Part 4

Competition and performance

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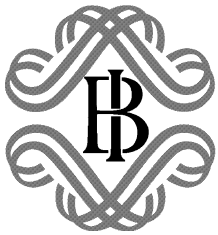

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BANK COMPETITION AND REGULATORY REFORM: THE CASE OF THE ITALIAN BANKING INDUSTRY

by Paolo Angelini* and Nicola Cetorelli**

Abstract

The paper analyzes the evolution of competitive conditions in the Italian banking industry using firm-level balance sheet data for the period 1983-1997. Regulatory reform, large-scale consolidation, and competitive pressure from other European countries have changed substantially the banking environment, with potentially offsetting effects on the overall degree of competitiveness of the banking market. We find that competitive conditions, relatively unchanged until 1992, have improved substantially thereafter, with estimated mark-ups decreasing over the last five years of the sample period. Also, there is no evidence that banks involved in mergers and acquisitions gained market power; at the same time, however, they exhibit lower than average marginal costs. Finally, after controlling for various factors that may have determined the time pattern of banks' estimated mark-ups, we still detect a significant unexplained drop in our competitive conditions indicators after 1992. This is consistent with the hypothesis that the introduction of the Single Banking License in 1993 contributed to improve bank competition.

JEL classification: G21, G34.

Keywords: bank competition, mergers and acquisitions, Lerner, consolidation.

Contents

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1. Introduction[1]

In the last twenty years, European countries have implemented numerous regulatory changes affecting the banking industry, motivated by the need to achieve the level of harmonization required for the establishment of a single, competitive market for financial services. This process culminated in the early 1990s with the implementation of the Second Banking Coordination Directive, which defined the basic conditions for the provision of the so-called Single Banking License. Prior to this initiative, cross-border expansions were subject to the authorization and subsequent control of the host country, as well as to capital requirements, as if the branch represented the establishment of a new bank. Under the current regime, in contrast, banks from European Union (EU) countries are allowed to branch freely into other EU countries.

The new legislation, by removing substantial entry barriers and exposing national banking markets to potential new entrants, should have produced pro-competitive effects.[2] However, another important recent development in the European banking system has been a significant consolidation process. On average, the number of banks in EU countries shrank by approximately 29 percent between 1985 and 1997, with about 90 percent of the reduction taking place between 1990 and 1997 (European Central Bank, 1999). In keeping with the structure-conduct-performance hypothesis (Bain, 1953), one might expect such notable structural transformation to have had negative effects on competition. Therefore, how bank competitive conduct has changed in Europe in recent years is a priori unclear.

In this study, we focus on the Italian banking industry over the 1983-1997 period. Italy implemented the Second Banking Directive in 1993.[3] Meanwhile, between 1985 and 1997 the process of consolidation brought with it a 20 percent reduction in the number of banks in the country (about 90 percent of the reduction took place between 1990 and 1997). Casual observation across

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1 The views expressed herein are those of the authors and not necessarily those of the Bank of Italy, the Federal Reserve Bank of Chicago or the Federal Reserve System. The authors would like to thank Bob DeYoung, Michele Gambera, Giorgio Gobbi, Dario Focarelli, Anil Kashyap, Nara Milanich, Alberto Pozzolo and Sherrill Shaffer for their comments. We also thank Fabio Farabullini, Roberto Felici, Christian Picker and Mike Sterling for their assistance with the data set. Email: angelini.paolo@insedia.interbusiness.it; ncetorel@frbchi.org.

2 See e.g. Vives (1991 a,b).

3 In December 1992 law 14.12.92 n° 481 introduces the Second EC Banking Directive into the Italian legislation. In September 1993 Legislative Decree 1.9.93, n° 385 rationalizes the banking regulatory framework, replacing some 1,400 previous regulations and completing the introduction of the Directive.

European banking markets seems to suggest a shift toward increased competition in recent years. Danthine, Giavazzi, Vives and von Thadden (1999) report a somewhat generalized decrease in banks' net interest margins across Europe during the 1990s. Consistent with the European evidence, a declining trend in bank margins is also observed across different markets in Italy. Based on this observation, we explore more thoroughly competitive conditions in the Italian banking industry by adopting a methodology developed in empirical industrial organization, and used extensively in banking, to estimate Lerner indexes (the complement to one of the ratio between marginal cost and price). Underlying the empirical analysis is the attempt to gauge the impact of the two mentioned factors – regulatory change and consolidation – on competition.

The effect of regulatory reform on bank competition has been analyzed with similar methodologies in other studies. Gelfand and Spiller (1984) and Spiller and Favaro (1987) investigate the competitive impact of the relaxation of entry restrictions in the Uruguayan banking industry, concluding that strategic interactions across banks and across different markets decreased after the regulatory reform. Shaffer (1993) focuses on the Canadian banking industry, finding an already perfectly competitive conduct prior to the reform and evidence of negative margins afterwards. Meanwhile, Ribon and Yosha (1999) find evidence of an improvement in competition in the Israeli banking industry in the years following financial liberalization.

Whereas much of the existing literature relies on aggregate time-series with relatively few observations, our dataset includes virtually all Italian banks (about 900 on average each year) over a sample period of 14 years. This provides us enough identification power to pursue multiple goals. First, a thorough investigation of banking competition in Italy during an important transition period is presented for the first time. Second, we estimate Lerner indexes in five distinct markets within the country, separating banks according to their prevalent geographical area of business (Nation-wide, North-West, North-East, Center and South). In contrast, in part due to the above mentioned data constraint, most existing studies analyze bank competition at the nation-wide level, thereby overlooking the problems associated with the notion of "relevant banking market"; the latter is generally considered of relatively narrow size, especially for anti-trust purposes. In addition, in light of the aforementioned theoretical connection between market concentration and competition, we give special attention to banks that have experienced mergers or acquisitions and test whether such banks have in fact increased their market power relative to the rest of the banking system. Furthermore, we analyze separately commercial banks and cooperative credit banks (CCBs henceforth), small

institutions somewhat similar to U.S. credit unions. Several characteristics documented below put CCBs in a "niche position" which potentially gives them extra market power, providing the opportunity to investigate the existence of market segmentation.

Finally, in a second stage of the analysis we attempt to identify the causes of the cross-market and time series pattern of the estimated indicators of competition. Did the regulatory reform of 1993 trigger changes in competitive conduct? In addressing this question, and in contrast to the existing literature, we control for concurrent economic factors, such as inflation, the business cycle, and market concentration, as well as other events that, while unrelated to competitive conditions, may in principle have affected our indexes and introduced a bias in the estimated degree of market power.

In the following section we lay out the details and discuss various issues related to the methodology adopted to estimate market power. In section 3 we briefly survey the literature on competition in the Italian banking industry. In sections 4 and 5 we illustrate the details of the dataset and present the empirical results. Concluding remarks are presented in section 6.

2. The methodology

2.1 The analytical framework

The traditional approach to the analysis of industry competition is based on the structure-conduct-performance hypothesis, which postulates a direct connection between concentration and performance: a rise in concentration should be associated with a decrease in the cost of collusion, in turn inducing non-competitive pricing behavior. This approach suggests the use of concentration measures (e.g. the Herfindahl index) to infer competitive conditions, and indeed these measures, intuitive to interpret and simple to construct, are popular in policy analysis and in research-oriented literature. Several empirical studies have detected a direct relationship between market concentration and market power in the banking industry (e.g. Berger and Hannan, 1989, Hannan and Berger, 1991, and Neuman and Sharpe, 1992). Other contributions, however (e.g. Jackson, 1992, 1997, Rhoades, 1995, and Hannan, 1997), have cast doubt on the overall robustness of the market concentration-market power relationship. In addition, while the relationship can be derived from oligopoly theory under the assumption of Cournot behavior, it is not warranted under alternative models.[4]

4 Some of the empirical applications to the banking industry surveyed in this paper, such as Gollop and Roberts (1984) and Berg and Kim (1994), have actually tested and rejected the hypothesis of Cournot conduct.

An alternative approach to the analysis of competitive conditions, based on more sound microeconomic foundations, draws inference from the econometric estimation of the parameters of a firm's behavioral equation.[5] More precisely, it is assumed that a firm (in our case, a bank) sets equilibrium prices and quantities in order to maximize profits. Such a decision is based on cost considerations and on the degree of competition in the market. In turn, the latter depends on the characteristics of interaction among firms and on demand conditions.

Consider an industry producing quantity Q at price p. Let q_j be the quantity produced by firm j, j=1, 2, ...m, and $\Sigma_j q_j \equiv Q$. Let the inverse demand function be $p=p(Q,z)$, where z is a vector of exogenous variables affecting demand. In addition, let $C(q_j,\mathbf{w}_j)$ be the cost function for firm j, where $\mathbf{w}_j$ is the vector of the prices of the factors of production employed by firm j. Firms in the industry solve:

$$\underset{q_j}{Max}\Pi = p(Q,z)q_j - C(q_j,w_j).$$

The corresponding first order condition is:

$$p_j = C'(q_j,w_j) - q_j \frac{\partial p}{\partial Q}\frac{\partial Q}{\partial q_j}, \tag{1}$$

where the second term on the right-hand side measures the departure from a perfectly competitive benchmark, where price would be set equal to marginal cost. This equilibrium condition can be rewritten as:

$$p_j = C'(q_j,w_j) - \frac{\Theta_j}{\tilde{e}}, \tag{2}$$

where Θ_j is usually defined as the conjectural elasticity of total industry output with respect to the output of the jth firm,

$$\Theta_j \equiv \frac{\partial Q/\partial q_j}{Q/q_j}, \tag{3}$$

and $\tilde{e}$ is the market demand semi-elasticity to the price,

[5] See Iwata (1974), Appelbaum (1979, 1982), Gollop and Roberts (1979), Bresnahan (1982), Roberts (1984).

$$\tilde{e} \equiv \frac{\partial Q / \partial p}{Q}, \qquad \tilde{e} < 0 \tag{4}$$

The combination of characteristics affecting firms' oligopolistic interaction and market demand elasticity determines the overall rent-extraction ability in the industry. Specifically, the parameter Θ_j measures the conjectured reaction of the other n-1 firms in the market to a change in quantity produced by firm j. In a perfectly competitive industry, Θ_j is equal to zero for all j, while in a pure monopoly Θ_j equals one. However, it is immediately clear from (2) that for a given value of Θ_j the actual ability of a firm to exercise market power is inversely related to the magnitude of the market demand semi-elasticity, $\tilde{e}$.

The separate identification of Θ_j and $\tilde{e}$ requires the simultaneous estimation of a supply equation such as (2) and a demand equation, from which the parameters necessary for the identification of $\tilde{e}$ can be recovered.[6] However, as noted by Appelbaum (1982, p. 297), if the goal of the investigation is to evaluate the industry's overall degree of market power (i.e. firms' ability to price over marginal cost) it is sufficient to identify and estimate the ratio $l \equiv -\Theta_j / \tilde{e}$, without identifying Θ_j and $\tilde{e}$ separately. Dividing l by the average price one obtains a Lerner index, $L \equiv l / p$, $L \in [0,1]$, measuring the relative mark-up of price over marginal cost (note from (2) that λ is the difference between the two).

Therefore, in the empirical section we focus on the estimation of λ and the related Lerner indexes. We estimate equation (2) simultaneously with a cost function, imposing cross-equation restrictions which should improve the precision of the estimates (Bresnahan 1989, p. 1040).[7] We assume the total cost function to have a translog specification:

$$\begin{aligned} \ln(C_j) = {} & c_0 + s_0 \ln q_j + \frac{s_1}{2}(\ln q_j)^2 + \sum_{i=1}^{3} c_i \ln w_{ij} + \ln q_j \sum_{i=1}^{3} s_{i+1} \ln w_{ij} \\ & + c_4 \ln w_{1j} \ln w_{3j} + c_5 \ln w_{1j} \ln w_{2j} + c_6 \ln w_{2j} \ln w_{3j} \\ & + \sum_{i=1}^{3} c_{i+6} (\ln w_i)^2 + \sum_g c_g \, dummy_g \end{aligned} \tag{5}$$

6 Due to the difficulty of gathering a suitable dataset for such estimation, many of the existing applications to banking borrow the estimated elasticity of demand from previous studies and then input it in (2) (see e.g. Berg and Kim, 1994, Spiller and Favaro, 1987, Gelfand and Spiller, 1984).

7 The parameters of the marginal cost functions could also be derived by estimating simultaneously (2) and input demand equations, and invoking standard cost duality results to impose similar cross-equation restrictions (see e.g. Appelbaum, 1982).

where w_{ij} are the prices for the three inputs, deposits, labor and capital for firm j. The dummy variables appearing in the last summation operator allow us to take into account several factors, mentioned in the introduction, which we intend to analyze separately: depending on the specification, we shall use dummies for the various geographical areas of the countries (g = Nation-wide, North-west, North-east, Center, South), for banks' type (g = Commercial banks, Cooperative credit banks) and for banks that underwent mergers or acquisitions.

We then estimate simultaneously equations (5) and (2), rewriting the latter as follows:

$$(6) \qquad p_j = \frac{C_j}{q_j}\left(s_0 + s_1 \ln q_j + \sum_{i=1}^{3} s_{i+1} \ln w_{ij} \right) + \sum_g l_g dummy_g ,$$

where the first term of the right-hand side is marginal cost, derived from (5), and where λ_g's are average values estimated across the different groups g. This procedure allows us to derive time series for the Lerner indexes; it also allows us to test whether they are significantly different from zero and whether they differ across bank groups.

2.2 Comments on the methodology

The accuracy of this methodology in providing estimates of market power conditions has recently been tested empirically by Genesove and Mullin (1998), using a controlled environment where a Lerner index could be measured directly and compared with the one estimated. The supply relationship (2) has actually a less restrictive interpretation than that implied by the argument on conjectural variations. As Bresnahan (1987) points out, a relationship such as (2) can be written without necessarily considering Θ_j as a parameter measuring firms' conjectures. In a broader sense, it can fit any oligopolistic model where products are priced above marginal costs. This consideration allows us to shield potential criticism strictly associated with models of conjectural variations (e.g. Carlton and Perloff, 1989).

As in Shaffer (1993), Shaffer and Di Salvo (1994), Berg and Kim (1994) and Shaffer (1996), in the empirical analysis of section 5 the bank is treated as a supplier of an aggregate product, proxied by total assets. This approach does not allow the identification of behavioral differences across single products (e.g. loans or deposits). However, if banks have a certain degree of market power over a specific product while behaving competitively in the supply of another, our aggregate approach is still able to capture a departure from marginal cost pricing. Alternatively, as in Spiller and

Favaro (1984) and Shaffer (1989), one could focus on a specific product; however, this approach fails to take into account the potential ability of banks to act strategically in the various markets (for instance, one product may be supplied at very competitive conditions to attract customers and then extract rents in the supply of other products). Focusing on one product only may therefore bias the estimation of market power.[8]

A related issue regards the treatment of bank deposits. A long running debate in the literature has centered on whether deposits should be considered an input or an output. Following the seminal model developed by Klein (1971), most studies on banking market power have considered deposits as an input. Alternatives, such as the value-added approach (Berger and Humphrey, 1992) or the user-cost model (Hancock, 1991), take the more general view that both assets and liabilities items may have output characteristics. In particular, such studies argue that deposits may be considered part of banking output in that they proxy for the services banks provide to depositors. Deposits are added to various asset measures in some studies (e.g. Berg and Kim, 1994), or treated as a separate output (Suominen, 1994, Shaffer, 1996, and Ribon and Yosha, 1999). We test the robustness of our results to the inclusion of deposits in the definition of output.

