EUROPEAN CENTRAL BANK

EUROSYSTEM

ECB LAMFALUSSY FELLOWSHIP PROGRAMME

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NO 932 / SEPTEMBER 2008

HOW DOES COMPETITION AFFECT EFFICIENCY AND SOUNDNESS IN BANKING?

NEW EMPIRICAL EVIDENCE

by Klaus Schaeck
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In 2008 all ECB publications feature a motif taken from the €10 banknote.

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Abstract

A growing body of literature indicates that competition increases bank soundness. Applying an industrial organization based approach to large data sets for European and U.S. banks, we offer new empirical evidence that efficiency plays a key role in the transmission from competition to soundness. We use a two-pronged approach. First, we employ Granger causality tests to establish the link between competition and measures of profit efficiency in banking, and find that competition indeed increases bank efficiency. Second, building on these results, we examine the relation between the Boone indicator [Boone, J. (2001) Intensity of competition and the incentive to innovate. IJIO, Vol. 19, pp. 705-726], an innovative measure of competition that focuses on the impact of competition on performance of efficient banks, and relate this measure to bank soundness. We find evidence that competition robustly increases bank soundness, via the efficiency channel.

Keywords: bank competition, efficiency, soundness; market structure; regulation

JEL Classification: *G21; G28; L11*

Non-technical Summary

This paper investigates a possible transmission mechanism by which higher competition can contribute to increased bank soundness. A large body of literature investigates the nexus between competition and bank soundness. While the relevant literature points towards negative-trade offs between competition and bank soundness (e.g., Keeley, 1990; Hellmann, Murdock, and Stiglitz, 2000; Hauswald and Marquez, 2006), more recent theoretical and empirical studies (e.g., Koskela and Stenbacka, 2000; Beck, Demirgüç-Kunt, and Levine, 2006; Carletti, Hartmann, and Spagnolo, 2007) report beneficial effects of bank competition on bank soundness. However, these studies do not analyze the underlying transmission mechanism by which competition can contribute to enhanced bank soundness. The current paper aims to fill this gap by focusing on efficiency as the possible conduit.

Our line of reasoning is as follows. Industrial organization literature finds that, at least among non-financial firms, competition positively affects efficiency (e.g., Tirole, 1998; Hay and Liu, 1997). At the same time, the banking literature suggests that efficient banks have incentives to engage in proper screening and monitoring of borrowers (e.g., Petersen and Rajan, 1995), and are characterized by lower levels of non-performing loans (e.g., Berger and DeYoung, 1997; Williams, 2004). To link these two lines of research, we perform two interrelated sets of analyses. First, we examine how competition among banks impacts on their efficiency, and, second, we relate a measure of competition that also captures efficiency, to bank soundness.

We collect data for Europe and the United Stats during 1995-2005. The data cover more than 3,600 banks from ten European countries, and more than 8,900 banks for the U.S. The reason for our focus on Europe is that it provides a fertile ground for analyzing the effects of changes in the intensity of competition. In the early 1990s, European banks have experienced dramatic changes in the regulatory environment aimed at creating a level playing field for competition among banks. These changes included the implementation of several EU banking directives (in particular the Second Banking Directive, which came into force on 1 January 1993) and the introduction of a 'single passport' allowing banks to operate across all EU member countries with standardized procedures for acquiring licenses, capital requirements, and supervisory guidelines. These changes in the institutional setting had substantial ramifications for competition among European banks. To cross-check the results from the European dataset, we analyze the U.S. dataset.

To analyze the transmission from bank competition to soundness, we pursue a two-step approach. In the first step, we establish the causality between competition and profit efficiency in banking. Specifically, we use Granger causality tests to examine the link between competition, measured by a Lerner index, and various measures of efficiency. The Granger causality tests indicate a positive effect of competition on measures of standard and alternative profit efficiency. When examining cost efficiency, we also find that competition positively affects cost efficiency in the U.S.

In the second step, we employ the Boone indicator (Boone, 2001), an innovative measure of competition that focuses on the impact of competition on performance of

efficient banks, and relate this measure to bank soundness. Specifically, we use instrumental variable estimation techniques and relate the Z-score (a measure of bank soundness popular in the recent literature) to the Boone indicator (an innovative measure of competition based on the idea that a competitive environment increases efficiency of a bank, and ultimately its market share). The findings from the second set of analyses indicate that increased competition robustly increases bank soundness for the European sample via the efficiency channel. Our analysis for the U.S. sample also points towards a positive effect of competition on bank soundness through the efficiency channel.

In terms of policy implications, our results suggest that policies supporting competition in banking are beneficial because they are associated with increased profit efficiency. In other words, more competitive banks will also be more successful in allocating resources more efficiently to society. Our analysis gives empirical support to pro-competition policies such as the single banking passport (which simplified cross-border operation of banks) and the third pillar of Basel II (which puts emphasis on the disclosures that the bank must make, increasing the role for market discipline in monitoring and enforcing efficiency and soundness).

"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)

I. Introduction

Recent years have been marked by a shift in theory and empirical evidence on the effect of competition on bank soundness. While the earlier literature points predominately towards a negative trade-off between competition and bank soundness (e.g., Keeley, 1990; Hellmann, Murdock, and Stiglitz, 2000; Hauswald and Marquez, 2006), recent theory and evidence suggest a positive link between the two (Koskela and Stenbacka, 2000; Beck, Demirgüç-Kunt, and Levine, 2006; Boyd and de Nicolò, 2005; Schaeck, Čihák, and Wolfe, 2006; Carletti, Hartmann, and Spagnolo, 2007; Schaeck and Čihák, 2007).[1]

In this paper, we investigate the transmission mechanism by which competition translates into greater degrees of soundness, and provide further evidence for the positive link between the two. To this end, we utilize an innovative measure of competition, the Boone (2001) indicator, which allows us to offer an industrial organization-based explanation for the positive impact of competition on banking soundness.

Industrial organization literature indicates that competition increases efficiency of firms (e.g., Tirole, 1998). At the same time, the banking literature suggests that more efficient banks have better screening and monitoring procedures in place, and are consequently less likely to suffer from non-performing loans (e.g., Petersen and Rajan, 1995; Berger and DeYoung, 1997; Williams, 2004). Based on these arguments, we hypothesize that efficiency could be the conduit through which competition makes banks more financially sound.

The correct identification of the underlying transmission mechanism by which competition translates into bank soundness has important bearing for safety and soundness regulation. First, uncovering the primary transmission channel allows focusing regulatory and supervisory actions more precisely. Second, policymakers will obtain feedback on i) how changes in the regulatory environment affect bank efficiency, and ii) on how efficiency affects bank soundness. Third, the findings from our analyses indicate possible directions for future policymaking regarding competition in banking.

We use a two-pronged approach to investigate the envisaged transmission mechanism from competition to soundness. First, to examine a direct link between competition and efficiency, we employ Granger causality tests to examine the link between competition, measured by a Lerner index, and efficiency.[2] The benefit of Granger causality analysis is that it permits examining the intertemporal relation between competition and efficiency. Second, we analyze the effect of competition, through efficiency, on bank soundness. For this analysis, we use the Boone (2001) indicator, an innovative measure of competition developed in the industrial organization literature. This indicator is based on the

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[1] Carletti and Hartmann (2003) and Berger et al. (2004) offer detailed review articles on the links between competition, concentration and stability in banking.

[2] Recent work by Casu and Girardone (2007) examines the link between cost efficiency and Lerner indices for commercial banks in Europe. Their findings indicate that the effect of competition on cost efficiency is not clear-cut. In contrast, Koetter, Kolari, and Spierdijk (2008) use efficiency adjusted Lerner indices and find robust evidence that banks with more market power are the most efficient ones.

efficiency hypothesis developed by Demsetz (1973) and gauges the strength of the relation between efficient banks (measured in terms of their marginal costs) and performance (measured in terms of bank market shares).

We examine our hypotheses using two datasets: a European dataset with more than 3,600 banks, and a U.S. dataset with more than 8,900 banks; both samples cover the period 1995–2005. We cover Europe because it provides a fertile ground for analyzing the effects of changes in the intensity of competition. In the early 1990s, European banks have experienced dramatic changes in the regulatory environment aimed at creating a level playing field for competition among banks. These changes included the implementation of several EU banking directives (in particular the Second Banking Directive, which came into force on 1 January 1993) and the introduction of a 'single passport' allowing banks to operate across all EU member countries with standardized procedures for acquiring licenses, capital requirements, and supervisory guidelines. These changes in the institutional setting had substantial ramifications for competition among European banks. To cross-check the results from the European dataset, we analyze the U.S. dataset.

Our results from the Granger causality tests provide evidence that increases in competition precede increases in bank profit efficiency in Europe and in the U.S. We also find evidence that competition positively affects cost efficiency in the U.S. These findings are largely insensitive to the way efficiency is measured, and robust to using alternative lag structures, and controlling for other factors that determine efficiency.

The analysis using the Boone indicator is in line with the hypothesis that the positive effect of competition on bank soundness reflects increases in bank efficiency. An important policy implication of our results is that policies promoting bank competition may have a positive impact on efficiency and soundness. Examples of such pro-competition policies include the single banking passport (which simplified cross-border operation of banks) and the third pillar of Basel II (which greatly increases the disclosures that the bank must make, increasing the role for market discipline in monitoring and enforcing efficiency and soundness).

The structure of the paper is the following. We present our hypotheses in Section II. Section III provides an overview of the dataset, the variables used to measure competition and efficiency, and the estimation procedures. Section IV reports the empirical results. Section V offers concluding remarks.

II. Hypotheses on Competition and Efficiency

Based on industrial organization theory, and informed by the empirical banking literature, we develop hypotheses for the relation between competition and efficiency. We focus on competition as the starting point because we are interested in how competition affects bank soundness.

The 'Competition-Efficiency' Hypothesis

Under the 'competition-efficiency' hypothesis, increases in competition precipitate increases in profit efficiency. This hypothesis is adapted from the efficient structure hypothesis proposed by Demsetz (1973). Consider an exogenous shock (e.g., deregulation under the Second EU Banking Directive) that forces banks to minimize costs, offer services at lower prices, and at the same time forces them to increase profits, e.g. through shifts in outputs.[3] Efficient banks (i.e. those with superior management and production technologies, that translate into higher profits) will increase in size and market share at the expense of less efficient banks. This is likely to lead to higher market concentration (Vander Vennet, 2002). In contrast, uncompetitive markets allow bank managers to enjoy a 'quiet life' whereby costs are not kept under control, leading to lower levels of efficiency (e.g., Pagano, 1993; Berger and Hannan, 1998). Under this hypothesis, we expect competition to Granger cause efficiency.[4]

The 'Competition-Inefficiency'-Hypothesis is the alternative to the 'competition-efficiency' hypothesis. It suggests that competition leads to a decline in bank efficiency. There are several reasons for why this might be the case. First, higher competition is likely to be associated with less stable, shorter relationships between customers and banks (Boot and Schmeits, 2005) as customers' propensity to switch to other providers increases in more competitive environments. This phenomenon will amplify information asymmetries that require additional resources for screening and monitoring borrowers. Second, since banks can expect a shorter duration of bank relationships in a competitive environment, they are likely to reduce relationship-building activities, which inhibits the reusability and value of information (Chan, Greenbaum, and Thakor, 1986). Taken together, these arguments suggest a reduction in the value of proprietary information held by banks, meaning that banks incur greater expenses in retaining old and attracting new customers through investments into ATMs, new information systems, and aggressive marketing efforts. Evanoff and Örs (2002), DeYoung, Hasan, and Kirchhoff (1998), and Kumbhakar et al. (2001) provide some empirical evidence for adverse effects of competition on bank efficiency. Thus, the alternative hypothesis implies that competition Granger causes decreases in bank efficiency.

In evaluating the 'competition-efficiency'-hypothesis, we primarily focus on profit efficiency because the concept of profit efficiency is more closely aligned with the goal of profit maximization in that it requires that just as much managerial attention is paid to raising a marginal dollar of revenue as is paid to decreasing a marginal dollar of cost (Berger and Mester, 1997) (see Section III for a further discussion).

