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Schaeck, K.; Cihák, M.

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Discussion paper

COMPETITION, EFFICIENCY, AND SOUNDNESS IN BANKING: AN INDUSTRIAL ORGANIZATION PERSPECTIVE

By Klaus Schaeck, Martin Cihák

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Competition, efficiency, and soundness in banking: An industrial organization perspective

KLAUS SCHAECK*

Bangor Business School
Hen Goleg, College Road
Bangor LL57 2DG, UK

MARTIN CIHÁK

International Monetary Fund
700 19th Street, N. W.
Washington, D. C. 20431, USA

ABSTRACT

How can competition enhance bank soundness? Does competition improve soundness via the efficiency channel? Do banks heterogeneously respond to competition? To answer these questions, we exploit an innovative measure of competition [Boone, J., A new way to measure competition, EconJnl, Vol. 118, pp. 1245-1261] that captures the reallocation of profits from inefficient banks to their efficient counterparts. Based on two complementary datasets for Europe and the U.S., we first establish that the new competition indicator captures a broad variety of other characteristics of competition in a consistent manner. Second, we verify that competition increases efficiency. Third, we present novel evidence that efficiency is the conduit through which competition contributes to bank soundness. In a final examination of banks' heterogeneous responses to competition, we find that smaller banks' soundness measures respond more strongly to competition than larger banks' soundness measures, and two-stage quantile regressions indicate that the soundness-enhancing effect of competition is larger in magnitude for sound banks than for fragile banks.

JEL Classification: G21; G28

Keywords: bank competition, efficiency, soundness; Boone indicator; quantile regression

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* *Corresponding author.* Tel.: ++ 44 (0) 1248 388 540
E-mail addresses: klaus.schaeck@bangor.ac.uk (Klaus Schaeck) and mcihak@imf.org (Martin Čihák)

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"if banks were strengthened by the gymnastics of competition, the banking system would be stronger and more resilient to shocks."

Padoa-Schioppa (2001, p. 16)

1. Introduction

Recent years have been marked by a shift in theory and evidence concerning the effect of competition on bank soundness. The traditional literature points towards a negative trade-off between competition and bank soundness (e.g., Keeley, 1990). However, new theory and evidence challenge this paradigm. At present, the balance of evidence suggests a positive link between competition and soundness (e.g., Carletti et al., 2007; Schaeck et al., 2009).

While the debate of whether competition is "good" or "bad" for bank soundness continues (Berger et al., 2009), the question of why competition has a soundness-enhancing effect has remained an underexplored area, despite its relevance for policy and regulation in banking.

In this paper, we therefore turn to the analysis of the mechanisms through which competition affects soundness. Specifically, we seek to answer the following questions: Is there a link from competition to soundness via the competition-efficiency nexus as proposed in the industrial organization literature? Do banks heterogeneously respond to competition, i.e., are there any differences in the way small and large banks and sound and fragile banks are affected by competition? To preview our results, the answer is "yes" in all cases.

Using two complementary datasets, one for European banks, and one for single-market banks operating in rural areas in the U.S., we offer several innovations in the debate on competition and bank soundness.

First, to investigate the mechanism by which competition contributes to greater soundness, we compute a novel measure of competition, the Boone (2008) indicator. This indicator focuses on the impact of competition on the performance of efficient banks, and allows providing an industrial organization-based explanation for why competition enhances soundness. We focus on efficiency as a possible conduit because it can be shown that competition motivates banks to specialize and differentiate themselves to maintain high profits. For instance, Zarutskie (2009) argues that competition makes banks more cost efficient relative to their competitors by either specializing in certain types of lending or, alternatively, by improving screening abilities for borrowers in particular segments of the credit market, and Dick and Lehnert (2010) provide evidence that competition increases banks' lending productivity and lowers loss rates on loans. In other words, these papers suggest that more efficient lending decisions of some institutions in response to competition can increase these banks' profitability relative to their competitors. The Boone indicator exploits this reallocation of profits from inefficient to efficient banks and is consequently well suited to test our hypothesis. To verify the validity of the indicator as a measure of competition for the banking industry, we examine in the first step of our analysis how it lines up with traditional measures of competition. This analysis shows that the Boone indicator captures a large proportion of the variation in other characteristics of competition.

Second, we focus on the ***direct*** effect of competition on efficiency using methods developed in the frontier efficiency literature. This examination is critical for our hypothesis because the proposed transmission mechanism rests on the assumption that competition drives efficiency. Here, we find support for the notion that efficiency increases in competitive environments.

Third, we analyze the link between competition and soundness via the efficiency channel, exploiting the unique properties of the Boone indicator. This analysis yields robust evidence that the beneficial effect of competition on soundness is due to a reallocation of profits because competition, measured by the Boone indicator, is positively linked with profitability.

Fourth, we examine banks' heterogeneous responses to competition, and ascertain whether different organizational forms that have implications for the type of lending technology can affect soundness differently. The results indicate that smaller banks that tend to make loans based on soft information are more responsive to competition in terms of increasing their soundness. Exploiting two-stage quantile regression to focus on whether sound banks respond differently than weak banks to competition, we find that fragile banks benefit less from competition than more stable banks.

A policy implication of our results is that policies promoting competition may have positive impacts on efficiency and soundness. An example of such policies is the single banking passport in the EU which deregulated banking markets with the idea to create a level playing field for competition. Another implication arises from the quantile regressions, which indicate that policymakers need to consider that competition affects the soundness of the institutions in the relevant market differently depending on the health of the banks in that market.

The paper is structured as follows. We develop hypotheses in Section 2. Section 3 provides an overview of the dataset and methodology. Section 4 reports results and Section 5 concludes.

2. Hypotheses on Competition, Efficiency, and Bank Soundness

Information asymmetries can affect the degree of competition, and the efficiency of lending decisions in banking. This reflects that banks generate proprietary information through lending activities that provide an information advantage over other, less informed lenders (Dell'Ariccia and Marquez, 2008). At the same time, studies in industrial organization suggest that competition increases efficiency (Tirole, 1989; Hay and Liu, 1997), and banking research reports evidence that efficient institutions maintain better screening and monitoring procedures. This makes them less likely to suffer from non-performing loans (Wheelock and Wilson, 1995). Consequently, examining the mechanism by which competition can contribute to bank soundness suggests a consideration of the effect of competition on bank efficiency in the first place before the nexus between competition and soundness can be explored.

Based on these key considerations, we derive testable hypotheses to investigate the possible transmission mechanism from competition to bank soundness. Specifically, we hypothesize that efficiency could be the conduit through which competition contributes to greater bank soundness. For this analysis, we use a modified version of a new competition indicator developed in the industrial organization literature in a series of papers by Boone et al. (2005), and Boone (2008). This indicator is based on the efficiency hypothesis proposed by Demsetz (1973), which stresses that industry performance is an endogenous function of the growth of efficient firms. Put simply, the indicator gauges the strength of the relation between efficiency (measured in terms of average cost) and performance (measured in terms of profitability).

Our Hypothesis: Competition increases soundness via the efficiency channel

Based on industrial organization theory, we expect more competitive environments to result in more efficient lending decisions, which ultimately increases soundness. We offer several arguments for why competition may have such beneficial effects.

The industrial organization literature has arrived at a consensus according to which competition triggers a reallocation of profits and market shares towards better, more efficient firms (e.g., Olley and Pakes, 1996). More efficient firms outperform their less efficient counterparts in terms of profits and size, and this fosters industry-wide efficiency.

For banks, Stiroh (2000) shows that dynamic reallocation of assets from weak to well performing banks maintains profits on the industry level, and Stiroh and Strahan (2003) report that competition, captured by deregulation, reallocates profits from weak banks toward better run institutions. This reallocation effect can operate through different channels. Zarutskie (2009) shows that banks respond to competition by specialization: they adjust their lending technologies and focus on certain types of loans, which enables them to lower the costs of processing and originating loans, or they become better at screening particular groups of borrowers. Dick and Lehnert (2010) also find evidence that competition raises lending efficiency and lowers banks' credit risk. Reductions in credit risk can be due to the fact that banks faced with threat of entry devote resources to screening and monitoring of borrowers, this reduces problems related to information asymmetries (Chen, 2007). In short, competition enhances the efficiency of lending decisions.

Information processing capabilities may also play a role. Greater availability of information in competitive environments can improve banks' abilities for screening and monitoring (Hauswald and Marquez, 2003). Provided that banks obtain information about borrowers from previous loans, the efficiency of lending decisions increases as a result of learning by lending (Dell'Ariccia et al., 1999). This suggests a corresponding decrease in the cost of screening, or, equivalently, an increase in its informativeness which leads to better loan differentiation and more adequate risk pricing.

These considerations deliver two empirical predictions: First, competition enhances efficiency. Second, efficient banks are sounder.

These predictions are supported in two strands of the empirical literature. Berger and Hannan (1998) show that banks operating in uncompetitive markets are more inefficient. Jayaratne and Strahan (1998) report that deregulation increases efficiency, and DeYoung et al. (1998) show that removing interstate branching restrictions motivates banks to improve efficiency. Similarly, Evanoff and Örs (2008) report that incumbent banks respond to threats of competition by improving efficiency. The literature is also clear on the link between efficiency and soundness. Berger and DeYoung (1997) and Kwan and Eisenbeis (1997) show that efficiency is positively associated with soundness.

Our paper aims to draw together these different strands of literature to provide a more comprehensive framework for the analysis of the mechanism by which competition enhances bank soundness.

3. Data and Methodology

We use two samples. The benefit of using two samples lays in the fact that they complement each other. Our first sample is a panel dataset for European banks, covering the period 1995–2005. This dataset is representative for European banking systems and not affected by selection problems. Unlike our second dataset, the European sample allows considering the evolution of competition over time. However, using this dataset comes at the cost of measurement problems that arise from the inclusion of many large and internationally active banks for which we have to make the assumption that their market is the respective domestic market. Our second dataset is a cross-sectional sample of single-market banks operating in rural counties in the U.S. in 2005. While this sample is not representative, exploiting this sample not only offers an opportunity to evaluate the proposed transmission mechanism from competition to soundness on a highly disaggregate level but also enables higher precision with respect to defining the boundaries of the relevant banking markets.

European sample characteristics

We primarily focus on the European sample because it provides a fertile ground for analyzing the effects of changes in competition. In the 1990s, European banks experienced changes in the regulation aimed at creating a level playing field for competition.

To construct this sample, we obtain data for Europe from BankScope. The sample covers Austria, Belgium, Denmark, France, Italy, Germany, Luxembourg, Netherlands, Switzerland, and the U.K.[1] We exclude Spain and Sweden as we cannot compute estimates for the Boone indicator. The final sample consists of 17,965 bank-year observations for 3,325 banks, 5,705 are savings banks, 9,297 are cooperatives, and 2,963 are commercial banks.

U.S. sample characteristics

For the U.S., we use a sample of banks that operate exclusively in rural, non-core based statistical areas (non-CBSA).[2] We do not claim that the data are representative for the population. However, this approach has the benefit that it permits a 'laboratory type' test for the effect of competition on banks that operate exclusively in one market. The intuition is that retail banking markets are local in nature because customers obtain banking services from nearby providers (Cohen and Mazzeo, 2007). Moreover, such banks are not to 'too big to fail' policies that distort competition.

1 Whenever possible, we use consolidated data to avoid double counting.

2 Non-CBSAs are defined as areas with less than 10,000 inhabitants.

Thanks to researchers at Board of Governors of the Federal Reserve System, we obtained data on Herfindahl Hirschman Indices (HHIs) for local deposit markets. The FRB maintains a database for HHIs for rural, non-CBSA markets, whereby a market is defined by a county's boundaries. With help from researchers from the FDIC, we also obtained location information for the banks' main offices and branches from the Summary of Deposits.[3] We integrate these datasets focusing on a cross-section from June 2005, match the data with Call Reports, and impose the following two criteria: First, we exclude banks that operate across counties so that all branches (including the main office) are located within the county's boundaries. Second, to obtain econometrically reasonable estimates for the Boone indicator, we only include rural non-CBSA counties with at least seven banks. The resulting dataset allows performing tests of our hypothesis on an extraordinarily high level of disaggregation.

While our initial dataset for single-market banks consists of more than 2,600 institutions, imposing these criteria reduces the sample to a maximum of 382 banks that operate in 43 local banking markets in eleven states.[4] Table 1 indicates a large degree of variation in these markets. For instance, the HHI varies between 0.09 and 0.87. Banks in these areas hold an average market share of 13 percent, with some having a dominant position of 70 percent.

[TABLE 1]

Competition expressed as a function of bank efficiency: The Boone indicator

To examine the effect of competition via the efficiency channel on bank soundness, we express competition as a function of efficiency. We therefore use an innovation in the industrial organization literature and use a modified version of an indicator proposed by Boone et al. (2005), and further developed by Boone (2008).