An additional issue stems from the treatment of income from services, which has become increasingly important in recent years. Not taking this source of revenue into account may generate a bias in estimated marginal cost, in turn affecting the estimated Lerner index, particularly if banks with more assets are also large providers of non-asset-based services, as seems likely (DeYoung, 1994). We use a measure of price for our aggregate banking product that explicitly incorporates revenues from services, and to assess the robustness of our results to this problem we re-run regressions excluding such component.

Another potential criticism is that the estimation relies on the choice of a proper functional form for the cost function. In this respect, however, the translog specification has the appealing property of being a highly flexible, second order approximation to any other functional form specification.[9]

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[8] A few authors have conducted multiproduct analysis of banks market power (e.g. Gelfand and Spiller, 1987, Suominen, 1994, Berg and Kim, 1996 and Vesala, 1995), thus taking into account cross-markets interactions. Such approach, however, increasing the number of coefficients to be estimated, is very demanding in terms of data requirements.

[9] The use of parametric cost functions, such as the translog, when the population of banks is highly heterogeneous in size and output mix, has been criticized by McAllister and McManus (1993). However, our approach, based on the separate analysis of multiple banking markets, with the further differentiation between

A final issue worth mentioning regards our definitions of both the price and the price-deposit margins. We compute the price of bank assets and the deposit rate from balance sheet items (rather than using actual posted interest rates, unavailable in our dataset). These are therefore ex-post measures. While ex-ante interest rates incorporate a risk premium, our ex-post measures, based on actual income obtained by the banks after accounting for bad loans, should not. In this respect, since we are focusing on banks' pricing behavior, we need not be overly concerned with controlling for risk in our estimation analysis.[10]

3. The literature on competition in the Italian banking industry

In what follows, forgoing any pretense of completeness, we focus on the subset of empirical papers that attempt to gauge changes in competitive conditions in the Italian banking industry.

Ferri and Gobbi (1992), analyzing the 1986-1990 period, find that after 1988 various measures of dispersion of interest rates on loans (across geographical areas of the country, sectors of economic activity and loan size) began to diminish; in addition, the correlation between the amount of bad and doubtful loans and the interest rate on loans began to increase. These facts are consistent with the implications of their theoretical model and point toward increased competition. However, Ferri and Gobbi (1997) find that the dispersion of interest rates on loans, after reaching a minimum in 1992, increased to a maximum in 1994 (similar measures computed with our dataset confirm this conclusion over the 1995-97 period). They conclude that such measure, although possibly related to competitive conditions, may at certain times be affected by other factors that may make it inadequate as an indicator of market power. Several such factors have been suggested: Ciocca (1995) attributes the mentioned increase in the dispersion of interest rates on loans in 1993-94 to the surge of bad and doubtful loans, to the unfavorable cyclical conditions and to heterogeneous interest rate elasticities across country areas. Also, Cottarelli, Ferri and Generale (1995) point out that this dispersion may depend on the monetary policy stance.

Using individual bank data over the 1980-1991 period, Focarelli and Tedeschi (1993) find that prior to 1988 the interest rate on deposits paid by a bank does not significantly affect its market

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institutional categories, should be largely shielded from such criticism. Moreover, since we evaluate the estimated marginal cost function at the means of the data, the translog's lack of flexibility for observations far from the means of the data is not especially problematic for our purposes.

[10] See also Demirguc-Kunt and Huizinga (1998) for a similar approach.

share, whereas it does afterwards. They interpret this as a sign of more competitive conditions in the deposits market. They also report the view, held by several commentators, that while the banking system had a substantial oligopolistic power in the period, this rent did not translate into high profits due to the inefficiency of the system, which created high operative costs.

Cesari (1999) builds a measure of competition based on the degree of mobility of customers among banks, under the hypothesis that increased competition should tend to disrupt customer relationships. Over the period 1984-1993 investor mobility increased significantly for small, local banks; however, his aggregate "fidelity" index does not display a clear trend.

Ciocca (1998) lists several indicators pointing to increased competition throughout the eighties: between 1979 and 1989 the average number of banks in each province increased from 20 to 27; the concentration of market shares decreased by 15 percent; the differential between interest rate on short-term loans and T-bills decreased from 5 percentage points in 1980 to less than one in 1989; over the same period the differential between the yield on assets and the interest rate on liabilities went down from 9 to 7 percentage points.

Using yearly aggregate data, Coccorese (1998) rejects the strong hypothesis of a joint monopoly, but fails to reject the hypothesis of perfect competition throughout the period 1971-1996. De Bandt and Davis (1999) find evidence of monopolistic competition for large and small Italian banks over the 1992-96 period; in France and Germany large banks are also characterized by monopolistic competition, whereas small banks tend to show monopolistic behavior.

Generale, Gobbi and Tedeschi (1999) point out that 1993 marks the beginning of a profitability crisis for the Italian banking system, brought about by three factors: the reduction in price-deposits margins; a reduction in costs insufficient to match the parallel reduction in gross income, in turn caused by excessively rigid cost structures, and a surge in bad and doubtful loans, partly related to the cycle. They emphasize that price-deposit margins can be influenced both by competitive conditions and by the bank's free capital. Specifically, a high proportion of bad and doubtful loans in a bank's balance sheet, reducing its free capital, might incorrectly signal that the bank is relatively competitive.

De Bonis and Ferrando (2000) find that over the 1990-97 period Herfindahl concentration indexes computed at the province level using various measures of bank activity display a declining trend, reflecting the liberalization of bank branches in 1989-1990.

Cerasi, Chizzolini and Ivaldi (2000), using a methodology that relies on observed branching

patterns, find that over the period 1988-1995 competition has been relatively more intense in the North-west and Center, less so in the South; also, while a deterioration of competitive conditions at the national level is detected, an improvement seems to have come from the implementation of the Second Banking Coordination Directive, proxied by a dummy for the 1993-95 period.

The main conclusions of the literature on banking competition in Italy can be summarized as follows. First, much emphasis is placed on the structural and normative changes implemented between 1985 and 1993, mentioned in the introduction, which suggests the likely occurrence of some change in competitive conditions at some point over the period. Second, while there is widespread agreement that competition increased during the decade following 1985, there seems to be less consensus over the timing of the change.

4. Data

The main dataset used in this study comprises balance sheet information on virtually all Italian banks for the period 1983-1997, obtained from supervisory reports. Missing from the sample are Italian branches of foreign banks as well as special credit institutions ("Istituti di credito speciale"), as their peculiarities (lack of a branch system, high level of specialization) would have complicated the estimation without adding significant identification power.[11]

Prior to the implementation of the Second Banking Directive in 1993, banks were classified into several different categories, partly reflecting their specialization. The 1993 reform left only three categories: commercial banks, “banche popolari” and CCBs. In the empirical section we group together commercial banks and popolari, and analyze CCBs separately.[12] We also pooled all the other categories existing prior to 1993 with the commercial banks, since we felt that, while meaningful in earlier decades, such categories had already lost most of their relevance over our sample period.

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11 Our empirical framework is not well suited to include branches and subsidiaries of foreign banks due to their location in few large centers (essentially Milan and Rome), substantial lack of a branch system and high level of activity specialization. However, market entry by foreign banks can in principle significantly affect competitive conditions and may have in practice. Fazio (1999b) notes that the market share of branches and subsidiaries of foreign banks in Italy has risen from 3 to 7 percent in the nineties, presently standing in intermediate position between France and Spain (12 percent) and Germany (4 percent).

12 Although “banche popolari” are characterized by a cooperative ownership structure, we pooled them with commercial banks since for our purposes a series of characteristics, including size, makes them more similar to commercial banks than to CCBs.

Table 1: Selected features of the dataset (1)

	North-west		North-east		Center		South and islands		National banks		NATION-WIDE TOTAL	
	Commercial banks	CCBs	Commercial Banks	CCBs	Commercial Banks	CCBs	Commercial banks	CCBs	Commercial banks	CCBs	Commercial banks	CCBs
1983-1990												
Total average number of banks	75	97	82	310	55	98	103	183	16	-	331	688
Annual average number of M&A	1.6	0.2	1.9	2.5	1.5	0.2	2.4	0.8	2.0	-	9.4	3.8
Average total assets per bank (billion ITL)	2,995	80	1,535	48	1,488	60	676	35	17,202	-	2,359	51
Average number of employees per bank	1,051	24	538	16	510	21	307	12	7,955	-	942	17
Total interest on assets/total assets (%)	11.9	13.4	12.3	13.2	12.8	13.9	13.9	14.3	11.5	-	12.8	13.6
Total interest on deposits/deposits (%)	9.0	9.6	9.0	9.5	9.1	9.6	9.5	9.5	8.6	-	9.1	9.5
1991-1997												
Total average number of banks	55	85	62	261	48	92	69	181	19	-	261	619
Annual average number of M&A	2.1	3.7	4.0	9.0	1.1	1.6	5.4	4.9	4.4	-	17.1	19.1
Average total assets per bank (billion ITL)	6,631	247	4,005	140	2,606	171	1,868	80	34,268	-	5,899	142
Average number of employees per bank	1,199	50	784	31	567	37	436	17	7,765	-	1240	30
Total interest on assets/total assets (%)	9.4	10.1	9.4	10.2	10.1	10.5	10.9	11.6	9.9	-	10.0	10.7
Total interest on deposits/deposits (%)	7.6	7.8	7.6	7.4	7.3	7.6	7.2	7.2	7.8	-	7.5	7.4
1983-1997												
Total average number of banks	66	91	72	287	51	95	91	182	18	-	298	656
Annual average number of M&A	1.9	1.9	2.9	5.5	1.3	0.9	3.8	2.7	3.1	-	13.0	10.9
Average total assets per bank (billion ITL)	4,421	152	2,516	87	1,973	110	1,145	56	25,864	-	3,803	91
Average number of employees per bank	1,106	35	637	22	535	28	358	14	7,859	-	1,064	23
Total interest on assets/total assets (%)	10.9	12.0	11.1	11.9	11.6	12.4	12.7	13.1	10.7	-	11.6	12.3
Total interest on deposits/deposits (%)	8.5	8.8	8.5	8.6	8.3	8.7	8.6	8.4	8.2	-	8.5	8.6

(1) The statistics reported are derived from the dataset used in the regression analysis prior to the application of the filters described in the appendix A; details about the variables are in the appendix.

The second main classification criterion relies on banks' geographical location. Banks are clustered in five separate markets (North-west, North-east, Center, South and Nation-wide), according to their "prevailing area of business". Appendix B contains details on the definition of the latter concept, and on the criterion used to assign banks to a given area.

Finally, banks are also classified based on whether they were involved in mergers or acquisitions. A summary of some key features of our dataset according to the criteria outlined above is given in Table 1. Further details on the dataset are reported in Appendix A.

5. Empirical results

In the next subsection 5.1 we estimate indexes of competitive conditions for commercial banks, CCBs and for banks involved in mergers or acquisitions. Section 5.2 presents evidence on the factors that may explain the cross sectional and time series pattern of the estimated indexes.

5.1 Estimation of the Lerner indexes

Estimation of the system (5)-(6) entails choosing an operational definition of the key variables appearing in the equations. As mentioned in section 2.1, we adopted a broad definition of banking output q_j, proxied by total assets. The price p_j is defined as interest from total assets plus revenue from services as a ratio to total assets. This choice, aimed at incorporating the unit revenue from services into the price of our composite banking product, is valid under the assumption that the stock of total assets is a good proxy for the heterogeneous flow of services supplied by banks (e.g. payment processing, portfolio management), which is unobservable in our dataset. Table 2 summarizes the benchmark definitions for the main variables used in subsections 5.1.1 through 5.1.3.

In section 5.1.4 several robustness checks are performed: p_j is defined as interest from total assets over total assets; also, deposits are treated as part of the output, thereby allowing differences in competitive conditions to stem also from the deposits market.

Cross-sectional estimation of system (5)-(6) was performed for each year in the sample period. Because of the endogeneity of the cost and quantity variables, C_j and q_j, we used instrumental variables (3SLS). Since lagged variables appear among the instruments, the results of the econometric analysis are available for the period 1984-1997. The full results of the estimation process, carried out one year at a time for two simultaneous equations generally involving over 20 coefficients overall, are

rather cumbersome to illustrate and are therefore reported in a series of appendix tables (Tables C1-C4).

Table 2: Operational definitions of the main variables used in the analysis(1)

p_j	$\frac{\text{Total interest earned on assets + Total revenues from services}}{\text{Total assets}}$
q_j	Total assets
C_j	Total costs
w_{1j}	$\frac{\text{Total interest paid on deposits}}{\text{Total deposits}}$
w_{2j}	$\frac{\text{Labor costs}}{\text{N° of employees}}$
w_{3j}	$\frac{\text{Total operating costs – Labor costs}}{\text{Total assets}}$
Price-deposit margin	$p_j - \frac{\text{Total interest paid on deposits}}{\text{Total assets}}$

(1) See Appendix A for further details on the variables.

The key results, summarized in a series of charts, are illustrated in the following four sub-sections. The first three deal with commercial banks, CCBs and banks that underwent a process of mergers or acquisitions. In all cases, we begin by looking at price-deposit margins, a first, customary indicator of the ability to price over marginal cost. We then move on to consider our estimated Lerner indexes, computed as the ratio between the estimated l_g and the average price for group g. Sub-section 5.1.4 reports the results of the robustness tests.

5.1.1 Commercial banks

Fig. 1a reports price-deposit margins for commercial banks operating in the four areas and for those with a nation-wide market. Several features are worth noting. First, in all cases considered margins remain relatively constant until 1992, declining rather sharply thereafter, albeit with a temporary increase in 1995.[13]

13 The 1995 increase is likely due to the monetary policy tightening which took place at the beginning of the year; a less pronounced increase can also be observed in 1992, when a rate increase occurred in the context of the Exchange Rate Mechanism crisis. Following a monetary tightening, banks tend to adjust rates on loans immediately and rates on liabilities with a lag; they tend to do the opposite after a loosening. The extent of this asymmetry has been proposed as a measure of banking competition (Hannan and Berger, 1991).

