A new approach to measuring competition in the loan markets of the euro area

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Abstract

This paper is the first that applies a new measure of competition, the Boone indicator, to the banking industry. This approach is able to measure competition of bank market segments, such as the loan market, whereas many well-known measures of competition can consider the entire banking market only. A caveat of the Boone-indicator may be that it assumes that banks generally pass on at least part of their efficiency gains to their clients. Like most other model-based measures, this approach ignores differences in bank product quality and design, as well as the attractiveness of innovations. We measure competition on the lending markets in the five major EU countries as well as, for comparison, the UK, the US and Japan. Bearing the mentioned caveats in mind, our findings indicate that over the period 1994-2004 the US had the most competitive loan market, whereas overall loan markets in Germany and Spain were among the best competitive in the EU. The Netherlands occupied a more intermediate position, whereas in Italy competition declined significantly over time. The French, Japanese and UK loan markets were generally less competitive. Turning to competition among specific types of banks, commercial banks tend to be more competitive, particularly in Germany and the US, than savings and cooperative banks.

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Key words: Banking industry, competition, loan markets, marginal costs, market shares;

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NON-TECHNICAL SUMMARY

This paper investigates the measurement of competition in the EU banking sector. Bank competition is pivotal to monetary policy as it may affect the way changes in the policy rates of the European Central Bank (ECB) are passed on to the interest rates that banks offer their customers.

The paper uses a new approach, the so-called Boone indicator, to estimate competition in the loan markets of the euro area. To our knowledge, this is the first paper which applies this method to the banking market. This indicator measures the effect of efficiency on performance in terms of profits or market shares. The idea underlining the Boone indicator is that competition enhances the performance of efficient firms and impairs the performance of inefficient firms, which is reflected in lower profits or smaller market shares.

Our approach is innovative in the sense that this method allows measurement of competition not only for the entire banking market, but also for separate product markets, such as the loan market, and for single types of banks, such as commercial, savings and cooperative banks. By contrast, other often applied measures of bank competition, such as the Panzar-Rosse model, typically only investigate the competitive nature of the aggregate of all banking activities. Another advantage of the Boone indicator is that it requires relatively little data, contrary to many other approaches, *e.g.* the Bresnahan model, which are very data intensive. That serves for the estimation of competition on an annual basis, which enables us to assess developments in competitive conditions over time. A disadvantage of the Boone-indicator is that it assumes that banks generally pass on at least part of their efficiency gains to their clients. Furthermore, like many other model-based measures, our approach ignores differences in product quality and design across banks, as well as the attractiveness of innovations.

We apply the Boone indicator to the loan markets of the five major countries in the euro area and, for comparison, to the UK, the US and Japan over 1994–2004. Our findings indicate that the US had the most competitive loan market, whereas Germany and Spain were among the best competitive EU markets. The German results seem to be driven partly by a competitive commercial banking sector reflecting the distinct nature of its "three-pillar" banking system. In Spain, competition remained strong and relatively stable over the full sample period, indicating the progress the Spanish banking system has made since the major liberalisation reforms in the late 1980s and early 1990s. The Netherlands took up a more intermediate position among the countries in our sample, despite having a relatively concentrated banking market dominated by a small number of very large players. Italian competition declined significantly over time, which may be due to the partial reconstitution of market power by the banking groups formed in the early 1990s. French and British loan markets were less competitive overall. In Japan, competition in loan markets was found to increase dramatically over the years, in line with the consolidation and revitalisation of the Japanese banking industry in recent years.

The paper also measures competition among specific types of banks. Commercial banks, which are more exposed to competition from foreign banks and capital markets, tend to be more competitive, particularly in Germany and the US, than savings and cooperative banks, which typically operate in local markets. An exception is Japan, where competition among savings and cooperative banks was considerably stronger than competition between commercial banks. This may indicate the adverse impact of the banking crises on bank competition, as the commercial banks were particularly hard-hit by the severe banking crisis that engulfed Japan during the 1990s.

All in all, according to the Boone indicator, competitive conditions in the loan markets and their developments over time are found to differ considerably across countries. These differences seem largely to reflect distinct characteristics of the national banking sectors, such as the relative importance of commercial, cooperative and saving banks respectively, and changes to the banks' institutional and regulatory environment during our sample period.

1. Introduction

This paper investigates the measurement of competition in the EU banking sector. Competition is a key driver of social welfare, as it may push down prices (*i.e.* interest rates) and improves services for consumers and enterprises (Cetorelli, 2001).[1] Also, competition is pivotal to monetary policy: in a competitive market, changes in the policy rates of the European Central Bank (ECB) are passed on more quickly to the interest rates that banks offer their customers.

The paper presents estimates of competition in loan markets of the major EU countries using a new approach, introduced and applied by Boone (2000, 2004), Boone *et al.* (2004) and CPB (2000). So far this method has not been applied to banking markets.[2] The so-called Boone indicator measures the impact of efficiency on performance in terms of profits or market shares. The idea behind the Boone indicator is that competition enhances the performance of efficient firms and impairs the performance of inefficient firms, which is reflected in their respective profits or market shares. This approach is related to the well-known efficiency hypothesis, which also explains banks' performances by differences in efficiency (Goldberg and Rai, 1996; Smirlock, 1985).

A well-known problem in the banking industry is that competition cannot be measured directly, as costs and often also price data of single banking products are usually unavailable. Hence, indirect measures are needed. This paper adds to the competition literature in applying a new competition indicator to the banking sector which is an improvement on widely accepted concentration measures, such as the Herfindahl-Hirschmann Index (HHI). The HHI has the disadvantage of not distinguishing between large and small countries. Furthermore, concentration may also be due to consolidation forced by severe competition. Hence, the concentration index is an ambiguous measure.[3]

Our approach to competition is also innovative in the sense that we can measure competition not only for the entire banking market, but also for various product markets, such as the loan market, and for several types of banks, such as commercial, savings banks and cooperative banks. An often applied measure such as the Panzar-Rosse model only investigates the competitive nature of the total of all banking activities. Another advantage of the Boone indicator is that it requires relatively little data, different from, *e.g.* the Bresnahan model which is very data intensive. This allows the estimation of competition on an annual basis to assess developments over time. A disadvantage of the Boone-indicator is that it assumes that banks generally pass on at least part of their efficiency gains to their clients. Like many other model-

[1] However, as is stressed by Allen *et al.* (2001), there is a conflict between this traditional view, stemming from the industrial organisation literature, and more recent theoretical models of bank competition, which raise the question whether competition between banks is good or bad. See, for example, Cetorelli and Strahan (2006).

[2] Boone has applied his indicator to various manufacturing industries and Bikker and Van Leuvensteijn (2007) to the life insurance business.

[3] A world-wide study by Claessens and Laeven (2004) found that bank concentration was positively instead of negatively related to competition.

based measures, our approach ignores differences in bank product quality and design, as well as the attractiveness of innovations.

The structure of this paper is as follows. Section 2 presents an overview of different approaches in the literature to measure banking competition. Section 3 provides a theoretical basis for the Boone indicator as a new measure for competition and discusses its properties. The data are described in the following section. The econometric method and the results are presented in Section 5. Finally, Section 6 concludes.

2. Literature on measuring competition

Competition in the banking sector has been analysed by measuring market power and efficiency. A well-known approach to measuring market power is suggested by Bresnahan (1982) and Lau (1982), recently used by Bikker (2003) and Uchida and Tsutsui (2005). They analyse bank behaviour on an aggregate level and estimate the average conjectural variation of banks. A high conjectural variation implies that a bank is highly aware of its interdependence with other firms in terms of output and prices (via the demand equation). Under perfect competition where output price equals marginal costs, the conjectural variation between banks should be zero, whereas a value of one would indicate monopoly.

Panzar and Rosse (1987) propose an approach based on the so-called H-statistic which is the sum of the elasticities of the reduced-form revenues with respect to the input prices. This H-statistic ranges from $-\infty$ to 1. An H-value equal to or smaller than zero indicates monopoly or perfect collusion, whereas a value between zero and one provides evidence of a range of oligopolistic or monopolistic types of competition. A value of one points to perfect competition. This approach has been applied to all EU countries by Bikker and Haaf (2002).

A third indicator for market power is the Hirschman-Herfindahl Index, which measures the degree of market concentration. This indicator is often used in the context of the 'Structure Conduct Performance' (SCP) model (see *e.g.* Berger *et al*., 2004, and Bos, 2004), which assumes that market structure affects banks' behaviour, which in turn determines their performance.[4] The idea is that banks with larger market shares may have more market power and use that. Moreover, a smaller number of banks make collusion more likely. To test the SCP-hypothesis, performance (profit) is explained by market structure (as measured by the HHI).

Market power may also be related to profit, in the sense that extremely high profits may be indicative of a lack of competition. A traditional measure of profitability is the price-cost margin (PCM), which is equal to the output price minus the marginal costs, divided by the output price. The PCM is frequently used in the empirical industrial organization literature as an empirical approximation of the theoretical Lerner index.[5] In the literature, banks' efficiency is

[4] Bikker and Bos (2005), pages 22 and 23.

[5] The Lerner index derives from the monopolist's profit maximisation condition as price minus marginal cost, divided by price. The monopolist maximises profits when the Lerner index is equal to the inverse

often seen as a proxy of competition. The existence of scale and scope economies has in the past been investigated thoroughly. It is often assumed that unused scale economies would be exploited and, consequently, reduced under strong competition.[6] Hence, the existence of non-exhausted scale economies is an indication that the potential to reduce costs has not been exhausted and, therefore, can be seen as an indirect indicator of (a lack of) competition (Bikker and Van Leuvensteijn, 2007). The existence of scale efficiency is also important as regards the potential entry of new firms, which is a major determinant of competition. Strong scale effects would put new firms into an unfavourable position.

