln(w_{kit}) + \phi_0 \ln(z_{it}) + \frac{1}{2}\phi_1 \ln(z_{it})^2 + \sum_m \omega_m \ln(y_{mit}) \ln(z_{it}) \\ + \sum_k \omega_k \ln(w_{kit}) \ln(z_{it}) + \varsigma t + v_{it} + u_i. \end{aligned} \tag{2}$$

C_{it} represents the production costs of bank i at time t. We assume that production is based on the factor inputs funding, labor and fixed capital, represented by w_{1it}, w_{2it} and w_{3it}, for each bank i and time t. We specify three different types of bank output: customer loans, business loans and securities, represented by y_{1it}, y_{2it} and y_{3it}. We also include bank equity capital (z_{it}) as further control variable into the translog cost function. v_{it} represents the model error term and u_i the bank-specific inefficiency term. Additionally we allow the production cost to contain a deterministic time trend ςt to capture general technological change. As usual, we impose homogeneity of degree one in the input prices by dividing all factor prices and total production cost by the price of fixed capital. The model is estimated using a stochastic cost frontier approach. Using Equation (2), the marginal cost of bank i at time t can be calculated as

$$mc_{it} = \sum_{m=1}^{3} \frac{C_{it}}{y_m}\left[\beta_1 + \beta_{11}\ln(y_1) + \frac{1}{2}\beta_{12}\ln(y_2) + \frac{1}{2}\beta_{13}\ln(y_3) + \sum_n \delta_{1i}\ln(w_i) + w_1\ln(z)\right]. \tag{3}$$

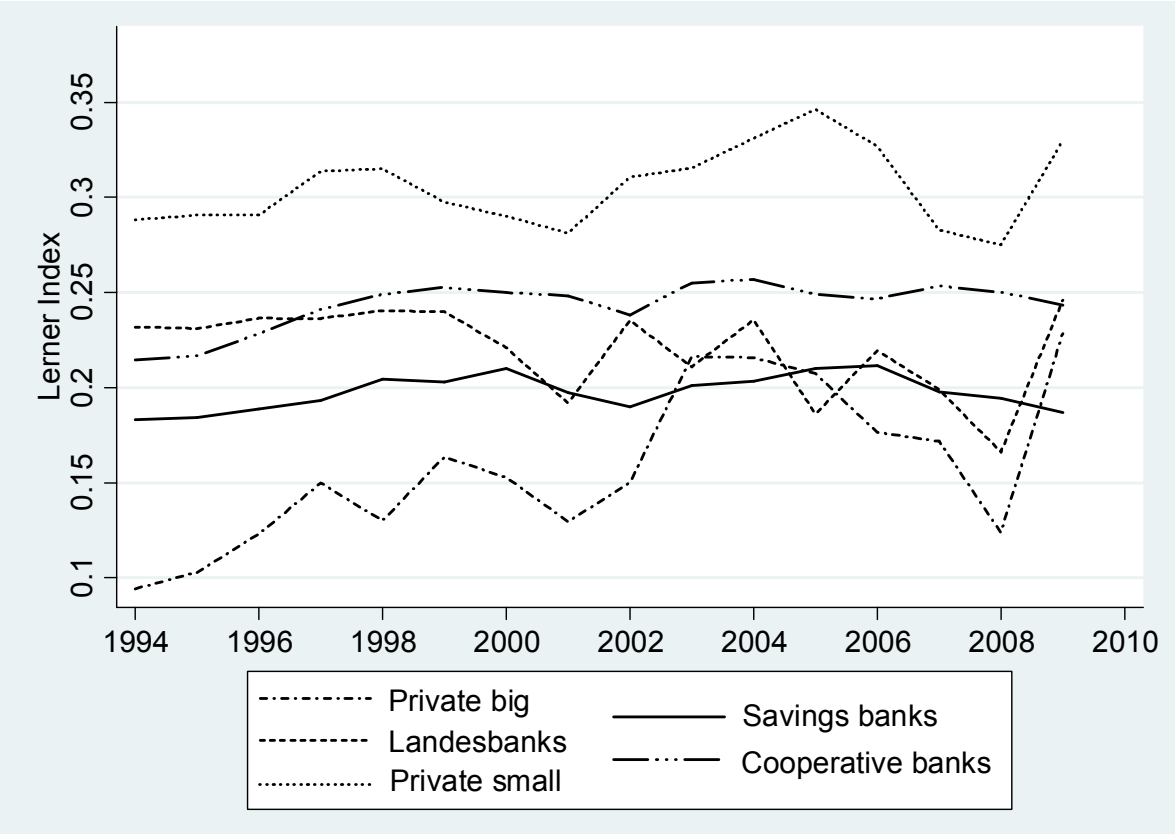
Concerning the average revenue, it is common to approximate it by the fraction of total revenue to total assets. However, unlike most other approaches to studying the relationship between bank competition and bank (in)stability, we explicitly allow for banks using less-than-optimal production technology. As argued by Koetter, Kolari, and Spierdijk (2012), ignoring possible inefficiencies in the production process might lead to biased estimates for the Lerner Index. We follow Koetter, Kolari, and Spierdijk (2012) and use the sum of the predicted values for total cost $\overline{C}$ from Equation (2) and the predicted profits $\overline{\pi}$ derived from the estimation of a profit function dual to the cost function depicted in Equation (2). The estimation of the standard stochastic profit function delivers predicted values of profits of bank i (see Berger and Mester (1997)). These predicted profit values, as well as the predicted costs of the stochastic cost frontier, are net of any inefficiencies and thus proxy the true average revenue more reliably. To be specific, the average revenue ar_{it} in Equation (1) is computed as

$$ar_{it} = \frac{\overline{C} + \overline{\pi}}{\text{Total Assets}}.$$

The evolution of our estimated Lerner Index is shown in Figure 1.