The 'Prudent and Efficient Management'-Hypothesis

The *'prudent and efficient management'* provides a rationale for the 'competition-efficiency' hypothesis. The theoretical underpinnings for the 'competition-efficiency' hypothesis can be found in a range of studies. In particular, Petersen and Rajan (1995) argue that in institutions exposed to more intensive competition, screening and monitoring procedures are more sophisticated, whereas banks in monopolistic markets spend less on monitoring. Similarly, Chen (2007) develops a theoretical model showing that competitive banks have better screening and monitoring procedures in place and are therefore less likely to suffer from nonperforming loans. This result is obtained since less risky borrowers have an incentive to obtain financing from a bank that can differentiate

[3] This interpretation also suggests that resources are more efficiently allocated to the benefit of society (Besanko and Thakor, 1993).

[4] In a related study, Casu and Girardone (2006) hypothesize that more efficient banks ensure the competitiveness of a banking system and examine the impact of efficiency on competition. However, their empirical findings show little evidence supporting the idea that efficiency would affect the level of competition in major European economies.

between good and bad credit risks, because good borrowers can reap benefits in the sense of better access to credit and higher credit lines. Institutions that maintain efficient monitoring and screening procedures avoid additional costs that arise in inefficient institutions due to resource-intensive monitoring of delinquent borrowers, analysis of workout arrangements, and seizing and disposing of collateral do not pose major problems in the more efficient banks. These theoretical arguments are reinforced in empirical studies by Wheelock and Wilson (1995), Berger and DeYoung (1997), Kwan and Eisenbeis (1997), and Williams (2004) who show that unsound banks suffer from high levels of inefficiency. Likewise, Koetter and Porath (2007) demonstrate that more efficient banks in Germany have lower risk and are sounder than their less efficient counterparts. We refer to this hypothesis as the 'Prudent and Efficient Management'-Hypothesis, and expect the Boone indicator to be negatively related to bank soundness.[5]

The 'Poor and Inefficient Management'-Hypothesis is the alternative to the 'Prudent and Efficient Management'-Hypothesis. This hypothesis states that competition adversely impacts bank efficiency, resulting in a negative effect on bank soundness. Consider a case where efficiency declines as outlined under the 'competition-inefficiency' hypothesis. Such institutions are preoccupied with retaining old and attracting new customers at any expense. Consequently, insufficient resources are allocated to underwriting standards, and screening and monitoring of borrowers (e.g., Dell'Ariccia and Marquez, 2005). Such banks are unlikely to employ sophisticated credit scoring models and might lack skills in appropriately assessing the value of collateral. This results in a high proportion of loans with low or negative net present values, which ultimately affects bank soundness negatively. Thus, inadequate underwriting standards and insufficient resources devoted to increasing profits result in increased inefficiencies, which is likely to give rise to unsound bank operations. Berger and DeYoung (1997) offer evidence that poor management, reflected in banking inefficiencies, precedes higher levels of nonperforming loans. Similarly, DeYoung (1997) finds that asset quality and efficiency are related via management quality. Under this alternative hypothesis, the Boone indicator would enter the regression equations positively.

III. Data and Methodology

Data

We use two datasets, both covering the period 1995–2005: a European dataset with more than 20,300 bank-year observations for over 3,600 banks, and a U.S. dataset with over 42,300 bank-year observations for more than 8,900 banks. These two samples complement each other. The European sample covers a number of countries with different institutional settings. We control for such different characteristics when we study the effect of competition on efficiency and, ultimately, on bank soundness. The U.S. sample allows us to examine the consistency of our inferences by exploiting cross-sectional and

[5] Note that the Boone indicator is decreasing in the degree of competition (see Section III). Consequently, if competition increases bank soundness, the relation between measures of bank soundness and the Boone indicator can be expected to be negative.

time-series variation in measures of competition, efficiency, and soundness by focusing on a large number of banks that operate in a more homogenous regulatory environment.

The bank-specific data are derived from BankScope, a commercial database provided by Bureau van Dijk. The European sample covers Austria, Belgium, Denmark, France, Italy, Germany, Luxembourg, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom, and includes all commercial, savings, and cooperative banks during 1995–2005.[6] The U.S. sample includes commercial, savings, and cooperative banks for the same period. Whenever possible, we use consolidated data to avoid double counting. The HHI and total banking system assets are also computed from BankScope data. For the U.S. sample, we calculate the HHI and banking system assets on the state level. The benefit of sampling the institutions for 1995–2005 is that the data cover a complete business cycle.

We drop observations for which the respective variables lie in the 1st or 99th percentile of the distribution, and exclude countries with less than 20 bank-year observations. The remaining dataset for Europe consists of 20,300 bank-year observations for 3,665 banks, of which 5,959 are savings banks, 10,268 are cooperative banks, and 4,082 are commercial banks. The remaining U.S. sample has 44,991 bank-year observations for commercial banks, 5102 savings banks, and 13 cooperative banks.

Measuring Efficiency

To measure efficiency, we primarily focus on profit efficiency, which has the benefit of taking into account performance not only on the cost side, but also on the revenue side of the bank business. This concept is superior to cost efficiency, which is also used in the literature, but this concept only looks at the cost side of bank business. This distinction is relevant in the analysis of competition, because banks can compete not only through cutting costs, but also through adjustments in revenues. In addition, profit efficiency can be thought of as the superior concept as it embraces cost efficiency, and hence an evaluation of profit efficiency simultaneously entails an evaluation of cost efficiency. In other words, changes in profit efficiency associated with competition not only incorporate whichever changes in cost efficiency occur but also extend to revenue effects of changes in output (Akhavein, Berger, and Humphrey, 1997). We use two measures of profit efficiency: standard profit efficiency and alternative profit efficiency.

Profit efficiency measures how close a bank gets to the efficiency frontier, which denotes the maximum achievable profit, given a particular level of input and output prices (Berger and Mester, 1997). In log-form, the standard profit function can be written as

$$\ln(\pi+\theta) = f(w,p,z) + \ln u_\pi + \ln \varepsilon_\pi \qquad (1)$$

where π denotes variable bank profits. We add the constant θ to the bank profits, to avoid taking the log of a negative number (without losing anything of substance); the price vector of the inputs is denoted by w, and the vector of output prices is denoted by p; z indicates the quantities of any fixed netputs (inputs or outputs), $ln\varepsilon_\pi$ is a random error term, and lnu_π is the inefficiency term that reduces profits. This specification assumes that output prices are taken as given but does not assume that output quantities are fixed.

[6] An anonymous referee suggested focusing more on suvirvorship bias, an issue not discussed by most of the other literature that uses the BankScope database, but examined recently by Gropp and Heider (2008). We have looked into the issue, which turns out to be limited for our country sample, reflecting the small number of true banking failures in Europe in the last decade.

Hence, the dependent variable allows both varying inputs as well as varying outputs. In this setup, output prices are exogenous, allowing for inefficiencies in output choice as a response to prices or to other arguments in the profit function.

Evaluating the effect of competition on profit efficiency based on the concept of standard profit efficiency imposes a number of restrictive assumptions. Standard profit efficiency assumes variable output quantities, perfectly competitive output markets, accurate measurement of output prices, and that no differences exist in the quality of banking products (Berger and Mester, 1997).

To address these restrictions, we focus on the concept of so-called alternative profit efficiency (Humphrey and Pulley, 1997). Rather than measuring how close a bank is to the efficiency frontier given its output prices, the alternative concept gauges how close the bank is to the efficiency frontier given its output levels. The alternative profit efficiency function is identical to Eq. (1), except that it replaces p with y, denoting the output quantities. This different setup of the equation allows variable output prices to vary freely and affect profits so that the function is written as

$$\ln(\pi+\theta)=f(w,y,z)+\ln u_{a\pi}+\ln\varepsilon_{a\pi}\,. \qquad (2)$$

The effect of the change in specification is that we obtain different values for the error term $\ln\varepsilon_{a\pi}$ and the inefficiency term $\ln u_{a\pi}$. Both standard and alternative profit efficiency are defined as the ratio of predicted actual profits to the predicted maximum profits the institution could earn if it were to be based on the efficiency frontier.

To estimate profit efficiency, we use stochastic frontier techniques that allow us to decompose the error term into two parts. The first part of the term captures random disturbance, and follows a symmetric normal distribution. The second part of the error captures inefficiency, and follows a positive half-normal distribution. The frontier functions are estimated for each country separately, because differences in the environment banks operate in hamper the estimation of a common frontier. We use a translog functional form with two outputs and specify

$$\begin{aligned}\ln(P+\theta)&=\alpha_0+\sum_{i=1}^{2}\alpha_i\ln Y_i+\sum_{k=1}^{2}\beta_k W_k+\sum_{h=1}^{2}\mu_h\ln E_h\\&+\frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2}\delta_{ij}\ln Y_i\ln Y_j+\frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2}\gamma_{km}\ln W_k\ln W_m\\&+\sum_{i=1}^{2}\sum_{k=1}^{2}\rho_{ik}\ln Y_i\ln W_k+\sum_{i=1}^{2}\sum_{h=1}^{2}\varepsilon_{ih}\ln Y_i\ln E_h\\&+\sum_{k=1}^{2}\sum_{h=1}^{2}\lambda_{kh}\ln W_k\ln E_h+\frac{1}{2}\sum_{h=1}^{2}\sum_{n=1}^{2}\psi\ln E_h\ln E_n+\ln u_\pi+\ln\varepsilon_\pi\,.\end{aligned} \qquad (3)$$

As highlighted above, we add the constant θ, calculated as $\ln\left[(\pi/W_3E_3)+\left|(\pi/W_3E_3)^{\min}+1\right]$ to the profit P to avoid taking the log of a negative value. Output quantities (loans and other earning assets) are denoted by the vector Y, W is the vector of inputs (labor, funding, and other costs), and netputs (fixed assets, loan loss provisions, and equity capital) are represented by the vector E. To impose standard homogeneity conditions, we scale all profits 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).[7]

For completeness, we also run our analysis with the concept of cost efficiency. Cost efficiency measures of 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). The cost function is similar to the profit functions above and is written as

$$\ln C = f(w, y, z) + \ln u_C + \ln \varepsilon_C, \qquad (4)$$

where C are variable cost; u_c is an inefficiency term that raises cost above the level of the best-practice bank, and e_c is the random error term. The other terms are identical to those used in the estimation of the alternative profit efficiency scores. A bank's cost efficiency ranges between 0 and 1, with larger values indicating greater cost efficiency.

Table 1 presents summary statistics for the variables we use to estimate translog cost and profit functions. The samples in Panel A (European sample) and Panel B (U.S. Sample) exhibit similar properties. On average, total costs amount to 5 percent of total assets. In terms of alternative and standard profit efficiency, we find that the banks operate close to the efficiency frontier. The average European and U.S. bank in the sample loses approximately 13 or 14 percent of the profits it could be earning due to inefficiencies,[8] and the average European bank is slightly more cost efficient than an average U.S. bank, but the difference is insignificant. We capture labor cost with the ratio of personnel expenses to total assets, funding costs as the ratio as interest expenses to total deposits and other borrowed money, and other operating and administrative expenses are used to proxy for the input price of fixed assets.

[TABLE 1]

A traditional measure of competition: Lerner index

As a starting point in assessing the degree of competition in banks, we use the Lerner index of market power. The Lerner index is a well-established measure of the degree of competition in banking. It captures the divergence between product prices and marginal cost of production, which indicates the degree of market power. We calculate the Lerner index as the mark-up of output prices over marginal cost of production as follows

$$LI_{it} = \frac{p_{it} - mc_{it}}{p_{it}} \qquad (5)$$

where p_{it} denotes the output price of bank i at time t and is defined as total revenue (interest and noninterest revenue) divided by total assets. Marginal cost mc_{it} are obtained by differentiating a translog cost function with one output (total assets) by output (see Appendix A). The Lerner index ranges between zero and one, whereby larger values indicate less competition and more market power.

[FIGURE 1]

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7 The translog functions for each country can be obtained from the authors on request.

8 A detailed breakdown of the efficiency scores for each country can be obtained from the authors on request. Note that profit efficiency can take on negative values because banks can lose more than 100% of their potential profits (Berger and Mester, 1997).

Figure 1 illustrates the evolution of the Lerner indices, by country, over time. It shows a slight upward trend for bank market power. The banking systems in Luxembourg, Switzerland, and Germany exhibit on average the lowest values for the Lerner index, indicating that banks in these markets do not wield much market power.