A whole strand of literature is focused on X-efficiency, which reflects managerial ability to drive down production costs, controlled for output volumes and input price levels. The X-efficiency of firm *i* is defined as the difference in costs between that firm and the best practice firms of similar size and input prices (Leibenstein, 1966). Heavy competition is expected to force banks to drive down their X-inefficiency, so that the latter is often used as an indirect measure of competition. An overview of the empirical literature is presented in Bikker (2004) and Bikker and Bos (2005).

A final area in the literature has been devoted to the Structure Conduct Performance (SCP) model where conduct reflects competitive behaviour. This hypothesis assumes that market structure affects competitive behaviour and, hence, performance. Many articles test this model jointly with an alternative explanation of performance, namely the efficiency hypothesis, which attributes differences in performance (or profit) to differences in efficiency (*e.g.* Goldberg and Rai, 1996, and Smirlock, 1985). As mentioned above, the Boone indicator can be seen as an elaboration on this efficiency hypothesis. This test is based on estimating an equation which explains profits by market structure variables and measures of efficiency. The efficiency hypothesis assumes that market structure variables do not contribute to profits once efficiency is considered as cause of profit. As Bikker and Bos (2005) show, this test suffers from a multicollinearity problem if the efficiency hypothesis holds.

3. The Boone indicator model

Boone's model is based on the notion, first, that more efficient firms (that is, firms with lower marginal costs) gain higher market shares or profits and, second, that this effect is stronger the heavier the competition in that market is. In order to support this quite intuitive market characteristic, Boone develops a broad set of theoretical models (see Boone, 2000, 2001 and 2004, Boone *et al*., 2004, and CPB, 2000). We use one of these models to explain the Boone

price elasticity of market demand. Under perfect competition, the Lerner index is zero (market demand is infinitely elastic), in monopoly it approaches one for positive non-zero marginal cost. The Lerner index can be derived for intermediary cases as well. For a discussion see Church and Ware (2000).

[6] This interpretation would be different in a market numbering only a few firms. Furthermore, this interpretation would also change when many new entries incur unfavourable scale effects during the initial phase of their growth path.

indicator and to examine its properties compared to common measures such as the HHI and PCM approaches. Following Boone *et al*. (2004), and replacing 'firms' by 'banks', we consider a banking industry where each bank i produces one product q_i (or portfolio of banking products), which faces a demand curve of the form:

$$p\,(q_i, q_{j\neq i}) = a - b\,q_i - d\sum_{j\neq i} q_j \tag{1}$$

and has constant marginal costs mc_i. This bank maximizes profits $\pi_i=(p_i-mc_i)\ q_i$ by choosing the optimal output level q_i. We assume that $a > mc_i$ and $0 < d \leq b$. The first-order condition for a Cournot-Nash equilibrium can then be written as:

$$a - 2\,b\,q_i - d\sum_{i\neq j} q_j - mc_i = 0 \tag{2}$$

When N banks produce positive output levels, we can solve the N first-order conditions (2), yielding:

$$q_i\,(c_i) = [(2\,b/d - 1)\,a - (2\,b/d + N - 1)\,mc_i + \sum_j mc_j]/[(2\,b + d\,(N-1))(2\,b/d - 1)] \tag{3}$$

We define profits π_i as variable profits excluding entry costs ε. Hence, a bank enters the banking industry if, and only if, $\pi_i \geq \varepsilon$ in equilibrium. Note that Equation (3) provides a relationship between output and marginal costs. It follows from $\pi_i=(p_i-mc_i)\,q_i$ that profits depend on marginal costs in a quadratic way.

In this market, competition can increase in two ways. First, competition increases when the produced (portfolios of) services of the various banks become closer substitutes, that is, d increases (keeping d below b). Second, competition increases when entry costs ε decline. Boone *et al*. (2004) prove that market shares of more efficient banks (that is, with lower marginal costs c) increase both under regimes of stronger substitution and amid lower entry costs.

Equation (3) supports the use of the following model for market share, defined as $s_i = q_i/\sum_j q_j$:

$$\ln s_i = \alpha + \beta \ln mc_i \tag{4}$$

The market shares of banks with lower marginal costs are expected to increase, so that β is negative. The stronger competition is, the stronger this effect will be, and the larger, in absolute terms, this (negative) value of β. We refer to the β parameter as the *Boone indicator*. For empirical reasons, Equation (4) has been specified in log-linear terms in order to deal with heteroskedasticty. Moreover, this specification implies that β is an elasticity, which facilitates

easy interpretation, particularly across equations.[7] The choice of functional form is not essential, as the log-linear form is just an approximation of the pure linear form. In Section 5.2.1, we will find that the results of the linear model are very similar to those of the log-linear model.

The theoretical model above can also be used to explain why widely-applied measures such as the HHI and the PCM fail as reliable competition indicators. The standard intuition of the HHI is based on a Cournot model with symmetric banks, where a fall in entry barriers reduces the HHI. However, with banks that differ in efficiency an increase in competition through a rise in d reallocates output to the more efficient banks that already had higher output levels. Hence, the increase in competition raises the HHI. The effect of increased competition on the industry's PCM may also be perverse. Generally, heavier competition reduces the PCM of all banks. But since more efficient banks may have a higher PCM (skimming off part of the profits stemming from their efficiency lead), the increase of their market share may raise the industry's average PCM, contrary to common expectations.

We note that the Boone indicator model, like every other model, is a simplification of reality. First, efficient banks may choose to translate lower costs either into higher profits or into lower output prices in order to gain market share. Our approach assumes that the behaviour of banks is between these two extreme cases, so that banks generally pass on at least part of their efficiency gains to their clients. More precisely, we assume that the banks' passing-on behaviour, which drives Equation (4), does not diverge too strongly across the banks. Second, our approach ignores differences in bank product quality and design, as well as the attractiveness of innovations. We assume that banks are forced over time to provide quality levels that are more or less similar. By the same token, we presume that banks have to follow the innovations of their peers. Hence, like many other model-based measures, the Boone indicator approach focuses on one important relationship, affected by competition, thereby disregarding other aspects (see also Bikker and Bos, 2005). Naturally, annual estimates of β are more likely to be impaired by these distortions than the estimates covering the full sample period. Also, compared to direct measures of competition, the Boone indicator may have the disadvantage of being an estimate and thus surrounded by a degree of uncertainty. Of course, other model-based measures, such as Panzar and Rosse's H-statistic, suffer from the same disadvantage. The latter shortcoming concerns to the annual estimates β_t rather than the full sample period estimate β.

As the Boone indicator may be time dependent, reflecting changes in competition over time, we estimate β separately for every year (hence, β_t). We do not have an absolute benchmark for the level of β. We only know that the more negative β is, the stronger competition must be. Comparing the indicator across regions or countries, or even across industries, may help to interpret estimation results. For that reason, Boone and Weigand in CPB (2000) and Boone *et al.* (2004) applied the model to different manufacturing industries. Since measurement errors –

[7] The few existing empirical studies based on the Boone indicator have all used a log linear relationship. See, for example, Bikker and Van Leuvensteijn (2007).

including unobserved country or industry specific factors – are less likely to vary over time than across industries, the time series interpretation of beta is probably more robust than the cross-sector one (that is, comparison of β for various countries or industries at a specific moment in time). Therefore, Boone focuses mainly on the *change* in β_t over time within a given industry, rather than comparing β between industries.

Because marginal costs cannot be observed directly, CPB (2000) and Boone *et al.* (2004) approximate a firm's marginal costs by the ratio of average variable costs and revenues. As dependent variable in Equation (4), CPB (2000) uses the *relative* values of profits and as explanatory variable the ratio of variable costs and revenues, whereas Boone *et al.* (2004) consider *absolute* instead of relative values.

We improve on Boone's approach in two ways. First, we calculate marginal costs instead of approximating this variable with average variable costs. We are able to do so by using a translog cost function, which is more precise and more closely in line with theory. An important advantage is that these marginal costs allow focussing on segments of the market, such as the loan market, where no direct observations of individual cost items are available. Second, we use market share as dependent variable instead of profits. The latter is, by definition, the product of market shares and profit margin. We have views on the impact of efficiency on market share and its relation with competition, supported by the theoretical framework above, whereas we have no a priori knowledge about the effect of efficiency on the profit margin. Hence, a market share model will be more precise. An even greater advantage of using market shares is that they are always positive, whereas the range of profits (or losses) includes negative values. A log linear specification would exclude negative profits (losses) by definition, so that the estimation results would be distorted by sample bias, because inefficient, loss-making banks would have to be ignored.