Hereby, the point estimates of the median values for each year and for each of the major German banking groups are depicted. The figure reveals that savings and cooperative banks, over time, enjoy a relatively stable market power (with cooperative banks having more market power), while private banks as well as Landesbanks show substantial

Figure 1: **Evolution of Competition - The Lerner Index**



fluctuation. Interestingly, big private banks have been gaining market power over time, while Landesbanks were losing such market power until the financial crisis in 2008 but were able to catch up with the big private banks later on in 2009. Koetter and Poghosyan (2009) depict a similar evolution of market power for the German banking system based on latent group-specific Lerner Index estimates.

County-level measures of concentration and contestability

In our analysis we aim to identify bank concentration in the relevant markets (where we disaggregate our data all the way down to the regional level). Therefore, we refrain from measuring concentration based on a bank's total assets or total lending for two reasons. The first reason concerns data availability, as banks' total assets represent balance sheet information which is available only at the bank level (but not disaggregated by regions). Also, data on bank lending can only be traced to certain regions using the Bundesbank's credit register which, however, has a substantial threshold of 1.5 million €. That is, even the use of lending data from the credit register would cause a substantial bias in the analysis, especially for small regional banks (i.e., cooperative banks, savings banks, small private banks). In order to overcome these data constraints, we measure competition by the availability of bank branches for private and corporate customers in certain regions. Using information on the location of branches from all German universal

banks we calculate the variable Regional Geographic Reach as the share of branches a given bank has per county; if a bank does business in several counties, we assign the average branch share per county (weighted by the bank's number of branches in each county) to the specific bank.[7]

The Boone Indicator

The central idea behind the Boone Indicator, as proposed by Boone (2000) and Boone, van der Wiel, and van Ours (2007), is that a more efficient bank is more profitable than less efficient banks. That is, markets map efficiency differentials into profit differentials. Boone (2000) is able to show within a broad set of theoretical models that this mapping of efficiency differentials into profit differentials becomes steeper as competition increases. That implies that the more competitive the market, the more harshly a bank is punished for inefficiencies in terms of relative profits. This last result enables the measurement of competition via the the response of profits to changes in marginal costs. The economic argumentation behind the idea of measuring the degree of competition by analyzing the relationship between profit and efficiency ratios is based on the selection effect of competition stressed by Vickers (1995). This line of thinking holds that "competition causes efficient organizations to prosper at the expense of inefficient ones" (Vickers, 1995, p.1). Boone (2000) argues that this selection effect is constituted by the reallocation effect of competition. A rise in competition reallocates output from less efficient to more efficient banks, measured by marginal costs. Firms with lower marginal costs are able to offer their product at a lower price. Increasing competition allows efficient banks to use their cost advantage more aggressively, which draws customers away from banks with higher marginal costs. This effect increases the output of more efficient banks. It is this reallocation of output that raises the profits of efficient banks relative to less efficient competitors. The above discussion supports the following log-linear relationship between relative profits and relative efficiency, measured by marginal costs (see also Boone, van der Wiel, and van Ours (2007)):

$$\ln(\pi_{ijt}) = \alpha + \beta_{jt} \ln(mc_{ijt}) \tag{4}$$

where π_{ijt}, mc_{ijt} indicate the time t profit and marginal cost of bank i located in federal state j.[8] The Boone Indicator, given by the parameter β_{jt}, measures the effect of changes in marginal costs on profits. The specification in logs allows us to interpret the Boone Indicator as elasticity. As indicated by the subscript jt, we estimate the above regression separately for each federal state and for each year. The Boone indicator thus varies between federal states and over time.

The Boone indicator β_{jt} should generally be negative. Regardless of the degree of competition, banks with higher marginal costs are expected to realize relatively lower profits. Furthermore, changes in competition over time should result in appropriate changes in the

[7] Until 2004 banks are legally bound to report the exact location of each of their branches to the Deutsche Bundesbank and the Federal Supervisory Authority (BaFin); from 2005-2010 branch shares and the branch HHI can be proxied from voluntary reporting and the cross-section of the data set. Note that for the adequate calculation of competition measures banks which are known for operating extremely small branches (e.g., "one-person counters" in shopping centers), are dropped from the analysis.

[8] Marginal costs are calculated, based on the estimated parameter of the translog cost function given in Equation (2), as shown in Equation (3).

Boone Indicator β_{jt}. This means that, according to the idea that the negative relationship between marginal costs and profit is steeper in more competitive banking markets, the Boone Indicator β_{jt} should take on higher values in absolute terms (i.e., more negative values) when competition increases.

We have argued above that for the majority of German banks the relevant market is indeed the county the bank is headquartered in. However, although a German savings bank normally does not run branches outside its county of domicile, there is nothing stopping a customer or depositor from choosing a bank outside the respective county. Ignoring this manifestation of bank competition would surely make our approach into the competition-bank risk nexus unreliable. The Boone indicator measured at the federal state level captures exactly this characteristic of bank market competition.[9]

2.2 Methodology

Since our main dependent variable is a binary variable which indicates whether or not a distress event has occurred, a natural starting point for our analysis is a binary response model. To analyze the effect of bank competition on bank risk taking, we study binary response models of the general form

$$P(y_{it} = 1|x_{it-1}) = G(x_{it-1}\beta) \equiv p(x_{it-1}) \tag{5}$$

where $P(\cdot)$ is the probability that bank i at time t experiences a default event given the set of observable covariates x_{it-1}, with β being fixed parameters to be estimated. In order to assure the exogeneity of the regressors x_i and to introduce a forward-looking dimension into the model, the explanatory variables are all lagged one period relative to the response variable y_i. The function $G(\cdot)$ is a link function mapping the linear index $x_{it-1}\,\beta$ to the response probability with support in the open unit interval. For the majority of the empirical analysis, we will use the logit model as a special case of the link function $G(\cdot)$. Hence, we will estimate models of the form:

$$P(y_{it} = 1|x_{it-1}) = G(x_{it-1}\beta) = \frac{\exp(x_{it-1}\beta)}{1+\exp(x_{it-1}\beta)}. \tag{6}$$