Granger causality tests and variables

To investigate the direct effect of competition on efficiency, we analyze the nexus between the two alternative measures of profit efficiency and the Lerner index.

In a similar vein to Berger (1995), Berger and DeYoung (1997), and Williams (2004), we use Granger causality tests as follows

$$y_{it} = \alpha_0 + \sum_{j=1}^{n} \alpha_j y_{i(t-1)} + \sum_{j=1}^{n} \beta_j x_{i(t-j)} + \gamma Z_{it} + \eta_i + \varepsilon_{it} \tag{6}$$

and regress measures of profit efficiency on lags of both itself (y_{t-1}, y_{t-2}), and on a Lerner index (x_{t-1}, x_{t-2}) as a measure of competition; Z_{it} is a vector of control variables; η_i is a bank-specific effect and ε_{it} denotes the error term. We also run the regressions with the Lerner index as dependent variable and regress it on lags of both itself and lags of the measures of profit efficiency. For this analysis, we employ a panel data estimator with bank-fixed effects.

We use two annual lags in the baseline setup of our models. This lag structure avoids dropping a vast amount of information by using deeper lags. Granger causality analysis focuses on the *F-Test* for the joint significance of the two annual lags of x. If the two annual lags are significant, we can predict that x Granger causes y, in the sense of changes in x preceding changes in y. Granger causality however does not constitute causality in the economic sense. Similar to Berger (1995), we hone in on the sum of the lagged coefficients, because we are interested in the total effect of competition on profit efficiency over the two-year period. To test whether the inferences from the basic setup are indeed causal in the Granger sense or merely spurious, we augment our regression specifications with a number of control variables.

Since we are predominantly interested in the effect of competition on efficiency, we choose control variables that are likely to affect efficiency. First, we include market share (log), total assets (log), asset growth, and squared asset growth into the Granger causality analysis. We expect that a bank's market share is positively related to profit efficiency because banks that are large relative to their relevant market can charge higher prices for their services (Berger and Mester, 1997). In contrast, profit efficiency of banks is frequently found to decrease in bank size, as larger banks have bigger difficulty in generating revenue efficiently (Stiroh, 2000; Berger and Mester, 1997). We also investigate the effect of asset growth. An expanding bank may not keep its efficiency under control and we therefore anticipate an inverse relation between asset growth and profit efficiency. We include a quadratic term to account for nonlinearities, since the effect of growth is likely to be different for aggressively growing institutions.

Second, we incorporate a Herfindahl-Hirschman index based on total assets to control for the degree of concentration in banking, and include a set of country dummies to soak up variation on the country level. Berger and Bonaccorsi di Patti (2006) show that profit efficiency is positively affected by concentration in banking markets because banks can increase net revenues by exerting market power, and Akhavein, Berger, and Humphrey (1997) find that mergers among large U.S. banks enable the merged entity to improve profit efficiency, a finding that they assign to benefits from diversification. Since we compare Herfindahl indices across different markets, we also include the log of total banking system assets to control for the size of the different systems (Breshanan, 1989).

An innovative measure of competition: the Boone indicator

An alternative way of measuring competition is the Boone indicator (Boone, 2001; Boone, Griffith, and Harrison, 2005). Unlike the Lerner index, the Boone indicator allows to capture more directly the link between competition and efficiency. It is based on the efficient structure hypothesis that associates firm performance with differences in efficiency. The basic idea is that more efficient firms achieve superior performance in the sense of higher profits or higher market shares, and that this effect is increasing in the degree of competition.

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

$$p\left(q_i, q_{j\neq i}\right) = a - bq_i - d\sum\nolimits_{j\neq i} q_j \qquad (7)$$

whereby each bank has constant marginal cost c_i. 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

$$\pi_i = \left(p_i - c_i\right) q_i \qquad (8)$$

The first order condition for equilibrium is then given by

$$a - 2bq_i - d\sum\nolimits_{i\neq j} q_j - c_i = 0\,. \qquad (9)$$

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

$$q_i(c_i) = \left[\left(2b/d - 1\right)a - \left(2b/d + N - 1\right)c_i + \sum\nolimits_j c_j\right] / \left[\left(2b + d\left(N-1\right)\right)\left(2b/d - 1\right)\right]. \quad (10)$$

Eq. (10) illustrates that there is a linear relation between output and marginal cost, and Eq. (8) indicates that profits depend on marginal cost in a quadratic way. If profits π_i are defined as variable profits excluding entry costs k, a bank will only enter the market if, and only if, $\pi_i \geq k$.

Based on the properties outlined above, competition increases in such a banking system for two reasons: First, competition will increase in circumstances when the products offered by different banks become closer substitutes, i.e., d increases (assuming that $d < b$). Second, competition will increase if entry costs k decline. Boone, Griffith, and Harrison (2005) prove that market shares of more efficient firms increase under these two different regimes. The Boone model for the market share s of bank i can then be characterized by the following two equations:

$$s_i = p_i q_i / \sum\nolimits_j p_j q_j \;\text{ and} \qquad (11)$$

$$\ln(s_i) = \alpha + \beta \ln\left(c_i / \sum_j c_j\right), \tag{12}$$

where β is referred to as the Boone indicator.

Market shares increase for banks with lower marginal costs (β<0). Thus, an increase in competition raises the market share of a more efficient bank relative to a less efficient one. The stronger the effect (i.e., the larger the β in magnitude), the stronger is competition. The log-log specification in Eq. (12) is used to deal better with heteroskedasticity. In addition, this form also simplifies interpretation because it illustrates the elasticity of the market share to a one percent change in the Boone indicator (see also van Leuvensteijn et al., 2007). For instance, an estimated β of -2 indicates that a bank with one percent higher marginal cost than another, more efficient bank would have 2 percent smaller market share than the more efficient bank.

Van Leuvensteijn et al. (2007) argue that one of the distinct features of the Boone indicator is that it is demonstrates why measures such as the Herfindahl-Hirschman index (HHI) do not fare well as measures of competition. The intuition of the HHI is derived from a Cournot model with symmetric banks, where a fall in entry barriers decreases the HHI. But if banks differ in terms of efficiency, increases in competition through an increase in *d* reallocate output to the more efficient banks that already had higher levels of output. Consequently, an increase in competition raises the HHI rather than decreases it as is often assumed under the so-called structure-conduct-performance paradigm.

Estimating the Boone indicator

As the first step to computing the Boone indicator, we calculate marginal cost, and replace the dependent variable in the translog function in Eq. (3) with total costs and differentiate the modified Eq. (3) with respect to the two output categories, loans and other earning assets. We obtain

$$mc_{L_{it}} = \frac{\partial c_{it}}{\partial L_{it}} = \left[\alpha_1 + \delta_{11} \ln Y_1 + \delta_{12} \ln Y_2 + \rho_{11} \ln W_1 + \rho_{12} \ln W_2 + \varepsilon_{11} \ln E_1 + \varepsilon_{12} \ln E_2\right] \frac{c_{it}}{L_{it}} \tag{13}$$

and

$$mc_{OA_{it}} = \frac{\partial c_{it}}{\partial OA_{it}} = \left[\alpha_2 + \delta_{22} \ln Y_2 + \delta_{21} \ln Y_1 + \rho_{21} \ln W_1 + \rho_{22} \ln W_2 + \varepsilon_{21} \ln E_1 + \varepsilon_{22} \ln E_2\right] \frac{c_{it}}{OA_{it}}, \tag{14}$$

which are the marginal costs of loans and of other earning assets, respectively.

In the second step, we estimate the relation between individual banks' market shares and marginal cost of production to obtain the Boone indicator as outlined in Eq. (12). We use a GMM-style estimator with two year lagged values of the explanatory variables as instruments to address concerns that market shares and marginal cost are jointly determined. For instance, banks that are large relative to the system might benefit from lower marginal cost of production due to market power.

To address changes in competition over time, we estimate the Boone indicator separately for each year in each country (Figure 2). We focus on the Boone indicator obtained for the loan market as traditional intermediation business still is the prevailing type of business the banks are engaged in.

[FIGURE 2]

Bank soundness and the Boone indicator

In this section, we use the Boone indicator to explore the predictions from the *'Prudent and Efficient Management'-Hypothesis* to establish the transmission mechanism by which competition impacts on bank soundness. To this end, we estimate a general class of panel data models of the form

$$Z_{ijt} = \alpha + \beta B_{jt} + \gamma X_{ijt} + \delta C_{jt} + \varepsilon_{ijt}, \qquad (15)$$

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 to control for other factors that impact on bank soundness. The error term is denoted by γ_{ijt}.

We use an instrumental variables estimator for Eq. (15) to address potential endogeneity of the measures of bank soundness, the Boone indicator, and one of the control variables, bank size. The Boone indicator and bank size are likely to be partially endogenous because more fragile institutions tend to 'gamble for resurrection' by increasing their risk-profile via the origination of risky loans, which by itself, can be interpreted as a sign of increased competition. Moreover, the Boone indicator could be affected by entry of new institutions that offer substitutes of banking services, thus forcing banks to manage costs more efficiently and lowering the Boone indicator.

Natural candidates to instrument the Boone indicator are the individual bank's market share and the degree of financial freedom in a country. The latter is measured by the Financial Freedom Index obtained from the Heritage Foundation. This index is designed to measure banking security and independence from government control (ranging from 0=no freedom to 100=maximum freedom), and is an excellent instrument for the Boone indicator, because state ownership and interference not only tend to increase inefficiencies but also affect competition in banking. The individual bank's market share also satisfies the excluding restrictions because it is likely to affect bank soundness indirectly through either the efficiency channel or bank size. Finally, we use fixed assets to total assets to instrument the two endogenous variables because a high level of fixed assets is likely to reflect that the bank has a wide ranging branch office network that can serve as an indicator for both market power and size.[9]

To measure a bank's financial soundness, we use the Z-score, calculated as

$$Z = \frac{\left(ROA + E / A\right)}{\sigma ROA}, \qquad (16)$$

where ROA is the bank's return on assets, E/A is its equity to asset ratio and σROA is its standard deviation of return on assets computed over the sampling horizon. The Z-score became rather popular in recent literature (e.g., Mercieca, Schaeck, and Wolfe, 2007; Stiroh, 2004a, 2004b; Boyd and Runkle, 1993; Stiroh and Rumble, 2006; Demirgüç-Kunt,

[9] The first stage regressions are reported in Appendix B.

Detragiache, Tressel, 2006; Čihák and Hesse, 2008). For a robustness test, we also use the standard deviation of ROA as a dependent variable.

There are several reasons for the z-score's popularity as a measure of bank soundness. First, it combines banks' buffers (capital and profits) with the risks they face (measured by the standard deviation of returns) in a way that is grounded in theory. In particular, it can be shown that the Z-score is inversely related to the probability of a financial institution's insolvency, i.e. the probability that the value of its assets becomes lower than the value of its debt. The probability of default is given by $p(ROA < E/A) = \int_{-\infty}^{E/A} \phi(ROA)dROA$. If ROA is normally distributed, then $p(ROA < E/A) = \int_{-\infty}^{z} N(0,1)\, dROA$, where z is the Z-score. In other words, if returns are normally distributed, the Z-score measures the number of standard deviations a return realization has to fall in order to deplete equity. Even if μ is not normally distributed, z is the lower bound on the probability of default (by Tchebycheff inequality). A higher Z-score therefore implies a lower probability of insolvency (e.g., Boyd and Runkle, 1993), providing a direct measure of banks' soundness that is superior to, for example, analyzing only banks' leverage.

Second, an important practical advantage of the Z-score is that it can be computed in an easy and transparent fashion for all banks in the sample as only accounting information is needed (in contrast, market-based measures such as distance to default require markets that are non-existent or illiquid for many of the banks in our sample).

Third, empirical studies confirm that the Z-score is indeed a useful measure of bank soundness. For example, Čihák (2008), using a sample of 29 countries, including 12 with systemic banking crises, finds that banks in theses crisis are characterized by significantly lower Z-scores than other banks. Similarly, when we juxtapose our U.S. sample with FDIC data on individual bank failures, we find that the mean z-score in failed banks was less than ¼ of the z-score in the rest of the sample (doing a similar analysis for European banks is difficult given the lack of comprehensive database on bank failures in Europe).