This indicator is based on the efficient structure hypothesis that associates performance with differences in efficiency. Under this hypothesis, we expect that more efficient banks, i.e. banks with lower marginal costs, achieve superior performance in the sense of higher profits at the expense of their less efficient counterparts, and this effect is monotonically increasing in the degree of competition when firms interact more aggressively and when entry barriers

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[3] We are indebted to Dean Amel and Elizabeth Kiser from the Federal Reserve Board and Gary Fissel from the FDIC for providing us with these data. We perform our tests on a cross-section of data only as integrating a time dimension into this non-userfriendly dataset proves difficult.

[4] The states are Connecticut, Illinois, Iowa, Kansas, Louisiana, Minnesota, Montana, Nebraska, Oklahoma, Texas, and Wisconsin.

decline. Thus, the Boone indicator theoretically underpins findings by Stiroh (2000) and Stiroh and Strahan (2003) who state that increased competition allows banking markets to transfer considerable portions of assets from low profit to high profit banks.

As shown theoretically in Boone (2008), the reallocation effect is a general feature of intensifying competition, so that the indicator can be seen as a robust measure of competition.[5] While different forces can cause increases in competition, e.g. increases in suppliers of banking services through lower entry cost, more aggressive interaction between banks (shift from Cournot to Bertrand competition), or banks' relative inefficiencies, as long as the reallocation conditions holds, the indicator remains valid. As the industry becomes more competitive, given a certain level of efficiency of each individual bank, the profits of the more efficient ones increase relative to those of the less efficient banks.

Following Boone et al. (2005) and van Leuvensteijn et al. (2007), we can write a banking system demand function in which bank i produces a product (or product portfolio) q_i so that

$$p\left(q_i, q_{j\neq i}\right) = a - bq_i - d\sum\nolimits_{j\neq i} q_j \qquad (1)$$

whereby each bank has constant marginal cost c_i. The parameter a captures market size, and b denotes the market elasticity of demand. We use the parameter d to characterize the extent to which consumers see the different products in a market as close substitutes for each other. It is assumed that $a > c_i$ and $0 < d \leq b$. To maximize profits, the bank decides on the optimal output level q_i so that

5 We note that the Boone indicator has a number of other appealing features. For instance, it overcomes many of the shortcomings of other traditionally used proxies for competition such as the Herfindahl-Hirschman index and the 3-bank concentration ratio that aim to infer competitive conduct by examining concentration levels in banking (Degryse et al., 2009). Unlike these concentration indices, the Boone indicator is able to capture interaction among banks by focussing on conduct, whereas concentration ratios only capture the outcomes of competitive conduct. For instance, fierce competition leads to exit of banks via failure or merger, thus raising concentration in the system. Relying on concentration measures will yield misleading inferences as high levels of concentration are frequently considered to be indicative for a lack of competition. Unsurprisingly, empirical studies that examine the link between competition and concentration in banking such as Claessens and Laeven (2004) conclude therefore that concentration is a poor proxy for competition. In addition, other widely used measures of competition in the empirical banking literature such as the Panzar and Rosse (1987) H-Statistic require restrictive assumptions about the banking market being in long-run equilibrium, and the frequently used Lerner index suffers from the problem that it is criticized for not being able to appropriately capture the degree of product substitutability (Vives, 2008). The Boone model neither requires the assumption of long-run equilibrium, nor does it suffer from the problem relating to product substitutability. What matters for the Boone indicator is how aggressively the more efficient banks exploit their cost advantage to reallocate profits away from the least efficient banks in the market.

$$\pi_i = (p_i - c_i)\, q_i \tag{2}$$

The first order condition for equilibrium is then given by

$$a - 2bq_i - d\sum_{i \neq j} q_j - c_i = 0\,. \tag{3}$$

For a banking system with N banks that produce positive levels of output, one obtains N first order conditions (3)

$$q_i(c_i) = \left[\left(2b/d - 1\right)a - \left(2b/d + N - 1\right)c_i + \sum_j c_j\right] / \left[\left(2b + d\left(N-1\right)\right)\left(2b/d - 1\right)\right]. \tag{4}$$

Eq. (4) illustrates the relation between output and marginal cost, and we can see from Eq. (2) that profits depend on marginal cost in a quadratic way. If profits π_i are defined as variable profits excluding entry costs ε, a bank will only enter the market if, and only if, $\pi_i \geq \varepsilon$.

Based on these properties, competition increases for two reasons: First, competition increases when the products offered by different banks become closer substitutes and banks interact more aggressively, i.e., d increases (assuming that $d < b$). Second, competition increases if entry costs ε decline. Boone (2008) proves that performance of more efficient firms improves under both these regimes.

Assuming that the relation between profits π_i and marginal costs c_i is downward sloping, it follows that higher marginal cost imply lower margins per unit of output for a given price. Moreover, if higher marginal cost lead to higher prices, output is reduced and market share declines.

For the empirical implementation, we characterize the Boone model for bank i as follows

$$\pi_{it} = \alpha + \beta \ln(c_{it})\,, \tag{5}$$

where π_{it} measures profits of bank i at time t, β is referred to as the Boone indicator, and c_{it} denotes marginal costs. Since we cannot observe marginal costs directly, we use average costs as a proxy.

We regress ROA on average cost to obtain information on how much performance covaries with cost. The intuition is as follows: while an increase in costs reduces profits in all markets, the same percentage increase in a more competitive market leads to a greater decline in profits because banks are punished more harshly for being inefficient. The indicator exploits this property because it measures the extent to which differences in efficiency are reflected in performance differences. In other words, the Boone indicator expresses the reduction of profits that arises from cost inefficiencies. The indicator is well suited for the objective of expressing competition as a function of efficiency because cost inefficiencies often reflect poor lending decisions.[6]

In our empirical setup, we also include a bank-specific effect to allow for heterogeneity. Since we are interested in the varying effect of competition on soundness over time, we estimate the Boone model as follows

$$\pi_{it} = \alpha_i + \sum_{t=1,\dots,T} \beta_t d_t \ln(c_{it}) + \sum_{t=1,\dots,T-1} \gamma_t d_t + u_{it} \qquad (6)$$

where π_{it} are the profits of bank i at time t as a proportion of total assets, c_{it} is average variable costs, d_t is a time dummy and u_{it} is the error term. Profits increase for banks with lower marginal costs (β<0). Thus, an increase in competition raises profits of a more efficient bank relative to a less efficient one. The stronger the effect (i.e., the larger the β in absolute value), the stronger is competition.

Estimating the Boone indicator

As the first step to computing the Boone indicator, we use average cost of bank i as a share of total income. Average costs comprise interest and personnel expenses, administrative and other operating expenses. Income consists of commission and trading income, interest income, fee income, and other operating income.

European sample

For Europe, we estimate the relation between profitability, measured by ROA, and average costs based on Eq. (6) using a GMM-style estimator, whereby we use one year lagged values of the explanatory variables as instruments. Our choice of a GMM-style estimator is due to concerns that performance and cost are jointly determined. Banks that are large relative to the system might benefit from lower cost of production due to market power. The efficiency gains of the two-step GMM estimator relative to a traditional instrumental variables estimator derive from the use of the optimal weighting matrix, the overidentifying restrictions, and the relaxation of the i.i.d. assumption. In our estimations, the coefficients for the Boone indicator are negative and significant. More details are presented in Panel A of Appendix I.

[FIGURE 1]

[6] For instance, poor lending decisions will give rise to additional cost that arise from resource intensive monitoring of delinquent borrowers, analysis of workout arrangements, and seizing and disposing of collateral (Berger and DeYoung, 1997).

Figure 1 illustrates how competition evolved in Europe. The Dutch banking system is the most competitive one, followed by the U.K. and Switzerland. In terms of the rankings of competition, our results are in line with Carbo et al. (2009). The greater variation in the Boone indicator for the Netherlands reflects a process of reorganisation in the late 1990s (van Leuvensteijn et al., 2007). Germany exhibits a low degree of competition. This finding is due to the fact that major proportions of the market are shielded from competition as co-operatives and savings banks only operate in local markets.[7]

To analyze whether the Boone indicator is a valid measure of competition in banking, we perform two tests: First, we analyze if its theoretical assumptions hold. Second, we examine how the indicator lines up with other characteristics of competition.

For the analysis of the theoretical assumptions it is important to recall that competition increases according to the Boone model under the two regimes of more aggressive interaction and declines of entry costs, or when product substitutes emerge. We approximate banks' potential for aggressive competition and the decline of entry costs using an index of activity restrictions and data for the proportion of rejected applications for bank licences relative to the number of applications received.[8] To capture information on product substitutes, we use ratios for stock market total value traded and insurance premiums to GDP because insurance policies and stock market investments are close substitutes for bank products.

In our tests, we first examine correlations of the Boone indicator with the other variables. To investigate whether these measures can be substituted for each other, we then regress the Boone indicator on each one of the other variables individually. A coefficient of determination (R^2) of 1.00 indicates that the measures would be perfect substitutes. Finally, we regress the indicator on all other variables jointly.[9]

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7 We note that larger European countries exhibit comparatively flat Boone indicators during the sampling period, and we are concerned that most of the variation stems from the Dutch and the Danish banking systems. In unreported regressions, we drop those countries and obtain qualitatively identical results to those reported in Section 4.

8 The data for activity restrictions and the proportion of entry applications denied are taken from the survey by Barth et al. (2001) and averaged for the three waves of the survey. We use an index of activity restrictions that takes on values between 1 and 4. The index provides information about whether banks can engage in securities, real estate, and insurance activities, and whether banks can hold stakes in non-financial firms. Larger values indicate more restrictions. Entry denied is the ratio of the number of entry applications by domestic and foreign banks into the industry relative to total entry applications.

9 This analysis is based on mean values of the Boone indicator, because some of the variables that capture other features of competition such as the data on government ownership are only available as a cross-section. As a consequence, n=10 for the European sample and n=43 for the U.S. sample.

Panel A in Table 2 shows positive correlations between the Boone indicator and the index for activity restrictions and denied entry applications, suggesting less competition when regulators impose restrictions and when applications for bank charters are rejected. The coefficient of determination R^2 (1) indicates that more than one tenth of the variation in the Boone indicator can be explained by activity restrictions.[10] The correlations between the indicator and our measures for substitutes are negative, lending support to the idea that competition increases when stock markets and insurance products gain importance in Europe. More than 44 percent of the variation in the Boone indicator is explained by stock market total value traded to GDP. Thus, this analysis indicates that the theoretical assumptions of the indicator are well reflected in empirical regularities.

Analyzing correlations between the indicator and other characteristics of competition such as the Panzar and Rosse (1987) H-Statistic, government ownership of banks, and the Financial Freedom index also suggest that the indicator is intuitively linked with competition. [11]

The negative correlation between the H-Statistic and the Boone indicator shows that both measures provide similar indications because the H-Statistic is increasing in competition.[12] The relation between the Financial Freedom Index and the indicator is also negative. This indicates that competition is higher in systems with more freedom. Moreover, the regression of the Boone indicator on the Financial Freedom Index highlights that 66 percent of the information contained in the Boone indicator is also reflected in the Financial Freedom Index. In line with intuition, government ownership is positively correlated with the indicator.

The OLS regression of the indicator on all other features of competition shows that the Boone indicator reflects more than 80 percent of the information that is contained in these other variables. This result reinforces the idea of employing the Boone indicator for our purpose because it captures a broad variety of other characteristics of competition.[13]

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10 Note that there is agreement in the literature that there is generally little relationship between traditional measures of competition. Carbo et al. (2009) offer a detailed discussion of this matter.

11 Information on government ownership is obtained from the updated dataset in Barth et al. (2001) and averaged over the three waves of the survey. The Financial Freedom Index is obtained from the Heritage Foundation. It measures banking independence from government control and state interference into banking business (ranging from 0=no freedom to 100=maximum freedom).

12 The H-Statistic discriminates between competitive, monopolistically competitive, and monopolistic markets. It is calculated by estimating the sum of the elasticities of reduced form revenue equations with respect to factor input prices. The H-Statistic ranges between $-\infty$ and 1, whereby higher values indicate greater competition (for details see Claessens and Laeven, 2004, and the notes to Table 2).

13 Our R^2 measures are higher than those reported in Carbo et al. (2009). They compare the consistency of HHI, net interest margins, H-Statistics, Lerner indices, and ROA in 14 European countries with each other and

U.S. sample

For the U.S., we estimate the Boone indicator by a similar regression of ROA on average cost. While we perform the ultimate analysis of the effect of the Boone indicator on soundness in a cross-sectional setting, we obtain Call Report data for 1995-2005 to estimate the indicator because we need a sufficiently large number of observations to compute reasonable estimates. We use a simplified version of Eq. (6) as detailed in the notes to Panel B of Appendix I to estimate the indicator. As instruments for average costs, we use one and two-year lags of average costs. This setup allows computing the Hansen *J*-Test. The regressions in Appendix I indicate considerable explanatory power, and the indicator is significant at conventional levels. Figure 2 plots the Boone indicators for rural banking markets in the U.S.