Model Specification

To determine the effect of the various measures of bank competition and concentration on banks' probability of experiencing a distress event, we define the following baseline specification written in the latent response representation

$$y^*_{it} = \alpha + \alpha_0 + \alpha_1 + \textsc{Control Variables}_{it-1}\beta_1 + \textsc{Bank Competition}_{it-1}\beta_2 + u_{it}. \tag{7}$$

The term u_{it} is a continuously distributed variable independent of the regressors and distributed according to a standard logistic distribution. The population mean is given by α, while α_0 and α_1 are stand-ins for full sets of banking group dummy variables and time dummy variables. The main focus of the empirical analysis will be on the direction of the

[9]It would, of course, be beneficial to estimate Boone indicators at the county level, too. This is, however, impeded by the fact that for all but the largest counties the number of distinct banks per county-year is too small to reliably estimate the Boone indicator.

effect of the different ways of approximating BANK COMPETITION$_{it-1}$. Since the number of potential bank-specific control variables CONTROL VARIABLES$_{it-1}$ to be included in the econometric model is immense, we orient ourselves to the existing literature, which uses the so-called CAMEL taxonomy (King, (Nuxoll, and Yeager)(2006)).

Table 2: **Summary Statistics of CAMEL Covariates**

This table presents descriptive statistics for regulatory data obtained from the Bundesbank. The sample comprises 37,529 bank-year observations on up to 5,035 banks over the period 1994–2010. A description of the variables is provided in the Appendix of this paper.

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**
Equity Ratio	8.962	3.309	4.812	34.999	37,529
Bank Reserves	1.222	1.015	0	5.017	37,529
Dummy Reserve Reduction	0.086	0.280	0	1	37,529
Share of Customer Loans	58.253	12.932	11.958	88.387	37,529
Sectoral Credit Portfolio Concentr.	14.915	10.930	7.218	98.465	37,529
Dummy for Hidden Liabilities	0.106	0.307	0	1	37,529
Share of Fee Income	10.822	5.079	0.585	53.576	37,529
Return on Equity	13.922	11.011	-42.283	56.164	37,529
Non-Performing Loans	3.380	2.755	0.005	18.415	37,529
Off-Balance Sheet Activity	2.817	2.298	0.019	16.166	37,529

We closely follow Kick and Koetter (2007) and De Graeve, Kick, and Koetter (2008) and specify ten CAMEL covariates. The upper panel of Table 2 shows summary statistics for the CAMEL covariates used in our baseline specification, which closely resembles the specification used in the existing literature on bank default prediction.

3 Results

Column one of Table 3 shows the results of the baseline logit regression. The model specification closely follows the standard bank rating model used at the Bundesbank. This model setup has performed reasonable well (see Kick and Koetter 2007 and Porath 2006). Although not shown, all regressions include time-specific and banking group dummies for large banks (i.e., big private), Landesbanks, central cooperative banks, savings banks, and small private banks (the reference group being cooperative banks) as further controls. We first present the results without including any measure of competition or concentration in order to see whether the pure model produces reasonable results.

The results for the CAMEL covariates are in line with the existing literature. The ratio of bank equity to total assets, and bank reserves to total assets are measures of the degree of capitalization of banks. As expected, better-capitalized banks have a lower probability of default (PD) relative to the sample mean. The dummy variable indicating the presence of hidden liabilities as well as the dummy variable indicating that the bank has reduced its reserves in the current reporting year have a positive and highly significant coefficient. The German institutional framework allows banks to build up hidden

liabilities in the balance sheet instead of writing off problem loans. Hidden liabilities thus indicate the existence of problem loans in the credit portfolio which, in turn, increases the overall riskiness of the bank as indicated by the positive coefficient. The share of customer loans as well as the sectoral concentration of the business loan portfolio both have a negative effect on the probability of experiencing a distress event. We interpret both measures as indicators of the degree of specialization of a bank. The profitability of banks, measured by return on equity, reduces the likelihood of a distress event, while the share of fee income has a risk-increasing effect. The share of fee income is a measure of the engagement of a bank in non-traditional banking activities. The income generated by non-traditional banking activities is generally riskier and less stable compared to more traditional types of banking business. The ratio of non-performing loans to total loans is an ex post measure of realized credit risk. As expected, higher non-performing loans increase PD. We also include the ratio of off-balance sheet activities to total assets in our baseline specification. Off-balance sheet items mainly comprise credit commitments, which may bear risks if numerous customers draw simultaneously on these lines. Indeed, the positive and significant coefficient indicates that higher off-balance sheet activities increase the the likelihood of a experiencing a distress event.[10] In columns two to four we add, one at a time, our indicators of the different dimensions of market power and market concentration discussed in the previous section, while in column five we add all the indicators simultaneously. In column two we add to the baseline specification the Lerner Index which measures the ability of each single bank to price its products above the marginal costs. The point estimate of the Lerner Index has a negative and highly significant effect on the distress probability of banks. Increasing the pricing power of banks (reducing competition) significantly reduces the likelihood of a distress event. The risk-reducing effect of bank-level market power is thus in line with the "competition fragility" or "franchise value" view of the competition-bank risk taking nexus: more intense competition between banks reduces the charter value of banks and thereby encourages banks to take more risk. This result thus supports the majority of theoretical studies in the bank competition-stability trade-off literature that predict a risk-increasing effect of competition (e.g. Keeley 1990, Matutes and Vives 2000, Hellmann, Murdock, and Stiglitz 2000, Allen and Gale 2004 and Wagner 2010). We want to emphasize that the risk-reducing effect of bank-level pricing power is neither driven by an efficiency story, nor by a business model or risk-level story. First, we intentionally computed a Lerner Index which takes into account that banks often operate using less-than-optimal production technology. The Lerner Index is, therefore, not biased by any inefficiencies at the bank level. Second, our set of exogenous variables controls sufficiently well for heterogeneity across banks arising from differences in the degree of specialization of banks. To make this point concrete, if the degree of specialization (or generally the business model) is not properly accounted for, it is possible that the Lerner Index will capture variation in the degree of specialization between banks. Banks specializing in providing loans to a certain group of borrowers might be able to set loan rates at a markup which would result in a higher Lerner Index. The variable sectoral concentration of credit portfolio controls for this channel. Finally, we also control for a large array of different risk categories. While the share of non-performing loans controls well for the ex-post realized risk in the balance sheet, a reserve reduction and the presence of hidden liabilities control for possible