In the regressions, we use total assets to control for bank size as larger banks are likely to be subject to regulators' too-big-to-fail policies (Mishkin, 1999). The equity ratio and asset growth are included to account for differences in the banks' risk preferences (Stiroh, 2004a). We include the ratio of loan loss provisions to total assets as a measure of asset quality. To account for the fact that better diversified banks are assumed to be less risky (Diamond, 1984), we control for diversification, measured by a diversification index proposed by Laeven and Levine (2007).[10]

The HHI is included to reflect on a growing body of research indicating that concentration and competition measure different characteristics of banking systems (e.g. Claessens and Laeven, 2004). Thus, while the Boone indicator takes into consideration the effect of competition, we additionally control for the effect of market structure, using the HHI. Given that comparing concentration indices across markets necessitates taking the

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

effect of market size into account, we also include total banking system assets (Breshanan, 1989). This reflects that a HHI may be smaller for mathematical reasons in larger markets since more banks can operate in larger markets.

To account for the macroeconomic setting in the different banking markets, we include GDP per capita and the real interest rate. Those regressions that are run with a random effects estimator additionally include country dummies and bank type dummies for savings banks and cooperative banks. Commercial banks are captured in the intercept to avoid perfect collinearity. Table 2 provides an overview of summary statistics of all variables used in the analysis.

[TABLE 2]

IV. Empirical Results

This section reports the main results and sensitivity tests. We start with the discussion of the 'C*ompetition-Efficiency'-Hypothesis* based on Eq. (6). Subsequently, we report the findings from the examination of the *'Prudent and Efficient Management'-Hypothesis* based on Eq. (15).

Testing the relation between competition and efficiency

European Sample

We run Granger causality tests to examine the nexus between competition and efficiency for the European sample. Columns (1) and (2) in Table 3 are based on two annual lags of the dependent and independent variable. In these baseline regressions, we only include market share (log) and total assets (log) as control variables. Although efficiency scores tend to be rather sticky over time, we find that the sum of the lagged coefficients for the Lerner index is negative and significant at the one percent level in column (1). This inverse relation between the Lerner index and alternative profit efficiency suggests that competition increases alternative profit efficiency as anticipated under the 'C*ompetition-Efficiency'-Hypothesis.* Negative conditional correlation is indicated by the sum of the coefficients of the alternative profit efficiency variable. In column (2), the sum of the coefficients of the alternative profit efficiency variable is negative and significant, indicating that progress in terms of alternative profit efficiency increases competition. Thus, efficiency also Granger-causes competition. The sum of the lagged Lerner indices is positive and significant, indicating positive conditional correlation.

Market share is also positively associated with profit efficiency. This positive effect could reflect that banks that are large relative to the system have better access to production technologies so that they can increase profit efficiency more easily than smaller banks. In contrast, bank size in terms of total assets is inversely related to the dependent variable in column (1), suggesting that large institutions tend to benefit less from efficiency increases than smaller banks.

[TABLE 3]

To further explore the result in column (1) that market power impedes alternative profit efficiency, we add additional control variables that may also influence efficiency. In columns (3) and (4), we include asset growth, asset growth squared, HHI and the log of total banking system assets. Our previous results supporting the 'C*ompetition-Efficiency'-Hypothesis* are corroborated, and changes in profit efficiency again precede changes in the

Lerner index. The findings in columns (3) and (4) also illustrate significant effects of asset growth on alternative profit efficiency. Our results confirm that causality runs from competition to alternative profit efficiency and vice versa. The HHI and the log of total banking system assets enter negatively and significantly in column (3), indicating that banks operating in more concentrated and larger markets are less profit efficient. Columns (5) – (8) use the concept of cost efficiency. Here, we find that increases in market power precede increases in cost efficiency. This result is similar to the findings reported by Koetter, Kolari, and Spierdijk (2008) and Casu and Girardone (2007). We are cautious assigning too much weight to these results since we are interested in the overall effect of competition on bank efficiency. Recall that the concept of profit efficiency is seen as superior to cost efficiency as the concept of cost efficiency omits any inefficiencies on the revenue side. Moreover, our result could simply indicate that the efficiency improvement in terms of profit efficiency outweighs the decline in efficiency on the cost side.

U.S. sample

In Table 4, we repeat the analysis with the Granger causality tests for the U.S. sample. Column (1) in Table 4 illustrates again that the Lerner index is inversely related to alternative profit efficiency when the effect of market share and bank size is accounted for. Similarly, we detect negative conditional correlation for the sum of the lagged coefficients of alternative profit efficiency in column (1). The finding for an inverse relation between the sum of the coefficients of the Lerner index and alternative profit efficiency is also reiterated in column (3), when the additional controls are included. The results for the effect of competition on cost efficiency for the U.S. in columns (5) – (8) are again supportive for our main hypothesis. We therefore argue that the analysis for the U.S. sample provides further support for the 'C*ompetition-Efficiency'-Hypothesis.*

[Table 4]

Robustness tests

To investigate the sensitivity of our results with respect to the measurement of efficiency, we run Granger causality tests in Table 5 with efficiency scores based on the concept of standard profit efficiency.

[Table 5]

The findings with the standard profit efficiency measure lend some more support to our *'Competition-Efficiency'-Hypothesis.* While the sum of the lagged coefficients of the Lerner index for the European sample in Panel A of Table 5 still enters with a negative sign implying that competition increases profit efficiency, the *F-Statistics* are not significant at conventional levels. In contrast, the results for the U.S. sample in Panel B are again fully aligned with the 'C*ompetition-Efficiency'-Hypothesis.* In a further set of robustness checks based on the concept of alternative profit efficiency and using both samples reported in Appendix C, we use three annual lags of the dependent and independent variable to examine the sensitivity of our results to the lag structure. Additionally, we constrain the sample to those banks that remain in the sample during the whole period 1995–2005 to examine survivorship bias. All these tests confirm the *'Competition-Efficiency'-Hypothesis.*

In sum, increasing competition, as measured by the Lerner index, Granger causes profit efficiency. Our results indicate that bank managers respond to competitive pressure by keeping costs under control as well as increasing profits accordingly. In the remainder of the analysis, we focus on the link between competition, efficiency, and soundness exploiting the Boone indicator.

Testing the relation between the Boone indicator and bank soundness

Table 6 presents the results of the test of the *'Prudent and Efficient Management'-Hypothesis* for European countries. For this analysis, we use the Boone indicator to gauge competition, and Z-scores are employed to measure bank soundness.

European Sample

In column (1), only the Boone indicator enters the equation along with a number of bank-specific variables. The negative sign at the one percent level for the Boone indicator confirms the *'Prudent and Efficient Management'-Hypothesis*, and underscores that competition increases banks' Z-scores via the efficiency channel.

Among the control variables, we find that larger banks and banks with more diversified income streams tend to have higher Z-scores. In contrast, a higher ratio of loan loss provisions to total assets decreases Z-scores, and asset growth also significantly affects Z-scores.

In columns (2) and (3), we additionally investigate whether the findings are altered if we take financial system characteristics and bank types into account.

The Boone indicator remains negatively and significantly associated with the dependent variable when we control for bank types and country dummies in column (2). The dummy for cooperative banks enters positively and significantly, showing that these institutions have higher Z-scores than have commercial banks (the omitted category). In contrast, savings banks have significantly lower Z-scores relative to commercial banks. These regressions are run with a random effects panel data estimator because a fixed effects estimator would wipe out the time-invariant variables in these regressions.

Column (3) furthermore controls for the HHI, banking system assets (log), and the macroeconomic environment. To this end, we include GDP per capita and the real interest rate. Banks that operate in more concentrated banking systems are less fragile, and Z-scores are higher in larger banking systems. The positive link between concentration and Z-scores supports the franchise value hypothesis according to which banks pursue low risk strategies when operating in a concentrated banking system (Boot and Greenbaum, 1993).

The two macroeconomic variables show the anticipated sign. Real interest rates exhibit a negative relation to Z-scores, whereas GDP per capita enters the equations positively and significantly.

In terms of the economic significance, the effect is also sizeable. Based on the results in columns (3), a one standard deviation decrease in the Boone indicator (0.22), increases the Z-score for the median bank in the sample from 22.5 to 26 standard deviations away from insolvency (0.22*(-15.7)=-3.5). The Hansen Sargan J-Test confirms the validity of our instruments in all regressions in Table 6.

[Table 6]

U.S. Sample

The regressions in Table 7 examine the *'Prudent and Efficient Management'-Hypothesis* for the U.S. sample.[11]

The Boone indicator is rendered insignificant in column (1), indicating no marked effect of competition on bank soundness via the efficiency channel in the U.S. The regression in column (2) uses a random effects estimator and controls for bank type. The Boone indicator enters this equation at the one percent significance level with a negative sign, providing further support for the *'Prudent and Efficient Management'-Hypothesis.*

Asset growth has again a significant effect on Z-scores, and loan loss provisioning goes hand in hand with declining Z-scores. The diversification index exhibits a negative sign, indicating that bank soundness declines in the U.S. if the institutions diversify into non-interest earning activities. This result reflects that many small banks in the U.S. operate on a locally constrained basis that increases the correlation among their exposures (e.g. Stiroh, 2004a). The findings in column (3) in which we additionally consider a HHI calculated on the state level, total banking system assets (log), also calculated on the state level, and the two macroeconomic control variables are again indicating an inverse relation between competition and Z-Scores. However, the Boone indicator does not assume significance at conventional levels. We therefore remain cautious assigning much weight to these results. Rather, these findings suggest that the different environment in which U.S. institutions operate in is likely to determine the impact of competition on bank soundness via the efficiency channel. Before we however accept this view, we perform a set of additional sensitivity checks.

[Table 7]

Robustness tests

European Sample

We present robustness tests for the European sample, in Table 8 using alternative samples, and an alternative dependent variable. We also correct the standard errors of the Boone indicator to account for the fact that the indicator is derived from a regression. In columns (1)–(3) we replicate regression (3) from Table 6 and constrain the sample to commercial, savings, and cooperative banks respectively. While the negative and significant coefficient for the Boone indicator is confirmed in columns (2) and (3), the Boone indicator is rendered insignificant when we focus on commercial banks only in column (1). Although this finding appears somewhat surprising at first glance, it may reflect that the effect of competition on efficiency of commercial banks is less pronounced. In fact, this result is aligned with evidence in recent work by Casu and Girardone (2007). In their analysis of European commercial banks, they find no obvious effect of competition on efficiency.

[TABLE 8]

Next, we remove Swiss banks from the sample to investigate sample selection problems in column (4) because the Swiss banking system was not subject to the above

[11] We weight these regressions with total assets, to account for the fact that numerous small depositories are operating in local markets in the US.

mentioned EU banking directives. To examine survivorship bias, we run the regressions in column (5) for those banks that remain in the sample during the period 1995–2005, and find no evidence for survivorship bias. The results indicate that our main finding for the beneficial effect of the Boone indicator on bank soundness is insensitive to sample selection.

We employ an alternative dependent variable in column (6) in which we use the standard deviation of ROA as dependent variable. The standard deviation is computed over the sampling period 1995–2005. Since a time-invariant dependent variable hampers the use of a panel data estimator, we revert to OLS for this test. The coefficient of the Boone indicator enters again with a negative sign, but is rendered insignificant in this setup. Column (7) uses a bootstrapping procedure with 250 replications to correct the standard errors of the Boone indicator. Our inferences regarding the effect of this variable remain unchanged.

U.S. Sample

Finally, we examine the sensitivity of our results for the U.S. sample in Table 9. In columns (1) and (2), we constrain the sample to commercial and savings banks respectively.[12] Although the Boone indicator enters with a negative sign, consistent with the predictions of the *'Prudent and Efficient Management'-Hypothesis*, the coefficient remains insignificant.

[Table 9]

When we run the analysis with banks that remain in the sample during 1995–2005 to investigate survivorship bias, the coefficient for the Boone indicator is again negative but also estimated with a large standard error. The indicator for competitiveness also remains insignificant in column (4), in which we use OLS to regress the standard deviation of ROA on the Boone indicator and the explanatory variables.

Finally, we correct the standard errors of the Boone indicator with a bootstrapping procedure based on 250 replications in column (5). The indicator enters negatively, but does not assume significance at conventional levels. Therefore, we remain cautious about drawing strong inferences based on this result and conclude that these findings imply that competition, via the efficiency channel, may not be conducive to achieving a more sound banking system in the U.S.