[FIGURE 2]

Since the U.S. sample only includes selected counties, we lack information for activity restrictions, denied bank charters, and government ownership. While we also have no data on insurance premiums and stock market activity on the county level, we can still examine the association of the Boone indicator with two other characteristics of competition.

First, we calculate again H-Statistics and confirm the negative association of the Boone indicator with the H-Statistic (Table 2, Panel B). More than 15 percent in the variation of the Boone indicator is reflected in the H-Statistic. Second, since we have population data and information about the number of bank branch offices in these markets from the Summary of Deposits, we test the relation between branch density, measured by the ratio of branches to population, and the Boone indicator. The negative correlation suggests that competition is higher in markets with greater branch density. Both findings confirm that the Boone indicator is also intuitively associated with other features of competition in rural markets in the U.S.

[TABLE 2]

The effect of competition on bank efficiency

Recall that our main hypothesis that efficiency is the conduit through which competition enhances soundness rests on the assumption that competition increases bank efficiency. As a further preliminary step in our analysis, we need to ascertain that this is the case. For the European sample, we estimate panel data models as follows

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obtain a maximum R^2 value of 0.37. Thus, the Boone indicator captures substantially more, and more consistently the information in other measures of competition.

$$Eff_{ijt} = \propto + \beta B_{jt} + \delta X_{ijt} + \sigma C_{jt} + \varepsilon_{it} \quad (7)$$

where Eff_{ijt} denotes cost efficiency of bank i in country j at time t. We estimate cost efficiency using stochastic frontier techniques as detailed in Appendix II. B_{jt} is the Boone indicator in country j at time t, X is a vector of bank-specific, and C is a vector of country-specific variables. Given that lower values of the Boone indicator signify more competition, we expect an inverse relation between the indicator and efficiency.

We choose control variables that affect efficiency. We include market share because banks that are large relative to their market can charge higher prices. Total assets (log), asset growth, and asset growth squared are also included. We control for asset growth because an expanding bank may not keep efficiency under control and anticipate an inverse link between growth and efficiency. The quadratic term accounts for nonlinearities as the effect of growth may be different for aggressively growing banks. On the country level, we use a HHI to control for the effect of market structure. Recent work by Claessens and Laeven (2004) and Schaeck et al. (2009) has shown that concentration cannot be considered as a proxy for competition. Rather, concentration has independent effects on performance outcomes in the banking industry. Thus, while the Boone indicator captures competition, we control for market structure with the HHI. Since we compare Herfindahl indices across different markets, we also include total banking system assets (log) to account for the size of the systems (Breshanan, 1989). Finally, we include a time trend to capture the gradual nature of changes in the regulatory environment. The time trend is calculated as the current year minus the start date of the sampling period. For the U.S., we estimate a modified version of Eq. (7) based on OLS and 2SLS. In these regressions, explanatory variables are lagged by one period.

Bank soundness and the Boone indicator

We use the Boone indicator to establish how competition impacts on soundness, and estimate a general class of panel data models of the form

$$Z_{ijt} = \alpha + \beta B_{jt} + \gamma X_{ijt} + \delta C_{jt} + \varepsilon_{ijt} \quad , \quad (8)$$

where Z_{ijt} is a measure of bank soundness for bank i in country j at time t, B_{jt} is the Boone indicator in country j at time t, and X and C are vectors of bank- and country-specific variables. For Europe, the vector C includes country dummies. All explanatory variables are lagged by one period unless stated otherwise. If we find a negative sign for the Boone indicator β, we can interpret this as direct evidence that the reallocation effect of profits from inefficient banks to efficient ones contributes to sound banking activities.

To measure soundness, we use the Z-score, calculated as

$$Z = \frac{(ROA + E/A)}{\sigma ROA}, \quad (9)$$

where *ROA* is return on assets, *E/A* denotes the equity to asset ratio and σROA is the standard deviation of return on assets. In the European sample, we use a three-year rolling time window for the σROA to allow for variation in the denominator of the Z-score. For the U.S. sample we use quarterly data from Call Reports, and also base our Z-scores on a rolling window estimate for three years. This approach avoids that the Z-scores are exclusively driven by variation in the levels of capital and profitability.

The Z-score combines banks' buffers (capital and profits) with the risks they face (measured by the standard deviation of returns). It can be shown that the Z-score measures the number of standard deviations a return realization has to fall in order to deplete equity. A higher Z-score implies a lower probability of insolvency, providing a direct measure of soundness that is superior to, e.g., analyzing leverage.

We use total assets (log) to control for size as larger banks are frequently subject to too-big-to-fail policies. The adaptation of these policies has been reflected in several bailouts of banks in Europe and in the U.S. Asset growth is included to account for differences in risk preferences. To consider the fact that better diversified banks are assumed to be less risky, we control for diversification, measured by a diversification index (Laeven and Levine, 2007).[14] We use the ratio of loan loss provisions to total assets as a measure of asset quality. The HHI is included to reflect on research indicating that concentration and competition measure different characteristics of banking systems. We use total banking system assets (log) to consider the effect of market size. GDP per capita (log) and unemployment adjust our regressions for the macroeconomic environment.

[14] We use a diversification index that is increasing in the degree of diversification. It is defined as $1 - \left| \frac{(Net\ interest\ income - Other\ operating\ income)}{Total\ operating\ income} \right|$.

4. Empirical Results

We present the results from the link between competition and efficiency in Section 4.1. The relation between the Boone indicator and bank risk is examined in Section 4.2 for the European sample and in Section 4.3 for the U.S. sample.

We use different estimation techniques, including 2SLS estimators to adjust for endogeneity between measures of competition and soundness. Standard errors are clustered at the bank level.[15] To examine allow for heterogeneous responses of banks to increases in competition, we also estimate a set of two-stage quantile regressions.

4.1 The relation between competition and efficiency

We show the empirical associations between the Boone indicator and efficiency in Table 3. Panel A reports the results for Europe, and Panel B presents the findings for the U.S.

Column (1) and (2) use panel data models with fixed effects and suggest that competition increases cost efficiency. However, we are concerned that competition and efficiency are endogenous because the direction of causality is *ex-ante* not clear. On one hand, competition is commonly perceived to provide incentives to increase efficiency. On the other hand, more efficient banks may compete more aggressively. To rectify this issue, we employ a two stage estimator using lagged values of Financial Freedom, and lagged values of an interaction term between market share and loan growth as instruments for the Boone indicator in column (3) and (4). The Financial Freedom index is an excellent instrument for the Boone indicator because state ownership and interference are frequently considered to affect competition. Moreover, the analysis in Table 2 shows a strong correlation between the index and the Boone indicator. We use the interaction term of the bank's market share with loan growth because it increases whenever market share or loan growth or both increase. Such increases signal a more aggressively competing institution, and rapid growth of one individual bank can be expected to affect the competitive nature of the relevant market.

The Boone indicator enters again significantly negatively. We use a Durbin-Wu-Hausman test to verify whether the two-step estimator is warranted and whether our instruments satisfy the exclusion restrictions. The test rejects the exogeneity of the Boone indicator. The Anderson test verifies the relevance of our instruments and we also pass the Hansen test.

[TABLE 3]

[15] In unreported regressions we reestimate our models by clustering the errors on the country level for Europe and on the county level for the U.S. The results remain unchanged and can be obtained upon request.

The results in Panel B provide additional evidence for a beneficial effect of competition on cost efficiency based on U.S. data. Using OLS and 2SLS (we use an interaction term of loan growth and market share, and population (log) on the county level instead of the Financial Freedom Index as instruments), the indicator remains significantly negatively associated with efficiency. Thus, these findings support the notion that competition improves cost efficiency. In the remainder of the study, we build on this assumption and model the effect of competition through the efficiency channel on soundness.

4.2 Competition, efficiency, and soundness: European sample

We estimate panel data models with fixed effects in columns (1) and (2) in Table 4. Column (1) contains bank-specific variables, controls for characteristics of the banking systems, and a time trend. The negative sign at the one percent level for the Boone indicator strongly supports the positive link between competition, efficiency, and soundness, and underscores that competition increases banks' Z-scores via the efficiency channel.

[TABLE 4]

In column (2), we incorporate GDP per capita (log) and the unemployment rate. The effect of the Boone indicator increases. Our results also indicate that banks operate with lower Z-scores in concentrated banking systems. This finding captures a pure and independent effect arising from market structure in regressions that are already adjusted for the level of competition. We believe that the inverse relation between the HHI and the dependent variable suggests that banks in more concentrated systems are more likely to be considered too-big-to-fail. Such institutions can afford to operate in a less sound manner. Consequently, these banks operate at lower capital ratios than would be appropriate given their risk profiles.

We also find that size and loan loss provisioning are negatively related to Z-scores. The diversification index also enters negatively, indicating that Z-scores decrease in diversification.

We remain concerned that the Boone indicator is endogenous because more fragile institutions may 'gamble for resurrection' by increasing risk via the origination of risky loans, which by itself can be interpreted as a sign of increased competition.

To address these concerns, we use a 2SLS estimator, and use again Financial Freedom, and an interaction term of market share and loan growth as instruments for the Boone indicator. The indicator remains significantly negative and increases in magnitude in Columns (3) and (4) in Table 4, indicating a bias in our previous estimates. We use the Durbin-Wu-Hausman test to compare the estimates obtained from the fixed-effects model with the estimates from the 2SLS estimator. All test statistics are significant and reject the exogeneity of the indicator, confirming that an instrumental variable approach is necessary.

Heterogeneous responses to competition

To better understand what drives the hypothesized mechanism, we perform additional tests. First examine if organizational form with its implications for different types of lending technologies matters for the effect of competition. The intuition behind this test is that competition incentivizes banks to specialize in certain lending technologies (Zarutskie, 2009). To capture organizational form as a proxy for different types of lending technologies, we use bank size because Berger et al. (2005) have shown that small banks primarily lend to opaque borrowers and specialize in processing soft information. In contrast, Berger et al. (2005) show that large banks originate loans on the grounds of easily verifiable hard information. Following this line of reasoning, we use the median bank size (407 m EUR) as a cut-off point, and focus in this analysis on the magnitude of the coefficient of the Boone indicator. The regression setup is identical to Column (4). Column (5) and (6) show that the indicator remains negatively and significantly associated with the Z-score, and the effect for the small banks is almost twice as large as for the bigger institutions. This result suggests that small banks adjust their soundness more than large banks in response to competition. The effect may be attributable to greater flexibility in processing soft information relative to the larger banks, and lends some support to the idea in Zarutskie (2009) that small banks become better at identifying high quality loans because competition provides incentives to specialize.

Second, we focus on the three different components of the Z-score to establish whether the beneficial effect of competition on soundness is primarily attributable to effects of competition on capitalization, profitability, or on the volatility of profits. Columns (7) – (9) show the results. These tests reveal an inverse relation of the Boone indicator with all three components of the Z-score, yet only the coefficients in the regressions with the capital ratio and ROA assume significance at conventional levels with similar magnitudes of their coefficients. Taken together, these findings suggest that competition, via the efficiency channel, principally drives

Z-scores higher via incentives to hold higher capital ratios, and via the reallocation of profits. The latter result illustrates nicely the intuition behind the Boone indicator.[16]

Third, we use quantile regression to allow for further heterogeneous responses to competition (Koenker and Bassett, 1978) in Table 5. The intuition is as follows: Particularly weak banks, i.e., banks with low Z-scores may respond in a different way to competition than do sound banks. Such varying effects indicate that more than one single slope parameter is necessary to describe the relation between competition and soundness. This situation calls for the use of quantile regression because it permits inferences about the impact of regressors conditional on the distribution of the measure of soundness.[17]

[TABLE 5]

Since we remain cautious about endogeneity of the Boone indicator, we use a two-stage quantile estimator (Amemiya, 1982). First, we regress the Boone indicator on the interaction term of the bank's market share and loan growth, Financial Freedom and the exogenous variables. In the second stage, we regress the Z-score on the predicted value for the Boone indicator and the exogenous variables. Since the standard errors from the second stage are incorrect, we use a bootstrapping procedure based on 1,000 replications to correct them.[18]

Our supposition that the transmission mechanism from competition via the efficiency channel on soundness depends on the soundness of the banks in question is confirmed in the quantile regression analysis. Table 5 reports the coefficients obtained with the two-stage quantile regression estimator for the 10th, the 25th, the 50th, the 75th, and the 90th quantile of the distribution of the Z-score. To illustrate the effect of a one-unit change of the Boone indicator on soundness with the other covariates held constant, we plot in Figure 3 the quantile regression estimates as a solid curve. The vertical axis indicates the effect of competition and the horizontal line represents the quantile scale. The grey area shows a 95 percent confidence interval for the quantile regression and the dashed line represents the OLS estimator and the concurrent confidence interval.