[10]For variable descriptions see also the Appendix of this paper.

assumed but not yet fully realized risk. A similar argument applies to the off-balance sheet activities of banks: a high level of off-balance sheet activity might indicate higher bank risk which is, however, unobservable when exclusively relying on balance sheet information. In column three we add the variable Regional Geographic Reach. This variable corresponds to a measure for a bank's market power at the regional level. Given that for the overwhelming majority of banks in Germany the relevant banking market is the county the bank is located in (either by law or size of the bank) this variable can therefore be interpreted as direct market-specific indicators of competition. The positive and highly significant coefficient on the market share indicator supports the conclusion that a higher market share of bank branches is positively related to bank instability in the regional market. The risk increasing effect of a higher market share in the regional market stands in contrast to the risk reducing effect of higher pricing power at the bank level measured using bank-specific Lerner Indexes. One possible interpretation of this result is that banks with a large branching network might be "too-big-to-fail" for this particular regions. Moral hazard issues associated with the "too-big-to-fail" paradigm might lead those banks to pursue riskier projects. Indeed, Dam and Koetter (2012) show that there exists a strong moral hazard behavior among German banks which can be explained by political economy considerations at the regional level. In column four we add the Boone Indicator of competition. In the way we have calculated the Boone Indicator, it is a competition measure which varies across the 16 federal states in Germany. The point estimate of the Boone Indicator variable is positive and highly significant. Recall that the Boone indicator measures how harshly banks are punished in terms of profits for being inefficient. Higher values of the Boone Indicator imply that a specific market allows banks to generate relatively high profits (although being relatively inefficient), thereby indicating that the market is characterized by a low degree of competitive pressure. A positive coefficient of the Boone indicator thus implies that banks operating in low-competition banking markets have a higher probability of experiencing a distress event. This result is in line with Schaeck and Cihak (2010), who also find that increasing competition, measured by the Boone Indicator, has a tendency to reduce risk taking at the bank level. In the last column we add all four distinct measures of competition simultaneously into the model. Since all of the competition indicators are meant to measure the degree of competition, the question emerges as to whether they measure the same effects or whether each of these variables has a direct and independent effect on bank risk-taking. Apparently they do all have independent effects on bank risk: each of the three variables remains highly significant and retains its original effect on bank risk-taking. The result that higher competition, measured using the Boone Indicator, reduces bank risk might seem to be at odds with the result that higher competition measured using a bank-specific Lerner Index increases bank risk. However, both indicators are measuring very different dimensions of bank competition. On the one hand, the (in-)efficiency adjusted Lerner Index captures reasonably well the possibility of banks to generate profits purely by extracting monopoly rents. The Boone Indicator, on the other hand, indicates how strongly the market punishes banks for inefficiencies. This gives rise to a different channel through which competition affects the probability of default: more competitive banking markets, as indicated by lower values of the Boone Indicator, are dominated by more efficient banks as competition drives out the less efficient banks (see also Schaeck and Cihak 2010 and Turk-Ariss 2010 for empirical evidence that bank competition increases efficiency

Table 3: **Bank Distress and Competition**

This table shows regression results from logit models. The dependent variable is a binary variable indicating the occurrence of a distress event as defined by the dummy variable Bank Distress. Column (1) shows the results of the baseline logit regression, in column (2) the Lerner Index is added, in column (3) and column (4) the variables Regional Geographic Reach is included, in column (5) we add the Boone Indicator, and in column (6) all four measures of competition are included simultaneously. $*$, $**$ and $***$ indicate statistical significance at the 10%, 5% and 1% level respectively.

	(1)	(2)	(3)	(4)	(5)
Equity Ratio	-0.084***	-0.063***	-0.078***	-0.083***	-0.061***
	[0.023]	[0.022]	[0.023]	[0.023]	[0.022]
Bank Reserves	-1.378***	-1.365***	-1.405***	-1.391***	-1.405***
	[0.115]	[0.116]	[0.117]	[0.114]	[0.117]
Dummy Reserve Reduction	0.312***	0.339***	0.312***	0.310***	0.332***
	[0.086]	[0.086]	[0.086]	[0.086]	[0.086]
Share of Customer Loans	-0.016***	-0.016***	-0.013***	-0.015***	-0.012***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Sectoral Credit Portfolio Concentr.	-0.011*	-0.008	-0.007	-0.011*	-0.006
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Dummy for Hidden Liabilities	0.679***	0.667***	0.684***	0.664***	0.658***
	[0.091]	[0.091]	[0.091]	[0.091]	[0.092]
Share of fee income	0.020**	0.018**	0.015*	0.018**	0.013
	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]
Return on Equity	-0.034***	-0.032***	-0.035***	-0.034***	-0.033***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Non-performing Loans	0.180***	0.174***	0.180***	0.177***	0.173***
	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]
Off-Balance Sheet Activity	0.045***	0.047***	0.044***	0.049***	0.050***
	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]
Per Capital GDP Growth	0.006	0.005	0.004	0.004	0.002
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
Lerner Index		-3.043***			-2.338***
		[0.744]			[0.732]
Regional Geographic Reach (Share)			0.026***		0.023***
			[0.005]		[0.005]
Boone Indicator				0.272**	0.254**
				[0.113]	[0.109]
Number of Observations	37,529	37,529	37,529	37,529	37,529
pseudo R^2	0.283	0.286	0.287	0.284	0.29
Banking Group Dummies	YES	YES	YES	YES	YES
Time Dummies	YES	YES	YES	YES	YES