Fig. 1: Indicators of competitive conditions: Commercial banks(1)
(by geographical area)

Fig. 1a: Price Deposit margins (2)

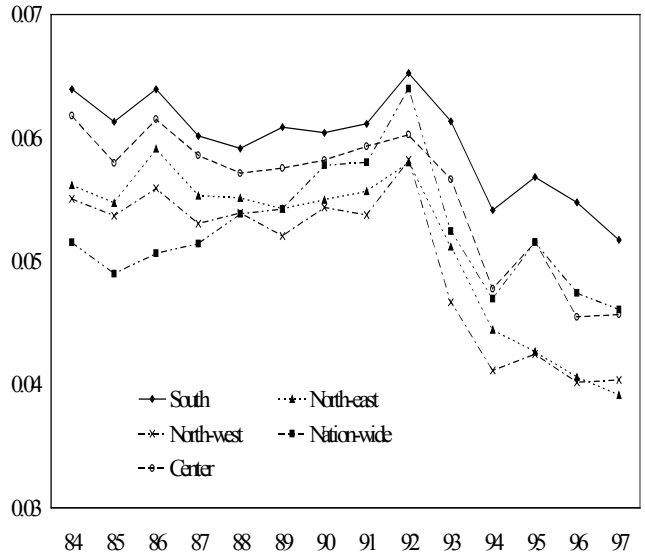


Fig. 1b: Lerner Indexes (3)
(constrained estimation)

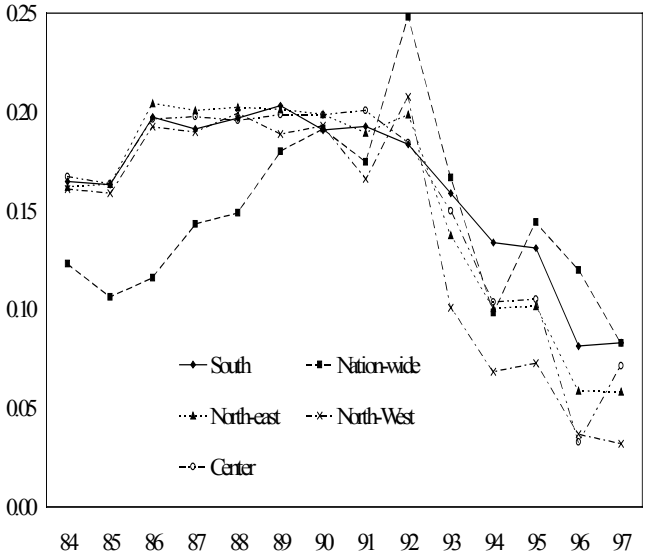


Fig. 1c: Marginal costs (4)
(constrained estimation)

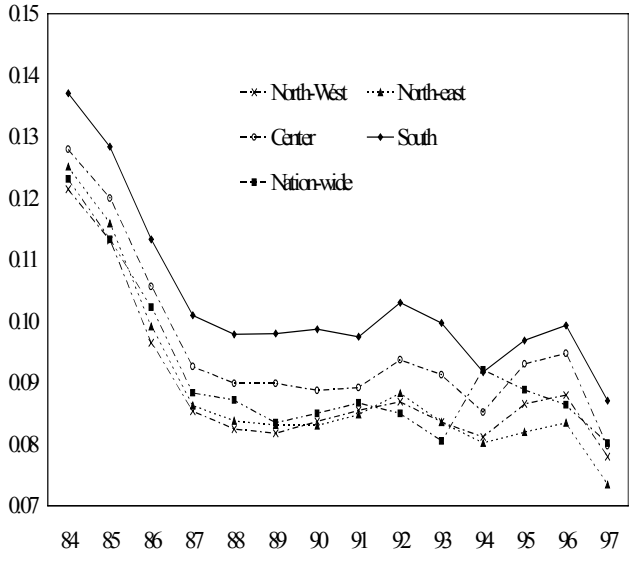
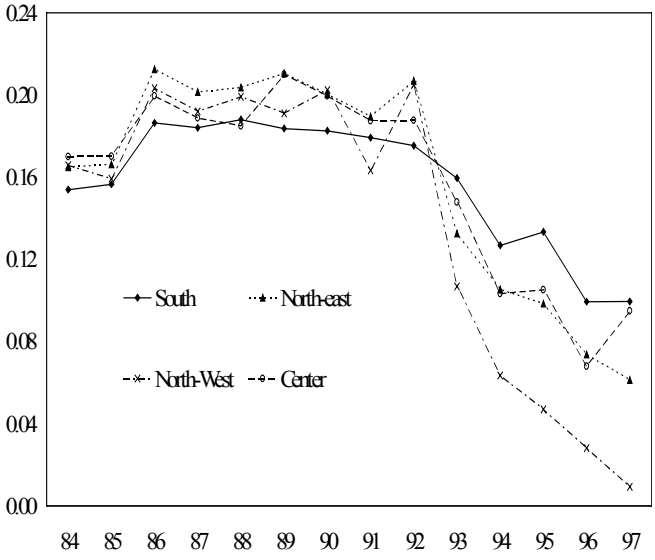


Fig. 1d: Unconstrained Lerner Index (5)



(1) Panels (b) and (c) are obtained from output generated via estimation of system (5) – (6) in Section 2; results of the estimates are reported in Table C1.
(2) See Table 2 for the definition.
(3) Computed as λ_g/p_g, g = North-west, North-east, Center, South and Nation-wide. Estimates for the λ_g for each year are reported in Table C1. The price p_g is a simple average of individual bank data (the p_j defined in Table 2) for group g.
(4) Computed using the regression coefficients reported in Table C1 and evaluating the regressors at their sample mean for each year and group.
(5) Computed by running 4 separate sets of estimates of system (5) – (6) in Section 2, one for each area. The results of the estimates are not reported.

Second, margins tend to increase from North to South; also, they display a roughly coherent time-series behavior across areas. Third, after 1992 the dispersion across the four areas increases substantially: the decline is moderate in the South, more pronounced in the Center, while a sharper drop is observed in the Northern areas.

The overall picture emerging from the corresponding Lerner indexes, broadly similar, confirms that in 1993 a relevant change in competitive conditions took place (Fig. 1b): all the indexes drop, although with differing degrees of intensity. Some differences are worth noting relative to Fig. 1a. First, the dispersion of the indexes across areas is very small between 1984 and 1992 (overlooking nation-wide banks). In particular, the index for the South is no longer above other areas, due to higher marginal costs (Fig. 1c). Recalling that the Lerner is computed as λ_g/p_g, an assessment of whether the differences among the various areas are statistically significant can be obtained from the *t*-statistics on the λ_g in equation (6) (Table C1). The λ_g for the North-west area (λ_{NW}) is always statistically greater than zero at the 1 percent level except for the last two year of the sample, when significance drops to 5 percent and then to zero. The λ_{NE} and λ_{CE} are always larger than λ_{NW}, although in general the difference is not statistically significant. Also, λ_{SO} is significantly larger than λ_{NW}, while the coefficient for nation-wide banks, λ_{NA}, is significantly smaller only in the initial part of the sample period.[14]

The regressions run to generate the data in Fig. 1b implicitly impose an analogous marginal cost structure for all four areas and for large banks; indeed, practically the entire cost function is assumed to be the same, as only the constant is allowed to vary across groups via ad hoc dummy variables. To assess the extent of the bias introduced by this assumption, we ran four separate regressions for each area (the exercise was not repeated for the nation-wide banks due to lack of degrees of freedom). The results (Fig. 1d) are broadly consistent with those obtained via the restricted version of the equations.

The finding of improved competitive conditions after 1993 is reinforced by the results of Schure and Wagenvoort (1999), who detect a significant reduction of X-inefficiency in the Italian banking sector over the 1993-97 period: other things equal, this should have increased bank margins.

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[14] Several authors have focused on the conditions prevailing in the market for bank loans in the South relative to the rest of the country. Based on a survey of the literature and his own calculations, Jappelli (1993) maintains that accounting for credit risk reduces, but cannot by itself completely explain, the interest rate differential between the South and the North. On the other hand, research conducted at the Bank of Italy finds that the differential (adjusted for a series of factors, most notably credit risk) has recently declined to zero (Annual Report on 1995).

5.1.2 Cooperative credit banks

The analysis of cooperative credit banks is relevant for several reasons. First, the banking services supplied by CCBs are comparable, in nature and quality, to those supplied by commercial banks. In fact, in Italy cooperative banks are the only alternative to commercial banks allowed for by the Second Banking Directive. Thus, the results obtained from this sub-sample represent a relevant robustness check of the main analysis.[15] At the same time, however, relative to commercial banks, CCBs are much smaller in size (three branches on average in 1997), are located primarily in small and medium-size centers, and mostly specialize in providing credit and other banking services to small businesses. Also, due to their cooperative ownership structure, the regulator has granted them special privileges and imposed additional constraints. These peculiar features thus put CCBs in a "niche position", which warrants investigation of potential extra market power.

Since CCBs are non-profit organizations, in principle the maximization problem described in section 2 is not well-suited to describe their behavior. In practice, however, things are not so clear-cut. In particular, in spite of the non-profit principle, net earnings are allowed to insure a proper capitalization, and there is evidence that Italian CCBs have consistently adopted this strategy. Also, it has been argued that in recent times competition between cooperative credit banks and commercial banks at the European level has significantly increased (Revell, 1989; Vittas et al., 1988); this is confirmed by the fact that following the deregulation process started in the mid-eighties, CCBs' share of business with non-member clients grew rapidly.[16] Furthermore, as pointed out in Shaffer (1999), whichever the strategy adopted by these banks, the methodology still allows us to compare their behavior with respect to the competitive benchmark implying marginal cost pricing.

All in all, these considerations suggest to treat CCBs as a separate case, and that an analysis performed along the lines used for commercial banks may yield useful insights. This view is confirmed by the main results of the empirical analysis, which turn out to be broadly in line with those for commercial banks. The behavior of the price-deposit margins (Fig. 2a) is globally similar to that of the analogous indicators in Fig. 1a: the curve for the South is consistently higher than average and a sharp

15 Although they are often overlooked in the literature on banking structure and performance, credit cooperatives are widespread in industrialized countries. In Germany, for example, the DG Bank federation comprises over 2,000 cooperative banks and 14 million members. In Italy there are almost 600 CCBs, totaling 500,000 members.

16 Even a summary description of these intermediaries is beyond the scope of the present paper. See e.g. Angelini, Di Salvo and Ferri, (1998) for a brief overview of this banking category, and Fazio (1987) for a historical perspective.

Fig. 2: Indicators of competitive conditions: Cooperative credit banks (1)
(by geographical area)

Fig. 2a: Price-Deposit margins (2)

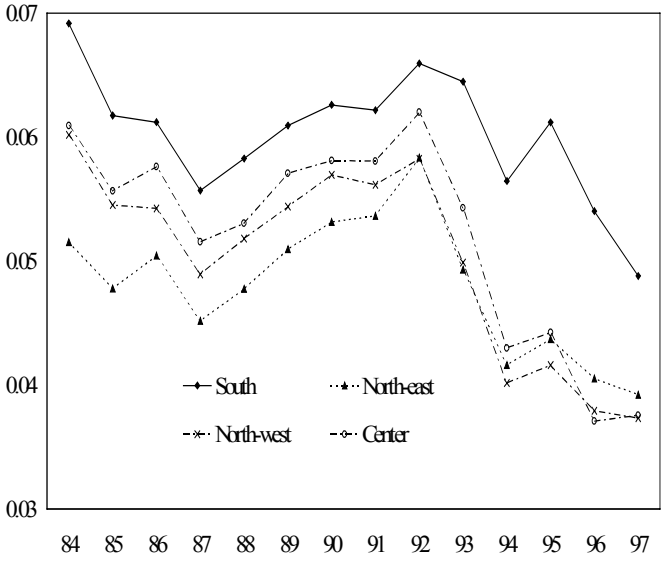


Fig. 2b: Lerner Indexes (3)
(constrained estimation)

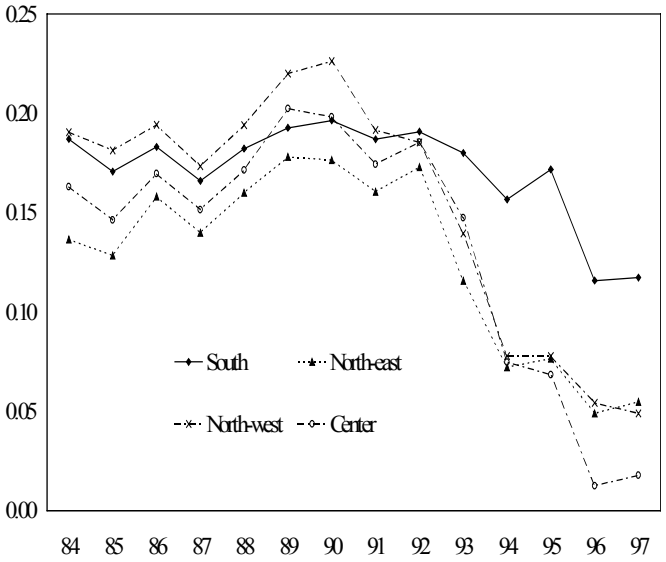


Fig. 2c: Marginal costs (4)
(constrained estimation)

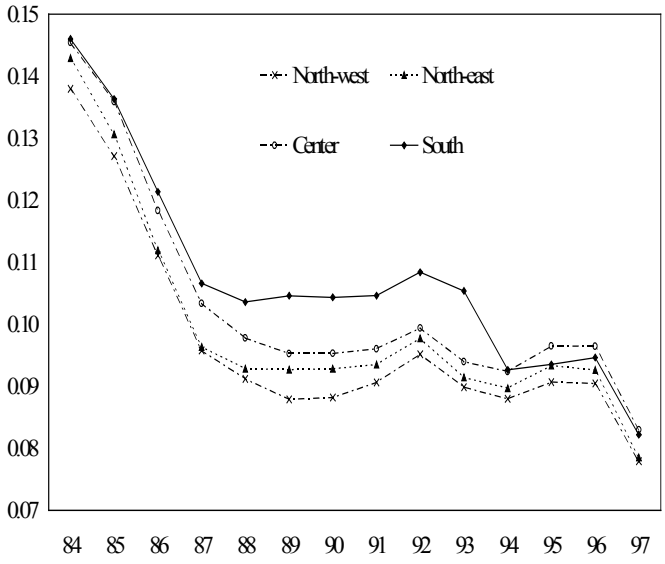
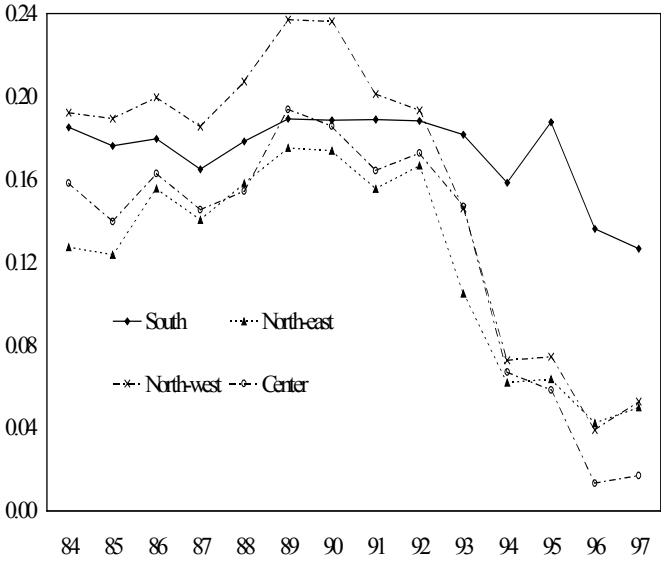


Fig. 2d: Unconstrained Lerner indexes (5)



(1) Panels (b) and (c) are obtained from output generated via estimation of system (5) – (6) in Section 2; results of the estimates are reported in Table C2.
(2) See Table 2 for the definition.
(3) Computed as λ_g/p_g, g = North-west, North-east, Center, South and Nation-wide. Estimates for the λ_g for each year are reported in Table C2. The price p_g is a simple average of individual bank data (the p_j defined in Table 2) for group g.
(4) Computed using the regression coefficients reported in Table C2 and evaluating the regressors at their sample mean for each year and group.
(5) Computed by running 4 separate sets of estimates of system (5) – (6) in Section 2, one for each area. The results of the estimates are not reported.