Our results also point towards a possible explanation for the positive link between market concentration and decreases in the probability of observing systemic crises reported in recent studies. Based on the evidence for a positive effect of competition on bank soundness via the efficiency channel in our empirical tests, and based on the efficient structure hypothesis according to which efficient firms increase market share at the expense of inefficient firms, we believe we have uncovered evidence that improvements in efficiency are the underlying reason for the results reported by Beck, Demirgüç-Kunt, and Levine (2006).

V. Conclusion

We analyze the link between competition, efficiency, and bank soundness to establish the possible conduit through which competition can contribute to bank stability.

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12 The number of cooperative banks in the U.S. sample is insufficient to run a regression for cooperative banks only.

Using a large sample of data on European and U.S. banks, we find evidence for the *'Competition-Efficiency'-Hypothesis*: competition measured by a Lerner index Granger-causes profit efficiency of banks. We also find support for the idea that competition increases cost efficiency for the U.S. sample. These results are robust to alternative measures of efficiency, different lag structures, and also remain stable when we account for additional factors that exogenously affect bank efficiency.

The findings for the European sample also confirm the *'Prudent and Efficient Management'-Hypothesis*. Instrumental variables regressions show that the Boone indicator enters the soundness regressions with a negative and significant sign, confirming that competition, via the efficiency channel, increases Z-scores. The analysis for the U.S. sample also weakly indicates a positive effect of competition on bank soundness through the efficiency channel. However, this finding is sensitive towards model specification and we are cautious about drawing strong inferences.

The results presented in this paper are only partially consistent with the literature. While the evidence in favor of the *'Competition-Efficiency'-Hypothesis* is in line with a large literature in industrial organization relating to non-financial firms, our finding that competition, measured by the Boone indicator, is positively related to bank soundness, challenges the prevailing view both in the literature and in policymaking. We attribute this finding to the new methodology and the fact that we take endogeneity between measures of bank soundness and the Boone indicator into account.

In terms of policy implications, our results highlight that competition in banking may be beneficial because: (i) it increases bank efficiency; and (ii) it increases soundness. Both are desirable from a policymaker's point of view because a competitive banking system will allocate resources more efficiently to society, and because bank soundness is likely to improve. Our analysis gives empirical support to pro-competition policies such as the single banking passport, which simplified cross-border operation of banks, and the third pillar of Basel II, which puts emphasis on banks' disclosures, increasing the role for market discipline in monitoring and enforcing efficiency and soundness.

Two caveats are in order. First, while our sampling horizon spans a whole business cycle for Europe and the U.S., some caution needs to be exercised, since the competition-efficiency relation may vary over time as both competition and efficiency are affected by regulatory policies and the riskiness of bank assets, which themselves vary over time. Second, the *'Prudent and Efficient Management'-Hypothesis* may be only one of the possible transmission mechanisms by which competition contributes to bank soundness. Other mechanisms and theories may also point towards a positive effect of competition on bank soundness. Further research would therefore be useful for understanding why competition can be beneficial for bank soundness.

Appendix A: Translog cost function for computation of Lerner index

To calculate the Lerner index, we first estimate the following translog cost function with one output (total assets), three input factors (labor, deposits, and capital), and three netputs (fixed assets, loan loss provisions, equity capital)

$$\ln C = \alpha_0 + \alpha_1 \ln Y + \frac{1}{2}\alpha_2 \ln Y^2 + \sum_{k=1}^{2} \beta_k W_k + \sum_{h=1}^{2} \mu_h \ln E_h$$

$$+ \frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2} \gamma_{km} \ln W_k \ln W_m + \sum_{k=1}^{2} \rho_k \ln Y \ln W_k + \sum_{h=1}^{2} \varepsilon_h \ln Y \ln E_h$$

$$+ \sum_{k=1}^{2}\sum_{h=1}^{2} \lambda_{kh} \ln W_k \ln E_h + \frac{1}{2}\sum_{h=1}^{2}\sum_{n=1}^{2} \psi \ln E_h \ln E_n + \ln u_c + \ln \varepsilon_c \qquad \text{(A.1)}$$

where C denotes total cost, and Y is total assets. As in Section III, W is the vector of inputs (labor, funding, and other costs), and netputs (fixed assets, loan loss provisions, and equity capital) are represented by the vector E. Standard homogeneity conditions are imposed by scaling all costs and input prices by one other input price (labor costs), and adjust for heteroskedasticity by scaling by equity capital.

To obtain marginal cost, we differentiate Eq. (A.1) with respect to Y as follows

$$mc_{it} = \frac{\partial C}{\partial Y} = \left[a_1 + \alpha_2 \ln Y + \rho_1 \ln W_1 + \rho_2 \ln W_2 + \varepsilon_1 \ln E_1 + \varepsilon_2 \ln E_2\right] \frac{c_{it}}{Y}. \qquad \text{(A.2)}$$

Appendix B: First-stage regressions

	Panel A: European sample		Panel B: U.S. sample	
	(1)	(2)	(3)	(4)
Dependent variable	**Boone indicator**	**Total assets (log)**	**Boone indicator**	**Total assets (log)**
Market share (log)	0.0272**	0.9999***	0.0003	0.9995***
	(0.0108)	(3.20e-08)	(0.0031)	(0.0009)
Financial freedom	-0.0034***	-3.34e-08***	-0.0012***	-0.0001***
	(0.0002)	(8.02e-10)	(0.0001)	(0.0000)
Total fixed asses/Total assets	0.4286*	-2.74e-07	-0.1709	-0.0081
	(0.2241)	(1.22e-06)	(0.2706)	(0.0594)
Equity/Total assets	0.0000	-5.20e-17	0.0000	0.0000
	(0.0000)	(1.29e-16)	(0.0000)	(0.0000)
Asset growth	-0.0828***	2.08e-08	0.0030	0.0009*
	(0.0094)	(3.67e-08)	(0.0022)	(0.0005)
Asset growth (squared)	0.0146***	3.13e-09	-0.0000	-0.0000*
	(0.0055)	(1.67e-08)	(0.0000)	(0.0000)
Loan loss provisions/Total assets	-0.0237***	4.78e-08***	0.0155***	0.0021**
	(0.0035)	(1.34e-08)	(0.0038)	(0.0009)
Diversification index	0.0777***	1.61e-08	-0.0170	-0.0051
	(0.0126)	(7.30e-08)	(0.0158)	(0.0034)
Herfindahl Hirschman index	-0.1388**	8.68e-07***	-37.2712***	-10.1731***
	(0.0631)	(1.53e-07)	(0.2284)	(0.0580)
Banking system assets (log)	-0.0017	0.9999***	0.3665***	0.6045***
	(0.0084)	(2.86e-08)	(0.0109)	(0.0026)
Real interest rate	-0.0406***	-1.20e-07	0.0348***	-0.0010***
	(0.0016)	(5.46e-09)	(0.0005)	(0.0001)
GDP per capita	-0.0000	-1.08e-11	0.0001***	0.0001***
	(0.0000)	(7.94e-12)	(0.0000)	(0.0000)
Observations	14463	14463	50032	50032
Number of banks	3415	3415	9080	9080
R-squared	0.1804	0.9999	0.9421	0.9998
F-Statistic	350.55***	1.69e+14***	14642.44***	1.87e+06***

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix C: Alternative lag structure for Granger causality analyses

European sample	Panel A: 3 annual lags of alternative profit efficiency				Panel B: Testing for survivorship bias				Panel C: Cost efficiency			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable	**Alternative profit efficiency**	**Lerner**	**Alternative profit efficiency**	**Lerner**	**Alternative profit efficiency**	**Lerner**	**Alternative profit efficiency**	**Lerner**	**Cost efficiency**	**Lerner**	**Cost efficiency**	**Lerner**
Alternative profit efficiency (t-1)	-0.2174***	-0.0015	-0.2149***	-0.0014	-0.1963***	-0.0002	-0.1918***	0.0003				
	(0.0286)	(0.0016)	(0.0279)	(0.0016)	(0.0524)	(0.0007)	(0.0487)	(0.0004)				
Alternative profit efficiency (t-2)	-0.1757***	-0.0028	-0.1733***	-0.0026	-0.1237***	-0.0015	-0.1225***	-0.0013				
	(0.0260)	(0.0020)	(0.0267)	(0.0020)	(0.0218)	(0.0013)	(0.0230)	(0.0011)				
Alternative profit efficiency (t-3)	-0.1148**	-0.0022	-0.1181**	-0.0023								
	(0.0536)	(0.0015)	(0.0513)	(0.0016)								
Alternative profit efficiency (total)	*-0.5080*	*-0.0064*	*-0.5062*	*-0.0063*	*-0.3200*	*-0.0016*	*-0.3142*	*-0.0010*				
F-Statistic	*509.88****	*7.04****	*572.07****	*8.53****	*5233.88****	*6.98****	*5061.11****	*10.01****				
Lerner (t-1)	-0.0290	0.6550***	0.1535	0.6650***	0.3936*	0.7830***	0.6272***	0.8072***	0.0130***	0.6113***	0.0134***	0.6177***
	(0.1433)	(0.0214)	(0.1608)	(0.0214)	(0.2167)	(0.0273)	(0.2360)	(0.0268)	(0.0022)	(0.0337)	(0.0023)	(0.0338)
Lerner (t-2)	-1.5116***	-0.0841***	-1.3376***	-0.0767***	-2.1918***	-0.1332***	-2.1692***	-0.1296***	0.0199***	-0.1303***	0.0205***	-0.1401***
	(0.1479)	(0.0195)	(0.1389)	(0.0194)	(0.1989)	(0.0253)	(0.1935)	(0.0256)	(0.0026)	(0.0318)	(0.0027)	(0.0307)
Lerner (t-3)	-0.9639***	-0.0201	-0.9940***	-0.0215					-0.0216***	0.0570**	-0.0219***	0.0619**
	(0.1302)	(0.0165)	(0.1267)	(0.0165)					(0.0024)	(0.0276)	(0.0024)	(0.0276)
Lerner (total)	*-2.5044*	*0.5507*	*-2.1780*	*0.5668*	*-1.7982*	*0.6498*	*-1.5420*	*0.6775*	*0.0113*	*0.5379*	*0.0119*	*0.5394*
F-Statistic	*94.67****	*517.07****	*80.22****	*477.24****	*82.35****	*1019.55****	*81.27****	*1038.91****	*44.32****	*123.71****	*45.90****	*121.40****
Market share (log)	0.0623***	-0.0018***	-0.1764***	0.0175***	0.0576***	-0.0018***	-0.1822***	0.0167***	0.0002*	-0.0027***	-0.0004	0.0132***
	(0.0051)	(0.0005)	(0.0165)	(0.0016)	(0.0070)	(0.0006)	(0.0237)	(0.0015)	(0.0001)	(0.0007)	(0.0003)	(0.0022)
Total assets (log)	-0.1562***	0.0240***	0.0000	0.0000	-0.1920***	0.0247***	0.0000	0.0000	-0.0015***	0.0173***	0.0000	0.0000
	(0.0143)	(0.0014)	(0.0000)	(0.0000)	(0.0167)	(0.0014)	(0.0000)	(0.0000)	(0.0002)	(0.0018)	(0.0000)	(0.0000)
Asset growth			0.1787***	0.0083***			0.1402***	0.0145***			-0.0019***	0.0005
			(0.0197)	(0.0018)			(0.0304)	(0.0016)			(0.0003)	(0.0027)
Asset growth (squared)			-0.0567***	-0.0012			-0.0449**	-0.0027***			0.0004***	0.0028*
			(0.0131)	(0.0019)			(0.0178)	(0.0008)			(0.0001)	(0.0016)
Herfindahl Hirschman index			-0.3118***	-0.0246***			0.0834*	-0.0112**			0.0046***	-0.0122***
			(0.0653)	(0.0053)			(0.0457)	(0.0050)			(0.0007)	(0.0046)
Banking system assets (log)			-0.2127***	0.0209***			-0.2336***	0.0201***			-0.0010***	0.0166***
			(0.0164)	(0.0014)			(0.0223)	(0.0014)			(0.0001)	(0.0014)
Country dummies												
Observations												
Number of banks												
R-squared												
Cost efficiency (t-1)									-0.2505***	-0.1749	-0.2740***	-0.1226
									(0.0176)	(0.1397)	(0.0157)	(0.1451)
Cost efficiency (t-2)									-0.2954***	0.1462	-0.3307***	0.2294
									(0.0179)	(0.1484)	(0.0196)	(0.1582)
Cost efficiency (t-3)									0.1323***	0.1532	0.1294***	0.1818
									(0.0171)	(0.1151)	(0.0169)	(0.1151)
Cost efficiency (total)									*-0.4135*	*0.1244*	*-0.4752*	*0.2885*
F-Statistic									*299.86****	*3.14***	*400.90****	*3.54***
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	16460	16461	16460	16461	10527	10526	10527	10526	5544	5543	5544	5543
Number of banks	3216	3216	3216	3216	1215	1215	1215	1215	1283	1283	1283	1283
R-squared	0.0964	0.5421	0.1040	0.5460	0.0763	0.6609	0.0797	0.6685	0.2405	0.4439	0.2581	0.4465