In order to be able to calculate marginal costs, we first estimate, for each country, a translog cost function (TCF) using individual bank observations. Such a function assumes that the technology of an individual bank can be described by one multiproduct production function. Under proper conditions, a dual cost function can be derived from such a production function, using output levels and factor prices as arguments. A TCF is a second-order Taylor expansion around the mean of a generic dual cost function with all variables appearing as logarithms. It is a flexible functional form that has proven to be an effective tool in explaining multiproduct bank services. The TCF has the following form:

$$ln\, c_{it}^{\,h} = \alpha_0 + \sum_{h=1,..,(H-1)} \alpha_h\, d_i^h + \sum_{t=1,..,(T-1)} \delta_t\, d_t + \sum_{h=1,..,H} \sum_{j=1,..,K} \beta_{jh}\, ln\, x_{ijt}\, d_i^h$$
$$+\sum_{h=1,..,H} \sum_{j=1,..,K} \sum_{k=1,..,K} \gamma_{jkh}\, ln\, x_{ijt}\, ln\, x_{ikt}\, d_i^h + v_{it} \qquad (5)$$

where the dependent variable $c_{it}^{\,h}$ reflects the production costs of bank i (i = 1, .., N) in year t (t = 1, .., T). The sub-index h (h = 1, .., H) refers to the type category of the bank, that is, commercial

bank, savings bank or cooperative bank. The variable d_i^h is a dummy variable, which is 1 if bank i is of type h and otherwise zero. The variable d_t is a dummy variable, which is 1 in year t and otherwise zero. The explanatory variables x_{ikt} represent three groups of variables (k = 1, .., K.). The first group consists of (K_1) bank output components, such as loans, securities and other services (proxied by other income). The second group consists of (K_2) input prices, such as wage rates, deposit rates (as price of funding) and the price of other expenses (proxied as the ratio of other expenses to fixed assets). The third group consists of (K-K_1-K_2) control variables (also called 'netputs'), *e.g.* the equity ratio. In line with Berger and Mester (1997), the equity ratio corrects for differences in loan portfolio risk across banks. The coefficients α_h, β_{jh} and γ_{jkh}, all vary with h, the bank type. The parameters δ_t are the coefficients of the time dummies and v_{it} is the error term.

Two standard properties of cost functions are linear homogeneity in the input prices and cost-exhaustion (see *e.g.* Beattie and Taylor, 1985, and Jorgenson, 1986). They imply the following restrictions on the parameters, assuming – without loss of generality – that the indices j and k of the two sum terms in Equation (5) are equal to 1, 2 or 3, respectively, for wages, funding rates and prices of other expenses (disregarding the sub-index h):

$$\beta_1 + \beta_2 + \beta_3 = 1,\ \gamma_{1,k} + \gamma_{2,k} + \gamma_{3,k} = 0 \text{ for k = 1, 2, 3, and } \gamma_{k,1} + \gamma_{k,2} + \gamma_{k,3} = 0 \text{ for } k = 4,..,K \qquad (6)$$

The first restriction stems from cost exhaustion, reflecting the fact that the sum of cost shares is equal to unity. In other words, the value of the three inputs is equal to total costs. Linear homogeneity in the input prices requires that the three linear input price elasticities (β_i) add up to 1, whereas the squared and cross terms of all explanatory variables ($\gamma_{i,j}$) add up to zero. Again without loss of generality, we also apply the symmetry restrictions $\gamma_{j,k} = \gamma_{k,j}$ for j, k = 1, .., K.[8] As Equation (5) expresses that we assume different cost functions for each type of bank, the restrictions (6) apply to each type of bank.

The marginal costs of output category $j = l$ (of loans) for bank i of category h in year t, mc_{ilt}^h are defined as:

$$mc_{i1t}^h = \partial c_{it}^h / \partial x_{i1t} = (c_{it}^h / x_{i1t})\, \partial \ln c_{it}^h / \partial \ln x_{ilt} \qquad (7)$$

The term $\partial \ln c_{it}^h / \partial \ln x_{ilt}$ is the first derivative of Equation (5) of costs to loans. We use the marginal costs of the output component 'loans' only (and not for the other K_1 components) as we investigate the loan markets. We estimate a separate translog cost function for each individual sector in each individual country, allowing for differences in the production structure across bank

[8] The restrictions are imposed on Equation (5) so that the equation is reformulated in terms of a lower number of parameters (see the appendix).

types within a country. This leads to the following equation of the marginal costs for output category loans (l) for bank i in category h during year t:

$$mc_{il_t}^{h} = c_{it}^{h} / x_{il_t} (\beta_{1h} + 2\ \gamma_{llh}\ ln\ x_{ilt} + \sum_{k=1,..,K;\ k \neq l} \gamma_{lkh}\ ln\ x_{ikt}\ )\ d_i^h \qquad (8)$$

4. The data

This paper uses an extended Bankscope database of banks' balance sheet data running from 1992 to 2004. We investigate banking markets of the major euro area countries, *i.e.* France, Germany, Italy, the Netherlands and Spain, as well as, for comparison, the UK, the US and Japan. The focus is on commercial banks, savings banks, cooperative banks and mortgage banks and, for most countries, ignores specialized banks, such as investment banks, securities firms and specialized governmental credit institutions. For Germany, some specialized governmental credit institutions, that is, the major *Landesbanks*, are included in the sample in order to have a more adequate coverage of the German banking system. In addition to certain public finance duties, these *Landesbanks* also offer banking activities in competition with the private sector banks (Hackethal, 2004). For Japan, in contrast with Uchida and Tsutsui (2005), we also include three long-term credit banks, because they traditionally have been offering long-term loans to the corporate sector and have increasingly become competitors of the commercial banks, due to the ongoing process of financial liberalisation in Japan which has eroded the traditional segmentation of the Japanese banking sector (Van Rixtel, 2002).

In order to exclude irrelevant and unreliable observations, banks are incorporated in our sample only if they fulfilled the following conditions: total assets, loans, deposits, equity and other non-interest income should be positive; the deposits-to-assets ratio and loans-to-assets ratio should be less than, respectively, 0.98 and 1; the income-to-assets ratio should be below 20 percent; personnel expenses-to-assets and other expenses-to-assets ratios should be between 0.05% and 5%; and finally, the equity-to-assets ratio should be between 1% and 50%. These restrictions reduced the sample by 3,980 observations mainly due to the equity-to-assets ratio restriction. As the Japanese banking sector experienced a deep crisis during most of our sample period, we have relaxed the equity ratio restriction for Japanese banks.

Table 4.1. Number of banks by country and by type in 2002

Country	Commercial banks	Cooperative banks	Long-term credit banks	Real estate banks/ Mortgage banks	Savings banks	Special governmental credit institutions	Total
DE	130	867	0	44	501	28	1,570
ES	61	17	0	0	43	0	121
FR	115	83	0	2	30	0	230
UK	80	0	0	57	3	0	140
IT	105	476	0	1	52	0	634
JP	169	676	3	0	1	0	849
NL	24	1	0	4	1	0	30
US	7,921	1	0	1	914	0	8,837
Total	*8,605*	*2,121*	*3*	*109*	*1,545*	*28*	*12,411*

As a result, the data set for 2002 totals 8,605 commercial banks (including *Landesbanks*), 2,121 cooperative banks, 1,545 savings banks and 109 mortgage banks, plus 31 other banks, which are 12,411 banks in total (see Table 4.1). Over all years of the sample, the number of observations is 88,647. German and, particularly, US banks dominate the sample with, respectively, 1,570 and 8,837 banks (in 2002). Before 1999, the number of US banks is only around one quarter of this number.

Table 4.2 gives a short description of the variables used in the estimations, such as costs, loans, securities and other services, each expressed as a share of total assets, income or funding. Costs are defined as the sum of interest expenses, personnel expenses and other non-interest expenses. Costs, loans and securities are, respectively, 6%, 61% and 25% of total assets. Average market shares differ strongly across countries, due mainly to country size effects. The output factor other services is proxied by non-interest income, which is around 12% of total income. Wage rates are proxied by personnel expenses as ratio of total assets, as for most banks the number of staff is not available. Wages average 1.5% of total assets. The other-expenses-to-fixed-assets ratio provides an input price for this input factor. Finally, interest rate costs, proxied by the ratio of interest expenses and total funding, run to around 3.1%.

Table 4.2. Mean values of key variables by countries for the period 1992-2004 (in %)

Country	Total costs as a share of total assets	Average market share of lending	Loans as a share of total assets	Securities as a share of total assets	Other services as a share of total income	Other expenses as a share of fixed assets	Wages as a share of total assets	Interest expenses as a share of total funding
DE	6.44	0.06	60	22	12	227	1.5	3.7
ES	6.63	0.98	58	14	16	167	1.5	4.1
FR	7.42	0.41	54	4	20	537	1.5	4.8
UK	6.29	0.78	59	11	14	885	0.9	5.1
IT	6.67	0.22	53	26	16	261	1.7	3.5
JP	2.89	0.25	58	20	14	128	0.1	0.4
NL	6.59	0.54	54	15	13	340	0.9	5.4
US	5.63	0.01	63	28	11	148	1.6	2.8
Total	*5.82*	*0.12*	*61*	*25*	*12*	*203*	*1.5*	*3.1*

5. Estimation results

5.1. Marginal costs

The first step of our estimation procedure is to calculate the marginal costs of the national banking sectors, that is, we estimate Equation (8) for each of the respective eight countries. For this purpose, we use the explanatory variables described in Section 4, namely bank outputs (loans, securities and other services), input prices (wages, funding rates and prices of other non-interest expenses) and the control variable (equity ratio). As an example, Table A.1 in the appendix presents the translog cost function for Germany.[9]

The development of the marginal costs of loans for all individual countries during our sample period is shown in Table 5.1. It is clear that these costs have gradually declined over time, which to a large extent reflects the decrease in funding rates during 1992-2004. However, the speed and magnitude of this decline differ across countries. Thus, differences in country specific characteristics, such as banking technology or differences in legislation and supervision play a role in the development of marginal costs. Germany and Spain have relatively high marginal costs compared to the Netherlands, which may be related to population density. A low population density may raise operating costs in relative terms, because it makes the retail distribution of banking services relatively more costly. Table 5.1 also shows that marginal costs in France are the highest of all countries during the second half of our sample period.