Fig. 3: Indicators of competitive conditions: Commercial vs. Cooperative credit banks (1)

Fig. 3a: Price-Deposit margins (2)

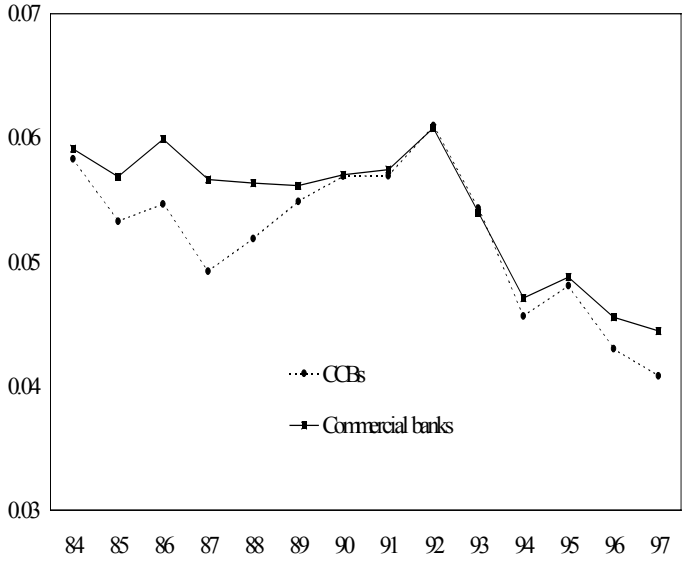


Fig. 3b: Lerner indexes (3)
(constrained estimation)

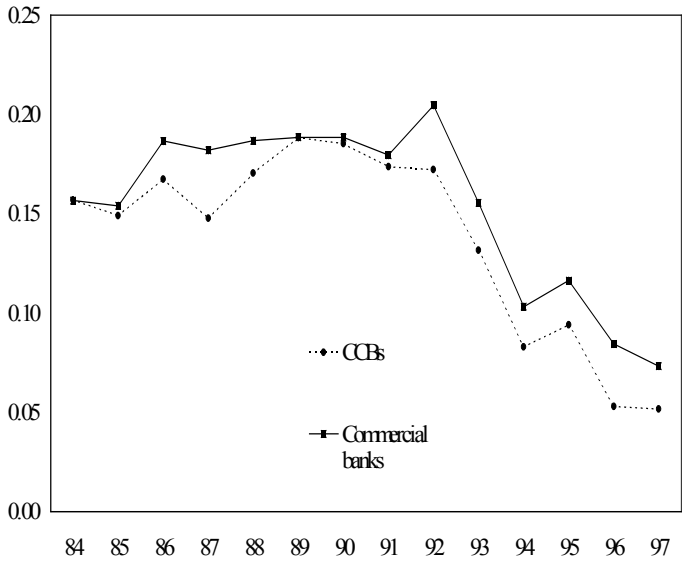


Fig. 3c: Marginal costs (4)
(constrained estimation)

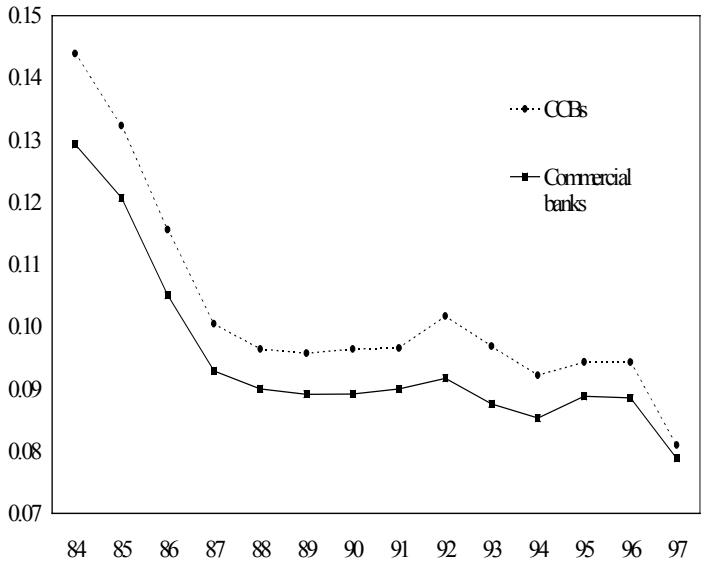
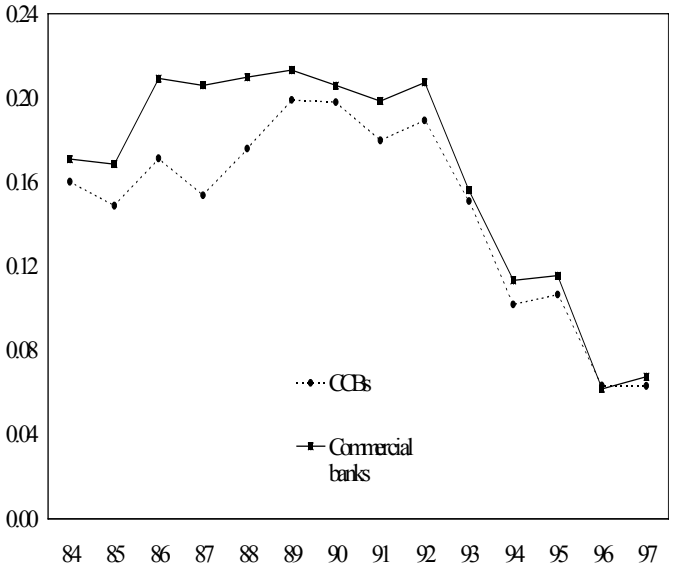


Fig. 3d: Unconstrained Lerner indexes (5)



(1) Panels (b) end (c) are obtained from output generated via estimation of system (5) – (6) in Section 2; results of the estimates are reported in Table C3.
(2) See Table 2 for the definition.
(3) Computed as λ_g/p_g, g = Commercial banks, Cooperative credit banks. Estimates for the λ_g for each year are reported in Table C3. The price p_g is a simple average of individual bank data (the p_j defined in Table 2) for group g.
(4) Computed using the regression coefficients reported in Table C3, and evaluating the regressors at their sample mean for each year and area.
(5) Computed by running 4 separate sets of estimates of system (5) – (6) in Section 2, one for each group. The results of the estimates are not reported.

drop is observed in 1993 in all areas, less pronounced for the South. The behavior displayed by the Lerner indexes is also roughly similar to those for commercial banks. Indexes for all areas are significantly different from zero at the one percent level (Table C2); however, in this case the decline observed for the South is definitely less pronounced than for commercial banks in the same area.

We also compared commercial banks to CCBs directly, overlooking the geographic dimension (Fig. 3). The Lerner indexes for CCBs are systematically lower, mainly as a result of higher marginal costs. However, the difference is not always statistically significant across years; also, it tends to vanish in the more recent period if the indexes are estimated using two separate sets of regressions for commercial banks and CCBs (Fig. 3d).

Altogether, the data seem to reject the hypothesis that CCBs operate in market niches sheltered from competition. This finding may also be relevant if one wishes to identify relevant banking markets of even smaller dimension, further disaggregating the territorial units considered in this study (the four areas). Since CCBs are very numerous and widespread throughout the country, it would be possible to pool them together with the commercial banks, thus obtaining the degrees of freedom necessary to undertake such econometric analysis.

5.1.3 Mergers and acquisitions

While a detailed analysis of the causes and consequences of mergers and acquisitions lies beyond the scope of the present study, we deemed it necessary to gauge the effect of these operations on our set of indexes, given that concentrations can in principle deeply affect competitive conditions.[17] Based on the structure-conduct-performance paradigm, the increase in concentration caused by mergers and acquisitions should cause bank margins to grow at the market level. We try to capture this effect in section 5.2; here we assess whether banks that underwent merger or acquisitions processes (M&A henceforth) gained market power relative to the rest of the banking system. To identify these banks we constructed a dummy variable which was set equal to one for the year of the operation and for all subsequent years. With this method, banks performing only one acquisition over the entire sample are pooled with those acquiring one or more banks each year; however, we deemed it appropriate for our purposes, since we are only interested in estimating an average indicator of competition for the entire group of M&A banks, without making any inference *across* them or explaining motivations behind M&A operations.

[17] For a thorough analysis of the effects of mergers and acquisitions across European banking markets, see Vander Vennet (1996).

Fig. 4: Indicators of competitive conditions: Mergers and acquisitions vs. other banks (1)
(total sample)

Fig. 4a: Price-Deposit Margins (2)

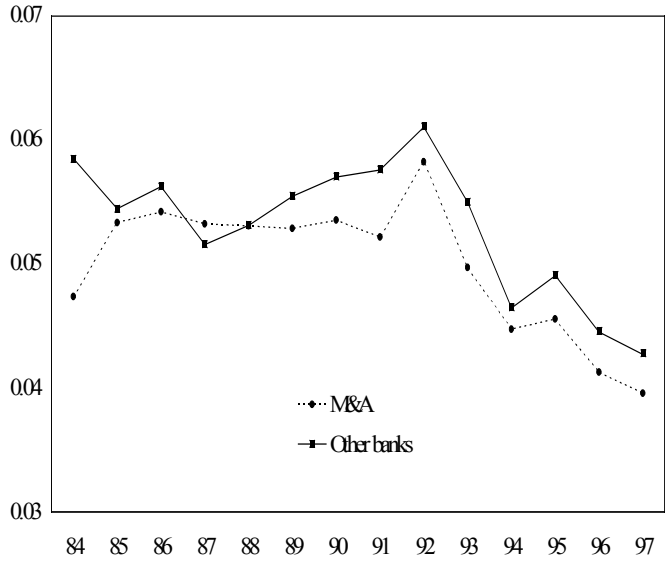


Fig. 4b: Lerner Indexes (3)
(constrained estimation)

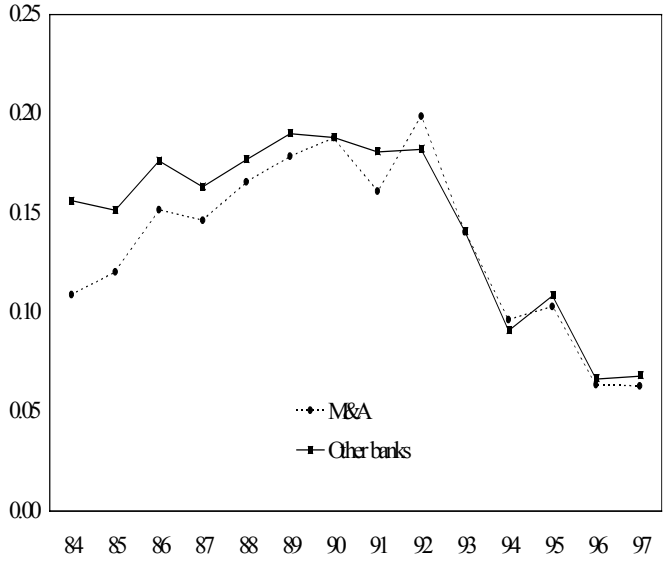
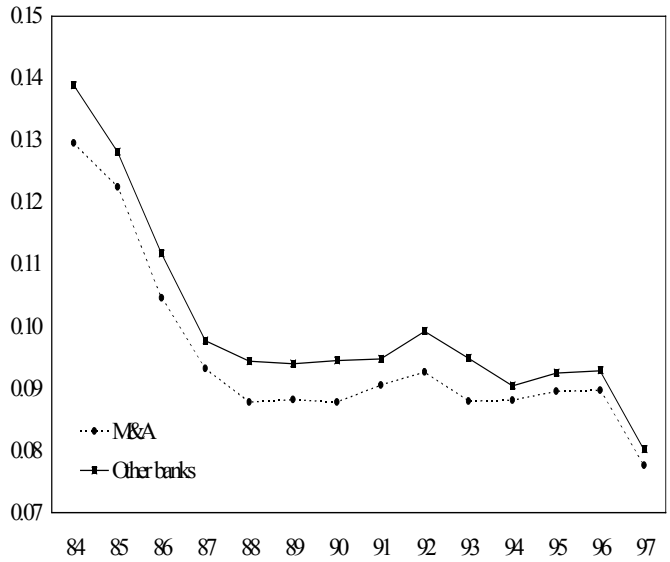


Fig. 4c: Marginal costs (4)
(constrained estimation)



(1) Panels (b) and (c) are obtained from output generated estimation of system (5) – (6) in Section 2; results of the estimates are reported in Table C4.
(2) See Table 2 for the definition.
(3) Computed as λ_g/p_g, g = banks which underwent at least one M&A operation within the sample period, other banks. Estimates for the λ_g for each year are reported in Table C4. The price p_g is a simple average of individual bank data (the p_j defined in Table 2) for group g.
(4) Computed using the regression coefficients reported in Table C4, and evaluating the regressors at their sample mean for each year and group.
(5) Computed by running 4 separate sets of estimates of system (5) – (6) in Section 2, one for each group. The results of the estimates are not reported.

Fig. 4 reports results for the entire sample (commercial banks and CCBs). Price-deposit margins are generally smaller for M&A (Fig. 4a). Similar indications come from the Lerner indexes, but only for the initial part of the sample, which should be regarded with caution, given the small number of observations in the M&A group. In the '90s, the period in which the phenomenon acquired relevance, there does not seem to be evidence of any gain in market power of banks involved in M&A's with respect to the control group. This finding was not obvious ex-ante, since one could have expected an increase in market power for the banks involved in mergers due to the gain in relative size. This result would be in keeping with the available literature, which typically fails to find significant effects of M&A operations (see e.g. the empirical evidence surveyed by Focarelli, Panetta and Salleo, 1999). However, the data also show that banks in the M&A group exhibit consistently lower marginal costs than other banks (Fig. 4c). This seems to suggest that, whatever the reasons for the consolidation (there is evidence that some operations, especially before 1990, were triggered by the need to help troubled banks), the resulting institutions are doing relatively well. Overall, banks involved in merger and acquisitions tend to be more cost-effective and to grant their clients better conditions (lower prices) than average.

While the rest of the banking system may not be the best control group to evaluate the performance of the M&A banks,[18] separate analyses of M&A for commercial banks and CCBs yield substantially similar results (not reported), thus adding confidence about the robustness of the findings.

5.1.4 Robustness checks

Using the commercial banks sample, which we view as the benchmark for our results, we performed several additional robustness checks of the estimation exercise, to account for potential problems arising from the model specification or from the definitions adopted for some of the key variables.

We experimented with several alternative definitions of banking product and price, in addition to the one presented in the previous paragraphs. First, in light of the still unsettled debate over whether deposits should be considered as input or output, discussed in Section 2.1, we modified the analytical setup to allow deposits to be considered as an output. To do so, our measure of the price for the composite banking product p_j was enhanced to include a shadow revenue on deposits (net of required reserves), computed as the difference between a money market interest rate and the interest rate paid on deposits (which is typically lower). The idea is that this interest differential is the price paid

[18] For instance, if most of the mergers occurred among the largest banks in the country, or those located in one

by depositors for the services (e.g. payment services) they obtain from their holdings of deposits. Also, the specification of the cost function (5) was modified, eliminating all the terms involving the interest rate on deposits from the right-hand side and netting the dependent variable of interest paid on deposits. We also redefined q_j as total assets plus total deposits. The changes are summarized in the following table 3.

Table 3: Changes in definitions of key variables implemented for robustness(1)

	Deposits treated as an output
P_j	$\frac{\text{TIA} + \text{TRS} + r*(\text{TD} - \text{RR}) - \text{TID}}{\text{Total assets} + \text{Total deposits}}$ Where: TIA = Total interest earned on assets r = Interest rate on T-bills TD = Total deposits RR = Required reserves TID = Total interest paid on deposits
Q_j	Total assets + Total deposits
C_j	Total operating costs = Total costs – Total interest paid on deposits
	Revenue from services omitted from price definition
P_j	$\frac{\text{Total interest earned on assets}}{\text{Total assets}}$
Q_j	Total assets

(1) See Appendix A for further details on the variables.

The resulting Lerner indexes are displayed in Fig. 5. The most evident change relative to the benchmark Fig. 1b is that the curves shift upwards; however, they retain a roughly similar shape. This sensitivity may be due to the fact that since a break-down of costs by product is not available in balance sheet data, there are few choices for the definition of C in equations (5) and (6), that is either total costs, used in the previous subsections, or total operating costs. Incorrectly attributing total cost to only one banking product (loans) or to an excessively broad definition of such a product (total assets plus deposits) may introduce a biasin the estimates.[19] Leaving the level of the indexes aside, the figure displays a roughly stationary pattern until 1992 and a sharp drop in 1993 for all areas, in line

specific banking market, then the matching group should be constructed controlling for such factors.