U.S sample	Panel A: 3 annual lags of alternative profit efficiency				Panel B: Testing for survivorship bias				Panel C: Cost efficiency			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable	Alternative profit efficiency	Lerner	Alternative profit efficiency	Lerner	Alternative profit efficiency	Lerner	Alternative profit efficiency	Lerner	Cost efficiency	Lerner	Cost efficiency	Lerner
Alternative profit efficiency (t-1)	0.0559***	-0.0030	0.0575***	-0.0022	-0.6498***	-0.0001	-0.6526***	-0.0002				
	(0.0020)	(0.0034)	(0.0021)	(0.0033)	(0.0100)	(0.0004)	(0.0108)	(0.0004)				
Alternative profit efficiency (t-2)	0.0153***	0.0008	0.0157***	0.0011	-0.3526***	0.0015***	-0.3512***	0.0016***				
	(0.0007)	(0.0013)	(0.0007)	(0.0013)	(0.0048)	(0.0003)	(0.0052)	(0.0003)				
Alternative profit efficiency (t-3)	0.0182***	0.0065***	0.0190***	0.0068***								
	(0.0006)	(0.0009)	(0.0006)	(0.0009)								
Alternative profit efficiency (total)	***0.0894***	***0.0043***	***0.0922***	***0.0056***	***-1.0024***	***0.0013***	***-1.0038***	***0.0013***				
F-Statistic	***404.32****	***206.65****	***385.35****	***215.93****	***3846.96****	***20.19****	***3316.25****	***22.06****				
Lerner (t-1)	0.6386***	0.2761**	0.6344***	0.2769**	-10.586***	0.8376***	-10.892***	0.8443***	-0.0023***	0.2634**	0.0013***	0.2267**
	(0.1643)	(0.1180)	(0.1648)	(0.1196)	(0.8304)	(0.0285)	(0.8560)	(0.0277)	(0.0002)	(0.1109)	(0.0005)	(0.1148)
Lerner (t-2)	-0.3072**	-0.0995***	-0.3125**	-0.1016***	-4.8652***	-0.2864***	-4.5421***	-0.2855***	-0.0035***	-0.0588***	-0.0011**	-0.0801***
	(0.1287)	(0.0074)	(0.1294)	(0.0075)	(0.7383)	(0.0304)	(0.7323)	(0.0298)	(0.0006)	(0.0082)	(0.0005)	(0.0112)
Lerner (t-3)	-0.7642***	-0.1489***	-0.7623***	-0.1471***					0.0053***	-0.0866***	0.0041***	-0.0702***
	(0.0628)	(0.0127)	(0.0630)	(0.0126)					(0.0004)	(0.0087)	(0.0003)	(0.0095)
Lerner (total)	***-0.4327***	***0.0275***	***-0.4403***	***0.0282***	***-15.4518***	***0.5511***	***-15.4350***	***0.5587***	-0.0004	0.1179	0.0042	0.0763
F-Statistic	***258.88****	***145.33****	***266.42****	***144.88****	***133.74****	***684.31****	***130.23****	***697.52****	70.65***	43.79***	188.39***	51.46***
Market share (log)	0.2764***	-0.0635**	0.2714***	-0.0649***	-4.8581***	-0.0164***	-4.8239***	-0.0143***	0.0101***	-0.1567***	0.0369***	-0.4928***
	(0.0140)	(0.0248)	(0.0137)	(0.0249)	(0.1199)	(0.0023)	(0.1294)	(0.0024)	(0.0001)	(0.0097)	(0.0004)	(0.0727)
Total assets (log)	-0.2987***	0.0665***	-0.2921***	0.0673***	4.9268***	0.0276***	4.9300***	0.0249***	-0.0100***	0.1601***	-0.0367***	0.4939***
	(0.0142)	(0.0254)	(0.0143)	(0.0261)	(0.1116)	(0.0023)	(0.1254)	(0.0027)	(0.0001)	(0.0105)	(0.0004)	(0.0740)
Asset growth			0.0006	0.0011			-0.2285**	0.0009			-0.0000	0.0014
			(0.0015)	(0.0012)			(0.0900)	(0.0025)			(0.0000)	(0.0012)
Asset growth (squared)			-0.0000	0.0000			0.0179**	0.0004			0.0000	0.0000
			(0.0000)	(0.0000)			(0.0089)	(0.0002)			(0.0000)	(0.0000)
Herfindahl Hirschman index (state level)			-0.0315***	0.0075**			-0.8114***	-0.0041			-0.2849***	2.5612***
			(0.0057)	(0.0032)			(0.1506)	(0.0043)			(0.0018)	(0.6030)
Banking system assets (log)			-0.0113***	-0.0050***			0.0489	0.0027			0.0204***	-0.2531***
			(0.0020)	(0.0013)			(0.0694)	(0.0019)			(0.0003)	(0.0492)
Cost efficiency (t-1)									0.0795***	0.6343	-1.4780***	16.6867***
									(0.0154)	(1.5567)	(0.0105)	(1.9922)
Cost efficiency (t-2)									-0.9740***	11.8509***	-1.3549***	16.5729***
									(0.0162)	(0.3283)	(0.0156)	(1.0309)
Cost efficiency (t-3)									-0.6369***	4.7185***	-0.8889***	6.8749***
									(0.0057)	(0.8913)	(0.0045)	(1.3648)
Cost efficiency (total)									***-1.5313***	***17.2037***	***-3.7217***	***40.1344***
F-Statistic									***9577.49****	***467.74****	***13816.09****	***381.63****
Observations	33299	33299	33299	33299	2619	2619	2619	2619	33299	33299	33299	33299
Number of banks	8696	8696	8696	8696	291	291	291	291	8696	8696	8696	8696
R-squared	0.4116	0.3349	0.4135	0.3369	0.6913	0.7455	0.6966	0.7472	0.7566	0.3654	0.8961	0.3847

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Table 1: Summary statistics for translog functions

	Panel A: European sample				Panel B: U.S. sample			
	N	Mean	Min	Max	N	Mean	Min	Max
Labor cost	20309	0.01	0.00	0.06	42352	0.02	0.00	0.13
Funding cost	20309	0.03	0.01	0.13	42352	0.02	0.01	0.06
Other cost	20309	1.21	0.18	20.97	42352	1.14	0.22	11.04
Interest income/Loans	20300	0.17	0.00	382.47	42328	0.10	0.00	81.55
Other income/Other earning assets	20308	0.04	-0.26	23.00	42334	0.01	-0.13	78.00
Equity capital/Total assets	20309	0.07	0.00	0.50	42352	0.10	0.00	0.85
Fixed assets/Total assets	20309	0.28	0.00	18.69	42352	0.20	0.00	7.67
Loan loss provisions/Equity capital	20309	0.09	-0.49	14.78	42352	0.02	-0.41	17.55
Total cost/Total assets	20309	0.05	0.01	0.32	42352	0.05	0.01	0.96
Loans/Total assets	20309	0.59	0.00	1.00	42352	0.64	0.00	0.98
Other earning assets/Total assets	20309	0.36	0.00	1.00	42352	0.29	0.00	0.98
Alternative profit efficiency	20309	0.87	-35.51	1.00	42352	0.87	-4.94	1.00
Standard profit efficiency	20299	0.86	-1891.1	1.00	42310	0.88	-5.29	1.00
Cost efficiency	20299	0.88	0.07	1.00	42310	0.61	0.02	1.00

Table 2: Descriptive Statistics

Variable	Panel A: European sample				Panel B: U.S. sample			
	N	Mean	Min	Max	N	Mean	Min	Max
Z-score	14389	27.19	2.64	274.04	50107	42.10	3.51	165.96
Boone indicator	14389	0.08	-0.95	0.54	50107	0.19	-0.16	0.33
Total assets (log)	14389	13.00	7.98	21.19	50107	11.81	7.75	20.80
Market share (log)	14389	-8.51	-13.06	-0.23	50107	-11.09	-15.07	-2.34
Financial freedom	14389	58.68	50.00	90.00	50107	86.08	70.00	90.00
Total fixed assets/Total assets	14389	0.02	0.01	0.16	50107	0.02	0.01	0.13
Equity capital/Total assets	14389	0.07	0.01	0.48	50107	0.10	0.03	0.96
Asset growth	14389	0.06	-0.95	8.84	50107	0.13	-0.97	221.36
Loan loss provisions/Total assets	14389	0.00	-0.06	0.13	50107	0.00	-0.04	0.21
Diversification index	14389	0.15	0.00	1.00	50107	0.31	0.00	1.00
Herfindahl Hirschman index	14389	0.08	0.01	0.64	50107	0.0004	0.0001	0.0112
Banking system assets (log)	14389	21.50	16.77	22.88	50107	18.5501	13.6595	21.2582
Real interest rate	14389	7.27	0.78	10.38	50107	3.62	1.67	7.16
GDP per capita	14389	22176.67	18009.77	40413.01	50107	35324.01	31716.04	37267.33
Cooperative bank dummy	14389	0.59	0	1	50107	0.10	0	1
Savings bank dummy	14389	0.26	0	1	50107	0.00	0	1
Commercial bank dummy	14389	0.16	0	1	50107	0.89	0	1

Table 3: Granger causality tests with alternative profit efficiency (European sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	**Alternative profit efficiency**	**Lerner**	**Alternative profit efficiency**	**Lerner**	**Cost efficiency**	**Lerner**	**Cost efficiency**	**Lerner**
Alternative profit efficiency (t-1)	-0.2832***	-0.0006	-0.2810***	-0.0004				
	(0.0670)	(0.0006)	(0.0667)	(0.0005)				
Alternative profit efficiency (t-2)	-0.2297***	-0.0021**	-0.2281***	-0.0020**				
	(0.0670)	(0.0010)	(0.0675)	(0.0009)				
Alternative profit efficiency (total)	***-0.5129***	***-0.0026***	***-0.5090***	***-0.0024***				
F-Statistic	***8.93****	***10.12****	***8.88****	***12.77****				
Lerner (t-1)	0.2655	0.6705***	0.3701	0.6815***	0.0095***	0.6447***	0.0092***	0.6519***
	(0.2569)	(0.0191)	(0.2527)	(0.0192)	(0.0019)	(0.0308)	(0.0019)	(0.0307)
Lerner (t-2)	-1.8137***	-0.0880***	-1.7939***	-0.0865***	-0.0018	-0.1203***	-0.0017	-0.1243***
	(0.1784)	(0.0162)	(0.1797)	(0.0161)	(0.0018)	(0.0209)	(0.0018)	(0.0211)
Lerner (total)	***-1.5482***	***0.5824***	***-1.4238***	***0.5949***	***0.0076***	***0.5244***	***0.0075***	***0.5275***
F-Statistic	***144.38****	***897.87****	***132.57****	***869.39****	***14.97****	***240.51****	***14.27****	***244.69****
Market share (log)	0.0524***	-0.0029***	-0.1818***	0.0151***	-0.0000	-0.0026***	-0.0016***	0.0125***
	(0.0039)	(0.0004)	(0.0245)	(0.0014)	(0.0001)	(0.0005)	(0.0002)	(0.0019)
Total assets (log)	-0.1916***	0.0218***	0.0000	0.0000	-0.0021***	0.0142***	0.0000	0.0000
	(0.0232)	(0.0012)	(0.0000)	(0.0000)	(0.0002)	(0.0016)	(0.0000)	(0.0000)
Asset growth			0.1025***	0.0085***			-0.0016***	-0.0042
			(0.0188)	(0.0018)			(0.0003)	(0.0030)
Asset growth (squared)			-0.0324***	-0.0011			0.0004***	0.0044
			(0.0092)	(0.0021)			(0.0001)	(0.0028)
Herfindahl Hirschman index			-0.1593***	-0.0082**			-0.0008	0.0031
			(0.0351)	(0.0041)			(0.0007)	(0.0039)
Banking system assets (log)			-0.2212***	0.0191***			-0.0018***	0.0147***
			(0.0240)	(0.0012)			(0.0001)	(0.0012)
Cost efficiency (t-1)					-0.2520***	-0.3086***	-0.2586***	-0.3285***
					(0.0188)	(0.1150)	(0.0187)	(0.1175)
Cost efficiency (t-2)					-0.3042***	-0.0213	-0.3082***	-0.0489
					(0.0171)	(0.1211)	(0.0174)	(0.1264)
Cost efficiency (total)					***-0.5562***	***-0.3299***	***-0.5667***	***-0.3774***
F-Statistic					***202.38****	***5.12****	***211.24****	***5.33****
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes
Observations	20309	20309	20309	20309	20309	20309	20309	20309
Number of banks	3665	3665	3665	3665	3665	3665	3665	3665
R-squared	0.1168	0.5214	0.1186	0.5245	0.1578	0.4326	0.1657	0.4350