Table 5.1. Marginal costs of loans over time, weighted by loans (in % of loans) [1)]

Year/country	*DE*	*ES*	*FR*	*UK*	*IT*	*JP*	*NL*	*US*	*Average*
1992	10.2	15.9	13.8	14.5	13.2	6.0	9.2	–	10.9
1993	9.4	17.2	13.4	11.3	12.0	5.4	8.1	–	9.8
1994	9.2	14.3	11.9	9.8	12.2	5.4	7.4	–	9.1
1995	8.9	15.4	11.7	10.2	11.8	5.6	7.1	–	9.3
1996	8.5	14.3	10.9	9.2	11.3	4.5	6.3	–	8.8
1997	7.4	11.7	10.9	9.0	9.7	5.0	6.4	–	8.2
1998	7.1	11.1	11.2	10.3	7.5	5.1	7.4	–	7.9
1999	6.4	8.8	10.0	7.7	6.7	4.0	6.4	6.8	6.8
2000	7.1	9.9	11.2	8.0	6.7	3.0	6.5	7.4	7.3
2001	7.3	9.6	11.7	7.2	6.6	3.2	6.4	6.9	7.6
2002	7.1	7.8	10.7	6.3	6.1	3.1	5.7	5.6	6.7
2003	6.4	5.9	8.9	5.8	5.3	2.8	4.9	4.9	5.9
2004	6.0	4.8	7.9	5.6	4.9	2.7	4.6	4.5	5.4

[1)] Marginal costs are first calculated with Equation (8) at the individual bank level. Next, the numbers are weighted by the amount of loans on the balance sheet and aggregated by country and by year.

Table 5.2 shows that commercial banks in general have higher marginal costs than savings and cooperative banks. A possible explanation is that these banks attract fewer deposits and therefore have higher funding costs.

[9] The translog cost functions for the other countries may be obtained from the authors.

Table 5.2. Marginal costs by country and by bank type in 2002 (in % of loans) [1)]

Country	*Commercial banks*	*Savings banks*	*Cooperative banks*
DE	7.14	5.80	6.13
ES	10.12	4.67	4.96
FR	10.31	6.89	11.52
UK	4.94	9.63	–
IT	6.64	4.28	4.77
JP	1.95	0.56	3.15
NL	6.52	–	3.83
US	5.71	4.78	–

[1)] Marginal costs are first calculated with Equation (8) at the individual bank level. Next, the numbers are weighted by the amount of loans on the balance sheet and aggregated by country, by year and by bank type.

5.2. The Boone indicator

Given the estimated marginal costs from the previous section, we are now able to estimate the Boone indicator. To do so, we use for each country the relationship between the marginal costs of individual banks and their market shares as in Equation (4): [10]

$$\ln s_{ilt} = \alpha + \beta \ln mc_{ilt} + \sum_{t=1,..,(T-1)} \gamma_t d_t + u_{ilt} \qquad (9)$$

where s stands for market share, mc for marginal costs, i refers to bank i, l to output type 'loans', and t to year t; d_t. are time dummies (as in Equation (5)) and u_{ilt} is the error term. This provides us with the coefficient β, the Boone indicator. We estimate this equation for, respectively, the overall banking sector in each country (Sections 5.2.1 and 5.2.2) and for the various banking categories separately: commercial banks, savings banks, cooperative banks and mortgage banks (Section 5.2.3). We present country estimates of β both for the entire period, referred to as full sample period estimates, and for each year separately, referred to as annual estimates.

The estimations are carried out using the Generalized Method of Moments (GMM) with as instrument variables the one-, two- or three-year lagged values of the explanatory variable, marginal costs.[11] To test for overidentification of the instruments, we apply the Hansen J-test for GMM (Hayashi, 2000). The joint null hypothesis is that the instruments are valid instruments, *i.e.* uncorrelated with the error term. Under the null hypothesis, the test statistic is chi-squared with the number of degrees of freedom equal to the number of overidentification restrictions. A rejection would cast doubt on the validity of the instruments. Further, the Anderson canonical correlation likelihood ratio is used to test for the relevance of excluded instrument variables (Hayashi, 2000). The null hypothesis of this test is that the matrix of reduced form coefficients has rank K-1, where K is the number of regressors, meaning that the equation is underidentified. Under the null hypothesis of underidentification, the statistic is chi-squared distributed with L-K+1 degrees of freedom, where L is the number of instruments (whether included in the equation

[10] As bank types do not play any role here, we do not refer to the index h. (Compare to Equation (11)).
[11] For Germany, the one-, two- or three-year lagged values of the average costs are used.

or excluded). This statistic provides a measure of instrument relevance, and rejection of the null hypothesis indicates that the model is identified. We use kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations. The bandwidth in the estimation is set at two periods and the Newey-West kernel is applied. Where the instruments are overidentified, 2SLS is used instead of GMM. For this 2SLS estimator, Sargan's statistic is used instead of the Hansen J-test.

5.2.1. Degree of competition across countries

This section discusses the full sample period estimates of the Boone indicator. The results in Table 5.3 suggest that competition in the bank loan market varies considerably across countries.[12] The full sample period estimates are derived by estimating one single β for the entire period, as in Equation (9), instead of estimating a β for each year. These full sample period estimates can be interpreted as averages of the year-to-year estimates over the entire 1994-2004 period, weighted by the number of observations in each year. The lagged instrument variables cover the 1992-2004 period. According to the full sample period estimates, the loan market in the euro area is less competitive than the US market. Note that the sample period for the US covers only the last five years, which may distort a comparison with the other countries. Competition in the euro area appears relatively strong compared to the UK and Japan. Japanese banks are less competitive, with, in absolute terms, a lowest β of -0.72.

Among the major countries in the euro area, the Boone indicator for Spain, Italy and Germany suggest comparatively competitive banking markets, while the Dutch banking sector takes up an intermediate position. Within the euro area, France has the least competitive banking market. These findings differ somewhat from recent empirical evidence from alternative measures of competition applied to the European banking sector, such as concentration and price-based measures. For example, recent findings by Carbó *et al.* (2006) suggest that on average, banking competition seems to be strong in the UK, followed by the Netherlands and France, while most measures they use suggest a lower degree of competition in Spain, Italy and Germany.[13] At the same time, Carbó *et al.* (2006) find that in general the correlation between the various competition measures is relatively weak. Moreover, they suggest that there is '… little relationship between structural and non-structural (*i.e.* price-based) measures of banking competition'. As mentioned in Section 3, the information on the degree of competition provided by the Boone indicator, on the one hand, and by price-based and concentration-based measures of competition, on the other hand, may differ, as the Boone indicator lacks some of the weaknesses of the latter measures which we identified in Section 3. So it is not surprising if the results of

[12] In order to test the robustness of the model specification, we re-estimated β with a linear model instead of a log-linear one. The changes are limited. For instance, the German coefficient shifts from -3.38 to -2.68.

[13] The estimated competition measures in Carbó *et al*. (2006) include the net interest margin, the return on assets ratio, the Lerner index, H-statistics and the Hirschmann-Herfindahl index. The sample applied by Carbó *et al.* (2006) is broadly similar to ours, although the number of banks in their study is somewhat smaller.

Carbó *et al.* (2006) differ from ours. We compare our estimates of the full-sample period Boone indicator with the HHI statistic and find a Pearson correlation coefficient of 0.30. This suggests that a higher number of banks (or lower concentration) correlates positively, be it weakly, with a larger (negative) value, in absolute terms, of the Boone indicator (indicating stronger competition).

Contrary to recent criticism on the functioning of the German banking sector (*e.g.* IMF, 2004), our estimates suggest that this sector is among the most competitive in the euro area. Most likely, this result for Germany hinges in part on the special structure of its banking system, being built on three pillars, namely commercial banks, publicly-owned savings banks and cooperative banks (see Hackethal, 2004). Contrary to most other euro area countries, the total market share of the commercial banks in the loan and deposit markets is relatively limited, amounting to a mere 20-30%. Thus, this distinct characteristic of the German banking system may partly explain why competition is found to be strongest in this country, since the Boone indicator is based on the relationship between banks' relative marginal costs (which in Germany, as in most countries, were found to be lower for the non-commercial banks than for the commercial banks) and their market share (which is larger for the non-commercial banks in Germany than for those in other countries). Hence, our results should not be seen as contradicting the concerns of the IMF (see IMF, 2004) about the inflexibility and distortive effects of the so-called three-pillar system in Germany, but rather as reflecting the structural characteristics discussed above (see also Section 5.2.3). The Boone indicator for Germany may rather reflect the competitive environment of the commercial banking sector, which operates countrywide, than the competitiveness of the savings and cooperative banks that, generally, are active in regional markets only.

Table 5.3. Estimates of the Boone indicator over 1994-2004 for various countries

	Boone indicator[1)]	*z-value*[2)]	*F-test*	*Anderson canon. corr. LR-test*	*Hansen J-test (p-value)*	*Number of observations*
DE[3)]	**-3.38	-10.80	18.03	930.7	0.00	14,534
ES	**-4.15	-3.99	2.87	162.7	1.339 (0.25)	734
FR	**-0.90	-4.89	7.98	1,122.7	1.816 (0.18)	936
IT	**-3.71	-7.77	19.16	1,613.6	1.690 (0.19)	3,419
NL	**-1.56	-3.46	2.59	159.2	1.106 (0.29)	197
UK	**-1.05	-3.12	1.50	1,068.4	0.396 (0.52)	787
US[3)]	**-5.41	-40.49	345.04	9,916.0	0.00	40,177
JP	*-0.72	-2.26	14.08	402.1	4.88 (0.03)	1,423

[1)] Asterisks indicate 95% (*) and 99% (**) levels of confidence.
[2)] The z-value indicates whether the parameter significantly differs from 0 under the normal distribution with zero mean and standard deviation one.
[3)] For Germany and the US, 2SLS is used and the equation is exactly identified, so that the Hansen J-test statistic is 0.00.