19 Probably due to an analogous bias problem, when we tried to use total loans and the related interest rate as alternative definitions of q_j and p_j, we obtained negative Lerner indexes for the entire sample.

Fig. 5: Lerner indexes when deposits are treated as an output (1)
(commercial banks)

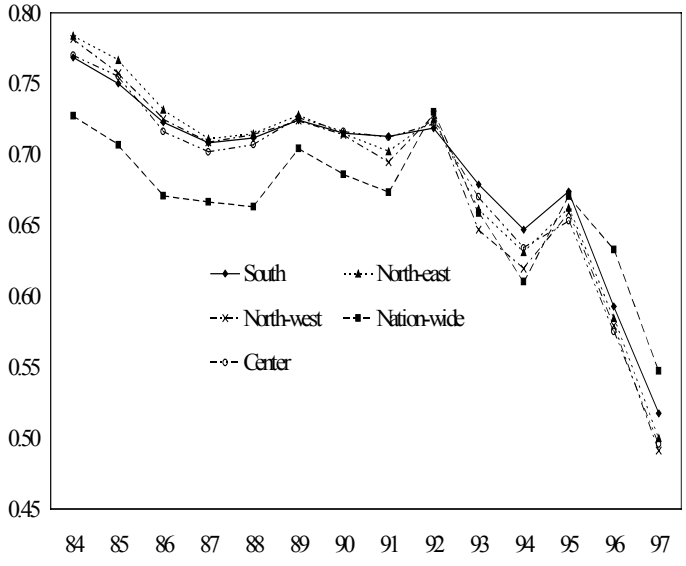


Fig. 6: Lerner indexes when p is defined as $\frac{\text{Total interest on assets}}{\text{Total assets}}$ (1)
(commercial banks)

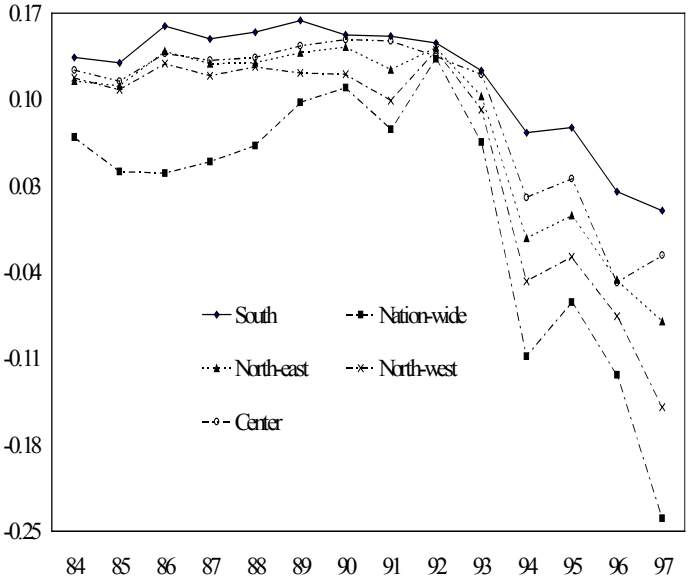
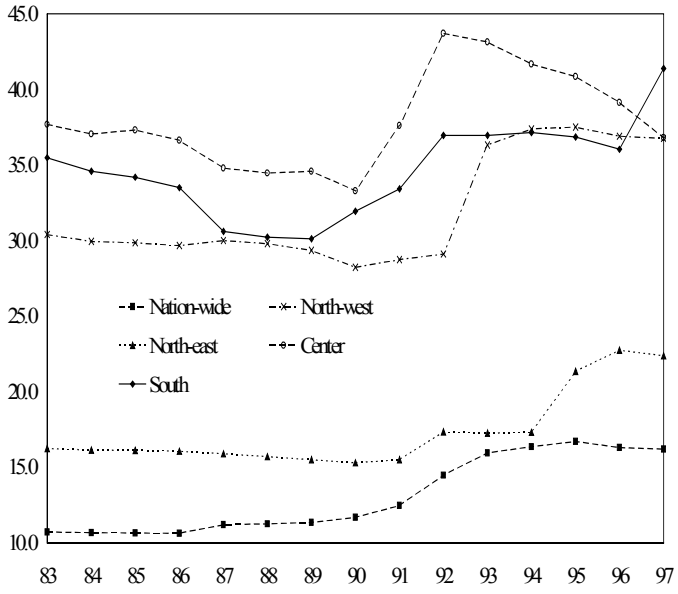


Fig. 7: Herfindhal indexes of market concentration
(computed from data on banks branches)



(1) The indexes are obtained from output generated via estimation of system (5) – (6) in Section 2; results of the estimates are not reported. Specifically, for each year the indexes are computed as λ_g/p_g, g = North-west, North-east, Center, South and Nation-wide. The price p_g is a simple average of individual bank data for group g. Details about the definition of the dependent variables are in Table 3.

with the evidence in Fig. 1b. However, differently from the benchmark case, there is no evidence of increasing dispersion across areas after 1993. This could be due to an improvement in competitive conditions in the Center-South areas stemming from the deposit side.

As a second robustness check, we redefined the output price p_j omitting revenue from services; this amounts to relaxing the assumption of proportionality between the flow of services supplied by a bank and its assets size adopted in subsections 5.1.1 through 5.1.3. The results are reported in Fig. 6. As before, all indexes display a sharp drop in 1993; in this case, however, they turn negative, and often significant, in most areas after 1994. This likely reflects the fact that services have become an increasing source of revenue in recent years; in addition, the mentioned profitability crisis that hit banks in the early 1990's has especially affected the traditional intermediation activity.

We also tried to control for the free capital effect pointed out by Generale, Gobbi and Tedeschi (1999), mentioned in Section 3. To this end, all observations for which the ratio between bad and doubtful loans and total assets exceeded 4 percent were dropped from the sample, and the regressions underlying Fig. 1b and Table C1 were re-run. Although the number of observations drops significantly, almost 30 percent on average over the 1984-1997 period, the shape of the curves (not reported) is roughly unaffected. However, the curves record an upward shift relative to those in Fig. 1b. Such shift is reasonable a priori, since we are dropping less profitable banks from the sample; its average magnitude over the entire sample period and across bank categories turns out to be 1 percentage point (2 percentage points for the South, where bad loans were much higher than average).

Finally, we used interest yielding assets and total interest on assets over interest yielding assets as alternative definitions of q_j and p_j (again, the results are not reported). In this case as well, no significant change in the Lerner indexes relative to the benchmark case portrayed in Fig. 1b could be detected.

Overall, while the results presented in this section lead us to look at the absolute value of the Lerner indexes with a degree of skepticism, they confirm the global time series patterns detected in Section 5.1.1.

5.2 An investigation of the factors affecting bank competition

One robust result emerging from the analysis of the previous section is that the Lerner indexes tend to maintain a rather constant pattern throughout the first part of the sample period and then decline steadily beginning in 1993. The decline occurs concomitantly with the implementation of the Second Banking Directive. For the reasons mentioned in the introduction, such regulatory reform may be responsible for a structural change in the competitive conditions across EU banking markets. The time series behavior of our estimates is consistent with this hypothesis. However, a number of other factors may have had an effect on banks' mark-ups. Before we can reach any conclusion regarding the impact of the regulatory reform, it is therefore necessary to gauge the importance of these other factors.

Recalling the analysis in section 2, the semi-elasticity of demand for banking products comes to mind as a potential candidate to explain the time series pattern of the Lerner indexes. This elasticity may have increased over time as a result of general economic growth and consequent financial deepening, with the emergence of suppliers of financial products alternative to banks, thereby contributing to the observed decline in mark-ups. While we do not provide an empirical assessment of this factor, we do not have evidence that the demand elasticity for banking products increased significantly after 1993. For example, Focarelli and Rossi (1998) estimate demand schedules for bank credit across the four geographical areas considered in this study and report no evidence of coefficient instability.

In addition to demand changes, the concentration of the banking market may affect pricing behavior and can thus account for the time series pattern of the Lerner indexes. Also, the economic cycle are likely to have an impact on banks' pricing decisions. For instance, in Rotemberg and Saloner's (1986) model of implicit collusion, mark-ups are countercyclical due to the fact that a relatively high demand raises each participant's incentives to deviate from the agreement, thereby causing the oligopoly to lower mark-ups to maintain discipline.[20] Since the decline in the Lerner indexes is observable over a period of five years only, we need to test whether this pattern could simply be the result of a short-term cyclical effect rather than a more fundamental change due to a new regulatory environment. Finally, we need to control for idiosyncratic or exceptional factors that may have had an impact on bank's profitability. Within this category, we control for the previously

[20] However, the opposite result is obtained in the implicit collusion model of Green and Porter (1984).

mentioned crisis experienced by the Italian banking industry in 1992-93, which is widely agreed to have been considerably more severe than warranted by general macroeconomic conditions; we also try to account for the administrative constraints imposed on the Italian banking system in the earlier part of our sample, which arguably had effects in subsequent years as well. In particular, until 1987 banks were subjected to portfolio constraints and ceilings on loans expansion, which determined abnormally high holdings of securities and in all likelihood caused profitable borrowers to be credit rationed; as soon as these measures were lifted, banks began to rebalance their assets side, rapidly increasing the share of loans.

To explain the pattern of bank competition emerging from the previous section we perform the following second-stage analysis. We arrange the Lerner indexes displayed in Fig. 1b in a panel and regress them against several variables that should proxy for the different factors described above.[21] We also use an indicator variable equal to one for the years 1993-97 and zero otherwise, which should identify the effect of other factors, such as the regulatory reform. The significance of this indicator after controlling for the other variables would be consistent with the hypothesis that the implementation of the Second Banking Directive, with the elimination of administrative barriers to entry, determined a structural improvement in bank competition.

We use GDP growth and inflation to account for macroeconomic conditions. If mark-ups are countercyclical, then we should expect a negative sign for both variables. At the same time, one could also argue that banks might demand a risk premium in an environment of high inflation or high nominal interest rates.[22] Therefore, the net effect of inflation on bank margins is ambiguous. We use the number of bank branches per capita and a Herfindahl index calculated on bank branches as indicators of market structure. According to the customary view associated with the structure-conduct-performance hypothesis, the signs of these indicators should be, in the order, negative and positive. We add a time trend to the regression to capture the general development in financial markets, and the increasing importance of markets and institutions alternative to banks. The trend should therefore have a negative sign. As a proxy for the general state of banks' health, we use the

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21 Hannan and Liang (1993), who analyze the U.S. deposits market, is to our knowledge the only other contribution to perform a similar two-stage study. Our paper differs from theirs in various ways. First, they impose constant conduct parameters through time, while we explore how conduct may have varied over time. In addition, they do not estimate marginal costs, while we run simultaneous systems imposing cross-equation parameter restrictions.

22 Saunders and Schumacher (1997) show that interest rate volatility, likely to be high in an environment of high and variable inflation, has a consistently positive effect on bank margins.

ratio of bad and doubtful loans to total assets, which due to the profitability crisis increased noticeably, especially in the South. The expected sign is negative. We also add the ratio between loans and total assets, with an expected positive sign: as banks replaced securities with more profitable loans, their margins should have increased. Finally, we include the indicator variable for the years 1993-97, which is expected to be negative and significant after controlling for the other factors.

The results are reported in Table 4. The estimation period ends in 1996 due to lack of data for GDP growth and inflation at the area level. All regressions include area-specific fixed effects (whose coefficients are not reported), and were estimated with instrumental variables to account for the potential endogeneity of the number of bank branches and loans.

The regression in the first column includes all the variables described above except the 1993-97 indicator variable. The coefficients of real GDP growth and inflation are negative, although the latter is not significant; in general, the significance of these effects does vary across specifications, but the sign pattern is consistently negative, lending some support to the Rotemberg and Saloner's (1986) implicit collusion theory. The number of branches per capita is negative and significant, consistent with expectations. The Herfindahl index has a negative sign, although it is not significant. Comparison of the time series pattern of the Herfindahls (Fig. 7) and the Lerners confirms the existence of a clear inverse relationship, which may be the result of a dynamic adjustment process. Theoretical models of industrial organization predict that the equilibrium number of firms operating in a market may decrease as a result of economic integration (Peretto, 1999). The indicator of banks' health has the expected sign and is significant, thus suggesting that the above mentioned profitability crisis of the early 1990's may have contributed to the decrease in the Lerners. This evidence is in line with the results of the sensitivity analysis reported in Section 5.1.4. The ratio between loans and total assets, proxying for the abolition of administrative controls in the middle eighties, has the expected positive sign and is significant.

To check the robustness of the results, we re-run a similar specification excluding the time trend, whose coefficient has a positive sign, contrary to the a priori that market developments and increasing competition from non-banks should have reduced margins overthe period (column 2).[23] The overall picture remains broadly unchanged.

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[23] Replacing the time trend with year dummies results in a significant increase in the standard errors of the coefficients, signaling that the cross-section variability of the data alone is not sufficient to achieve identification.

Table 4: Factors affecting proposed measures of bank competition[(1)]

(Fixed effects panels for commercial banks; sample period: 1984-1996)

	Dependent variable:							
	Lerner indexes				**Price-deposit margins**			
Real GDP growth	-0.20	-0.21	-0.38	-0.38	-0.09**	-0.09**	-0.11**	-0.11**
	(0.8)	*(1.0)*	*(1.3)*	*(1.5)*	*(3.4)*	*(3.4)*	*(3.6)*	*(3.8)*
Inflation	-1.15**	-1.42**	-0.40	-1.21**	0.11*	-0.09**	-0.02	-0.06*
	(2.7)	*(5.6)*	*(0.8)*	*(5.4)*	*(2.1)*	*(2.7)*	*(0.5)*	*(2.0)*
Herfindahl index	-2.7e-3	-2.8e-3	1.1e-4	-8.9e-4	8.4e-5	9.2e-5	3.8e-4	3.4e-4
	(1.3)	*(1.4)*	*(0.1)*	*(0.4)*	*(0.4)*	*(0.5)*	*(1.9)*	*(1.8)*
Bank branches/Population	-1.10**	-1.03**	-0.64**	-0.55**	-0.11**	-0.12**	-0.06*	-0.06*
	(6.5)	*(7.0)*	*(3.4)*	*(2.9)*	*(5.8)*	*(7.1)*	*(2.4)*	*(2.4)*
Bad and doubtful loans/Total assets	-1.41**	-1.23**	-0.92**	-0.56*	-0.10*	-0.11**	-0.04	-0.02
	(4.9)	*(5.2)*	*(2.9)*	*(2.0)*	*(2.2)*	*(3.1)*	*(1.4)*	*(1.1)*
Loans portfolio/Total assets	0.67*	0.86**	-0.20	0.43	010**	0.09**	5.5e-3	0.03
	(2.6)	*(5.2)*	*(0.5)*	*(1.8)*	*(3.0)*	*(4.8)*	*(0.2)*	*(1.5)*
Linear trend	5.2e-3	-	0.01*	-	-3.8e-4	-	6.8e-4	-
	(0.9)	-	*(2.1)*	-	*(0.5)*	-	*(1.0)*	-
Dummy for 1993-1997	-	-	-0.07**	-0.06*	-	-	-8.4e-3**	-7.8e-3**
	-	-	*(2.7)*	*(2.4)*	-	-	*(3.4)*	*(3.2)*
N° obs.	65	65	65	65	65	65	65	65
R^2	0.60	0.59	0.73	0.71	0.75	0.75	0.83	0.83

(1) In each regression, the dependent variable is obtained by stacking the five time series of the Lerner indexes (the price-deposit margins) displayed in Fig. 1b (Fig. 1a); the regressors are also created with a similar stacking procedure. Each regression includes 5 dummies to eliminate fixed effects specific to the geographical location of the bank (North-west, North-east, Center, South and Nation-wide); the coefficients are not reported. Estimation method: Two-stage least squares; variables with potential endogeneity problems (bad and doubtful loans/total assets, n° bank branches/population, loans portfolio/total assets) were instrumented using their lagged values and exogenous or predetermined variables (current GDP growth and inflation, current and lagged real GDP (levels and logs), lagged bank branches (levels and logs), current and lagged per capita GDP (levels and logs). Heteroskedastiticy-robust *t* statistics are reported in parenthesis in italics. One or two asterisks denote significance at the five and one percent level, respectively. Inflation is computed using the GDP deflators for each area, in turn obtained as a weighted average of regional deflators. Similar results are obtained when the nation-wide category is omitted, leaving 52 observations for each regression.