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Granger causality tests with alternative profit efficiency (U.S. sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Alternative profit efficiency	Lerner	Alternative profit efficiency	Lerner	**Cost efficiency**	**Lerner**	**Cost efficiency**	**Lerner**
Alternative profit efficiency (t-1)	-0.2595***	-0.0059***	-0.2757***	-0.0060***				
	(0.0132)	(0.0015)	(0.0130)	(0.0015)				
Alternative profit efficiency (t-2)	-0.2445***	-0.0003	-0.2440***	-0.0003				
	(0.0063)	(0.0004)	(0.0062)	(0.0004)				
Alternative profit efficiency (total)	***-0.5040***	***-0.0061***	***-0.5197***	***-0.0062***				
F-Statistic	***829.00****	***11.95****	***813.40****	***13.81*****				
Lerner (t-1)	-4.2143***	0.4594***	-4.0977***	0.4615***	-0.0082***	0.4527***	-0.0065***	0.4380***
	(0.4355)	(0.1031)	(0.4365)	(0.1042)	(0.0014)	(0.0931)	(0.0011)	(0.0949)
Lerner (t-2)	-2.6657***	-0.1952***	-2.4999***	-0.1947***	0.0033***	-0.0940***	0.0021**	-0.0988***
	(0.1083)	(0.0422)	(0.1073)	(0.0418)	(0.0011)	(0.0296)	(0.0008)	(0.0293)
Lerner (total)	***-6.8800***	***0.2642***	***-6.5975***	***0.2667***	***-0.0049***	***0.3586***	***-0.0044***	***0.3392***
F-Statistic	***314.67****	***10.98****	***295.45****	***11.47****	***310.88****	***40.10****	***246.65****	***22.24****
Market share (log)	-1.8572***	-0.0727***	-1.7245***	-0.0725***	0.0039***	-0.1196***	0.0337***	-0.3996***
	(0.0936)	(0.0116)	(0.0926)	(0.0120)	(0.0001)	(0.0038)	(0.0014)	(0.0550)
Total assets (log)	1.9320***	0.0757***	1.7890***	0.0744***	-0.0038***	0.1212***	-0.0335***	0.3992***
	(0.0941)	(0.0119)	(0.0942)	(0.0126)	(0.0001)	(0.0040)	(0.0014)	(0.0556)
Asset growth			-0.0189*	0.0011			0.0000	0.0020**
			(0.0111)	(0.0010)			(0.0000)	(0.0009)
Asset growth (squared)			0.0001	0.0000			-0.0000	0.0000
			(0.0002)	(0.0000)			(0.0000)	(0.0000)
Herfindahl Hirschman index			-0.5181***	0.0040			0.0166***	0.6312***
			(0.0648)	(0.0031)			(0.0019)	(0.1025)
Banking system assets (log)			0.2334***	0.0012			0.0224***	-0.2078***
			(0.0201)	(0.0012)			(0.0010)	(0.0396)
Cost efficiency (t-1)					0.0418***	1.9278*	-0.5580***	9.4534***
					(0.0063)	(1.0017)	(0.0269)	(0.5578)
Cost efficiency (t-2)					-0.3602***	11.4859***	-0.7538***	15.9491***
					(0.0050)	(0.1466)	(0.0181)	(0.7672)
Cost efficiency (total)					***-0.3184***	***13.4137***	***-1.3118***	***25.4024***
F-Statistic					***4427.59****	***3518.37****	***1944.16****	***219.11****
Country dummies	No	No	Yes	Yes	No	No	Yes	Yes
Observations	42352	42352	42352	42352	42352	42352	42352	42352
Number of banks	8990	8990	8990	8990	8990	8990	8990	8990
R-squared	0.2557	0.4943	0.2672	0.4952	0.5705	0.5791	0.6350	0.5845

Clustered standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. Herfindahl Hirschman index and banking system assets are measured on the state level.

Table 5: Robustness tests for Granger causality analyses

	Panel A: European sample				Panel B: U.S. sample			
Dependent variable	**(1) Standard profit efficiency**	**(2) Lerner**	**(3) Standard profit efficiency**	**(4) Lerner**	**(1) Standard profit efficiency**	**(2) Lerner**	**(3) Standard profit efficiency**	**(4) Lerner**
Standard profit efficiency (t-1)	-0.4947***	0.0000	-0.4947***	0.0000	-0.2574***	-0.0068***	-0.2736***	-0.0068***
	(0.0084)	(0.0000)	(0.0084)	(0.0000)	(0.0131)	(0.0018)	(0.0129)	(0.0018)
Standard profit efficiency (t-2)	-0.3305	-0.0003**	-0.3307	-0.0003**	-0.2489***	-0.0006	-0.2485***	-0.0005
	(0.3404)	(0.0001)	(0.3398)	(0.0001)	(0.0058)	(0.0004)	(0.0058)	(0.0004)
Standard profit efficiency (total)	***-0.8251***	***-0.0002***	***-0.8253***	***-0.0002***	***-0.5301***	***-0.0040***	***-0.5221***	***-0.0073***
F-Statistic	***1775.36****	***2.11***	***1786.76****	***2.38****	***1071.00****	***77.17****	***1018.91****	***10.85****
Lerner (t-1)	4.2196	0.6681***	3.7069	0.6792***	-3.5765***	0.4603***	-3.4782***	0.4624***
	(4.2233)	(0.0191)	(3.9189)	(0.0192)	(0.3597)	(0.1036)	(0.3605)	(0.1047)
Lerner (t-2)	-7.1079	-0.0851***	-7.3891	-0.0836***	-2.4194***	-0.1963***	-2.2806***	-0.1958***
	(5.2668)	(0.0161)	(5.3736)	(0.0160)	(0.0989)	(0.0425)	(0.0966)	(0.0421)
Lerner (total)	***-2.8883***	***0.5829***	***-3.6822***	***0.5955***	***-6.8327***	***0.3553***	***-5.7588***	***0.2665***
F-Statistic	***1.10***	***893.45****	***1.11***	***862.52****	***434.45****	***3072.99****	***281.78****	***11.54****
Market share (log)	0.0276	-0.0030***	-0.0018	0.0154***	-1.5850***	-0.0728***	-1.4771***	-0.0727***
	(0.0712)	(0.0004)	(0.2097)	(0.0014)	(0.0808)	(0.0117)	(0.0802)	(0.0121)
Total assets (log)	-0.1805	0.0222***	0.0000	0.0000	1.6611***	0.0758***	1.5433***	0.0746***
	(0.2069)	(0.0011)	(0.0000)	(0.0000)	(0.0813)	(0.0121)	(0.0817)	(0.0127)
Asset growth			-0.6113	0.0086***			-0.0121	0.0011
			(0.4876)	(0.0018)			(0.0090)	(0.0010)
Asset growth (squared)			0.2824	-0.0012			-0.0000	0.0000
			(0.2048)	(0.0021)			(0.0002)	(0.0000)
Herfindahl Hirschman index			-1.4707	-0.0086**			-0.4673***	0.0037
			(2.0063)	(0.0041)			(0.0550)	(0.0030)
Banking system assets (log)			-0.0470	0.0195***			0.1965***	0.0012
			(0.1817)	(0.0012)			(0.0182)	(0.0012)
Country dummies	No	No	Yes	Yes	No	No	No	No
Observations	20294	20298	20294	20298	42285	42301	42285	42301
Number of banks	3657	3659	3657	3659	8977	8981	8977	8981
R-squared	0.2404	0.5211	0.2405	0.5243	0.2531	0.4945	0.2643	0.4953

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1; Herfindahl Hirschman index and banking system assets are measured on the state level for the U.S. sample.

Table 6: Boone indicator and Z-Score (European sample)

	(1)	(2)	(3)
Dependent variable	**Z-Score**	**Z-Score**	**Z-Score**
Boone indicator	-15.8333***	-25.3312***	-15.6961***
	(3.9747)	(2.7555)	(2.9062)
Total assets (log)	7.3427***	3.5874**	-6.4764***
	(2.0573)	(1.5548)	(0.6778)
Equity/Total assets	0.0000	0.0000	0.0000***
	(0.0000)	(0.0000)	(0.0000)
Asset growth	-5.4943***	-4.0039***	0.6168*
	(1.0403)	(0.7539)	(0.3726)
Asset growth (squared)	0.2469***	0.1943***	-0.0081
	(0.0400)	(0.0297)	(0.0852)
Loan loss provisions/Total assets	-0.7663***	-0.9019***	-0.8571***
	(0.2055)	(0.1026)	(0.1947)
Diversification index	2.8923***	3.5635***	1.1590*
	(0.9021)	(0.6269)	(0.7016)
Herfindahl Hirschman index			3.8943*
			(2.0692)
Banking system assets (log)			0.3661**
			(0.1768)
Real interest rate			-0.7892***
			(0.1317)
GDP per capita			0.0008***
			(0.0001)
Cooperative bank		8.3224***	
		(2.2333)	
Savings bank		-3.1374**	
		(1.5323)	
Country dummies	No	Yes	No
Fixed/Random effects	Fixed effects	Random effects	Fixed effects
Observations	19172	19706	13872
Number of banks	3098	3632	2872
Hansen Sargan J-Statistic	2.123	n/a	0.958
p-value	0.1451	n/a	0.3276

Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Boone indicator and Z-Score (U.S. sample)

	(1)	(2)	(3)
Dependent variable	**Z-score**	**Z-Score**	**Z-score**
Boone indicator	15.0697	-6.4351***	-39.7983
	(13.8552)	(0.4865)	(34.2599)
Total assets (log)	1.6474	-1.7145***	-2.6765
	(1.2178)	(0.1129)	(2.8216)
Equity/Total assets	0.0000**	0.0000***	0.0000***
	(0.0000)	(0.0000)	(0.0000)
Asset growth	0.0932	-0.8773***	-0.7923
	(0.6007)	(0.0748)	(0.7562)
Asset growth (squared)	-0.0039	0.0182***	0.0151
	(0.0115)	(0.0018)	(0.0152)
Loan loss provisions/Total assets	-1.1164	-1.4769***	2.9806
	(1.5096)	(0.0783)	(4.1154)
Diversification index	0.0853	-0.9727***	3.7455
	(2.1046)	(0.2822)	(2.6256)
Herfindahl Hirschman index			-1.1818**
			(0.5421)
Banking system assets (log)			4.0160
			(5.1516)
Real interest rate			1.0284
			(1.2174)
GDP per capita			0.0033
			(0.0024)
Savings Bank		-0.3529	
		(0.9397)	
Cooperative bank		-10.3744	
		(15.9454)	
Observations	49776	50032	49776
Number of banks	8824	9080	8824
Hansen Sargan J-Test	2.706	n/a	1.985
p-value	0.1000	n/a	0.1588

Clustered standard errors in parentheses; observations weighted by bank assets; *** p<0.01, ** p<0.05, * p<0.1