The results for Spain and Italy seem to be driven mainly by the boost to competition following the deregulation and liberalisation of the banking sector in the two countries in the early 1990s.[14] In the Netherlands, the banking sector went through a process of profound reorganisation and consolidation during the 1980s and 1990s.[15] This development increased concentration in the Dutch banking sector, but may also have led to efficiency improvements. All in all, the Boone indicator suggests that from an international perspective competitive conditions in the Dutch banking sector take up an intermediate position.[16] Finally, the French banking sector is found to be the least competitive of the euro area countries considered. This finding may in part stem from the fact that although most French banks have now been privatized and the government continues its withdrawal from the banking industry, the role of the State in the French banking sector remains non-negligible, in that some important entities remain State-controlled (see for example: Fitch Ratings, 2001; Moody's Investors Service, 2004; S&P, 2005b).

Turning to the non-euro area countries, the Boone indicator suggests that in the UK, competition in the loan market is weak. This may be because in specific segments of the UK loan market, in particular mortgage lending, other institutions play an important role.[17] Our results are in line with Drake and Simper (2003) who find that due to the change in the ownership structure of building societies ('de-mutualisation') competition in retail banking activities in the UK declined during 1999-2001. As a matter of fact, the Boone indicator for the loan market without the real estate and mortgage banks shows that competition in this segment is significantly stronger.[18]

The US banking sector appears to be the most competitive among the countries in our sample, reflecting the significant changes in the US banking system over the past two decades. While it remains largely bifurcated along metropolitan and rural lines and continues to hinge on the principles of specialisation and regionalism (basically stemming from legislation enacted following the Great Depression), especially the lifting of restrictions on the range of banking activities and of the ban on interstate banking have transformed the US banking system.[19]

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[14] See for example S&P (2004) and Moody's Investors Service (2006). Our results are in line with Maudos *et al.* (2002), who find that profit margins during that decade declined significantly in Spain, especially for commercial banks and, to a lesser extent, for saving banks. For Italy, Coccorese (2005) presents evidence for the largest eight Italian banks during 1988-2000 that despite increased concentration the degree of competition remained considerable.

[15] See for example Moody's Investors Service (2005a).

[16] Our results are in line with other empirical investigations, such as on competition in the Dutch market for revolving consumer credit, which showed that this market is competitive indeed (see Toolsema, 2002).

[17] The UK has over 100 mortgage lenders. See also Moody's Investors Service (2005c).

[18] According to Heffernan (2002), the mortgage market in the UK is relatively competitive, but in other market segments such as personal loans there is substantially less competition. Results for the UK of estimations using a sample in which the mortgage lenders can be obtained from the authors upon request.

[19] See for overviews of the various legislative changes for example Cetorelli (2001), Clarke (2004) and Fitch Ratings (2005). Emmons and Schmid (2000) find evidence that even before most of this new legislation was enacted, banks and credit unions competed directly.

Finally, the poor result for Japan is largely driven by the regulation of the banking industry during the 1990s. As will be shown in the next section, however, competition in the Japanese loan market increased dramatically during the period under investigation.

This section's estimates, based on the entire sample period, may conceal considerable differences over time and across types of banks. We investigate developments in the level of competition over time in the next section and differences across types of banks in Section 5.2.3.

5.2.2. Developments in competition over the years

Table 5.4 shows the estimates of the Boone indicator across countries and over time (usually 1994-2004, depending on the respective country), based on:

$$\ln s_{ilt} = \alpha + \sum_{t=1,..,T} \beta_t d_t \ln mc_{ilt} + \sum_{t=1,..,(T-1)} \gamma_t d_t + u_{ilt} \quad (10)$$

Note that, in this section, the indicator β_t is time dependent. While the above conclusions based on the full sample period estimates generally remain valid, there are some notable differences across countries in the Boone indicator's development during the sample period. In most countries, not all the β_t's differ significantly from zero for all years. Only for the US, the betas differ from zero for all years. For Spain and the Netherlands, we observe substantial jumps in the series over time (see also Chart 5.1). However, generally, the estimated successive annual betas do not differ significantly from each other.[20] Finally, for Japan (for six years), France (for 2 years) and the Netherlands and the UK (for one year), the value of β_t is positive instead of, as expected, negative, in line with the rationale of Equation (4).[21] This paragraph discusses only the countries with statistically significant changes over time: Italy, the US and Japan.[22] Chart 5.1 shows the results for the other countries.

The banking sector in Italy, particularly the savings banks, went through a process of deregulation and liberalisation in the early 1990s, fuelled in part by the adoption of various EU Directives on financial institutions, which led to a consolidation wave.[23] Whereas the EU legislative initiatives affected all EU banking sectors, their eventual impact on competition was most probably driven by the actual implementation at the national level and by additional country-specific initiatives. In Italy, in particular, these institutional and regulatory changes are likely to have had a catalytic effect on competition, as our estimates suggest strong competition

[20] In this paper, 'significant' refers to the 95% level of confidence all along.

[21] An alternative explanation is that competition on quality may lead to both higher marginal costs and higher market shares.

[22] For these countries a Wald test with an H_0 hypothesis of no change over time was rejected at the 5% level of significance.

[23] In the early 1990s, large universal banking groups were established in Italy, as various restrictions on business activities were abolished. See for example Fitch Ratings (2002b), Moody's Investors Service (2005d) and S&P (2005a). The process of financial deregulation was partly affected via Community legislation such as the Second Banking Coordination Directive; see Angelini and Cetorelli (2003) and Cetorelli (2004). A largely similar development took place in Spain, where important mergers involving the largest commercial banks took place in 1999 and 2000. See, for example, Fitch Ratings (2002a).

around the mid-1990s (see Coccorese, 2005; Gambacorta and Iannotti, 2005). In more recent years, the new banking groups formed in the early 1990s may have been able to reconstitute some market power, as our results point to a continuous decline in competition since 1997 (see also Chart 5.2).[24]

Although our estimates of the Boone indicator for the US show a significantly increasing trend (indicating a decline in competition),[25] the level of competition remains comparatively high. A possible explanation for this gradual decline of competition is the decrease in market share of commercial banks, which are generally more competitive than savings banks, as will be shown in Section 5.2.3 (see also Jones and Critchfield, 2005).

In Japan, competition seems to have improved significantly (see Chart 5.3). This remarkable increase can be partly attributed to a history of no or very little competition in the mid-1990s. The Wald test rejects the null hypothesis of no change at 1% for Japan. In particular, our estimates show that the Japanese banking sector experienced a rather marked transformation from a climate with very little competition in the mid-1990s to a more competitive environment in recent years, to where Japan ranked second in 2004, behind the US. This partly reflects the process of financial deregulation and the gradual resolution of the bad loan problems that plagued Japanese banks throughout the 1990s (Van Rixtel, 2002). Eventually, this development involved the de-facto nationalisation of the worst-performing institutions and a major wave of consolidations, resulting in the establishment of a small number of large commercial banking groups in 2000 and 2001 (Van Rixtel *et al*., 2004). Our estimates suggest that the profound and structural changes in the Japanese banking sector have helped to foster a competitive environment.

Table 5.4. Developments of the Boone indicator over time for various countries[2)]

	Germany[1)]		**France**		**Italy**[1)]	
The Boone indicator	β_t	*z-value*	β_t	*z-value*	β_t	*z-value*
1993					-5.90	-1.18
1994					**-7.25	-3.24
1995	-4.47	-1.40	**-1.28	-3.36	**-4.51	-3.53
1996	**-7.09	-2.92	**-1.28	-3.56	**-5.58	-3.98
1997	**-4.64	-3.41	**-1.11	-3.55	**-5.89	-4.08
1998	**-5.10	-3.97	*-0.79	-1.99	**-4.60	-6.08
1999	**-2.60	-4.04	*-0.78	-2.30	**-4.05	-4.39
2000	**-2.50	-4.60	-0.46	-1.34	**-3.32	-4.39
2001	**-3.31	-7.02	-0.68	-1.67	**-2.66	-3.62
2002	**-4.53	-4.71	-0.40	-0.78	-1.59	-1.82
2003	**-2.73	-5.62	0.27	0.39	**-2.42	-3.69
2004	**-2.66	-4.15	0.10	0.12	**-1.81	-2.79
F-test	10.70		5.10		13.23	
Anderson canon corr. LR-test	185.2		1,023.7		300.3	

[24] In 2005 and 2006, a new wave of consolidation in the Italian banking sector was initiated. However, as our sample ends in 2004, our results do not capture these events.
[25] The Wald test rejects the null hypothesis of no change at the 1% level of significance.