In the third and fourth columns of the table we add the indicator variable to the first two specifications to capture any unmeasurable factor that had effects after 1992, such as the implementation of the Second Banking Directive. The coefficient is negative and significant. The number of branches per capita and the indicator of banks' health maintain sign and significance, although with a reduced coefficient. As a robustness test, the exercise was replicated using price-deposit margins as the dependent variable (last four columns of the table). The general pattern of sign and significance of the variables is not altered, with a few exceptions (in particular, GDP growth has a consistently significant effect). The regressions in the first four columns were also re-run using the unconstrained Lerners displayed in Fig. 1d, without detecting significant changes in the results (not reported).

Altogether, between 1992 and 1996 the estimated Lerner index for commercial banks drops by 13 percentage points, from an average value of 20 percent across markets to 7 percent. The equation including the time trend and the 1993-96 dummy explains over 75 percent of the reduction. Among the regressors, a prominent role is played by the 1993-96 dummy itself, which accounts for about 6-7 percentage points of the drop. The increase of bank branches accounts for about 5 points; the growth of bad and doubtful loans for about 2. The effect of the latter regressor would suggest that as the credit risk situation goes back to normal, an increase in the Lerner indexes, unrelated to competitive conditions, may be expected.

In sum, this analysis does not allow us to rule out the hypothesis that a series of relevant events, which affected the banking environment in 1993 or in previous years had a major role in shaping the observed pattern of our indicators of competitive conditions.[24] Nevertheless, even after controlling for a number of factors, the evidence is consistent with the hypothesis that the process of

[24] While a history of the events that contributed to reshape the Italian financial environment in recent years lies outside the scope of this paper, some of the main regulatory changes are worth recalling. In 1989, an EC regulation concerning the creation of new banks is enforced, eliminating previously existing barriers. The completion of the branching liberalization process in March 1990 was followed by a significant increase in the number of branches per capita. In May 1990 geographical limits to the expansion of banks' activity are removed, with the only exception of CCBs. In July 1990 government-owned banks are allowed to choose the joint stock company model and barriers to mergers among banks belonging to different categories are removed, introducing incentives in this sense; also, the law introduces the possibility for the government to authorize the privatization of public banks. The privatization process started in 1993 with the IPO of three large banks, and gained momentum in subsequent years. In October 1990 an Anti-trust Authority is created. Responsibility for competition in the banking sector is assigned to the Bank of Italy, with which the Anti-trust Authority cooperates. In February 1992 minimum transparency requirements concerning terms, prices and supply conditions of banking services are introduced.

regulatory reform had an important impact on the competitive conditions of the Italian banking industry.

6. Conclusions

Banking industries throughout Europe have experienced major transformations in recent years. Important regulatory reforms, aimed at creating the conditions for a single banking market, have been implemented. Significant structural changes, through an intense process of consolidation, have taken place. This study explores the dynamic evolution of banking competition in Italy in response to such modifications, offering at the same time some insights whose relevance extends beyond the Italian experience. Using a dataset that includes balance sheet information on virtually all Italian banks over the 1983-1997 period, we estimate Lerner indexes for five markets, separating banks according to their relevant area of operation. This geographical partition allows us to better approximate the concept of "relevant market". While most analyses of competition in the banking industry adopt a national definition of markets, typically anti-trust regulators operate with a local one.

Our benchmark results relate to the commercial banks cluster, which accounts for more than 90 percent of total assets. However, we also explore the case of cooperative credit banks (CCBs), which are the main institutional alternative to commercial banks in Italy. The main results can be summarized as follows.

Average mark-ups in the supply of banking products remained roughly unchanged throughout the first part of the sample period analyzed and declined steadily after 1992. This pattern is the most robust of our results, as it is detected across geographical areas and bank categories. In particular, it holds for both commercial banks and cooperative credit banks. It is also robust to alternative definitions of bank output and price: we account for revenues from services and we treat deposits as part of banks' output, thereby allowing for the possibility that deposits are a relevant source of market power for banks. This result, which suggests that the Italian banking industry has become more competitive in recent years, is reinforced by recent findings by other authors that X-inefficiencies characterizing the Italian banking sector diminished significantly over the 1993-97 period.

Most of the results obtained for CCBs are remarkably similar to those for commercial banks; estimated Lerner indexes are generally lower than those for commercial banks due to higher marginal costs, but the difference tends to disappear in the more recent period. This suggests that there is little market segmentation between these two bank categories; although CCBs exhibit features

that have lead to their characterization as “niche banks,” no evidence is found that they are protected from competitive pressures. Given the current debate regarding the potential for anticompetitive behavior of U.S. credit unions with respect to commercial banks, the issue invites further investigation.

It is worth remarking that this homogeneity of behavior, together with the large number of CCBs operating throughout geographical markets, could be usefully exploited to increase the geographical breakdown of the analysis. In other words, our regional analysis could be pushed one step further to allow for a better approximation of relevant banking markets.

We also consider the recent process of consolidation in the banking industry, focusing on its impact on competitive conditions. To the best of our knowledge, the literature on the banking industry has not examined the impact of mergers on competitive conditions. Yet waves of mergers have been observed in both Europe and the United States in recent years. A plausible supposition is that because of their increased market share, banks involved in M&A operations would gain market power. However, their Lerner indexes do not differ from the average; also, these banks tend to be more cost-effective and to grant clients lower-than-average prices. While these results suggest a positive impact of the consolidation process on social welfare, they also encourage some speculation regarding the dynamic, long-run impact of the wave of mergers and acquisitions on industry structure. The fact that M&A banks have lower marginal costs and offer products at lower prices suggests that this situation might lead to a process of gradual increase in their market share. Consequently, while no evidence is found that merged banks enjoy extra market power, different conclusions might hold in a long-run equilibrium, suggesting the need for further monitoring.

Finally, we arrange the estimated indexes of competitive conditions for the five geographical markets in a panel; this yields enough observations to perform a second stage analysis aimed at identifying factors and events underlying the observed time pattern of the mark-up indicators. We find that this pattern is related to the expansion of bank branches, to a profitability crisis of exceptional relevance in the early 1990’s, and in some measure to the business cycle. The proposed equation explains over 75 percent of the drop in the mark-up indicators observed after 1992. About half of the explained drop is accounted for by a dummy for the 1993-97 years. This evidence is consistent with the hypothesis that the 1993 bank reform introducing the Single Banking License, removing important administrative barriers to entry, contributed to improving competitive conditions.

Appendix A: The data

The dataset, derived from the monthly and annual statistical reports sent by the banks to the Bank of Italy, has an annual frequency. Stock variables are computed as averages of quarterly data, except for 1983 (the initial year of the sample), for which only end-of-period stocks were available. Variables from the profit and loss account are genuinely annual, in that the account is published annually and pertains to the economic performance over the budget year. The following variables were used to create the dataset for the regression analysis.

Stock variables (in million of Italian lire)

Bad and doubtful loans: Do not include non-performing loans.

Deposits: Include savings deposits, certificates of deposit, checking accounts vis-à-vis resident non-bank customers.

Interbank deposits: Held with resident as well as non resident counterparts.

Loans: Include short-term and long-term loans. The main categories of operations include current account overdrafts, portfolio discount, advances on import-export operations, mortgages. The total includes bad and doubtful loans.

Real estate property: At book value.

Required reserves: Outstanding amounts recorded on banks reserve accounts held at the central bank.

Total assets: Total of the assets side of the balance sheet, net of losses pertaining to the current budget.

Total deposits: Computed as the sum of deposits and interbank deposits.

Total interbank assets: Includes interbank deposits and deposits with the central bank for reserve requirements.

Total interbank liabilities: Interbank deposits on the liability side.

Flow variables from the profit and loss account (in million of Italian lire)

Interest on loans: Interest accrued on loans portfolio, including repurchase agreements, with resident non-bank customers.

Labor costs: staff costs.

Total costs: Total operating costs plus interest paid on deposits.

Total interest earned on assets: Includes interest accrued from both the loans and the bond portfolio, commissions, interest from total interbank assets.

Total interest paid on deposits: Interest cost on deposit liabilities, both vis-à-vis non-bank customers and interbank liabilities.

Total operating costs: Inclusive of Labor costs.

Total revenues from services.

Other variables

Number of bank branches: In 1987 the series records a large increase due to the inclusion of offices with limited operational capabilities, previously treated separately from a statistical and normative viewpoint. The regression analysis of section 5.2 was re-run with a corrected series, in which branches for 1987 are computed via interpolation of adjacent years. No significant changes in the results was detected.

Herfindahl index of branch concentration: The index was computed using total bank branches in each of the four areas of the country.

Number of employees: Total of bank staff of all status.

Interest rate on T-bills: computed as a volume-weighted average of yields on three, six and twelve month bills in the primary market.

Classification variables

Ist: Discrete variable taking integer values from 1 through 7, used to create dummy variables for banks' institutional type: "Istituti di diritto pubblico" (large government-owned banks), "banche di interesse nazionale", ordinary commercial banks, "banche popolari" (relatively large-size cooperative banks), "casse di risparmio" (similar to the US savings and loans), "Monti di credito di 1° categoria" (almost extinct even at the beginning of our sample period), Cooperative Credit Banks (small cooperative banks).

Dim: Discrete variable taking integer values from 1 through 5, used to create dummy variables for banks' dimension (major, large, medium, small, very small).

Dummy for M&A: Dummy variable equal to one for banks which in a given year acquire or merge with at least one other bank; specifically, the dummy was set equal to zero for all years prior to the operation, and to one for the year of the operation and for all other years following it. All mergers or acquisitions between banks and non-bank financial institutions are not considered. See also the section below.

Mergers and acquisitions

In the dataset each bank is identified by a special 4-digit code. We addressed the problem of acquisitions by adding a fifth digit - a "1" - to the bank code for the year in which the acquisition took place and all subsequent years. Further acquisitions are labeled with increasing fifth digits. Thus, if bank 1307 buys bank 3421 in 1986 and bank 4456 in 1991, it will appear in our dataset as 1307 between 1983 and 1986, 13071 between 1987 and 1990, and 13072 between 1991 and 1993. Mergers are treated by creating a new bank code. Thus, if banks 4432 and 5674 merge in 1987 forming bank 3344, our sample will have both 4432 and 5674 until 1986, and only 3344 from 1987 onward. In practice, in the analysis a bank that has acquired another bank is treated as a new unit altogether.

All the relevant stock data are adjusted accordingly. Suppose bank 1307 acquires bank 3421 in the third quarter of 1986. All the stock variables for 1307 in this year are computed as follows. In each quarter prior to the acquisition (the first and the second), the stocks are obtained as

the sum of the stocks of 1307 and 3421. After the acquisition we use the stock variables of 1307 as they appear in the monthly reports to the central bank.

Filters

We dropped from the dataset: observations with nonpositive operating expenses or staff costs (19 observations for the entire sample period); observations with missing key variables, such as interest on loans or total loans (104 observations). We also dropped observations: if the annual yield on loans was more than 50 percent (6 observations) or less than 2.5 percent (10); if the ratio between total loans and total deposits was over 2.5 (6) or less than 0.15 (1); if the average interest rate on total deposits was more than 24 percent (3) or less than 0.5 percent (1); if the unit cost of labor was more than 200 billion Italian lira (1) or less than 10 billion (10); if the yield on loans increased by more than 200 percent from one year to the next (5) or decreased by more than 180 percent (2).

Variables from national and regional accounts

This part of the dataset, used only for the regressions in Table 4, comprises real GDP and the GDP deflator as reported in national and regional accounts. Area-wide values were computed via aggregation of regional series. The source is the National Institute for Statistics.

Appendix B: Geographical breakdown

The country is partitioned in four areas, North-west, North-east, Center, South and islands.[25] We assume that a bank belongs to a certain area if it collects at least 80% of its deposits in that area.[26] Both the 80 percent threshold and the aggregate chosen to compute the measure (deposits) are arbitrary. As the threshold is increased, the criterion tends to move banks with an area-wide outreach to the nation-wide category, and vice-versa if the threshold is reduced; for instance, moving the threshold from 80 to 90 percent, a bank with 85 percent of its deposits in the Center area, previously labeled "Center", would become "Nation-wide". Similarly, the relevant variable could be loans, or total assets, instead of deposits. We performed some sensitivity analysis along both dimensions, without detecting significant changes in the identification of the market clusters. A classification of the Italian banks based on their area of operation, published by the Bank of Italy in 1995, is also based on a similar criterion. This methodology is amenable to analysis of finer partitions, overlooked in the present study: the 4 areas can be partitioned into 20 regions, which in turn can be partitioned into 98 provinces.

[25] The North-west comprises Val D'Aosta, Piemonte, Lombardia and Liguria, the North-east includes Veneto, Trentino Alto Adige, Friuli Venezia Giulia and Emilia Romagna, the Center comprises Toscana, Umbria, Marche and Lazio, while the South and islands includes Campania, Basilicata, Puglia, Calabria, Abruzzo, Molise, Sardegna and Sicilia.

[26] For a detailed survey of the methodologies proposed for the identification of the relevant banking market see, for example, Wolken (1984).