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16 The positive effect of competition on bank capital holdings is fully in line with theoretical predictions in Allen et al. (forthcoming), and the closely related empirical evidence in Schaeck and Cihak (forthcoming).

17 We note two important differences between quantile regression and OLS. First, quantile regression provides information about the slope at different points of the dependent variable given the set of explanatory variables, whereas OLS provides information about the slope at different points of the explanatory variables. Second, least absolute deviation estimation is more robust to departures from normality, because linear estimators are more likely to produce inefficient estimates.

18 Appendix III provides technical details for the derivation and estimation of the quantile regressions.

[FIGURE 3]

The coefficient of competition remains negative and significant across the quantiles. The quantile regressions offer additional insights. Figure 3 highlights departures from the previous estimates of the Boone indicator at the upper and the lower tails of the distribution of the Z-score. The inference from the visual inspection is also validated when we use an *F-Test* to check if the coefficients of the Boone indicator are equal across all quantiles. Our *F-Test* rejects the null hypothesis for the equality of the coefficients. This suggests that relying on a single measure of central tendency may be insufficient to evaluate the effect of competition.

Our result highlights that policymakers need to consider that any competition increasing policy may differently affect soundness in the relevant banking market depending on the health of the banks. Second, the increasing magnitude of the coefficient of the Boone indicator underscores that banks at the lower tail of the distribution of the Z-score benefit less from competition. This is intuitive. A fragile institution is likely to have a low capital ratio, lower and more volatile profits, and is likely to operate at higher costs. Such an institution will find it harder to survive increases in competition than more efficient banks.

Robustness tests

We perform robustness checks in Appendix IV, Panel A. First, we use the aggregate ratio of non-performing loans to total loans on the country level as a dependent variable to check if measurement issues drive the significant association of the Z-score with the Boone indicator. This analysis shows a positive association of the Boone indicator with the level of non-performing loans, confirming that competition contributes to soundness, also on the systemic level. Further, we separately re-run the regressions for commercial, savings, and cooperative banks, and use an estimation procedure that assigns less weight to observations where the indicator is estimated with greater variance to account for the fact that the Boone indicator is derived from a regression. Finally, we test whether industry composition and survivorship bias affect our findings, and we also adjust the regressions for the fact that the Z-score is truncated. All tests confirm the validity of our previous inferences.

4.3 Competition, efficiency, and soundness: U.S. sample

We examine the U.S. sample in Table 6. The regressions are identical to those for Europe in terms of the control variables except that we replace GDP per capita with personal income due to data availability and the absence of country dummies. Columns (1) and (2) use OLS, and columns (3) and (4) are estimated with 2SLS to account for endogeneity between the Boone indicator and soundness. Columns (5) - (6) run the tests separately for small and large banks, and Column (7) – (9) show results for the components of the Z-score.

[TABLE 6]

The indicator confirms our inferences for the soundness enhancing effect of competition in column (1), although it remains insignificant in column (2). However, when we turn to 2SLS, our earlier results are reinforced, and the significant Durbin-Wu-Hausman statistics suggest that the 2SLS estimator is more appropriate.[20]

The analysis of local banking markets in the U.S. yields a further insight. The HHI does not confirm our results for Europe. The HHI enters only in a few regressions with a negative and significant sign, indicating that that our argument about 'too-big-to-fail' policies does not hold for the U.S. This observation is intuitive: First, the sample consists exclusively of single-market banks that are far from being subject too-big-to-fail policies. Second, regulatory authorities in the U.S. have shown greater propensity to allow banks, including larger institutions, to fail.

Heterogeneous responses to competition

We perform again the three additional tests mentioned above to better understand the hypothesized transmission mechanism.

In the first test, we split the sample banks at the median bank size (104 m USD) to focus on organizational form as a proxy for different lending technologies. Column (5) and (6) in Table 6 confirm the findings for Europe that smaller banks' Z-scores benefit more than larger banks' Z-scores from competition.

The remaining columns show the results for the components of the Z-score. We find again a significantly negative relation of the Boone indicator with the capital ratio and with ROA, whereas the volatility of profits is significantly positively associated with the Boone indicator. This positive association between profit volatility is however not strong enough to dominate the negative link between the indicator and the capital ratio and ROA.

We report quantile regression results in Table 7. However, since quantile regression requires large sample sizes, we do not assign too much weight to these results, merely reporting

[20] The magnitude of the coefficients of the Boone indicator for the U.S. sample is considerably smaller than in the regressions for the European banks. While this result may partially reflect a greater degree of heterogeneity of banks in the European sample, we believe it also offers some indication that the mechanism in Europe is more prevalent than in rural banking markets in the U.S.

them for completeness.[21] The two-stage quantile regression estimator encounters inference problems due to the small sample size. The coefficient for the indicator remains negative, and is significant at the 10th, at the 75th, and at the 90th quantile. In a similar vein to the results for the European sample, the magnitude of the coefficient increases considerably for the sound banks located at the upper tail of the distribution, suggesting again heterogeneous effects.

[TABLE 7]

Figure 4 illustrates the behavior of the coefficient of the indicator. The trend of the slope coefficients resembles the pattern for the European sample in that sense that we observe an increase in terms of the magnitude of the effect towards the upper tail of the distribution, and the quantile regression estimates also depart significantly from the linear predictions. The *F-Test* rejects the hypothesis for the equality of coefficients across the quantiles, lending more support to the idea that competition affects soundness in a heterogeneous manner.

[FIGURE 4]

Robustness tests

We run robustness tests for the U.S, and use the aggregate level of non-performing loans to total loans on the county level as an alternative dependent variable, account for the generated regressor problem, and adjust for the truncated nature of the Z-score. These checks leave our key result unchanged (Appendix IV, Panel B).

5. Conclusion

We inform the debate about how competition contributes to bank soundness as argued in recent studies. Specifically, we propose that competition incentivizes banks to enhance cost efficiency, and that competition rewards successful banks by reallocating profits from inefficient ones to more efficient institutions. In other words, the underlying idea is a stylized picture of competition: Banks with strong performance will pass a market test and survive whereas weak institutions will shrink, sell out, and exit the market. Based on this conjecture, we formulate and test hypotheses that allow examining the transmission mechanism from competition via the efficiency channel to bank soundness.

We use an innovative measure of competition, the Boone indicator, which is based on the idea of analyzing cost elasticity of performance by capturing the link between competition and

[21] Note that quantile regression effectively fits a line for each conditional quantile. This means that the observations that do not belong to the particular conditional quantile receive a small weight in the optimization algorithm. As a result standard inference problems are present in particularly small datasets.

efficiency. To test our hypothesis, we first establish the effect of competition on efficiency, and subsequently relate the Boone indicator to measures of bank soundness.

Using panel data for Europe, and a sample for single-market banks operating in the U.S., we show in an initial analysis that the new measure of competition captures over 80 percent in the variation of many other features of banking competition in Europe, suggesting that the Boone indicator is able to comprehensively capture characteristics of competition. Next, we establish evidence for the assumption that competition increases efficiency. Building on this, we then present robust evidence for a positive link between competition and soundness via efficiency. Specifically, when we decompose the Z-score into its components to observe the mechanism in greater detail, we show that profitability is positively associated with competition. A final set of tests focuses on banks' heterogeneous responses to competition. Here, we find that smaller banks' soundness measures respond more strongly to competition. This finding can be interpreted as suggestive evidence that they tend to specialize in more competitive environments which we attribute to their better ability to process soft information loans. Using quantile regressions, we show that weak banks, in terms of their soundness, benefit less from competition than do sound institutions.

Two caveats apply. First, our investigation does not account for contagion among banks arising from the failure of inefficient institutions. The recent crisis has shown that banks are interconnected via credit derivatives in a way that is difficult to trace. Since testing for such effects is beyond the scope of the present analysis, we view our study as a partial equilibrium analysis. Second, the findings for the U.S. are obtained for a non-representative sample of single-market banks.

Our results have implications for policymaking in banking. First, promoting competition does seem to have benefits for efficiency and soundness. Second, the findings obtained with quantile regression suggest that policymakers need to consider that any action that raises competition in banking can affect the soundness of the institutions in the relevant banking market in a heterogeneous way.

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Appendix I: Boone indicators for Europe and the U.S.

Panel A: Europe

	Austria		*Belgium*		*Denmark*		*France*		*Italy*		*Germany*		*Luxembourg*		*Netherlands*		*Switzerland*		*United Kingdom*	
Year	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*	*Boone*	*t-value*
1996	-0.059	-2.431	-0.048	-3.015	-0.051	-3.643	-0.014	-1.228	-0.079	-13.793	-0.037	-15.287	-0.037	-6.288	-0.130	-2.550	-0.060	-4.282	-0.100	-7.420
1997	-0.038	-2.590	-0.052	-3.216	-0.034	-2.231	-0.012	-0.837	-0.067	-11.481	-0.033	-13.469	-0.034	-6.312	-0.082	-1.533	-0.063	-5.452	-0.093	-9.295
1998	-0.037	-2.304	-0.055	-3.781	-0.030	-2.244	-0.019	-1.626	-0.058	-13.082	-0.029	-10.543	-0.039	-5.079	-0.067	-1.459	-0.069	-6.381	-0.090	-8.477
1999	-0.034	-2.424	-0.057	-3.986	-0.018	-1.331	-0.025	-2.240	-0.042	-8.945	-0.026	-8.519	-0.027	-6.370	-0.095	-1.933	-0.061	-5.608	-0.081	-7.571
2000	-0.036	-3.123	-0.066	-4.131	-0.035	-2.565	-0.024	-2.470	-0.045	-11.366	-0.021	-6.940	-0.045	-7.671	-0.123	-2.749	-0.076	-6.648	-0.081	-7.508
2001	-0.034	-2.474	-0.055	-3.414	-0.022	-1.546	-0.025	-2.644	-0.043	-10.033	-0.016	-5.026	-0.033	-6.145	-0.098	-1.843	-0.070	-4.885	-0.070	-6.622
2002	-0.028	-2.183	-0.059	-3.426	-0.024	-1.725	-0.020	-2.310	-0.039	-8.236	-0.015	-5.409	-0.030	-4.440	-0.059	-1.517	-0.063	-4.525	-0.066	-6.041
2003	-0.026	-2.315	-0.053	-3.473	-0.045	-3.357	-0.019	-2.509	-0.036	-8.205	-0.019	-7.675	-0.024	-5.053	-0.061	-1.100	-0.059	-4.498	-0.062	-7.652
2004	-0.029	-2.646	-0.047	-3.567	-0.035	-2.635	-0.024	-3.210	-0.037	-9.171	-0.017	-7.727	-0.026	-6.196	-0.030	-0.716	-0.053	-4.160	-0.082	-5.221
2005	-0.030	-2.890	-0.048	-3.849	-0.042	-3.416	-0.023	-3.064	-0.039	-9.155	-0.024	-10.302	-0.028	-8.000	-0.064	-1.791	-0.053	-4.704	-0.056	-4.754
Observations		1074		282		480		1631		3145		12670		625		97		1642		346
R^2		0.1267		0.5764		0.3833		0.1295		0.4339		0.3433		0.3997		0.4674		0.2287		0.3204
Anderson cor.		22.063**		17.911*		188.527***		79.951***		730.112***		3750.837***		88.536***		19.902**		74.773***		76.845***

We report the estimates of the Boone indicator based on average costs with ROA as dependent variable, adjusted for heteroskedasticity. The estimates are obtained using a two-step GMM panel data estimator with bank-fixed effects whereby we employ one-year lagged values of the explanatory variables as instruments. All regressions have considerable explanatory power; we also present the Anderson canonical correlation coefficient for the excluded instruments. All equations are exactly identified. *** p<0.01, ** p<0.05, * p<0.1