in banking). There exist theoretical arguments as well as empirical evidence that more efficient banks are less risky. First, Petersen and Rajan (1995) argue that more efficient banks have better screening and monitoring abilities. At the empirical front, Berger and DeYoung (1997) show that more efficient banks have lower non-performing loans ratio. Taken together with our finding that the Boone Indicator has a negative effect on bank risk taking suggests that competition has a stability enhancing effect *via* an improvement in bank efficiency, and more specifically by improving banks' monitoring and screening procedures (see Schaeck and Cihak 2010 for a similar argument). Viewed from a more theoretical angle, the result that higher pricing power reduces bank risk taking supports the idea that higher franchise values mitigate the risk-shifting incentives of banks, thus contributing to a more stable banking system. Simultaneously, higher bank competition reduces risk-shifting incentives at the borrower level by forcing banks to develop more efficient screening and monitoring mechanisms.

Robustness with Bank Default and Alternative Risk Measures

Table 4 contains robustness checks of our results against changing the bank distress to a bank default measure. As explained in greater detail in Section 2, a distress event consists of either a direct capital injection into the bank, a distressed merger event, or a moratorium. Since the distressed merger and moratoria events are the strongest default events in our dataset, we check whether the effect of competition and concentration on the distress probability changes with the severity of the distress event. One might argue, for instance, that it is especially the most risky banks which benefit from an increase in their pricing power.

Column one is just a replication of the results of the full benchmark model from Table 3 which we present here for the convenience of the reader. The results presented in column two, however, indicate that increasing the bank-level pricing power - that is, increasing the Lerner Index - no longer has a risk-reducing effect when concentrating on the probability of a distress merger or a moratorium (i.e., focusing the analysis on actual bank defaults). The same holds for the Boone Indicator. While more competitive behavior in the (more broadly defined) banking market, i.e. a lower Boone Indicator, has a risk-alleviating effect in the benchmark regression, the Boone Indicator has no significant effect on the default probability of banks. In this regression, the sign of the variable Regional Geographical Reach changes, too, indicating that a higher market share of bank branches reduced the probability of a bank default (even when it does positively affect weaker forms of bank distress, as shown in the baseline regressions in Table 3).

In column three we present regression results using the z-score as the dependent variable. The z-score is a widely used variable in the empirical banking literature to approximate the overall level of banks. The success of the z-score can mostly be attributed to the fact that it can be easily calculated from banks' balance sheet information. Although we think that using actual distress events is more appropriate when trying to study the competition-risk nexus, we present, for reasons of comparability with the existing literature, the results for the z-score model in the third column of Table 4.[11] In general, the results from the z-score fixed-effects OLS regressions are qualitatively similar to those of the logit model. Note that, since the z-score increases with the soundness of banks, a positive coefficient indicates a risk-reducing effect - in contrast to the logit model where a negative coefficient indicates lower risk. A few differences are worth noting: First, neither the level of reserves nor the dummy for hidden liabilities exerts a significant effect on risk. The insignificance of bank reserves and the hidden liabilities dummy is very counterintuitive given the importance of these variable in the German banking landscape. However, given the drawbacks of the z-score, we do not give too much weight to these results.

Finally, the last column in Table 4 contains the results from a model which specifies the non-performing loans ratio as dependent variable. The non-performing loans ratio is the single most important determinant of a bank's credit risk. The results of this

[11] The z-score is calculated as the ratio of Tier 1 capital and operating profits of bank i to the standard deviation of operating profits where each position is measured relative to risk weighted total assets. To take into account that capital and total asset positions are end-of-year figures while profits are within-year flows, Tier 1 capital and total assets are averaged over two years (i.e., we calculate "mid-point values"). To account for changes in the volatility of profits over time, the standard deviation of operating profits is calculated over a window of three years. Taking the natural logarithm of the z-score ensures that results are not driven by extreme values.

model show that higher market power at the bank level reduces bank risk-taking *via* the credit portfolio, that is, banks with a higher Lerner Index seem to choose to finance safer projects. At the same time, and mirror imaging the previous results, competition measured by the Boone Indicator suggests that lower competition increases credit risk-taking of banks. The coefficient of our competition measure related to the banks' home county has a negative sign, indicating that banks with more market power in the relevant banking market take out safer loans. This is in contrast to the results from the broad distress measure but might help reconcile the finding that banks with higher regional market power have a lower probability of outright bank failure. However, the coefficient of the variable Regional Geographic Reach is not significantly different zero. One possible reason for this finding might be neglected endogeneity of the Lerner Index with respect to the risk measures used, an issue which we address next.