Appendix C: Regression tables

Table C1: Estimates of system (5) - (6): Commercial banks, by geographical area (1)

dependent variables: total costs, C, for (5) and yield on total assets, p, for (6)

	Cost equation (5)														**Supply equation (6)**										
	c_0	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{NW}	c_{NE}	c_{CE}	c_{SO}	s_0	s_1	s_2	s_3	s_4	l_{NW}	l_{NE}	l_{CE}	l_{SO}	l_{NA}	*N. obs.*
1984	-3.201,6	-823,5	558,0	-811,8	-160,3	41,2	99,9	-71,3	-13,9	-26,6	-11,8	-10,6	-7,1	-2,7	4,1	-1,5	-22,0	6,3	-9,8	2,3	0,1	0,2	0,4	-0,6	347
	-5,4	*-3,4*	*3,4*	*-5,8*	*-4,7*	*1,3*	*5,1*	*-3,2*	*-0,8*	*-5,3*	*-5,0*	*-4,4*	*-3,0*	*-1,1*	*0,2*	*-5,4*	*-5,7*	*2,0*	*-6,7*	*16,2*	*0,5*	*1,0*	*2,1*	*-1,8*	
1985	-5.256,8	-1.567,2	1.030,1	-977,9	-181,1	174,1	122,7	-110,9	-26,6	-26,2	-8,0	-5,4	-2,6	3,1	-10,7	-1,3	-25,7	7,7	-8,8	2,1	0,1	0,2	0,4	-0,8	339
	-5,3	*-4,4*	*3,6*	*-6,2*	*-5,0*	*2,5*	*4,3*	*-4,4*	*-1,2*	*-4,0*	*-3,3*	*-2,2*	*-1,0*	*1,2*	*-0,7*	*-4,9*	*-6,0*	*2,7*	*-5,7*	*16,7*	*0,8*	*1,1*	*2,3*	*-2,5*	
1986	-6.128,8	-2.222,1	1.192,3	-810,3	-194,0	236,0	73,4	-165,2	-53,5	-23,1	-14,5	-11,6	-8,9	-2,1	-19,8	-1,4	-22,6	9,9	-9,9	2,3	0,2	0,3	0,5	-1,0	324
	-4,3	*-5,0*	*3,3*	*-4,3*	*-5,1*	*3,6*	*2,5*	*-5,1*	*-3,0*	*-3,2*	*-6,1*	*-4,8*	*-3,5*	*-0,8*	*-1,0*	*-4,8*	*-5,3*	*3,3*	*-5,5*	*20,6*	*1,7*	*1,6*	*3,2*	*-3,3*	
1987	-2.390,5	-650,1	684,3	-359,3	-58,5	79,2	78,2	-52,9	-38,0	-5,8	-15,4	-12,8	-9,4	-3,9	-13,9	-1,5	-11,1	14,0	-10,6	2,0	0,2	0,3	0,4	-0,5	309
	-3,1	*-2,2*	*3,0*	*-3,5*	*-3,0*	*1,5*	*3,5*	*-1,6*	*-1,5*	*-2,2*	*-5,7*	*-4,8*	*-3,2*	*-1,5*	*-0,8*	*-4,7*	*-3,0*	*4,2*	*-6,1*	*21,7*	*1,3*	*1,8*	*2,8*	*-2,0*	
1988	-4232,2	-1.081,4	636,3	-955,5	-137,6	66,7	147,8	-91,1	10,3	-17,0	-14,7	-13,3	-11,4	-2,9	-1,3	-1,5	-15,9	8,3	-9,8	2,1	0,1	0,1	0,3	-0,5	291
	-5,2	*-3,2*	*4,0*	*-4,7*	*-3,5*	*1,1*	*4,3*	*-2,5*	*0,6*	*-1,7*	*-4,7*	*-4,3*	*-3,6*	*-0,9*	*-0,1*	*-4,5*	*-4,2*	*2,9*	*-6,0*	*22,0*	*0,6*	*0,9*	*2,5*	*-2,2*	
1989	-2.614,0	-1.301,2	-80,5	-813,6	-186,6	36,3	43,5	-128,2	32,4	-37,8	-8,7	-6,7	-1,6	4,8	-16,9	-1,4	-20,6	7,4	-11,3	1,9	0,2	0,3	0,6	-0,1	280
	-2,4	*-2,6*	*-0,3*	*-4,9*	*-4,6*	*0,4*	*1,7*	*-3,2*	*2,1*	*-5,5*	*-2,4*	*-1,8*	*-0,4*	*1,2*	*-0,8*	*-3,2*	*-4,5*	*2,0*	*-4,8*	*16,4*	*1,4*	*1,8*	*3,6*	*-0,3*	
1990	-309,9	-883,4	-555,1	-315,5	-73,6	108,7	12,5	-62,6	101,6	-24,6	-10,1	-10,3	-4,1	3,6	32,2	-1,1	-14,0	2,0	-8,4	2,0	0,1	0,2	0,3	0,0	271
	-0,3	*-1,7*	*-1,9*	*-2,3*	*-1,9*	*1,2*	*0,5*	*-1,7*	*3,1*	*-3,9*	*-3,7*	*-3,8*	*-1,5*	*1,3*	*1,6*	*-2,8*	*-3,5*	*0,5*	*-4,0*	*17,8*	*0,4*	*1,1*	*1,9*	*0,1*	
1991	-1.650,0	-41,1	200,0	-655,6	-109,4	-48,9	95,8	21,1	7,3	-12,4	-7,0	-5,9	-1,2	6,7	42,2	-0,5	-4,9	2,3	-9,3	1,7	0,3	0,5	0,6	0,1	246
	-1,0	*-0,1*	*0,5*	*-4,3*	*-2,9*	*-0,5*	*5,6*	*0,4*	*0,3*	*-4,9*	*-2,4*	*-2,0*	*-0,4*	*2,2*	*1,6*	*-1,0*	*-1,1*	*0,5*	*-3,5*	*12,1*	*1,7*	*2,6*	*3,0*	*0,4*	
1992	-453,4	188,4	374,8	-43,9	-5,0	-14,5	26,8	14,6	-56,4	6,8	-5,3	-6,3	-0,6	7,0	44,7	-1,6	-2,2	15,5	-0,5	2,3	-0,1	-0,2	0,0	0,5	240
	-0,2	*0,4*	*0,7*	*-0,3*	*-0,2*	*-0,2*	*0,9*	*0,5*	*-1,3*	*1,3*	*-2,7*	*-3,0*	*-0,3*	*3,2*	*1,6*	*-3,4*	*-0,6*	*2,6*	*-0,2*	*16,3*	*-0,5*	*-0,6*	*0,2*	*1,5*	
1993	-3.829,1	-10,9	1.079,0	-848,7	-62,6	80,1	169,6	78,1	-31,1	-7,5	-6,4	-6,6	-1,6	6,4	27,3	-2,1	-10,7	9,3	-7,5	0,9	0,4	0,7	0,9	0,7	249
	-3,1	*0,0*	*3,6*	*-4,9*	*-1,5*	*1,0*	*5,3*	*1,8*	*-1,9*	*-1,0*	*-2,3*	*-2,3*	*-0,6*	*2,1*	*1,2*	*-3,8*	*-2,0*	*2,8*	*-2,7*	*4,8*	*1,5*	*2,6*	*3,9*	*1,4*	
1994	-2.692,3	260,9	1.011,8	-669,6	-76,1	-53,9	111,0	36,8	-110,2	-2,9	-6,6	-8,4	-1,7	4,1	-13,5	-1,3	-6,4	23,1	-2,2	0,6	0,3	0,4	0,8	0,4	220
	-2,2	*1,3*	*2,4*	*-2,4*	*-3,3*	*-1,3*	*2,3*	*3,8*	*-2,3*	*-0,4*	*-2,8*	*-3,4*	*-0,7*	*1,7*	*-0,4*	*-2,6*	*-2,2*	*4,5*	*-1,2*	*5,0*	*1,7*	*1,8*	*3,9*	*0,5*	
1995	-211,3	280,7	29,7	-270,4	-61,9	-74,7	30,4	3,0	-13,1	1,6	-6,6	-13,2	-3,6	2,5	68,0	-0,4	-10,0	3,2	0,9	0,7	0,2	0,4	0,8	0,8	194
	-0,2	*1,7*	*0,1*	*-1,3*	*-3,4*	*-1,9*	*0,8*	*0,4*	*-0,3*	*0,4*	*-2,3*	*-4,3*	*-1,3*	*0,8*	*2,2*	*-0,8*	*-2,2*	*0,6*	*0,6*	*5,0*	*1,3*	*1,9*	*2,4*	*1,0*	
1996	-443,0	-268,3	-55,1	-155,0	-63,3	16,5	14,9	-20,3	9,5	7,0	-4,3	-9,7	-1,3	3,0	66,0	-1,0	-9,4	5,7	0,7	0,3	0,2	0,0	0,5	0,8	210
	-0,8	*-0,9*	*-0,3*	*-1,2*	*-4,3*	*0,3*	*0,5*	*-2,0*	*0,3*	*1,8*	*-1,5*	*-3,3*	*-0,4*	*1,0*	*2,8*	*-1,9*	*-2,8*	*1,0*	*0,4*	*2,2*	*0,9*	*-0,1*	*1,8*	*1,1*	
1997	236,3	-200,9	-327,6	120,7	-36,1	5,9	-41,9	-17,1	34,6	7,9	-3,2	-6,0	1,5	5,5	145,8	1,0	-2,9	-9,4	5,8	0,3	0,2	0,4	0,5	0,5	214
	0,3	*-0,9*	*-1,6*	*0,8*	*-2,3*	*0,1*	*-1,2*	*-2,5*	*1,5*	*1,3*	*-1,0*	*-1,7*	*0,4*	*1,5*	*5,6*	*1,4*	*-1,1*	*-1,6*	*1,9*	*1,2*	*0,9*	*1,5*	*1,9*	*0,6*	

(1) Coefficients are multiplied by 100; t statistics, reported in italics below each coefficient, are robust to heteroskedasticity. Column λ_{NW} reports estimated differences between price and marginal cost for banks in the North-west; columns λ_g, g = *NE, CE, SO, NA* report differential effects relative to λ_{NW} for banks in the North-east, Center, South areas and for those with a nation-wide dimension, respectively. The coefficient c_0 measures the cost function intercept for banks with a nation-wide reach. The system is estimated with 3SLS using a TSP program. A separate estimation is carried out for each year in the sample. The instruments used are: lagged p and q (levels and logs), current and lagged ω_1, ω_2, ω_3 (levels and logs), lagged C (levels and logs), current and lagged number of employees (levels and logs), total interbank assets, liabilities and the sum of the two (levels and logs), total assets minus real estate property and loans (a proxy for the portfolio of equity and bonds; levels and logs), four dummies for geographical areas, five for bank type, four for bank dimension.

Table C2: Estimates of system (5) - (6): Cooperative credit banks, by geographical area (1)

dependent variables: total costs, C, for (5) and yield on total assets, p, for (6)

	Cost equation (5)													**Supply equation (6)**									
	c_0	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{NE}	c_{CE}	c_{SO}	s_0	s_1	s_2	s_3	s_4	l_{NW}	l_{NE}	l_{CE}	l_{SO}	*N. obs.*
1984	-356,6	165,4	189,9	-164,7	-20,5	-20,8	53,5	-9,8	1,1	3,2	3,7	3,1	4,4	47,8	0,9	-15,2	-1,6	-3,7	3,2	-1,0	-0,4	0,1	638
	-1,1	*1,2*	*1,5*	*-3,2*	*-1,2*	*-0,5*	*4,7*	*-0,9*	*0,1*	*1,9*	*5,9*	*3,9*	*5,4*	*3,8*	*3,8*	*-3,8*	*-1,0*	*-5,2*	*29,1*	*-8,9*	*-2,9*	*0,8*	
1985	-808,3	-241,1	245,3	-66,8	-30,4	70,0	16,1	3,2	-1,2	4,0	2,8	3,2	3,3	68,7	1,2	-8,0	-1,4	-1,1	2,8	-0,9	-0,5	0,0	647
	-1,3	*-0,8*	*2,0*	*-0,8*	*-1,2*	*1,7*	*1,8*	*0,1*	*-0,3*	*1,8*	*4,5*	*4,2*	*3,4*	*5,5*	*5,3*	*-2,3*	*-1,0*	*-1,5*	*27,2*	*-8,6*	*-3,6*	*-0,1*	
1986	-684,2	-187,7	88,7	-123,7	-32,9	7,1	35,2	-18,2	11,2	7,1	2,9	3,3	3,8	84,3	0,9	-1,5	-1,0	-1,1	2,7	-0,6	-0,3	0,0	660
	-1,4	*-0,9*	*0,5*	*-1,4*	*-1,9*	*0,1*	*1,7*	*-0,5*	*1,5*	*3,6*	*4,4*	*4,6*	*4,7*	*4,9*	*3,9*	*-0,3*	*-0,5*	*-1,6*	*28,7*	*-5,9*	*-2,1*	*0,3*	
1987	-40,9	-175,3	56,4	131,9	-9,6	-8,7	-9,4	-50,7	-10,5	8,4	2,5	3,5	3,3	74,8	1,5	-3,4	-2,6	-2,3	2,0	-0,4	-0,2	0,1	663
	-0,1	*-1,1*	*0,7*	*2,7*	*-1,2*	*-0,2*	*-1,0*	*-5,5*	*-2,0*	*11,6*	*3,8*	*4,7*	*4,0*	*8,3*	*6,8*	*-1,4*	*-1,6*	*-2,9*	*25,8*	*-5,6*	*-1,7*	*1,1*	
1988	582,4	269,7	-28,7	134,6	-1,2	-60,5	-14,3	-3,2	-15,6	3,3	2,6	3,6	3,4	96,3	1,1	-0,2	-5,3	-2,6	2,2	-0,4	-0,2	0,1	667
	1,2	*1,7*	*-0,2*	*1,7*	*-0,1*	*-1,5*	*-0,9*	*-0,6*	*-1,9*	*6,8*	*3,9*	*4,5*	*4,0*	*5,7*	*3,6*	*0,0*	*-2,2*	*-4,7*	*32,0*	*-6,0*	*-2,0*	*0,9*	
1989	302,5	-53,5	-222,5	32,4	-34,6	-82,3	-8,5	-61,7	5,5	6,5	5,6	5,1	7,7	107,9	0,9	-1,5	-6,3	-0,6	2,5	-0,5	-0,1	0,0	662
	0,8	*-0,5*	*-2,4*	*0,5*	*-2,5*	*-2,7*	*-0,7*	*-6,6*	*0,8*	*3,2*	*8,5*	*5,9*	*9,1*	*8,2*	*2,7*	*-0,4*	*-2,8*	*-0,6*	*33,3*	*-5,7*	*-0,5*	*0,2*	
1990	-224,7	-237,9	81,0	139,5	0,1	26,6	-4,9	-31,6	-3,6	8,7	4,6	4,8	5,7	83,8	0,6	1,3	0,6	-1,9	2,6	-0,6	-0,2	0,0	651
	-0,6	*-2,2*	*1,0*	*2,1*	*0,0*	*1,6*	*-0,5*	*-5,4*	*-0,5*	*4,6*	*6,5*	*5,8*	*6,6*	*5,8*	*1,7*	*0,4*	*0,2*	*-2,0*	*24,9*	*-5,6*	*-1,8*	*-0,2*	
1991	-665,8	-398,7	73,7	59,3	-30,7	49,7	-13,4	-31,0	9,1	1,9	4,9	4,4	5,9	98,5	0,2	-5,2	-7,0	-3,5	2,1	-0,4	-0,1	0,3	633
	-1,3	*-1,9*	*0,6*	*0,7*	*-1,4*	*0,8*	*-0,8*	*-1,5*	*1,1*	*0,7*	*6,1*	*5,1*	*6,3*	*6,8*	*0,5*	*-1,4*	*-2,5*	*-2,7*	*28,0*	*-4,3*	*-0,9*	*2,1*	
1992	-1267,2	-516,3	189,3	-116,0	-11,8	91,9	38,6	-29,0	25,0	-0,3	4,4	4,2	5,2	70,3	0,2	-3,8	-1,7	-5,8	2,2	-0,1	0,1	0,4	644
	-3,4	*-3,6*	*1,8*	*-1,8*	*-0,9*	*2,2*	*3,7*	*-2,0*	*2,8*	*-0,1*	*6,1*	*5,1*	*6,3*	*4,9*	*0,4*	*-1,3*	*-0,6*	*-5,1*	*23,7*	*-1,2*	*0,8*	*3,0*	
1993	507,8	139,1	-98,1	12,0	8,6	-38,1	20,4	-17,5	2,7	-1,7	2,9	2,6	4,2	63,3	-0,8	2,2	5,7	-6,0	1,5	-0,3	0,2	0,9	601
	1,6	*1,2*	*-1,1*	*0,3*	*0,4*	*-1,2*	*1,2*	*-1,1*	*0,3*	*-0,3*	*4,0*	*3,3*	*4,9*	*3,5*	*-1,7*	*0,5*	*1,8*	*-3,4*	*10,0*	*-1,6*	*0,8*	*5,0*	
1994	-1401,2	-387,4	305,7	-389,4	-77,6	94,1	51,3	10,8	5,9	-2,9	1,8	3,1	0,9	-26,7	0,6	-21,8	9,3	-4,2	0,7	0,0	0,0	1,0	568
	-2,0	*-1,8*	*2,2*	*-3,5*	*-3,4*	*2,4*	*3,3*	*2,1*	*0,9*	*-0,5*	*1,9*	*2,9*	*0,8*	*-1,1*	*0,8*	*-4,5*	*1,9*	*-1,5*	*6,3*	*-0,4*	*0,0*	*6,6*	
1995	643,4	267,3	26,1	-248,9	-4,4	3,6	66,9	6,2	4,2	-2,1	1,0	2,3	1,3	-71,4	0,7	-19,5	19,3	-5,2	0,8	0,0	-0,1	1,2	534
	0,7	*1,0*	*0,1*	*-2,1*	*-0,2*	*0,1*	*2,4*	*0,6*	*0,4*	*-0,4*	*1,0*	*2,1*	*1,1*	*-2,5*	*1,0*	*-4,4*	*4,3*	*-2,7*	*6,1*	*0,1*	*-0,3*	*6,9*	
1996	-693,4	-10,9	172,5	-529,2	-29,2	71,8	114,9	21,1	33,5	-4,4	1,1	2,2	3,0	-58,7	-0,5	-24,5	15,1	-7,3	0,5	0,0	-0,4	0,7	508
	-0,9	*-0,1*	*1,0*	*-3,3*	*-1,3*	*1,4*	*3,3*	*1,6*	*1,3*	*-0,8*	*1,0*	*1,7*	*2,1*	*-2,6*	*-0,8*	*-6,9*	*3,6*	*-3,9*	*4,4*	*-0,4*	*-2,7*	*4,5*	
1997	-887,9	230,0	453,9	-207,6	40,6	49,2	106,1	20,2	10,5	6,9	0,4	3,0	6,3	27,0	-0,1	-13,1	1,7	-7,3	0,4	0,1	-0,3	0,7	497
	-1,5	*1,6*	*2,5*	*-2,1*	*2,7*	*1,2*	*3,8*	*3,2*	*0,6*	*1,0*	*0,4*	*2,5*	*4,4*	*1,3*	*-0,2*	*-5,9*	*0,4*	*-4,0*	*4,8*	*0,6*	*-2,1*	*5,8*	