Panel B: U.S. (local markets)							
County	State	Boone	t-value	N	R^2	Anderson corr.	Hansen *J*-Test
Adams	IL	-0.013	-3.777	33	0.641	5.428*	1.572
Benton	IA	-0.016	-2.701	21	0.132	17.568***	0.052
Bremer	IA	-0.010	-4.867	27	0.222	13.307***	0.519
Brown	MN	-0.063	-0.808	23	0.208	1.860	0.111
Buffalo	NE	-0.022	-0.457	21	0.231	2.706	0.816
Caddo	OK	-0.017	-2.404	21	0.599	3.129	0.147
Carroll	IA	-0.010	-4.546	23	0.711	9.202**	1.171
Christian	IL	-0.001	-0.735	24	0.221	5.214*	3.428*
Clayton	IA	-0.007	-1.059	21	0.555	0.680	0.060
Cole	MO	-0.007	-2.867	21	0.556	15.864***	0.149
Dodge	WI	-0.010	-1.621	21	0.783	1.397	0.715
Faribault	MN	-0.033	-0.445	24	0.106	0.430	0.001
Fayette	TX	-0.007	-1.492	21	0.453	1.198	0.000
Goodhue	MN	-0.012	-4.182	21	0.873	2.326	0.001
Grant	WI	-0.018	-2.961	24	0.327	6.629**	1.258
Hancock	IL	-0.008	-1.642	26	0.538	6.602**	1.649
Iroquois	IL	-0.013	-4.271	34	0.692	2.357	0.794
Jackson	IL	-0.011	-6.439	21	0.697	7.936**	0.245
Jefferson	WI	-0.012	-3.267	24	0.569	20.462***	2.609
Kandiyohi	MN	-0.006	-2.419	29	0.297	3.599	0.095
Lee	IA	-0.031	-0.991	20	0.700	0.702	0.276
Litchfield	CT	-0.003	-0.695	26	0.380	0.363	0.100
Livingston	IL	-0.007	-1.201	33	0.435	1.075	0.486
Lyon	KS	-0.013	-11.053	21	0.939	9.405***	0.003
Macoupin	IL	-0.006	-1.476	24	0.684	3.157	3.320*
Marshall	KS	-0.034	-1.154	18	0.363	11.971***	0.109
Martin	MN	-0.020	-4.783	30	0.753	2.207	0.260
McPherson	KS	-0.011	-2.281	21	0.757	1.765	1.447
Medina	TX	-0.021	-2.366	21	0.457	10.367***	0.145
Montgomery	IL	-0.016	-1.596	27	0.941	1.840	1.320
Mower	MN	-0.018	-5.709	18	0.577	9.821***	0.018
Randolph	IL	-0.004	-1.333	21	0.384	1.238	0.6647
Saunders	NE	-0.012	-2.180	33	0.862	11.003***	0.114
Sioux	IA	-0.009	-3.814	27	0.584	8.221**	0.002
Stephenson	IL	-0.013	-5.338	30	0.624	12.292***	0.5840
Story	IA	-0.003	-0.898	26	0.170	2.461	1.355
Sumner	KS	-0.011	-5.013	30	0.844	6.895**	0.552
Trempealeau	WI	-0.010	-1.073	23	0.283	2.313	1.895
Vermilion	LA	-0.010	-2.855	21	0.727	4.460	0.024
Vermilion	IL	-0.012	-2.981	26	0.596	5.201*	1.910
Vernon	WI	-0.022	-1.458	20	0.302	1.893	0.051
Wood	WI	-0.009	-6.258	21	0.748	9.971***	1.340

We report the estimates of the Boone indicator based on average costs with ROA as dependent variable, adjusted for heteroskedasticity. The estimates are obtained using a two-step GMM estimator with one and two year lagged values of the explanatory variables as instruments based on the following specification: $\pi_{it} = \alpha_i + \beta \ln(c_{it}) + u_{it}$. The regressions have considerable explanatory power. We additionally present the Anderson canonical correlation coefficient for the excluded instruments, and the Hansen J-Test for instrument exogeneity. *** p<0.01, ** p<0.05, * p<0.1

Appendix II: Measuring and estimating cost efficiency

For the analysis of efficiency, we focus on the concept of cost efficiency because the intuition behind the Boone indicator is to analyze cost elasticity of bank performance. Cost efficiency measures how close the bank's cost is to the best practice bank's cost if it would produce the same output bundle under the same conditions (Berger and Mester, 1997). We write a bank's cost function as

$$ln\ C = f(w,y,e) + ln\ u_c + ln\varepsilon_c \qquad (A.1)$$

where C measures variable cost. The price vector of the inputs is denoted by w, and the vector of output quantities is captured by y. E indicates the quantities of any fixed netputs (inputs or outputs), u_c denotes an inefficiency term that raises cost above the level of the best-practice bank, and ε_c is the remaining random disturbance. Cost efficiency ranges between 0 and 1, whereby larger values indicate greater cost efficiency.

To estimate cost efficiency, we use stochastic frontier techniques that allow us to decompose the error term into two parts, one term captures random disturbance and follows a symmetric normal distribution. The second part of the error captures inefficiency, following a positive half-normal distribution. The frontier functions are estimated for each country separately. We follow the intermediation approach and use a translog functional form with two outputs and specify

$$lnC = \alpha_0 + \sum_{i=1}^{2} \alpha_i lnY_i + \sum_{k=1}^{2} lnW_k + \sum_{h=1}^{2} lnE_h$$
$$+\frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2} \delta_{ij} lnY_i lnY_j + \frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2} \gamma_{km} lnW_k lnW_m$$
$$+\sum_{i=1}^{2}\sum_{k=1}^{2} \rho_{ik} lnY_i lnW_k + \sum_{i=1}^{2}\sum_{h=1}^{2} \varepsilon_{ih} lnY_i lnE_h$$
$$+\sum_{i=1}^{2}\sum_{h=1}^{2} \theta_{kh} lnW_k lnE_h + \frac{1}{2}\sum_{h=1}^{2}\sum_{n=1}^{2} \vartheta_{hn} lnE_h lnE_h + lnu_c + ln\varepsilon_c.$$

(A.2)

C is our measure of cost. Output quantities (loans and other earning assets) are denoted by Y, W is the vector of inputs (labor, funding, and other costs), and netputs (fixed assets, loan loss provisions, and equity) are represented by the vector E. To impose standard homogeneity conditions, we scale all costs and input prices by one other input price (labor costs), and adjust for heteroskedasticity and scale biases by scaling by one of the netputs (equity capital).

Efficiency scores

	Panel A: European sample				Panel B: U.S. sample			
	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Cost efficiency	17965	0.95	0.164	1.00	382	0.83	0.186	1.00

The table suggests that banks in Europe and in local markets in the U.S. operate close to their efficiency frontier. The average European bank loses about 5 percent due to inefficiency whereas single-market banks in the U.S. lose 17 percent.

Appendix III: Two-stage least absolute deviation estimator (2SLAD)

Quantile regression is appropriate in instances, where characteristics in the data suggest that more than one single slope parameter is necessary to describe the relation between the dependent variable and the regressors. If we assume that fragile banks respond differently to competition than do sound institutions, a case may be made to focus the analysis on the tails of the distribution of the dependent variable. Quantile regression permits inferences about the impact of regressors conditional on the distribution of the soundness variable as it provides information about the slope at different points of the dependent variable. Thus, whereas classical linear regression estimates conditional mean functions, quantile regression estimates conditional quantile functions, i.e., models in which quantiles of the dependent variable are expressed as functions of a set of explanatory variables.[22]

Similarly to the widely used two-stage least squares estimator, we can obtain quantile estimates for a model with endogenous variables with the two-stage least absolute deviation estimator (2SLAD). Amemiya (1982) defines a class of estimators called the two-stage least absolute deviation estimators, and he also derived their asymptotic properties. In his article, he points how we can derive the least absolute deviation estimator that is analogue of 2SLS in the estimation of C in a structural equation and a reduced form as given below

$YA + XB + E = ZC + E$ and

$$Y = X\pi + V, \text{ where } Z = (Y, X) \text{ and } C = \begin{pmatrix} A \\ B \end{pmatrix}. \qquad (B.1)$$

Amemiya (1982) highlights that all previous studies relating to the subject define LAD as the value of C that minimized

$$S_a = \sum \left| Y_1 - P_1' ZC \right| \text{ , where } P = X(X'X)^{-1} X' \qquad (B.2)$$

Theil (1961) interpreted 2SLS so as to minimize $S_L = \sum (Y_1 - P_1' ZC)^2$. However, if we intend to use an interpretation of 2SLS as the instrumental variable estimator minimizing $S_{1L} = \sum (P'Y - P'ZC)^2$, we can define 2SLAD analogously to minimize

[22] Quantiles divide the cumulative distribution function of a random variable into a number of equally sized segments. Quantiles are the general case of splitting a population into segments. For instance, quartiles divide a population into four segments, with equal proportions of the reference population in each segment.

$S_{1A} = \sum |P'Y - P'ZC|$. Combining the above two ideas, 2SLAD is a class of estimators obtained by minimizing

$$S_{qA} = \sum |qY + (1-q)P'Y - P'ZC| \qquad (B.3)$$

where q is the parameter to be determined by the researcher. The parameter q determines the point of the distribution of the dependent variable. The minimization of

$$S_{qL} = \sum \{qY + (1-q)P'Y - P'ZC\}^2 \qquad (B.4)$$

yields 2SLS for any value of q whereas the minimization of its absolute analogue (S_{qA}) depends crucially on the value of q. If $q = 0$, it yields the estimator which is asymptotically equivalent to 2SLS. As a result, in the asymptotic sense the class of 2SLAD estimator contains 2SLS as a special case. Given the standard regression model, $Y = Xa + E$ where X is a $n \times k$ matrix of bounded constants such that $\lim_{\rightarrow\infty}(n^{-1}X'X)$ is a finite positive-definite matrix and E is a n-vector of i.i.d random variables, the LAD estimator has been defined to be a value of $\hat{a}$ that minimizes $S = \sum_{i=1}^{n}|Y_i - X_i'\hat{a}| - \sum_{i=1}^{n}|E_i|$, where X_1' is the i^{th} row of X. The second term of the right- hand side of the equation does not affect the minimization since it is independent of $\hat{a}$. It is added to facilitate proof of consistency without assuming the existence of a finite first moment. Amemiya (1982) proves the consistency of LAD by showing that $n^{-1}S$ converges almost surely uniformly in $\hat{a}$ to a function which attains the minimum at a, the true value. Strong consistency of 2SLAD for any value of $q>0$ follows from the consistency of LAD.

In the 2SLAD estimation, it is assumed that the minimization of the sum of absolute deviation is applied only to a specific equation to be estimated and not to the reduced form equation. In other words, LAD is applied only in the second stage of regression and not in the first. The first stage is based on OLS. Since the standard errors from the second stage are incorrect, we bootstrap the whole system of equations to account for the fact that the endogenous variable is itself subject to sampling variation.

Appendix IV: Robustness tests for the effect of competition via efficiency on bank soundness

Panel A: European sample								
Estimator	**Two-stage least squares**							**Two-stage Tobit**
Model setup	***(1) Aggregate Non-performing loans/Total loans***	***(2) Commercial banks***	***(3) Savings banks***	***(4) Cooperative banks***	***(5) Adjustment for generated regressor problem***	***(6) Banks in sample during entire sampling period***	***(7) Banks that exit during sampling period***	***(8) IV Tobit***
Bank-specific variables								
Total assets (log)	0.235***	-0.325***	-0.173***	-0.175***	-0.282***	-0.142***	-0.244***	-0.0258***
	(2.67)	(-8.75)	(-7.76)	(-12.8)	(-9.49)	(-6.5907)	(-13.6200)	(-6.73)
Asset growth	0.0848	-0.111***	0.0109	0.0331***	-0.0489*	-0.0218	-0.00209	-0.0975***
	(1.39)	(-4.76)	(0.78)	(4.00)	(-1.82)	(-1.1658)	(-0.1573)	(-4.37)
Diversification index	-1.590***	-0.727***	-0.539***	-0.467***	-0.602***	-0.603***	-0.580***	-0.829***
	(-4.78)	(-6.15)	(-9.62)	(-10.2)	(-6.59)	(-8.6622)	(-11.5962)	(-14.4)
Loan loss provisions/Total assets	6.217**	-3.052***	-7.716***	-3.926***	-3.374***	-4.878***	-4.038***	-10.89**
	(2.29)	(-2.59)	(-9.65)	(-8.82)	(-3.17)	(-7.3576)	(-6.0544)	(-2.46)
Country-specific variables								
Herfindahl Hirschman index	-1.071	-0.588***	-0.0986	0.791	-0.473***	-0.263**	-0.270**	-1.972***
	(-0.47)	(-4.07)	(-0.70)	(1.41)	(-5.79)	(-1.9606)	(-2.3604)	(-6.81)
Banking system assets (log)	-0.0421*	0.0292***	0.0646***	0.00106	0.0418***	0.00271	0.0138***	-0.0400***
	(-1.80)	(3.19)	(5.68)	(0.22)	(7.11)	(0.3639)	(3.4770)	(-7.14)
GDP per capita (log, t-2)	0.381	0.567*	-0.507	1.835***	0.00557	0.0438	0.840***	0.0160
	(0.12)	(1.87)	(-1.59)	(3.70)	(0.027)	(0.1270)	(3.3257)	(0.26)
Unemployment (t-2)	0.273***	-0.0238***	-0.0258***	0.0179***	-0.0329***	-0.00820*	0.00185	-0.00123
	(5.55)	(-3.41)	(-4.79)	(4.55)	(-6.80)	(-1.8679)	(0.5726)	(-0.25)
Competition indicator								
Boone indicator	78.89***	-9.675***	-5.579***	-10.76***	-2.407*	-4.975***	-7.251***	-10.94***
	(2.68)	(-3.22)	(-5.99)	(-11.3)	(-1.91)	(-5.0625)	(-8.4433)	(-16.6)
Time effect								
Time trend	-0.0898**	0.0209***	0.0357***	0.0159**	0.0319***	0.0297***	0.0228***	0.0382***
	(-2.21)	(3.40)	(7.98)	(2.52)	(7.41)	(5.9928)	(5.6355)	(19.3)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11450	2855	5628	9085	17568	6948	10620	17965
Number of banks	2462	535	845	1548	2928	772	2156	3325
R^2	0.3180	0.2305	0.3969	0.2870	0.3529	0.2950	0.2435	n/a
Andersen Test χ^2	11.711***	66.008***	1107.133***	3489.431***	1312.030***	338.942***	485.193***	n/a
Hansen *J-Test* χ^2	1.790	4.169**	0.360	0.610	0.138	7.815***	0.709	n/a
Wald Test of exogeneity χ^2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17.53***
Wald model $\chi 2$	82.61***	26.71***	85.97***	182.80***	53.75***	86.00***	70.47***	3163.83***

In column (1), we use the level of non-performing loans to total loans on the country level as dependent variable (obtained from International Financial Statistics). Column (2), (3), and (4) constrain the sample to commercial, savings, and cooperative banks respectively. In column (5), we use the inverse of the variance of the Boone indicator as a weight to account for the generated regressor problem. Columns (6) and (7) adjust our sample for industry composition. We constrain the sample to banks that do not exit the dataset during the entire sampling period in column (6), whereas column (7) excludes banks that exit the market at any point in time. In column (8) we use a two-stage Tobit model. All models use an interaction term of market share and loan growth, and Financial Freedom as instruments for the Boone indicator. Robust z statistics in parentheses, all standard errors are clustered on the bank level. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1.