Hansen J-test	0.00	19.69 (0.48)	0.00
Number of observations	14,534	918	4,918

	Spain[1)]		**Netherlands**		**US**[1)]	
The Boone indicator	β_t	*z-value*	β_t	*z-value*	β_t	*z-value*
1993	*-4.21	-2.49				
1994	*-4.80	-2.28	-1.92	-1.42		
1995	-5.20	-1.92	*-4.42	-2.42		
1996	-9.61	-0.67	**-2.09	-2.58		
1997	-4.36	-1.78	-3.57	-1.70		
1998	-5.40	-0.86	1.04	0.38		
1999	*-5.46	-2.21	-1.44	-0.85		
2000	-3.44	-1.93	**-3.26	-3.00	**-6.89	-20.34
2001	**-4.38	-2.55	**-3.91	-4.71	**-6.16	-20.94
2002	*-3.88	-2.09	*-2.45	-2.44	**-5.54	-22.61
2003	-3.42	-1.20	-2.22	-1.80	**-4.87	-22.15
2004	**-2.69	-5.62	**-3.09	-2.85	**-4.54	-25.53
F-test	3.33		3.90			198.30
Anderson canon corr.						
LR-test	38.8		31.7		7,084.3	
Hansen J-test	0.00		20.5 (0.04)		0.00	
Number of observations	1,015		241		40,177	

	United Kingdom		**Japan**	
The Boone indicator	β_t	*z-value*	β_t	*z-value*
1994	0.36	0.55		
1995	-0.95	-1.57	**7.30	4.93
1996	-0.48	-0.64	**13.88	6.63
1997	-1.33	-1.52	**5.98	3.97
1998	*-1.87	-2.17	**3.97	4.04
1999	*-1.52	-1.96	**4.85	2.58
2000	*-1.56	-2.05	0.11	0.03
2001	*-1.46	-1.97	**-2.52	-4.04
2002	-1.22	-1.65	**-2.63	-3.73
2003	-0.43	-0.66	**-2.90	-6.56
2004	-0.49	-0.93	**-3.63	-5.95
F-test	1.25		23.48	
Anderson canon corr.				
LR-test	1,468.2		214.8	
Hansen J-test, (p-value)	20.88 (0.03)		34.43 (0.02)	
Number of observations	912		1,476	

Notes: Asterisks indicate 95% (*) and 99% (**) levels of confidence. Coefficients of time dummies have not been shown.

[1)] 2SLS is used and the equation is exactly identified, so that the Hansen J-test is 0.00.

[2)] Equation (10) is estimated with the GMM. The number of observations for Italy, Japan, the Netherlands, Spain and the UK is higher than in Table 5.3, due to the use of instrumental variables with lags of a higher order in Table 5.3.

Chart 5.1. Indicators of the countries with no significant change in competition over time

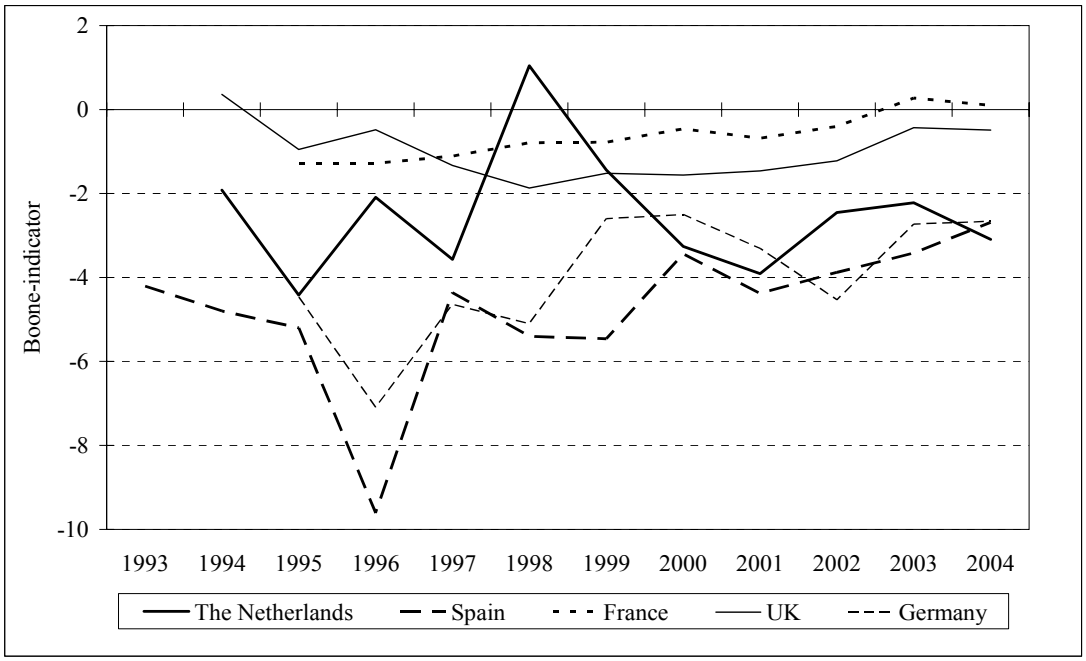


Chart 5.2. Indicators of the countries with significantly diminishing competition over time

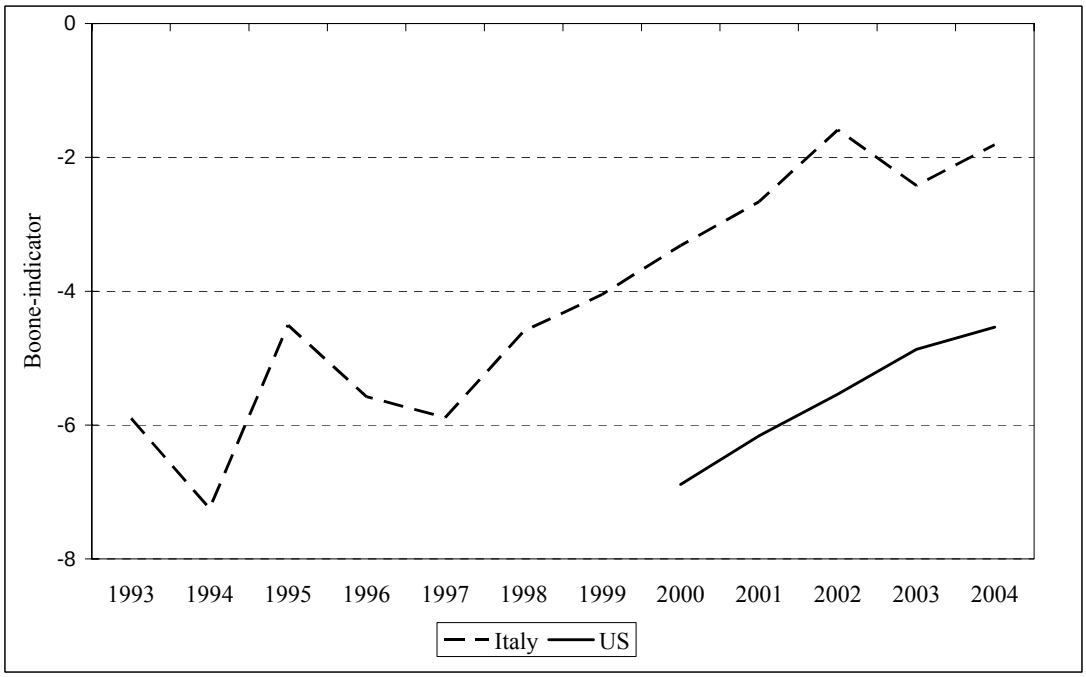
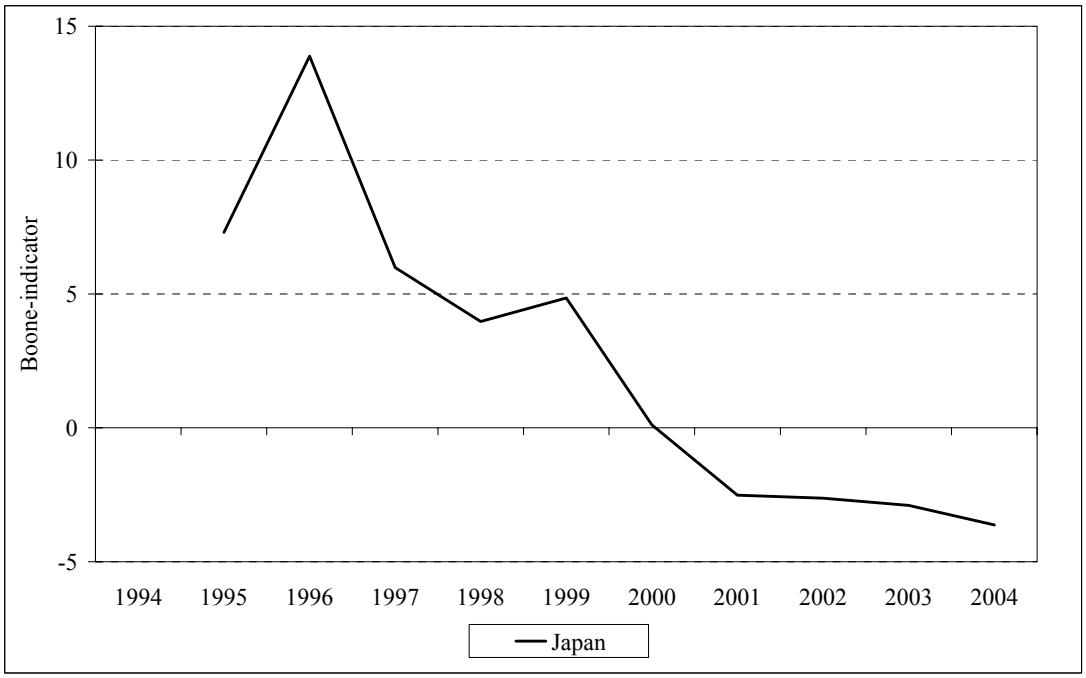


Chart 5.3. The indicator of the country with significantly improving competition over time



5.2.3. Competition in the separate bank categories

Possibly, banks in some countries compete mainly with other banks in the same category, rather than with all the other banks. It is conceivable that small cooperative and savings banks offer mainly traditional bank products to retail customers and to small and medium-sized enterprises, whereas the large commercial banks serve mainly larger firms and wealthy individuals in need of a diversified palette of advanced services. In such countries, competition estimates for separate bank categories may be more accurate than estimates based on all banks. Therefore, this section estimates separate Boone indicators for commercial banks, savings banks and cooperative banks, for all countries, except the Netherlands and the UK, based on:

$$\ln s_{ilt}^{h} = \alpha^{h} + \sum_{t=1,..,T} \beta_{t}^{h} \ln mc_{ilt}^{h} + \sum_{t=1,..,(T-1)} \gamma_{t}^{h} d_{t}^{h} + u_{ilt}^{h} \qquad (11)$$

The banking sectors in the latter markets show only minor segmentation, so that estimating indicators for specific bank categories seems irrelevant. For Germany we consider, on the one hand, commercial banks and *Landesbanks*, which are assumed to compete with each other, and on the other, cooperative banks and small savings banks, as they compete in local markets only (see Hackethal, 2004). In Italy, competition is estimated separately for the three bank types considered. Some cooperative banks, *e.g.* the *banche populari*, operate on a local level, whereas the *banche di credito cooperative* (BCC) operate on a regional to national level, competing more directly with the commercial banks (Fitch Ratings, 2002b). The sample of cooperative banks is dominated by the BCCs, which also explains the fact that the level of competition is closely in line with that of the Italian commercial banks. For the other countries, cooperative banks and

savings banks are bundled together, as they behave quite similarly. The results are presented in Table 5.5.