Table 4: **Robustness with Alternative Bank Risk Measures**

This table shows robustness regression results from logit (column (1) and (2)) models. Column (1) is just a replication of the results of the full benchmark model from Table 3 (in which a dummy variable for bank distress, Bank Distress, is used as the dependent variable), column (2) shows results for a dummy variable indicating distressed bank mergers and moratoria, i.e. Bank Default, on the left-hand side of the regression. Column (3) reports results from fixed-effects OLS regressions with the $z-score$ as dependent variable. Column (4) reports results from fixed-effects OLS regressions with the non-performing loans to total loans (NPL) as dependent variable. In all regressions all four measures of competition are included simultaneously. $*$, $**$ and $***$ indicate statistical significance at the 10%, 5% and 1% level respectively.

	Bank Distress (1)	Bank Default (2)	z-score (3)	NPL (4)
Equity Ratio	-0.063***	-0.059**	0.037***	-0.014
	[0.022]	[0.026]	[0.006]	[0.019]
Bank Reserves	-1.405***	-1.462***	0.016	-0.173***
	[0.117]	[0.155]	[0.014]	[0.050]
Dummy Reserve Reduction	0.332***	0.644***	-0.159***	0.305***
	[0.086]	[0.121]	[0.015]	[0.053]
Share of Customer Loans	-0.012***	0.000	0.008***	0.055***
	[0.004]	[0.005]	[0.001]	[0.006]
Sectoral Credit Portfolio Concentr.	-0.006	-0.003	-0.001	0.004
	[0.006]	[0.006]	[0.002]	[0.005]
Dummy for Hidden Liabilities	0.658***	0.503***	0.015	-0.024
	[0.092]	[0.130]	[0.017]	[0.059]
Share of fee income	0.013	0.039***	-0.002	-0.053***
	[0.009]	[0.012]	[0.004]	[0.013]
Return on Equity	-0.033***	-0.029***	0.004***	-0.049***
	[0.003]	[0.005]	[0.001]	[0.002]
Non-performing Loans	0.173***	0.083***	-0.018***	–
	[0.012]	[0.015]	[0.004]	–
Off-Balance Sheet Activity	0.050***	0.032	-0.004	0.080***
	[0.016]	[0.021]	[0.005]	[0.018]
Per Capital GDP Growth	0.002	0.000	0.001	0.001
	[0.008]	[0.014]	[0.001]	[0.003]
Lerner Index	-2.338***	-0.688	0.385***	-2.601***
	[0.732]	[0.945]	[0.137]	[0.515]
Regional Geographic Reach (Share)	0.023***	-0.018**	-0.006**	-0.010
	[0.005]	[0.007]	[0.003]	[0.007]
Boone Indicator	0.254**	0.146	-0.036*	0.253***
	[0.109]	[0.136]	[0.020]	[0.074]
Number of Observations	37,529	37,529	29,680	33,983
(pseudo) R^2	0.29	0.211	0.127	0.213
Banking Group Dummies	YES	YES	YES	YES
Time Dummies	YES	YES	YES	YES
Bank Fixed Effects	n.a.	n.a.	YES	YES

Estimation Methods and Endogeneity Issues

A valid concern to the results presented so far is the potential endogeneity of the Lerner Index. Schaeck and Cihak (2010), for instance, argue that the level of bank risk might also affect the competitive conduct of banks. Banks facing a high probability of default, in an attempt to "gamble for resurrection", might try to attract new businesses by aggressively pricing its products, ultimately affecting measures of bank competition such as the Lerner Index. One might argue that our modeling approach mitigates endogeneity issues by including the explanatory variables with a lag of one period. However, endogeneity

between bank risk and bank competition might still be an issue if bank managers form expectations about their default probability and anticipate future distress events. Our strategy to deal with the endogeneity of the Lerner Index is to instrument the Lerner Index with appropriate instrumental variables. Following Koetter, Kolari, and Spierdijk (2012) and motivated by the dynamic panel literature (e.g. Blundell and Bond 1998), our first instrumental variable consists of the lagged values of the Lerner Index. The second set of instruments consists of the bank's home counties' ability to bear debt (debt sustainability). The idea behind this instrument is that German counties rely heavily on (local) banks to cover their (short term) financing need, with savings banks and Landesbanken having a predominant position in this market. We reckon that banks located in more indebted counties have different opportunities to exert pricing power against the public sector. On the other hand, given that German counties cannot default, there should not be a direct relation between the relative indebtedness of counties and the probability of default at the bank level. Our final two sets of instruments consist of the share of bank employees relative to the overall credit portfolio and of the Herfindahl-Hischmann-Index (HHI) of bank branches at the regional level.[12] We present the results from our Instrumental Variables (IV) approach in Table 5. We use both, a two-step IV-probit approach (column (1) and column (3)) and an IV linear probability model (column(2) and column(4)). The first two columns correspond to the model using the broader distress definition as dependent variable (Bank Distress) while the third and the fourth column use the distress definition taking into account only outright bank failures (Bank Default). We also estimated our benchmark regressions using simple linear probability models and probit models (results not shown): the results from these robustness checks, available upon request, leave the main message of the previous results unaltered. For completeness we also present the results of the IV regressions of the models using the z-score and the non-performing loans ratio as dependent variables. The results of IV-probit regression using the broader distress measure (column (1)) tell the same story as the simple logit approach of the previous sections: Increasing bank-level pricing power reduces the probability of experiencing a distress event, providing further support for the competition-fragility hypothesis. Simultaneously, more concentrated banking markets are, *ceteris paribus*, characterized by riskier banks. Finally, banks located in states with a lower competitive conduct, i.e. higher values for the Boone Indicator, have also higher distress probabilities. Results are slightly different when applying the IV-linear probability model. The Lerner Index and the Boone Indicator enter significantly and have their familiar signs (negative and positive, respectively). In contrast, the variable measuring the market contestability/concentration, although still positive, looses its significant effect. Concerning the results of the IV-regressions employing the narrowly defined distress indicator (column (3) and column (4)), we again find that all our previous results remain valid when applying an IV-probit approach (column(3)). The same hold for the IV-linear probability model, except that the Lerner index remains significant (column(4)). Column (5) and column (6) present the results from IV regressions when using as dependent variable the z-score and the non-performing loans ratio, respectively. Again, the findings of