Panel B: U.S. sample			
Estimator	**Two-stage least squares**		**Two-stage Tobit**
	(1)	***(2)***	***(3)***
Model setup	***Aggregate Non-performing loans/Total loans***	***Adjustment for generated regressor problem***	***IV Tobit***
Bank specific-variables			
Total assets (log)	0.0001	0.309	-0.167
	(0.3424)	(1.6214)	(-0.2671)
Asset growth	0.0009	-0.664	-0.422
	(0.5602)	(-0.7937)	(-0.4345)
Diversification index	0.0038	-5.243***	-9.459*
	(1.0867)	(-3.2276)	(-1.8125)
Loan loss provisions/Total assets	-0.907	-551.0*	1431
	(-0.8499)	(-1.8617)	(1.0725)
Country-specific variables			
Herfindahl-Hirschman index	0.0011	-0.968*	1.325
	(0.7893)	(-1.7068)	(1.0277)
Total banking system assets (log)	0.0001	0.329	1.046
	(0.3290)	(1.4443)	(1.0000)
Personal income (log, t-2)	2.90e-08	-0.000190***	-0.000231**
	(0.2780)	(-3.2178)	(-2.4626)
Unemployment (t-2)	0.0002	-0.191**	1.139*
	(0.7097)	(-2.0220)	(1.7544)
Competition indicator			
Boone indicator	0.0027**	-2.564***	-4.519***
	(2.3658)	(-2.6265)	(-2.7588)
Observations/Number of banks	382	382	382
R^2	0.1170	n/a	n/a
Anderson Test χ^2	9.205**	23.732***	n/a
Hansen J-Test χ^2	3.735*	27.727***	n/a
Wald test of exogeneity χ^2	n/a	n/a	8.04***
F-Test model χ^2/Wald model χ^2	42.65***	12.13***	38.48***

In column (1), we use the level of non-performing loans to total loans on the country level as dependent variable (calculated by the authors). Column (2) and (3) use the Z-score (log) as dependent variable. We report 2SLS estimates in column (1) and (2) and use a Tobit model with instruments in column (3). As instruments we use county population (log), and an interaction term of market share and loan growth for the Boone indicator. Robust t statistics in parentheses. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 1: Summary statistics

Panel A: European data					
Variable	Obs	Mean	Std. Dev.	Min	Max
Z-score	17965	29.596	22.859	5.201	257.506
Total assets (TEUR)	17965	1374203	3636810	11131	113000000
Total assets (log)	17965	13.156	1.308	9.317	18.542
Asset growth	17965	0.069	0.221	-0.868	4.974
Diversification index	17965	0.588	0.113	0.068	0.999
Loan loss provisions/Total assets	17965	0.004	0.005	-0.058	0.438
Herfindahl-Hirschman index	17965	0.006	0.019	0.000	0.206
Total banking system assets (log)	17965	21.549	1.174	17.363	23.199
GDP per capita	17965	23247.610	4697.686	17564.960	48837.730
Unemployment	17965	0.082	0.024	0.002	0.123
Boone indicator	17965	-0.030	0.015	-0.123	-0.012
Financial Freedom	17965	60.376	13.723	50	90
Loan growth	17965	0.084	0.307	-0.934	19.714
Market share	17965	0.001	0.007	0.000	0.120
Panel B: U.S. data					
Z-score	382	49.024	95.651	0.773	564.980
Total assets (TUSD)	382	64731	2.521	3261	1414095
Total assets (log)	382	11.078	0.925	8.090	14.162
Asset growth	382	0.052	0.187	-0.256	3.192
Diversification index	382	0.488	0.094	0.078	0.916
Loan loss provisions/Total assets	382	0.000	0.001	-0.002	0.004
Herfindahl-Hirschman index	382	0.1691	0.1044	0.0878	0.8742
Total banking system assets (log)	382	13.470	0.520	12.562	15.025
Personal income	382	26767.580	3104.245	19940.000	38582.000
Unemployment	382	5.480	1.418	2.800	8.700
Boone indicator	382	-0.0141	0.0105	-0.063	-0.001
Financial Freedom	382	90.000	0.000	90.000	90.000
Loan growth	382	0.097	0.212	-0.270	3.422
Market share	382	0.125	0.106	0.005	0.690

Table 2: Boone indicators and other characteristics of competition

Panel A: European sample

Country	N	Boone indicator	Activity restrictions	Entry denied	Stock market value/GDP	Insurance premiums/GDP	H-Statistic	Financial Freedom index	Government ownership
Austria	136	-0.031	1.583	0.022	0.070	0.057	0.522	70.8	0
Belgium	29	-0.055	2.083	0	0.172	0.085	0.585	70	0
Denmark	53	-0.031	2.250	0.079	0.361	0.069	0.310	77.9	0
France	162	-0.021	1.750	0	0.537	0.090	0.430	50	0
Germany	1388	-0.022	1.583	0	0.460	0.066	0.456	52.3	42.2
Italy	410	-0.042	2.666	0.186	0.394	0.058	0.390	70	10
Luxembourg	67	-0.032	1.750	0	0.026	0.310	0.855	79.3	5.05
Netherlands	11	-0.073	1.500	0	1.207	0.095	0.970	90	3.9
Switzerland	215	-0.062	1.666	0.004	1.895	0.119	0.591	90	14.12
UK	43	-0.076	1.166	0	1.082	0.137	0.590	90	0
	Correlation		0.335	0.156	-0.666	-0.050	-0.521	-0.812	0.279
	R^2 (1)		0.112	0.024	0.443	0.003	0.272	0.660	0.078
	R^2 (2)						0.807		

We report mean values of the variables for the European countries in Panel A for 1995-2005. The H-Statistics are calculated by regressing the ratio of interest revenue to total assets on the ratio of interest expenses to total deposits (proxy for funding costs), personnel expenses to total assets (proxy for labor cost), administrative expenses to total assets (proxy for price of fixed capital), and control variables (loans to total assets, equity to total assets, bank size, and year dummies), whereby all financial variables enter the regression in logs. The insurance premiums/GDP are taken from the updated database provided by Beck et al. (2000). The Financial Freedom Index is obtained from the Heritage Foundation. The data for government ownership, the proportion of entry applications denied, and for activity restrictions are taken from the updated database provided by Barth et al. (2001). Entry denied is the ratio of the number of entry applications by domestic and foreign banks into the industry relative to total entry applications. Activity restrictions is an index that takes on values between 1 and 4 that provides information about whether banks can engage in securities, real estate, and insurance activities, and whether banks can hold stakes in non-financial firms. Larger values indicate more restrictions. We use the average value of the three surveys taken by Barth et al. (2001) for the calculations of the variables entry denied and activity restrictions. We present correlation coefficients between the Boone indicators and the other variables, and R^2 (1) OLS regression statistics of the Boone indicator on the respective variables to examine how much variation in the Boone indicator is explained by the other measures of market structure and competition. The final row presents the coefficient of determination R^2 (2) for an OLS regression of the Boone indicator on Activity restrictions, Entry denied, Stock market value/GDP, Insurance premiums/GDP, H-Statistic, Financial Freedom Index, and government ownership.

Panel B: U.S. sample

County	N	Boone indicator	H-Statistic	Branches/Population
Adams, IL	11	-0.013	0.316	*0.433*
Benton, IA	7	-0.016	0.274	*0.267*
Bremer, IA	9	-0.010	0.376	*0.639*
Brown, MN	8	-0.063	0.697	*0.306*
Buffalo, NE	7	-0.022	0.339	*0.249*
Caddo, OK	7	-0.017	0.262	*0.807*
Carroll, IA	8	-0.010	0.307	*1.003*
Christian, IL	8	-0.001	0.125	*0.373*
Clayton, IA	7	-0.007	0.134	*0.726*
Cole, MO	7	-0.007	0.193	*0.220*
Dodge, WI	7	-0.010	0.163	*0.194*
Faribault, MN	8	-0.033	0.146	*0.593*
Fayette, TX	7	-0.007	0.157	*1.566*
Goodhue, MN	7	-0.012	0.527	*0.287*
Grant, WI	8	-0.018	0.355	*0.468*
Hancock, IL	9	-0.008	0.306	*0.838*
Iroquois, IL	11	-0.013	0.419	*0.657*
Jackson, IL	7	-0.011	0.316	*0.186*
Jefferson, WI	8	-0.012	0.337	*0.228*
Kandiyohi, MN	10	-0.007	0.318	*0.341*
Lee, IA	7	-0.031	0.353	*0.608*
Litchfield, CT	9	-0.003	0.285	*0.191*
Livingston, IL	11	-0.007	0.346	*0.542*
Lyon, KS	7	-0.013	0.303	*0.306*
Macoupin, IL	8	-0.006	0.256	*0.206*
Marshall, KS	7	-0.034	0.629	*1.946*
Martin, MN	10	-0.020	0.746	*0.578*
McPherson, KS	7	-0.011	0.278	*0.581*
Medina, TX	7	-0.021	0.302	*0.235*
Montgomery, IL	9	-0.016	0.229	*1.301*
Mower, MN	7	-0.018	0.910	*0.340*
Randolph, IL	7	-0.004	0.234	*0.484*
Renville, MN	8	-0.001	0.240	*0.665*
Saunders, NE	11	-0.012	0.087	*0.741*
Sioux, IA	9	-0.009	0.422	*0.814*
Stephenson, IL	10	-0.013	0.284	*0.316*
Story, IA	9	-0.003	0.804	*0.219*
Sumner, KS	10	-0.011	0.297	*0.450*
Trempealeau, WI	8	-0.010	0.336	*0.761*
Vermilion, IL	9	-0.012	0.248	*0.195*
Vermilion, LA	7	-0.010	0.261	*0.382*
Vernon, WI	7	-0.022	0.606	*0.730*
Wood, WI	7	-0.009	0.334	*0.228*
	Correlation		*-0.395*	*-0.135*
	R^2 (1)		*0.156*	*0.018*
	R^2 (2)		*0.174*	

We report cross-sectional results for local banking markets in selected rural areas in the U.S. in Panel B for 2005. The H-Statistics are calculated by regressing the ratio of interest revenue to total assets on the ratio of interest expenses to total deposits (proxy for funding costs), personnel expenses to total assets (proxy for labor cost), administrative expenses to total assets (proxy for price of fixed capital), and control variables (loans to total assets, equity to total assets, and bank size, whereby all financial variables enter the regression in logs. We present correlation coefficients between the Boone indicators and the other variables, and R^2 (1) OLS regression statistics of the Boone indicator on the respective variables to examine how much variation in the Boone indicator is explained by the other features of competition. The variable branches/population captures the number of branch offices per 1,000 inhabitants. The final row presents the coefficient of determination R^2 (2) for an OLS regression of the Boone indicator on the H-Statistic, and on branch density. In these regressions, n=43.