Table 8: Robustness tests for soundness regressions (European sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	**Z-score**	**Z-score**	**Z-score**	**Z-score**	**Z-score**	**S.D. ROA**	**Z-score**
Boone indicator	5.7587	-5.5733***	-15.0790***	-16.4025***	-18.7123***	-0.0171	-15.6987***
	(9.2540)	(2.1211)	(2.0619)	(2.9841)	(3.5555)	(0.0183)	(3.2153)
Equity/Total assets	0.0000***	0.0000***	0.0000	0.0000***	0.0000***	-0.0005	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0003)	(0.0000)
Asset growth	-0.4741	1.7738**	0.3045	0.5840	0.1583	0.0000	0.6562
	(0.9977)	(0.8761)	(0.3003)	(0.3757)	(0.5091)	(0.0000)	(0.4101)
Asset growth (squared)	0.0740	-0.2028	0.2072	-0.0029	0.2601	0.0034**	-0.0107
	(0.1289)	(0.1438)	(0.2060)	(0.0866)	(0.1765)	(0.0017)	(0.0906)
Loan loss provisions/Total assets	-0.6391*	-0.8282***	-0.6277***	-0.8770***	-1.2503***	-0.0001	-0.8665***
	(0.3727)	(0.2660)	(0.1514)	(0.1982)	(0.2823)	(0.0001)	(0.2106)
Diversification index	0.4721	0.8400	-0.4007	1.1835*	2.2419**	0.0018***	0.0000
	(1.6797)	(0.6465)	(0.6603)	(0.7128)	(0.9868)	(0.0005)	(0.0000)
Herfindahl Hirschman index	-5.3884**	-11.1718***	37.8166***	3.8549*	-2.7841	0.0034***	4.0866*
	(2.1733)	(2.7103)	(5.2008)	(2.0968)	(2.3569)	(0.0010)	(2.4548)
Banking system assets (log)	1.5452***	0.9462*	0.0991	0.3477*	-0.0782	-0.0334	0.3762
	(0.5654)	(0.4840)	(0.1026)	(0.1788)	(0.2832)	(0.0324)	(0.1919)
Real interest rate	-0.4563	-0.2333	-0.9074***	-0.8203***	-0.7918***	-0.0020*	-0.7888***
	(0.3174)	(0.1497)	(0.1400)	(0.1343)	(0.1611)	(0.0012)	(0.1498)
GDP per capita	0.0004	0.0001	0.0006***	0.0008***	0.0008***	-0.0005	0.0008***
	(0.0005)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0007)	(0.0001)
Total assets (log)	-10.5779***	-6.1839***	-5.2948***	-6.4793***	-2.8675***	-0.0000	-6.5859***
	(1.9358)	(1.7403)	(0.4086)	(0.6794)	(0.8290)	(0.0000)	(0.7139)
Observations	2040	3662	8170	13862	6418	2810	13872
Number of banks	487	709	1676	2870	1121	2810	2872
Hansen Sargan J-Test	0.063	5.457**	0.885	0.026	5.067**	1.569	2.136
p-value	0.8012	0.0195	0.3469	0.8708	0.0244	0.2103	0.1439

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
(1) commercial banks only; (2) savings banks only; (3) cooperative banks only; (4) excludes Switzerland; (5) controls for survivorship bias; (6) SD ROA is the dependent variable; (7) uses a bootstrapping procedure with 250 replications

Table 9: Robustness tests for soundness regressions (U.S. sample)

	(1)	(2)	(3)	(4)	(5)
Dependent variable	Z-score	Z-score	Z-score	S.D. ROA	Z-score
Boone indicator	-46.8339	-50.8275	-63.9354	0.0225	-54.6806
	(29.2480)	(103.7977)	(56.2287)	(0.0314)	(45.3455)
Total assets (log)	-2.7173	-5.1667	-3.6399	0.0001	-3.8653
	(3.2749)	(7.4542)	(6.0920)	(0.0002)	(4.4422)
Equity/Total assets	0.0000***	-0.0000	0.0000***	-0.0000**	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Asset growth	-0.8913	-3.0357	-0.2440	0.0023**	-0.9820
	(0.6690)	(4.5184)	(2.4446)	(0.0010)	(0.8368
Asset growth (squared)	0.0157	0.1128	0.0429	-0.0000	0.0194)
	(0.0109)	(0.1805)	(0.2819)	(0.0000)	0.0167
Loan loss provisions/Total assets	3.7046*	1.1510	5.8697	0.0016*	4.1782
	(1.9285)	(1.6864)	(5.9968)	(0.0009)	(3.2925)
Diversification index	3.2180	8.2854	6.8669	0.0019	4.7638
	(3.1947)	(16.2553)	(4.5795)	(0.0014)	(4.0902)
Herfindahl Hirschman index	-1.3721*	-1.0098	-1.2026	-0.0001	-1.4771
	(0.7583)	(2.6884)	(0.9808)	(0.0018)	(1.0209)
Banking system assets (log)	4.9101	5.8858	2.2475	-0.0002	6.1312
	(4.6924)	(11.9228)	(6.3405)	(0.0002)	(6.4562)
Real interest rate	1.2642	1.6041	1.4900	-0.0000	1.4740
	(0.7726)	(3.6762)	(1.3695)	(0.0016)	(1.2578)
GDP per capita	0.0038*	0.0044	0.0061	-0.0000	0.0043
	(0.0021)	(0.0089)	(0.0043)	(0.0000)	(0.0032)
Observations	44731	5033	2543	8216	49776
Number of banks	7916	906	286	8216	88254
Hansen Sargan J-Test	0.191	0.004	0.215	1.796	0.189
p-value	0.6619	0.9470	0.6429	0.18019	0.6640

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
(1) focuses on commercial banks only, (2) focuses on savings banks only; (3) controls for survivorship bias; (4) S.D. ROA is the dependent variable; (5) uses a bootstrapping procedure with 250 replications; Herfindahl Hirschman index and banking system assets are measured on the state level.

Figure 1: Lerner indices

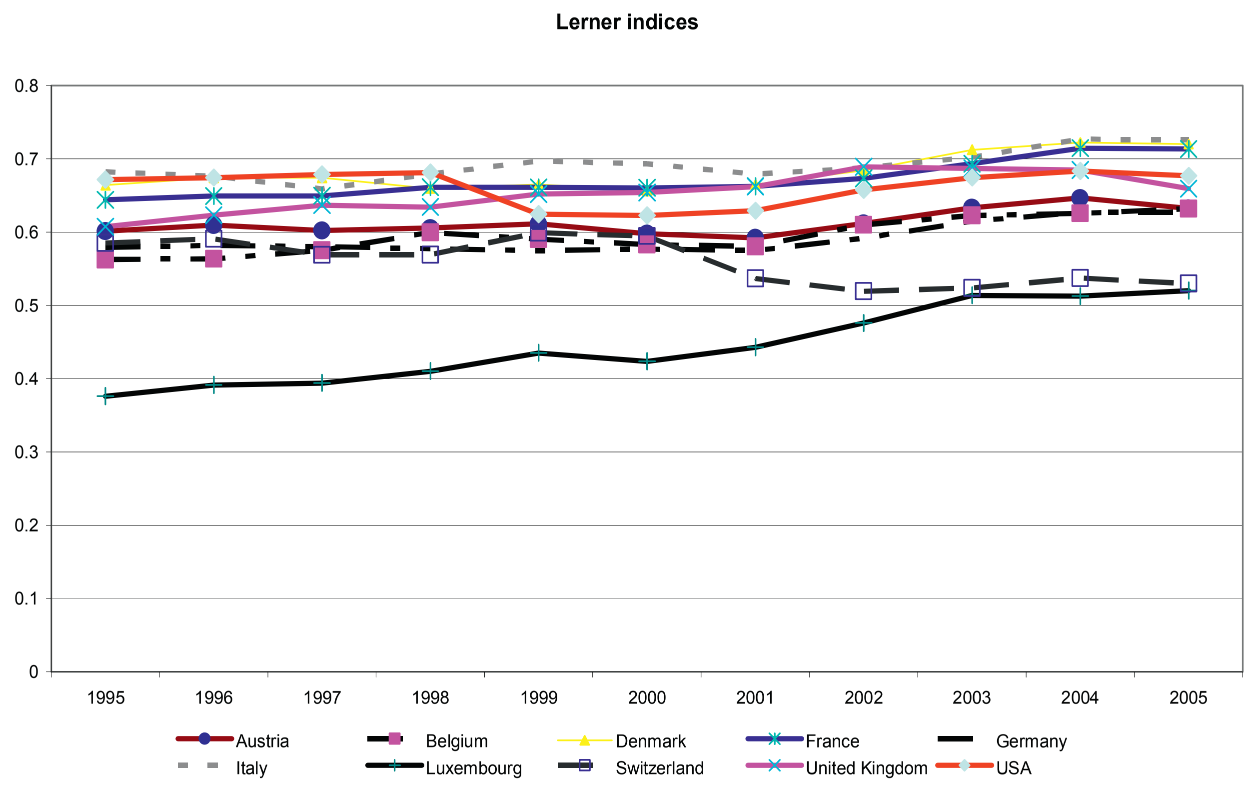
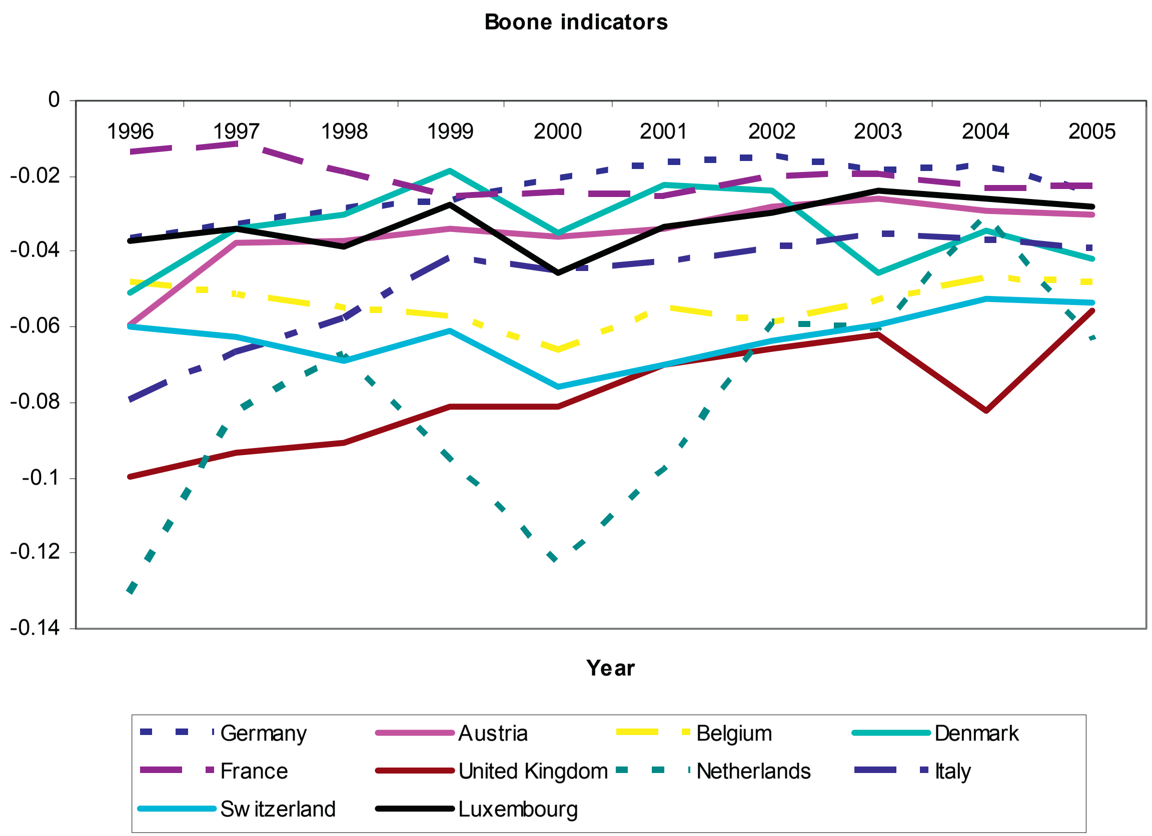


Figure 2: Boone indicators



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