[12]Clearly, the HHI index is conceptually similar to the variable Regional Geographic Reach. We therefore tested the validity of including the HHI in the set of excluded instruments, besides the more formal test presented below, by including the HHI directly into our benchmark regression. The results support our choice since the HHI never entered the model with a significant coefficient.

the previous sections are confirmed. Furthermore, the negative coefficient of the Regional Geographic Reach is now significant at the 10% level. The lower part of Table 5 presents formal tests on the validity of our IV setup. Note that we only present results for the test statistics based on the linear probability model simply because these test are not properly defined in a (non-linear) probit framework. The first test statistic correspond to the relevance of the instruments, that is whether the instrument variables are sufficiently correlated with the bank lending rate. We report the Wald F-statistic based on the Kleinbergen-Paap rk statistic. The results show that the F-statistic is well above the commonly used critical value of 10 in all model setups. A F-statistic well above 10 is generally viewed as indication that instrument weakness is not a major problem.[13] The Hansen J-test concerns the validity of the instruments; that is, whether they are uncorrelated with the error term of the main equation. The null hypothesis is that the instruments can be excluded from the main equation. The result indicates that we can not reject the null hypothesis in neither one of the regressions but in the regression when using the narrowly defined distress measure as dependent variable. However, it is also this regression model where the test on the exogeneity of the Lerner Index cannot be rejected, suggesting that the Lerner Index can be treated as exogenous to outright bank failures. For all other risk measures the test on the exogeneity of the Lerner Index is rejected.

[13]Note that the values of the Kleinbergen-Paap statistic are identical in both IV linear probability models simply because in both models the first stage regressions are identical.

Table 5: **Sensitivity to Estimation Method and Endogeneity Issues**

This table shows regression results from IV-probit models and IV-linear-probability-models (IV-LPM): a two-step IV-probit approach is shown in (column (1) and column (3)) and an IV-LPM in (column (2) and column (4)). The first two columns correspond to the model using the broader distress definition as dependent variable (Bank Distress) while the third and the fourth column use the distress definition taking into account only outright bank failures (Bank Default). Column (5) and column (6) reports results from IV regressions with the z-score and non-performing loans to total loans (NPL) as dependent variable, respectively. In the instrumental variables regression we instrument the Lerner Index using the lagged Lerner Index, a bank's home counties' debt sustainability, the share of bank employees relative to the overall credit portfolio and the Herfindahl-Hischmann-Index (HHI) of bank branches at the regional level (see the main text for a detailed discussion). *, **, *** indicate statistical significance at the 10%, 5%, 1% level respectively; standard errors (clustered at the bank level) in parentheses.

	Bank Distress		Bank Default		$z-$score	NPL
	1	2	3	4	5	6
	IV-probit	IV-LPM	IV-probit	IV-LPM	IV	IV
Equity Ratio	-0.031***	-0.002***	-0.022*	-0.001***	0.035***	-0.003
	[0.012]	[0.001]	[0.012]	[0.000]	[0.006]	[0.021]
Bank Reserves	-0.576***	-0.016***	-0.548***	-0.005***	0.015	-0.145***
	[0.054]	[0.002]	[0.070]	[0.001]	[0.014]	[0.055]
Dummy Reserve Reduction	0.161***	0.011*	0.318***	0.017***	-0.163***	0.301***
	[0.049]	[0.007]	[0.061]	[0.004]	[0.015]	[0.060]
Share of Customer Loans	-0.008***	-0.001***	-0.001	-0.000***	0.008***	0.054***
	[0.002]	[0.000]	[0.002]	[0.000]	[0.001]	[0.006]
Sectoral Credit Portfolio Concentr.	0.000	0.000	0.000	0.000	-0.001	0.004
	[0.003]	[0.000]	[0.003]	[0.000]	[0.002]	[0.006]
Dummy for Hidden Liabilities	0.342***	0.049***	0.271***	0.014***	0.019	0.027
	[0.051]	[0.007]	[0.062]	[0.003]	[0.018]	[0.067]
Share of fee income	0.006	0.000	0.016***	0.001***	-0.003	-0.054***
	[0.005]	[0.000]	[0.005]	[0.000]	[0.004]	[0.015]
Return on Equity	-0.018***	-0.002***	-0.014***	-0.001***	0.004***	-0.051***
	[0.002]	[0.000]	[0.002]	[0.000]	[0.001]	[0.003]
Non-performing Loans	0.090***	0.015***	0.041***	0.003***	-0.017***	–
	[0.006]	[0.001]	[0.007]	[0.000]	[0.004]	–
Off-Balance Sheet Activity	0.021**	0.000	0.013	0.000	-0.004	0.069***
	[0.008]	[0.001]	[0.010]	[0.000]	[0.005]	[0.020]
Per Capital GDP Growth	0.000	0.000	-0.000	0.000	0.001	0.006351*
	[0.005]	[0.000]	[0.007]	[0.000]	[0.001]	[0.003]
Lerner Index	-1.825***	-0.222***	-0.971	-0.049***	1.308***	-4.512***
	[0.508]	[0.039]	[0.599]	[0.018]	[0.452]	[1.626]
Regional Geographic Reach (Share)	0.008***	0.000	-0.011***	-0.000***	-0.006**	-0.012*
	[0.003]	[0.000]	[0.004]	[0.000]	[0.003]	[0.007]
Boone Indicator	0.121**	0.014***	0.088	0.003*	-0.045**	0.243***
	[0.058]	[0.005]	[0.066]	[0.002]	[0.020]	[0.081]
Number of Observations	32,578	32,578	32,578	32,578	29,229	29,026
R^2	n.a.	0.13	n.a.	0.041	0.124	0.116
Banking Group Dummies	YES	YES	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES	YES	YES
Bank Fixed Effects	n.a.	YES	n.a.	YES	YES	YES
weak identification test						
F-statistic	n.a.	2004	n.a.	2004	182	225
overidentification test						
Hansen J-statistic	n.a.	3.698	n.a.	10.505	3.69	3.508
p-value	n.a.	0.296	n.a.	0.015	0.158	0.1731
Endogeneity Test						
F-statistic	n.a.	11.247	n.a.	0.656	7.194	3.105
p-value	n.a.	0.0008	n.a.	0.4178	0.007	0.078