Table 3: The effect of competition on efficiency

	Panel A: European Sample				Panel B: Local U.S. markets			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Estimator	*Fixed effects*	*Fixed effects*	*Two-stage least squares*	*Two-stage least squares*	*OLS*	*OLS*	*Two-stage least squares*	*Two-stage least squares*
Dependent variable	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*	*Cost efficiency*
Competition indicator								
Boone indicator	-0.101**	-0.139**	-3.017***	-3.599***	-0.0089***	-0.0086***	-0.0374**	-0.0461**
	(-2.09)	(-2.44)	(-12.4)	(-11.6)	(-2.72)	(-2.68)	(-2.24)	(-2.50)
Bank-specific variables								
Market share		0.132		-0.167		-0.0110		0.0383
		(1.11)		(-1.07)		(-0.12)		(0.25)
Total assets (log)		0.0010		-0.0080***		0.0078		-0.0001
		(0.60)		(-2.75)		(0.59)		(-0.0007)
Asset growth		-0.0095***		-0.0095***		0.0141		0.0086
		(-5.57)		(-3.63)		(0.46)		(0.28)
Asset growth squared		0.0032***		0.0023		-0.0007		-0.0007
		(4.62)		(1.01)		(-0.42)		(-0.41)
Country-specific variables								
HHI		-0.0079		0.172***		-0.0020		-0.0195
		(-0.33)		(5.48)		(-0.043)		(-0.41)
Banking system assets (log)		-0.0022*		-0.0178***		-0.0047		0.0051
		(-1.86)		(-8.29)		(-0.33)		(0.25)
Time effect								
Time trend	0.0010***	0.0014***	0.0080***	0.0111***				
	(6.55)	(6.32)	(11.6)	(10.9)				
Observations	16646	16646	16230	16230	378	378	378	378
Number of banks	3161	3161	2745	2745	378	377	377	377
R2	0.0090	0.0167	0.0514	0.0461	0.0228	0.0265	0.0307	0.03723
Durbin-Wu-Hausmann test $\chi 2$	n/a	n/a	511.24***	483.73***	n/a	n/a	4.34	6.45**
Anderson Test $\chi 2$	n/a	n/a	245.686***	192.937***	n/a	n/a	21.538***	18.492***
Hansen J-Test $\chi 2$	n/a	n/a	1.522	2.557	n/a	n/a	0.472	0.003
F-Test model $\chi 2$	36.62***	13.36***	89.39***	22.35***	7.40***	14.66***	4.97**	10.52***

Panel A reports results for the European sample. In column (1) and (2) we use fixed effects panel models. Column (3) and (4) in Panel A use 2SLS estimators and we instrument the Boone indicator with lagged values of Financial Freedom, and lagged interactions term between market share and loan growth. We presents results for the sample of rural U.S. markets in Panel B. Column (1) and (2) in Panel B use OLS, and column (3) and (4) in Panel B use 2SLS whereby we instrument the Boone indicator with lagged values of population (log) and an lagged interaction term between market share and loan growth. Robust t statistics in parentheses, standard errors are clustered on the bank level in Panel A. Explanatory variables lagged by one period unless stated otherwise.*** p<0.01, ** p<0.05, * p<0.1.

Table 4: The effect of competition on bank soundness in Europe

Estimator	*Fixed effects*		*Two-stage least squares*		*Two-stage least squares*		*Two-stage least squares*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Model setup	***Bank level variables***	***Bank and macro variables***	***Bank level variables***	***Bank and macro variables***	***Small banks***	***Large banks***	***Capital ratio***	***ROA***	***S.D. ROA***
Bank-specific variables									
Total assets (log)	-0.2044***	-0.201***	-0.2198***	-0.206***	-0.260***	-0.179***	-0.0213***	-0.00166***	-0.000481***
	(-15.26)	(-14.4)	(-14.86)	(-14.7)	(-15.4665)	(-8.9927)	(-10.8085)	(-4.9999)	(-2.8945)
Asset growth	-0.0003	-0.0108	0.0211*	-0.00667	0.0421**	-0.0247	0.000527	-0.000340	0.000216*
	(-0.04)	(-1.04)	(1.79)	(-0.61)	(2.5499)	(-1.6325)	(0.4867)	(-1.3216)	(1.9150)
Diversification index	-0.5871***	-0.597***	-0.5846	-0.597***	-0.508***	-0.712***	-0.0494***	-0.00664***	-0.00162***
	(-14.21)	(-14.6)	(-13.79)	(-14.6)	(-12.0394)	(-10.3251)	(-9.3551)	(-6.1621)	(-2.8602)
Loan loss provisions/Total assets	-4.2818***	-4.366***	-3.6263***	-4.208***	-3.839***	-5.777***	-0.0308	-0.256***	0.0216***
	(-8.83)	(-8.82)	(-7.87)	(-8.59)	(-6.1546)	(-9.4032)	(-0.4824)	(-10.5435)	(3.0887)
Country-specific variables									
Herfindahl Hirschman index	-0.2900***	-0.290***	-0.1086	-0.238***	0.0295	-0.869***	-0.0464***	-0.00670*	-0.00382*
	(-3.63)	(-3.55)	(-1.16)	(-2.73)	(0.3487)	(-4.1903)	(-3.9309)	(-1.8943)	(-1.9564)
Banking system assets (log)	0.0079**	0.00925***	0.0021	0.00713**	0.00621	0.0198***	0.00115***	-6.49e-05	3.16e-05
	(2.28)	(2.60)	(0.57)	(2.03)	(1.6298)	(3.2887)	(2.8599)	(-0.6208)	(0.5715)
GDP per capita (log, t-2)		0.476**		0.521**	0.691***	0.138	0.0421***	-0.000625	0.00223
		(2.33)		(2.46)	(2.8416)	(0.4833)	(3.1272)	(-0.1611)	(1.2868)
Unemployment (t-2)		0.000342		-0.000906	0.00402	-0.0167***	0.000280	-0.000389***	0.000131***
		(0.12)		(-0.35)	(1.3216)	(-4.3282)	(1.0232)	(-6.2278)	(4.1485)
Competition indicator									
Boone indicator	-5.0054***	-5.263***	-9.1704***	-6.540***	-9.409***	-5.100***	-0.226***	-0.251***	-0.00432
	(-16.64)	(-16.5)	(-8.30)	(-10.5)	(-11.8104)	(-5.6167)	(-3.7455)	(-14.6569)	(-0.4592)
Time effect									
Time trend	0.0331***	0.0254***	0.0406***	0.0269***	0.0271***	0.0298***	0.00175***	0.000267***	-5.45e-05
	(28.96)	(7.60)	(16.01)	(8.40)	(6.6852)	(6.9493)	(6.6594)	(3.7913)	(-1.6240)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes			
Observations	17965	17965	17568	17568	7905	9469	17568	17568	17568
Number of banks	3325	3325	2928	2928	1658	1585	0.1904	0.1479	0.0162
R^2	0.2576	0.2610	0.2306	0.2585	0.2164	0.3043	2928	2928	2928
Durbin-Wu-Hausman test χ^2	n/a	n/a	98.99***	10.28***	85.75***	0.02	1.11	24.74***	6.31**
Anderson *Test* χ^2	n/a	n/a	512.801***	2843.872***	320.421***	523.817***	803.831***	803.831***	803.831***
Hansen *J-Test* χ^2	n/a	n/a	2.091	1.793	0.183	1.207	0.454	4.640**	1.894
F-Test model $\chi2$/Wald model $\chi2$	173.22***	167.58***	167.65***	151.83***	81.08***	99.23***	109.88***	130.97***	10.62***

Dependent variable: Z-score (log). Columns (1) and (2) report panel data models with bank-fixed effects. Columns (3) and (4) present 2SLS models using an interaction term of market share and loan growth and Financial Freedom as instruments for the Boone indicator. Columns (5) and (6) report the regressions separately for small and large banks, whereby we use the median bank size in the sample as a cut-off point. Regressions (7)-(9) use the components of the Z-score as dependent variables to understand what drives the negative relationship between the Boone indicator and the Z-scores in detail. Robust t statistics in parentheses, standard errors are clustered on the bank level. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 5: The effect of competition on bank soundness in Europe – Quantile regression estimates

Estimator	***Two-stage quantile regressions***				
Model setup	***(1)*** ***10th*** ***Quantile***	***(2)*** ***25th*** ***Quantile***	***(3)*** ***50th*** ***Quantile***	***(4)*** ***75th*** ***Quantile***	***(5)*** ***90th*** ***Quantile***
Bank-specific variables					
Total assets (log)	-0.0102*	-0.0162***	-0.0341***	-0.0403***	-0.0304***
	(-1.67)	(-3.41)	(-3.97)	(-7.79)	(-4.13)
Asset growth	-0.135***	-0.0937***	-0.0439	-0.0339	-0.0523*
	(-3.45)	(-3.58)	(-1.10)	(-1.26)	(-1.73)
Diversification index	-1.034***	-0.959***	-0.745***	-0.543***	-0.187
	(-12.0)	(-15.0)	(-6.83)	(-8.26)	(-1.62)
Loan loss provisions/Total assets	-19.86***	-20.26***	-20.61***	-18.11***	-8.469*
	(-13.4)	(-13.9)	(-10.3)	(-6.12)	(-1.65)
Country-specific variables					
Herfindahl Hirschman index	-2.685***	-2.668***	-1.564***	-1.346***	-1.117
	(-6.34)	(-6.53)	(-4.65)	(-2.92)	(-1.27)
Banking system assets (log)	-0.0180**	-0.0462***	-0.0566***	-0.0598***	-0.0660***
	(-2.22)	(-6.81)	(-8.71)	(-6.36)	(-4.34)
GDP per capita (log, t-2)	-0.377***	-0.379***	-0.128	0.309***	0.579***
	(-3.54)	(-4.54)	(-1.27)	(4.35)	(4.03)
Unemployment (t-2)	0.000320	-0.00309	-0.00771	0.00329	0.00222
	(0.035)	(-0.49)	(-0.98)	(0.67)	(0.22)
Competition indicator					
Boone indicator	-6.462***	-6.783***	-10.02***	-12.53***	-16.33***
	(-8.36)	(-11.6)	(-9.39)	(-15.2)	(-12.4)
Time effect					
Time trend	0.0390***	0.0385***	0.0446***	0.0436***	0.0505***
	(12.6)	(18.0)	(14.1)	(15.7)	(12.6)
Country dummies	Yes	Yes	Yes	Yes	Yes
Observations	17965	17965	17965	17965	17965
Number of banks	3325	3325	3325	3325	3325
R^2	n/a	n/a	n/a	n/a	n/a
Durbin-Wu-Hausman test χ^2	n/a	n/a	n/a	n/a	n/a
Anderson *Test* χ^2	n/a	n/a	n/a	n/a	n/a
Hansen *J-Test* χ^2	n/a	n/a	n/a	n/a	n/a
F-Test model $\chi2$/Wald model $\chi2$	1006.99***	2282.33***	2789.28***	2549.45***	1403.43***
F-Test for quantile coefficients			58.52***		

Dependent variable: Z-score (log). The regressions use two stage quantile regression estimators, the regression setup is as in columns (2), (4), (5) and (6) of Table 4. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 6: The effect of competition on bank soundness in local U.S. markets

Estimator	*OLS*		*Two-stage least squares*		*Two-stage least squares*		*Two-stage least squares*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Model setup	***Bank level variables***	***Bank and macro variables***	***Bank level variables***	***Bank and macro variables***	***Small banks***	***Large banks***	***Capital ratio***	***ROA***	***S.D. ROA***
Bank specific-variables									
Total assets (log)	0.143	0.156	-0.0258	-0.00313	0.432	0.980**	-0.00612**	0.000250*	-0.000168
	(1.0720)	(1.2345)	(-0.0634)	(-0.0092)	(0.6286)	(2.3037)	(-2.2558)	(1.6799)	(-0.0315)
Asset growth	0.760**	0.385	-0.240	-0.0232	-2.963	1.067*	-0.0174*	0.000326	-0.00259
	(2.2588)	(1.1399)	(-0.3849)	(-0.0459)	(-0.8012)	(1.6666)	(-1.7991)	(1.1090)	(-0.3133)
Diversification index	-3.226***	-3.694***	-6.393**	-6.630**	-12.99***	-1.182	-0.114***	-0.00139	0.0962**
	(-2.6721)	(-3.0244)	(-2.0690)	(-2.3988)	(-2.7669)	(-0.5125)	(-3.5614)	(-1.0340)	(2.1802)
Loan loss provisions/Total assets	-297.7*	-291.8*	599.6	593.0	1742	-496.7	-2.135	-0.0595	-10.35
	(-1.9424)	(-1.8560)	(0.7707)	(0.9660)	(1.5304)	(-1.2539)	(-0.4595)	(-0.1930)	(-1.0898)
Country-specific variables									
Herfindahl-Hirschman index	-0.285	0.801	-1.492*	0.885	1.486	-0.108	0.00141	-0.00156	-0.0144
	(-0.3496)	(1.0979)	(-1.9041)	(0.9984)	(0.9369)	(-0.0648)	(0.1522)	(-0.6918)	(-0.9283)
Total banking system assets (log)	-1.145***	-0.388	0.179	0.390	0.0392	-0.479	0.0204***	0.000283**	0.000419
	(-5.5632)	(-1.5081)	(0.5836)	(1.3479)	(0.0660)	(-1.0703)	(6.4160)	(2.1690)	(0.0915)
Personal income (log, t-2)		-0.000245***		-0.000219***	-0.000265***	-0.000132*	-2.17e-06**	-9.75e-08***	3.34e-06***
		(-5.8873)		(-3.7851)	(-2.5786)	(-1.7488)	(-2.3681)	(-3.2943)	(3.4956)
Unemployment (t-2)		-0.177**		0.516**	1.084***	-0.159	0.00153	-7.60e-05	-0.00745**
		(-2.0635)		(2.5315)	(2.6705)	(-1.0738)	(0.7831)	(-0.8848)	(-2.3037)
Competition indicator									
Boone indicator	-0.0735*	-0.0602	-2.693***	-2.371***	-3.499***	-0.854***	-0.0111**	-0.000383*	0.0371***
	(-1.6642)	(-1.2293)	(-4.3303)	(-4.2564)	(-3.3657)	(-2.9785)	(-2.0708)	(-1.9590)	(4.1930)
Observations/Number of banks	382	382	382	382	273	109	382	382	382
R^2	0.1015	0.1740	0.2191	0.2938	-2.7564	0.1134	0.8911	0.7516	0.0588
Durbin-Wu-Hausmann test χ^2	n/a	n/a	68.71***	48.64***	55.44***	13.66***	129.49***	2.55	4.08**
Anderson Test χ^2	n/a	n/a	26.610***	24.404***	7.112*	22.981***	24.404	24.404***	24.404***
Hansen J-Test χ^2	n/a	n/a	7.241**	6.871**	5.182*	5.675*	11.863***	2.869	8.679*
F-Test model χ^2/Wald model χ^2	9.23***	10.21***	8.72***	12.38***	7.79***	6.07***	426.69***	219.72***	53.29***