Particularly in Germany and the US, competition is found to be stronger among commercial banks than among cooperative and savings banks. In Italy, commercial banks are found to be more competitive than the savings banks for most of the period.[26] These findings may be explained by the fact that traditionally, savings banks and cooperative banks tend to operate at the local level and have access to a stable and cheap pool of deposits from a loyal customer base. Furthermore, savings and cooperative banks are often partly protected from competition, being unable (either through regulation or by tradition) to compete across regional borders.[27] Commercial banks are typically larger and operate on a national (or at least supra-regional) level, where they face competition from other regional and foreign banks. Lacking easy access to a stable pool of deposits, they depend more on costly interbank and market-based funding. They provide loans and services predominantly to larger corporate customers and face competition from the capital markets. These factors may induce commercial banks to behave more competitively than the protected savings and cooperative banks.[28]

In France, the estimated degrees of competition among commercial banks and among other banks are similar. This may be due to a considerable degree of consolidation across the different banking sectors. Possibly, our results may be explained by this lack of effective or de facto segmentation. However, the results for both the commercial banks and the other banks are only significant for a limited number of years, and so should be interpreted carefully. In the case of Spain, none of the yearly estimates for the category of savings and cooperative banks is significant. As a matter of fact, it may be doubted whether segment specific estimation makes sense for Spain, as savings banks, which dominate the other banks category, are seen to compete at the national level with commercial banks, rather than at the regional or local level.[29]

Results for Japan indicate that the savings and cooperative banks there have generally been more competitive than the commercial banks. This result may reflect the fact that savings and cooperative banks were much less exposed to the collapse of the Japanese 'bubble' economy, with its inflated real estate and other asset prices, than the large commercial banks (including

[26] The finding that the cooperative banks in Italy are highly competitive (compared to the commercial and savings banks) are surprising, as the Italian cooperative banking sector traditionally has been dominated by a large number of small banks that have a solid franchise in the local market benefiting from strong customer loyalty. However, as is reported in Fitch Ratings (2002b), the cooperative sector has seen strong rationalisation, with the remaining cooperative banks falling into two categories: a small group of larger multi-regional cooperative banks and a group of small cooperative banks serving their home regions. This process may actually have been beneficial to competition.

[27] This is the case in Germany through the so-called *Regionalprinzip*, or principle of market demarcation within the banking groups (see *e.g.* Fischer and Pfeil, 2004; Fischer and Hempel, 2005). In Italy and the US restrictions to cross-regional competition were effectively lifted during the 1990s, although in practice the majority of the local banks continue to operate predominantly within their historical regional borders.

[28] Furthermore, in Germany these competitive features may be further amplified by the existence of the three-pillar system, which hinders consolidation across the three bank types (see Fischer and Pfeil, 2004; IMF, 2005).

[29] Crespí *et al*. (2004) find that competition in retail banking in Spain, including both commercial and savings banks, remains high.

long-term credit and trust banks). The latter, being more strongly exposed to the real estate sector, bore the brunt of this collapse (Van Rixtel, 2002). The substantial government support commercial banks received in order to avoid bankruptcy distorted competition.

Table 5.5. Segmented markets in Germany, Italy, France, Spain, Japan and the US

Germany	**Commercial banks and *Landesbanken***		**Cooperative banks and savings banks**	
Boone indicator	β_t	*z-value*	β_t	*z-value*
1995	*-3.01	-2.44	0.52	0.39
1996	*-3.89	-2.12	**-1.94	-3.10
1997	**-4.08	-2.69	**-1.92	-4.66
1998	**-3.11	-3.23	**-2.08	-5.87
1999	-2.54	-1.45	**-2.19	-6.34
2000	*-3.61	-2.45	**-2.39	-9.21
2001	**-6.09	-3.96	**-2.94	-8.48
2002	-9.36	-1.65	**-3.41	-8.19
2003	*6.06	-2.13	**-2.46	-8.19
2004	**-5.41	-2.66	**-2.39	-7.34
F-test	3.68		18.95	
Anderson canon corr. LR-test	56.6		719.7	
Hansen J-test	12.7 (0.24)		24.2 (0.01)	
Number of observations	849		11,097	

Italy	**Commercial banks[1)]**		**Savings banks[1)]**		**Cooperative banks[1)]**	
Boone indicator	β_t	*z-value*	β_t	*z-value*	β_t	*z-value*
1993	-8.44	-0.60	-1.97	-0.55	-6.10	-1.51
1994	-9.01	-1.46	-2.38	-1.66	**-8.08	-3.16
1995	*-2.87	-2.00	-2.10	-1.43	**-9.54	-4.15
1996	**-3.73	-2.68	-1.40	-0.98	**-5.73	-5.57
1997	**-5.87	-2.80	-1.56	-1.05	**-5.53	-7.60
1998	**-4.56	-3.17	-2.59	-1.70	**-4.41	-8.47
1999	*-3.07	-2.42	*-1.91	-2.10	**-4.67	-10.27
2000	**-2.59	-2.91	-0.78	-1.93	**-5.69	-11.05
2001	*-1.69	-2.39	-1.43	-1.70	**-5.40	-9.13
2002	*-0.95	-2.37	**-3.29	-3.36	**-4.95	-11.30
2003	**-2.48	-3.20	**-3.60	-3.05	**-5.08	-11.84
2004	*-1.77	-2.48	-2.84	-1.58	**-4.96	-8.45
F-test	2.30		2.69		31.26	
Anderson canon corr. LR-test	28.55		70.5		1,425.7	
Hansen J-test	0.00		0.00		0.00	
Number of observations	1,010		608		3,296	

France	**Commercial banks**		**Savings, cooperative and mortgage banks**	
Boone indicator	β_t	*z-value*	β_t	*z-value*
1995	**-1.45	-2.76	*-1.16	-2.10
1996	**-1.82	-3.18	-0.65	-1.26
1997	**-1.59	-2.98	-0.58	-1.58
1998	-0.85	-0.99	-0.66	-1.59
1999	-0.91	-1.39	**-0.87	-3.10
2000	0.28	0.24	-0.61	-1.92
2001	-0.43	-0.47	**-1.07	-3.19
2002	0.52	0.47	-0.98	-1.80
2003	0.63	0.61	1.06	1.87
2004	-0.03	-0.02	*1.23	2.28

F-test	2.48	4.91
Anderson canon corr. LR-test	378.9	745.5
Hansen J-test	25.763 (0.17)	7.83 (0.65)
Number of observations	482	440

Spain	**Commercial banks[1)]**		**Savings and cooperative banks[1)]**	
Boone indicator	β_t	*z-value*	β_t	*z-value*
1993	**-4.10	-2.71	5.83	1.52
1994	**-4.67	-2.61	9.57	1.43
1995	-5.67	-1.90	3.82	1.11
1996	-8.75	-0.67	2.42	0.94
1997	-4.16	-1.76	1.38	0.38
1998	-4.90	-0.85	-2.76	-1.11
1999	*-5.10	-2.14	3.70	0.73
2000	-3.15	-1.75	2.89	0.59
2001	*-4.18	-2.48	-1.64	-0.37
2002	*-3.29	-2.12	-3.97	-0.61
2003	-2.96	-1.17	-3.49	-0.80
2004	**-2.54	-4.86	-0.88	-0.28
F-test	2.35		1.37	
Anderson canon corr. LR-test	22.8		21.8	
Hansen J-test	0.00		0.00	
Number of observations	525		486	

United States	**Commercial banks[1)]**		**Savings banks[1)]**	
Boone indicator	β_t	*z-value*	β_t	*z-value*
2000	-6.06**	-19.44	-3.40**	-5.63
2001	-5.54**	-21.17	-3.60**	-7.14
2002	-4.63**	-24.22	-3.61**	-8.41
2003	-7.01**	-19.81	-3.50**	-6.15
2004	-4.97**	-20.90	-3.62**	-6.62
F-test	177.9		20.57	
Anderson canon corr. LR-test	6,541.4		1,175.8	
Hansen J-test	0.00		0.00	
Number of observations	36,229		3,939	

Japan	**Commercial banks**		**Savings banks and cooperative banks**	
Boone indicator	β_t	*z-value*	β_t	*z-value*
1995	4.30	1.41	**1.44	4.07
1996	**14.18	7.03	**2.43	2.56
1997	** 9.09	5.37	0.55	0.28
1998	**3.68	3.87	*7.16	2.50
1999	**5.82	6.81	-0.78	-0.87
2000	**13.98	1.86	-1.26	-0.35
2001	**-1.01	-11.40	**-3.14	-4.07
2002	**-1.59	-13.56	**-3.42	-3.68
2003	**-2.36	-19.94	**-3.63	-3.45
2004	**-2.20	-15.50	**-3.69	-2.75
F-test	127.55		93.90	
Anderson canon corr. LR-test	13.6		73.6	
Hansen J-test	6.863 (0.55)		22.25 (0.13)	
Number of observations	63		1,416	

Notes: Asterisks indicate 95% (*) and 99% (**) levels of confidence. Coefficients of time dummies have not been shown.