4 Conclusion

The developments in the banking market leading to the financial crisis in 2008 have once again heightened interest in the determinants of bank risk. An increasingly competitive environment caused by the growing internationalization of financial markets and the emergence of non-bank players in the market for corporate financing has often been seen as contributing to increasing banks' incentives to take risks. This perception of the effects of higher competition on bank risk is confirmed by a large array of theoretical and empirical banking models. Using unique regulatory data available from the Bundesbank we revisit the bank competition-stability nexus.

We improve on the existing literature along three crucial dimensions. First, in contrast to other bank-level studies, we use the most direct measure of bank risk available. Our measurement of bank-level risk is generated from the distress database collected by the Bundesbank. This dataset contains information on bank distress and bank default events (i.e., distressed bank mergers and bank moratoria). Hence, our measurement of bank risk directly captures the possibility of a bank defaulting. We concur with Aspachs, Goodhart, Tsomocos, and Zicchino (2007), who correctly state that the probability of bank default is the most appealing bank risk statistic because, by considering all types of risks, it provides a more exhaustive picture of risk borne by the banking system.

Second, the richness of our dataset allows us to control for a wide array of different time-varying characteristics of banks which are likely to influence the competition-risk taking channel. We control for a number of different dimensions of risk at the bank level while determining the effect of competition on the probability of default. Besides measures of realized risk, we also have at our disposal measures of potential risks assumed by banks which have, however, not yet materialized. Furthermore, our dataset contains detailed information on the business model of banks. Ignoring the time-varying heterogeneity induced by differences in business model might distort the assessment of the risk taking-competition relationship.

Finally, in an approach to take existing empirical evidence seriously, we allow competition to affect the probability of default along four different dimensions. We include different measures of competition, contestability and concentration, each corresponding to a different contextual level of a bank's competitive environment.

The main messages which emerge from our empirical analysis can be summarized as follows. An increase in the market power of banks at the level of the individual institution, measured via (in)efficiency-adjusted Lerner Indexes, tends to reduce the probability of default of that bank. This result is thus consistent with the majority of theoretical contributions showing that a reduction in the pricing power of individual banks due to fiercer competition leads to increasing bank risk. In contrast, our competition measures applying to the level of the bank market (i.e., measuring competition via geographical reach and the Boone Indicator at the county and federal state level) tend to indicate that a more competitive market environment goes hand in hand with a lower level of bank risk. Thus, when looking upon competition as altering the working mechanism at the (relevant) market level (which must not necessarily be a one-to-one mapping to the ability of banks to price products over marginal costs), our evidence supports the recent theoretical and empirical contributions stressing the transmission channels which lead to a risk-reducing effect of higher bank competition.

From a policy perspective, our results indicate that competition-reducing regulation (e.g., artificial entry barriers) does not necessarily enhance the stability of individual banks. Instead, our results show that the degree of competition affects bank risk in a manifold number of ways, some of them with stability-enhancing effects, but others apparently without such effects.

Appendix: Descriptions of Variables

Variable	Description
I. Bank Stability Indicators	
Bank Distress	Dummy variable that takes on one for banks receiving capital support measures from the deposit insurance funds, or exiting the market in a distressed merger/in a moratorium
Bank Default	Dummy variable that takes on one for banks exiting the market in a distressed merger/ in a moratorium
$z-$score	ln of the z-score calculated as the ratio of Tier 1 capital and operating profits to the standard deviation of operating profits. Tier 1 capital and operating profits are measured relative to risk weighted total assets.
II. Bank-Specific Controls	
Equity Ratio	Tier 1 capital to total assets
Bank Reserves	Hidden bank reserves (according to section 340 f of the German Commercial Code) to total assets
Dummy Reserve Reduction	Dummy variable that takes one if hidden bank reserves are reduced
Share of Customer Loans	Customer loans to total assets
Sectoral Credit Portfolio Concentr.	HHI measuring concentration in the loan portfolio (calculated from 23 industry sectors)
Dummy for Hidden Liabilities	Dummy variable that takes one for banks with avoided write-offs on its balance sheets
Share of fee income	Fee income to total income
Return on Equity	Operative result to equity capital
Non-performing Loans (NPL)	Non-performing loans to total assets
Off-Balance Sheet Activity	Off-balance sheet positions to total assets
III. Controls for Competition/Concentration	
Lerner Index	Lerner Index calculated from a stochastic frontier analysis
Regional Geographic Reach	Share of bank branches (county level)
Boone Indicator	Boone Indicator (federal state level)
IV. Macroeconomic Controls	
Business Climate Index	Percentage change in Business Climate Index
Long-Short Spread	Yield curve (calculated as ten-year minus one-year risk-free bond rate)
GDP per capita (log, real)	Ln of real GDP per capita (county level)
GDP growth (real)	Percentage change in real GDP (county level)

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