Dependent variable: Z-score (log). Column (1) and (2) report OLS estimates. Columns (3) and (4) use 2SLS models using county population (log), and an interaction term of market share and loan growth for the Boone indicator. Columns (5) and (6) present the regressions separately for small and large banks, whereby we use the median bank size in the sample as a cut-off point. Regressions (7)-(9) use the components of the Z-score as dependent variables to understand what drives the negative relationship between the Boone indicator and the Z-scores in detail. Robust t statistics in parentheses. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Table 7: The effect of competition on bank soundness in local U.S. markets – Quantile regressions

Estimator	***Two-stage quantile regressions***				
Model setup	***(1) 10th Quantile***	***(2) 25th Quantile***	***(3) 50th Quantile***	***(4) 75th Quantile***	***(5) 90th Quantile***
Bank specific-variables					
Total assets (log)	-0.0129	-0.0260	-0.0161	0.125	-0.0587
	(-0.2604)	(-0.5120)	(-0.0646)	(0.2180)	(-0.1218)
Asset growth	-0.301	-0.292	-0.290	0.00824	-0.322
	(-0.9399)	(-0.7192)	(-0.2489)	(0.0031)	(-0.1554)
Diversification index	-1.232***	-1.509***	-2.856	-11.08**	-5.707
	(-2.5889)	(-2.7373)	(-0.8087)	(-2.0598)	(-1.3936)
Loan loss provisions/Total assets	55.45	13.91	135.2	1162	699.5
	(0.5314)	(0.1197)	(0.1996)	(0.8648)	(0.6431)
Country-specific variables					
Herfindahl-Hirschman index	0.269	0.175	0.328	-0.963	-2.540
	(1.0919)	(1.1412)	(0.2668)	(-0.3540)	(-0.7890)
Total banking system assets (log)	0.0660	0.0512	0.186	0.438	0.706
	(0.7359)	(0.4775)	(0.4023)	(0.4528)	(0.8104)
Personal income (log, t-2)	0.0000	-0.0001**	-0.0001	-0.0002*	-0.0002**
	(-1.3430)	(-2.2627)	(-0.7347)	(-1.8059)	(-2.1424)
Unemployment (t-2)	0.0662	0.0292	0.137	0.956*	0.755
	(1.5149)	(0.5681)	(0.4172)	(1.6630)	(1.3333)
Competition indicator					
Boone indicator	-0.236*	-0.201	-0.779	-3.913**	-2.953*
	(-1.6743)	(-1.1656)	(-0.6219)	(-2.3154)	(-1.6518)
Observations/Number of banks	382	382	382	382	382
R^2	n/a	n/a	n/a	n/a	n/a
Durbin-Wu-Hausmann test χ^2	n/a	n/a	n/a	n/a	n/a
Anderson Test χ^2	n/a	n/a	n/a	n/a	n/a
Hansen J-Test χ^2	n/a	n/a	n/a	n/a	n/a
F-Test model χ^2/Wald model χ^2	12.43	23.50***	1.61	27.50***	55.93***
F-Test for quantile coefficients			8.14*		

Dependent variable: Z-score (log). Column We report two-stage quantile regression estimates based on the regression setup in columns (2), (4), (5), and (6) in Table 6. Explanatory variables lagged by one period unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Boone indicators in European countries

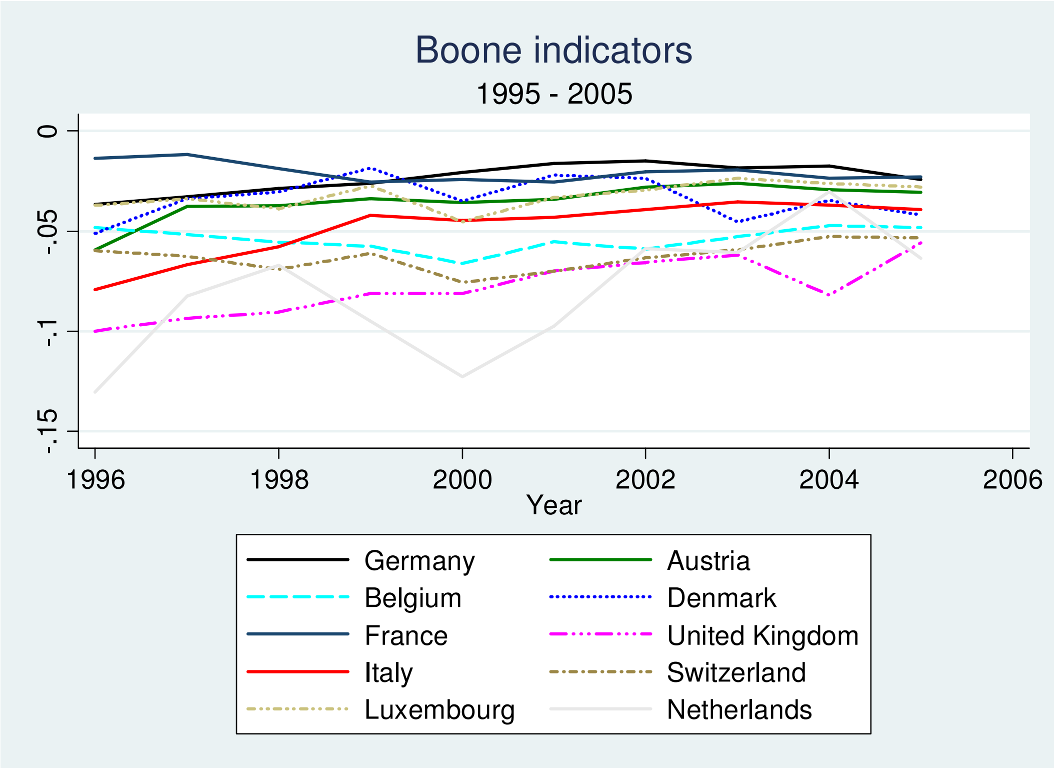

Figure 2: Boone indicators in banking markets in the U.S.

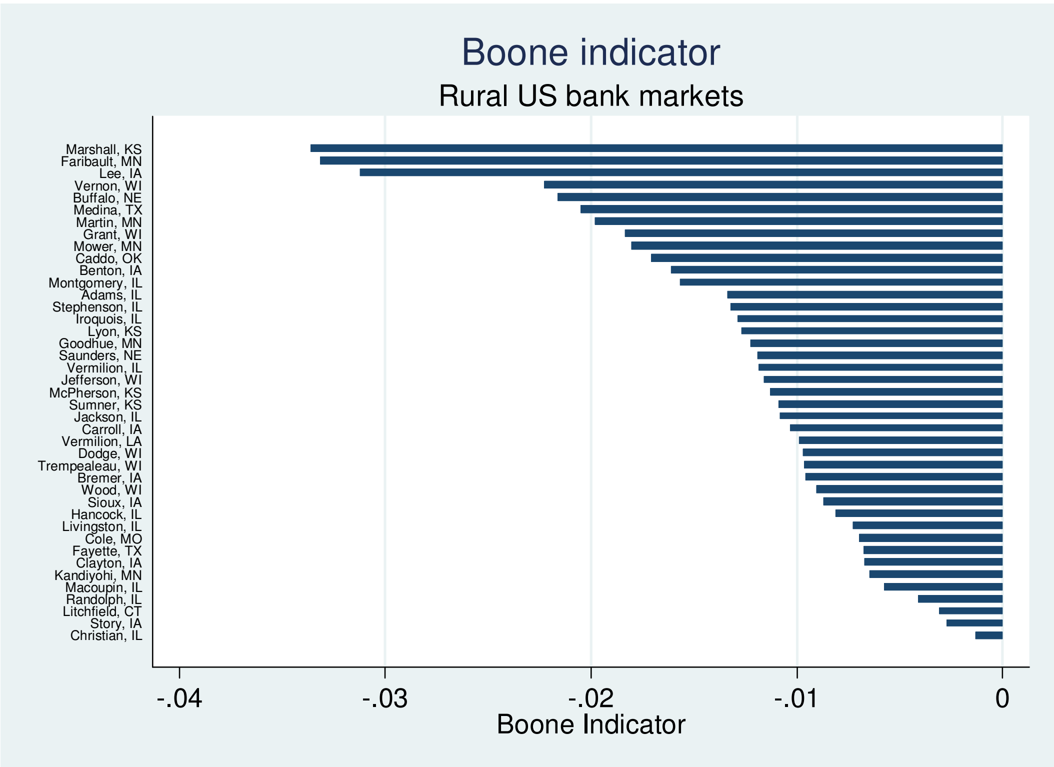

Figure 3: Quantile regression estimates of Boone indicator (European sample)

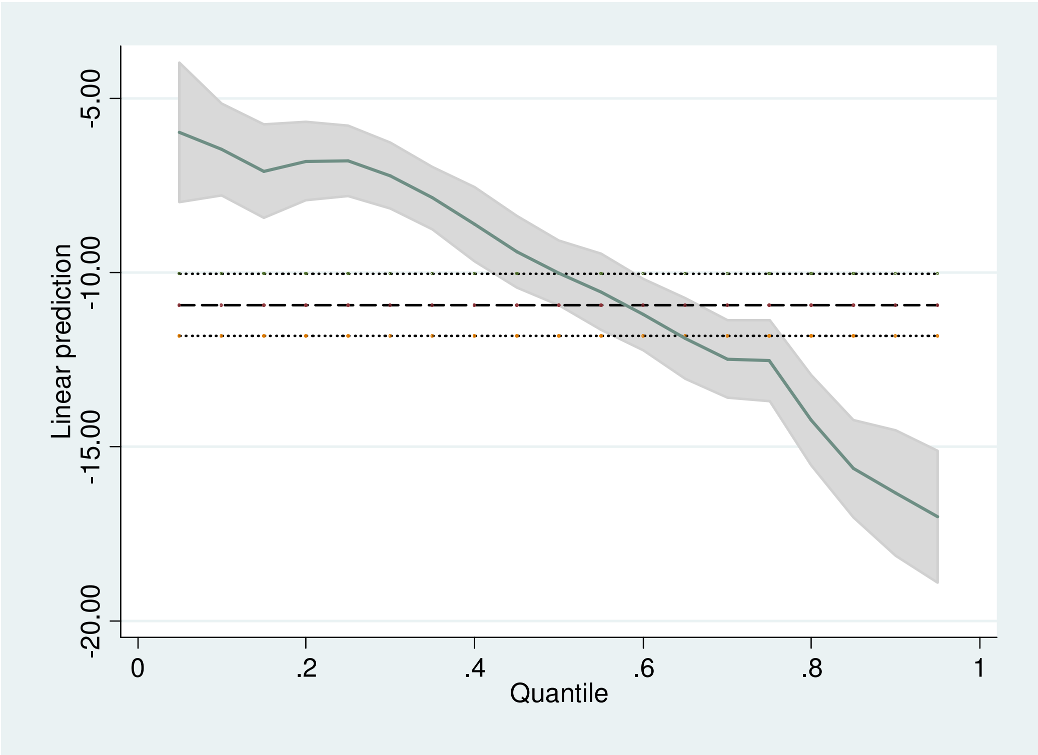

Figure 4: Quantile regression estimates of Boone indicator (U.S. sample)