[1)] 2SLS is used and the equation is thus exactly identified, so that the Hansen J-test is 0.00.

6. Conclusions

This paper uses a new measure for competition, the Boone indicator, and is the first study that applies this approach to the banking markets. This indicator quantifies the impact of marginal costs on performance, measured in terms of market shares. We improve the original Boone indicator by calculating marginal costs instead of approximating marginal costs by average variable costs. This approach has the advantage of being able to measure bank market segments, such as the loan market, whereas many well-known measures of competition, such as the Panzar-Rosse method, consider only the entire banking market. Moreover, estimation of the Boone indicator requires relatively moderate amounts of data only. A disadvantage of the Boone-indicator is that it assumes that banks generally pass on at least part of their efficiency gains to their clients. Furthermore, like many other model-based measures, our approach ignores differences in bank product quality and design, as well as the attractiveness of innovations. Finally, as all model-based measures, the Boone indicator should only be regarded as an estimate.

We apply the Boone indicator to the loan markets of the five major countries in the euro area and, for comparison, to the UK, the US and Japan over the 1994-2004 period. Our findings indicate that during this period the US had the most competitive loan market, whereas overall loan markets in Germany and Spain were among the best competitive in the EU. The German results seem to be driven partly by a competitive commercial banking sector reflecting the distinct nature of its "three-pillar" banking system. In Spain, competition remained strong and relatively stable over the full sample period, indicating the progress the Spanish banking system has made since the major liberalisation reforms in the late 1980s and early 1990s. The Netherlands occupied a more intermediate position among the countries in our sample, despite having a relatively concentrated banking market dominated by a small number of very large players. Italian competition declined significantly over time, which may be due to the partial reconstitution of market power by the banking groups formed in the early 1990s. French and British loan markets were less competitive overall. In Japan, competition in loan markets was found to increase dramatically over the years, in line with the consolidation and revitalisation of the Japanese banking industry in recent years.

Turning to competition among specific types of banks, we found that commercial banks, which are more exposed to competition from foreign banks and capital markets, tend to be more competitive, particularly in Germany and the US, than savings and cooperative banks, which typically operate in local markets. Competition among savings and cooperative banks in Japan was considerably stronger than competition between commercial banks. This may indicate the adverse impact of banking crises on bank competition, as the commercial banks were particularly hard-hit by the severe banking crisis that engulfed Japan during the 1990s.

All in all, according to the Boone indicator, competitive conditions in the loan markets and their developments over time are found to differ considerably across countries. These

differences seem largely to reflect distinct characteristics of the national banking sectors, such as the relative importance of commercial, cooperative and saving banks respectively, and changes to the banks' institutional and regulatory environment during our sample period.

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APPENDIX ESTIMATIONS OF THE TRANSLOG COST FUNCTION

Table A.1. Estimations of the translog cost function for Germany

Dependent variable: ln(costs)-ln(other expenses)	**Coefficient**	**t-value**	**P>|t|**
Outputs			
ln(loans)_comm. banks	0.01	0.43	0.67
$(\ln(\text{loans}))^2$_comm. banks	0.08	45.14	0.00
ln(securities)_comm. banks	0.11	9.32	0.00
$(\ln(\text{securities}))^2$_comm. banks	0.04	39.84	0.00
ln(other services)_comm. banks	0.66	34.45	0.00
$(\ln(\text{other services}))^2$_comm. banks	0.06	24.31	0.00
ln(loans)_savings banks	-0.55	-5.16	0.00
$(\ln(\text{loans}))^2$_savings banks	0.21	20.25	0.00
ln(securities)_savings banks	0.60	10.79	0.00
$(\ln(\text{securities}))^2$_savings banks	0.05	24.39	0.00
ln(other services)_savings banks	0.92	7.93	0.00
$(\ln(\text{other services}))^2$_savings banks	0.07	5.73	0.00
ln(loans)_coop. banks	0.19	6.02	0.00
$(\ln(\text{loans}))^2$_coop. banks	0.11	26.79	0.00
ln(securities)_coop. banks	0.42	27.56	0.00
$(\ln(\text{securities}))^2$_coop. banks	0.04	42.97	0.00
ln(other services)_coop. banks	0.42	14.93	0.00
$(\ln(\text{other services}))^2$_coop. banks	0.05	13.86	0.00
Input prices			
ln(wage)-ln(other expenses)_comm. banks	-0.02	-0.78	0.44
$(\ln(\text{wage}) - \ln(\text{other expenses}))^2$_comm. banks	0.12	26.00	0.00
ln(funding rate)-ln(other expenses)_comm. banks	0.85	28.35	0.00
$(\ln(\text{funding rate})-\ln(\text{other expenses}))^2$_comm. banks	0.15	22.66	0.00
Ln(wage)-ln(other expenses)_savings banks	0.79	5.55	0.00
$(\ln(\text{wage}) - \ln(\text{other expenses}))^2$_savings banks	0.06	2.18	0.03
ln(funding rate)-ln(other expenses)_savings banks	0.14	0.94	0.35
$(\ln(\text{funding rate}) - \ln(\text{other expenses}))^2$_savings banks	0.08	2.91	0.00
ln(wage)-ln(other expenses)_coop. banks	0.15	4.16	0.00
$(\ln(\text{wage}) - \ln(\text{other expenses}))^2$_coop. banks	0.65	15.58	0.00
ln(funding rate)-ln(other expenses)_coop. banks	0.09	15.26	0.00
(ln(funding rate) -ln(other expenses))2_coop. banks	0.10	12.40	0.00
Cross-products between input prices			
(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other expenses))_ comm. banks	-0.27	-26.54	0.00
(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other expenses))_savings banks	-0.15	-2.84	0.01
(ln(wage) -ln(other expenses))*(ln(funding rate)-ln(other expenses))_coop. banks	-0.20	-14.82	0.00
Cross-products between outputs			
ln(loans) * ln(securities)_comm. banks	-0.03	-16.25	0.00
ln(loans) * ln(other services)_comm. banks	-0.10	-27.25	0.00
ln(securities) * ln(other services)_comm. banks	-0.03	-15.70	0.00
ln(loans) * ln(securities)_savings banks	-0.21	-20.79	0.00
ln(loans) * ln(other services)_savings banks	-0.21	-10.44	0.00
ln(securities) * ln(other services)_savings banks	0.08	7.58	0.00
ln(loans) * ln(securities)_coop. banks	-0.12	-34.04	0.00
ln(loans) * ln(other services)_ coop. banks	-0.10	-15.55	0.00
ln(securities) * ln(other services)_coop. banks	0.03	9.17	0.00
Cross-products between outputs and input prices			
ln(loans)*(ln(wage)-ln(other expenses))_comm. banks	0.06	13.48	0.00

ln(loans)*(ln(funding rate)-ln(other expenses))_comm. banks	-0.04	-8.27	0.00
ln(loans)*(ln(wage)-ln(other expenses))_savings banks	0.00	-0.11	0.91
ln(loans)*(ln(funding rate)-ln(other expenses))_savings banks	0.02	0.78	0.44
ln(loans)*(ln(wage)-ln(other expenses))_coop. banks	0.10	11.44	0.00
ln(loans)*(ln(funding rate)-ln(other expenses))_coop. banks	-0.08	-8.09	0.00
ln(securities)*(ln(wage)-ln(other expenses))_comm. banks	0.03	11.11	0.00
ln(securities)*(ln(funding rate)-ln(other expenses))_comm. banks	-0.04	-10.00	0.00
ln(securities)*(ln(wage)-ln(other expenses))_savings banks	-0.10	-6.34	0.00
ln(securities)*(ln(funding rate)-ln(other expenses))_savings banks	0.06	3.88	0.00
ln(securities)*(ln(wage)-ln(other expenses))_coop. banks	-0.06	-14.28	0.00
ln(securities)*(ln(funding rate)-ln(other expenses))_coop. banks	0.05	10.49	0.00
ln(other services)*(ln(wage)-ln(other expenses))_comm. banks	-0.05	-9.36	0.00
ln(other services)*(ln(funding rate)-ln(other expenses))_comm. banks	0.04	6.74	0.00
ln(other services) *(ln(wage)-ln(other expenses))_savings banks	0.07	2.22	0.03
ln(other services)*(ln(funding rate)-ln(other expenses))_savings banks	-0.06	-1.89	0.06
ln(other services)*(ln(wage)-ln(other expenses))_coop. banks	-0.04	-4.48	0.00
ln(other services)*(ln(funding rate)-ln(other expenses))_coop. banks	0.03	2.79	0.01
Control variables			
ln(equity/assets)_comm. banks	-0.15	-4.26	0.00
$\ln(\text{equity/assets})^2$_comm. banks	0.01	1.96	0.05
ln(equity/assets)_savings banks	1.11	6.80	0.00
$\ln(\text{equity/assets})^2$_savings banks	0.21	7.86	0.00
ln(equity/assets)_coop. banks	0.51	10.03	0.00
$\ln(\text{equity/assets})^2$_coop. banks	0.10	11.86	0.00
dummy savings banks	2.63	6.12	0.00
dummy coop. banks	-0.15	-13.49	0.00
Intercept	3.07	48.08	0.00
Number of observations	19,551		
F(80, 19,470)	25,462.91		
Adjusted R-square	0.99		

Explanation: Coefficients of time dummies have not been shown.