(1) Coefficients are multiplied by 100; t statistics, reported in italics below each coefficient, are robust to heteroskedasticity. Column λ_{NW} reports estimated differences between price and marginal cost for banks in the North-west; columns λ_g, $g = NE, CE, SO, NA$ report differential effects relative to λ_{NW} for banks in the North-east, Center, South areas, respectively. The coefficient c_0 measures the cost function intercept for banks with a nation-wide reach. The system is estimated with 3SLS using a TSP program. A separate estimation is carried out for each year in the sample. The instruments used are: lagged p and q (levels and logs), current and lagged ω_1, ω_2, ω_3 (levels and logs), lagged C (levels and logs), current and lagged number of employees (levels and logs), total interbank assets, liabilities and the sum of the two (levels and logs), total assets minus real estate property and loans (a proxy for the portfolio of equity and bonds; levels and logs), four dummies for geographical areas.

Table C3: Estimates of system (5) - (6): Commercial vs. Cooperative credit banks (1)

dependent variables: total costs, C, for (5) and yield on total assets, p, for (6)

	Cost equation (5)																		**Supply equation (6)**							
	c_0	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{NW}	c_{NE}	c_{CE}	c_{SO}	$c_{NW,CCB}$	$c_{NE,CCB}$	$c_{CE,CCB}$	$c_{SO,CCB}$	s_0	s_1	s_2	s_3	s_4	l_{COMM}	l_{CCB}	N. obs.
1984	-696,3	-64,1	135,8	-253,4	-63,2	-38,9	49,4	-32,8	-4,2	2,1	-8,2	-3,8	-1,7	7,5	9,0	4,1	2,2	-7,6	51,7	-0,1	-12,4	2,8	-2,7	2,4	0,3	985
	-1,5	-0,3	1,2	-2,9	-2,6	-1,3	3,0	-2,0	-0,5	1,5	-3,8	-1,5	-0,6	3,0	3,3	1,8	0,5	-3,9	*5,3*	*-1,0*	*-4,4*	*1,7*	*-3,9*	*30,4*	*2,9*	
1985	-3.674,9	-1.536,9	644,9	-454,6	-131,1	197,2	42,8	-109,3	-4,7	-6,4	-7,6	-2,1	4,6	12,7	12,5	4,9	-3,0	-11,2	44,5	0,0	-18,1	0,3	-3,0	2,2	0,1	986
	-4,2	-4,2	3,6	-3,3	-3,9	3,3	2,6	-3,9	-0,6	-1,7	-2,9	-0,7	1,3	4,4	4,3	1,9	-0,7	-4,9	*4,4*	*0,2*	*-6,4*	*0,2*	*-3,8*	*29,9*	*1,3*	
1986	-43,4	-255,7	-313,5	-166,3	-103,7	-99,1	-8,8	-62,4	6,3	-0,3	-12,5	-11,4	-3,1	7,0	7,3	8,4	-1,4	-12,9	81,8	0,0	-3,1	-0,1	-2,2	2,4	-0,1	984
	-0,1	-1,0	-1,7	-1,7	-4,6	-1,8	-0,4	-2,2	0,9	-0,1	-5,6	-4,1	-0,8	2,3	2,3	3,5	-0,3	-5,0	*7,6*	*0,3*	*-1,2*	*-0,1*	*-3,2*	*33,2*	*-1,0*	
1987	188,8	-180,8	-256,9	-24,6	-60,1	-121,4	-2,8	-96,4	-5,3	8,3	-10,6	-11,9	-2,9	8,1	4,2	7,6	-2,5	-16,3	89,7	0,1	-1,7	-1,2	-1,8	2,1	-0,3	973
	0,4	-0,7	-1,7	-0,3	-3,0	-1,8	-0,2	-2,9	-0,6	3,1	-4,1	-4,2	-0,8	2,6	1,3	2,9	-0,5	-7,1	*9,6*	*0,6*	*-0,7*	*-0,7*	*-2,4*	*31,3*	*-4,0*	
1988	59,7	134,5	-38,0	-47,9	-27,5	-60,6	11,7	-8,4	-7,3	5,1	-10,4	-14,1	-6,1	5,5	2,0	8,5	0,0	-14,6	97,0	0,2	0,1	-0,4	-0,1	2,1	-0,1	958
	0,1	0,6	-0,3	-0,4	-1,5	-1,3	0,5	-1,1	-0,7	7,9	-3,5	-4,7	-1,5	1,6	0,7	3,3	0,0	-6,8	*7,7*	*1,2*	*0,0*	*-0,2*	*-0,1*	*32,6*	*-1,1*	
1989	149,2	-83,9	-314,6	-123,0	-53,2	-91,3	6,1	-57,9	17,7	0,8	-5,7	-13,1	6,5	10,0	-0,7	13,9	-11,1	-11,2	104,8	0,3	-0,5	-3,3	-0,5	2,1	0,2	942
	0,3	-0,5	-2,5	-1,3	-2,0	-2,1	0,4	-3,8	2,1	0,3	-1,7	-3,4	1,2	2,4	-0,3	5,1	-2,4	-5,1	*10,0*	*1,6*	*-0,2*	*-1,6*	*-0,4*	*29,0*	*1,7*	
1990	-1.394,9	-748,1	187,3	-1,3	-28,8	107,1	-2,9	-49,3	10,3	1,2	-7,2	-17,9	5,6	11,9	-0,5	16,8	-13,5	-18,0	86,3	-0,1	-2,2	0,0	-1,8	2,1	0,1	922
	-2,2	-3,1	1,3	0,0	-1,7	3,1	-0,2	-3,6	0,8	0,3	-2,4	-5,3	1,1	3,3	-0,2	4,7	-2,5	-7,6	*7,8*	*-0,3*	*-0,8*	*0,0*	*-1,7*	*27,9*	*1,3*	
1991	-493,2	-1,8	46,5	-154,9	-25,9	-27,6	35,0	-18,2	8,2	0,2	-5,7	-15,2	6,4	9,3	-2,3	14,3	-13,4	-12,8	92,7	0,1	-2,6	-3,4	-3,0	2,0	0,1	879
	-0,9	0,0	0,3	-1,2	-1,1	-0,3	1,5	-0,9	0,9	0,1	-1,9	-4,6	1,4	2,5	-0,8	4,5	-3,3	-5,3	*7,3*	*0,3*	*-0,9*	*-1,5*	*-2,2*	*24,2*	*0,6*	
1992	-430,3	44,6	19,3	-146,7	20,1	-2,5	65,2	-10,3	30,3	1,5	-4,5	-19,6	7,5	9,8	-1,3	21,7	-12,2	-10,7	105,8	-0,5	4,0	-2,3	-4,7	2,4	-0,2	884
	-0,7	0,2	0,1	-1,4	0,8	0,0	3,0	-0,5	2,1	0,4	-1,6	-5,6	1,9	3,1	-0,4	6,5	-2,6	-3,7	*8,2*	*-1,9*	*1,4*	*-0,9*	*-3,8*	*26,7*	*-2,4*	
1993	1.382,1	602,2	-332,5	-39,7	3,7	-143,5	27,9	-9,5	5,4	-0,3	-11,0	-17,9	3,9	9,7	6,7	16,4	-11,5	-13,9	91,8	-0,7	5,2	2,8	-4,0	1,6	-0,1	850
	2,3	2,4	-2,0	-0,6	0,1	-2,2	1,3	-0,5	0,3	-0,1	-3,6	-5,1	0,9	2,8	1,5	6,0	-2,3	-5,3	*6,4*	*-2,3*	*1,6*	*1,2*	*-2,4*	*16,6*	*-1,2*	
1994	627,5	335,0	-249,2	-344,2	-66,1	-81,9	54,9	16,3	15,4	5,2	-8,4	-15,9	-1,0	9,6	3,1	14,8	-2,3	-14,3	27,4	0,1	-7,9	10,3	-0,6	1,0	-0,1	788
	0,6	1,1	-1,4	-2,1	-2,1	-1,5	2,6	1,4	1,8	1,0	-2,1	-3,6	-0,2	2,5	0,7	4,7	-0,6	-5,5	*1,4*	*0,4*	*-2,4*	*3,1*	*-0,3*	*9,1*	*-1,2*	
1995	-677,1	21,7	97,8	-446,8	-58,5	-0,2	72,0	5,5	11,0	-3,6	-5,4	-23,7	0,2	0,9	-7,4	17,8	-10,0	-6,8	10,3	-0,1	-15,0	8,2	-3,1	1,2	-0,2	728
	-0,7	0,1	0,4	-2,5	-2,4	0,0	2,1	0,7	0,6	-0,8	-1,4	-5,0	0,0	0,2	-2,3	5,4	-2,3	-2,4	*0,5*	*-0,2*	*-3,9*	*1,9*	*-1,6*	*9,1*	*-1,2*	
1996	-1.861,9	-474,8	164,9	-741,1	-115,0	108,3	100,3	17,7	50,8	-16,5	2,5	-28,2	10,1	4,3	-12,9	28,6	-19,6	-2,9	-26,9	-1,1	-28,6	5,2	-10,5	0,8	-0,3	718
	-2,7	-1,4	1,0	-5,3	-5,6	1,4	3,7	2,2	1,4	-2,6	0,4	-4,8	1,4	0,7	-2,1	6,1	-3,5	-0,8	*-1,5*	*-2,2*	*-8,4*	*1,3*	*-4,6*	*6,8*	*-2,1*	
1997	-2.949,3	-1.020,2	436,9	-368,7	-3,9	271,0	92,3	4,8	72,7	-1,5	0,7	-23,6	3,7	-1,5	-13,6	20,9	-12,6	6,4	43,8	-0,3	-16,2	0,0	-4,1	0,6	-0,2	711
	-3,1	-3,5	1,6	-2,5	-0,2	3,7	2,7	0,5	2,1	-0,2	0,1	-3,9	0,6	-0,2	-2,8	4,8	-2,1	1,6	*2,7*	*-0,6*	*-7,7*	*0,0*	*-1,4*	*6,0*	*-1,6*	

(1) Coefficients are multiplied by 100; t statistics, reported in italics below each coefficient, are robust to heteroskedasticity. Column λ_{COMM} reports estimated differences between price and marginal cost for commercial banks; λ_{CCB} gives the differential effect for CCBs relative to λ_{COMM}. The coefficient c_0 measures the cost function intercept for banks with a nation-wide reach. The system is estimated with 3SLS using a TSP program. A separate estimation is carried out for each year in the sample. The instruments used are: lagged p and q (levels and logs), current and lagged ω_1, ω_2, ω_3 (levels and logs), lagged C (levels and logs), current and lagged number of employees (levels and logs), total interbank assets, liabilities and the sum of the two (levels and logs), total assets minus real estate property and loans (a proxy for the portfolio of equity and bonds; levels and logs), four dummies for geographical areas, six for bank type, four for bank dimension.

Table C4: Estimates of system (5) - (6): Merger and acquisitions vs. other banks, total sample (1)

dependent variables: total costs, C, for (5) and yield on total assets, p, for (6)

	Cost equation (5)																**Supply equation (6)**							
	c_0	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{NW}	c_{NE}	c_{CE}	c_{SO}	$c_{M\&A}$	c_{CCB}	$c_{M\&A,CCB}$	s_0	s_1	s_2	s_3	s_4	l	$l_{M\&A}$	N. obs.
1984	-824,8	-46,5	174,2	-285,0	-63,1	-35,2	55,4	-26,4	-4,8	1,1	-5,7	-3,4	-3,1	0,6	4,3	0,7	-20,1	54,3	-0,4	-12,6	2,5	-2,8	2,6	-1,0	1.004
	-1,8	*-0,2*	*1,4*	*-3,4*	*-2,6*	*-0,9*	*3,3*	*-1,8*	*-0,5*	*0,8*	*-3,3*	*-1,9*	*-1,8*	*0,3*	*1,7*	*0,9*	*0,0*	*5,4*	*-2,8*	*-3,8*	*1,5*	*-3,5*	*48,6*	*-3,5*	
1985	-4.068,3 -	1.564,3	739,2	-529,9	-143,3	215,9	50,6	-88,3	-6,2	-8,2	-3,0	-0,9	0,3	3,5	3,3	-0,7	22,6	49,9	-0,1	-18,5	-0,8	-2,9	2,3	-0,6	1.010
	-4,6	*-4,2*	*3,9*	*-3,8*	*-4,2*	*3,3*	*2,9*	*-3,4*	*-0,7*	*-2,2*	*-1,4*	*-0,4*	*0,2*	*1,6*	*0,8*	*-0,7*	*0,5*	*4,9*	*-1,2*	*-6,4*	*-0,5*	*-3,6*	*44,8*	*-2,5*	
1986	-1.266,7	-336,4	201,8	-218,1	-45,8	18,1	42,9	-25,9	0,1	2,9	-10,2	-7,9	-6,6	-3,7	-1,7	-1,2	20,0	82,8	0,0	-0,3	2,2	-1,4	2,4	-0,5	1.011
	-1,9	*-1,3*	*1,4*	*-2,2*	*-3,4*	*0,4*	*2,2*	*-1,3*	*0,0*	*1,4*	*-5,3*	*-3,9*	*-3,2*	*-1,8*	*-0,5*	*-1,5*	*1,1*	*6,8*	*-0,1*	*-0,1*	*1,0*	*-1,4*	*56,3*	*-2,5*	
1987	24,8	-184,0	-281,5	-110,8	-69,0	-159,4	6,5	-114,0	-10,9	7,5	-7,9	-5,4	-4,0	-1,4	-0,1	-4,4	-9,4	95,1	0,3	0,8	-0,2	-0,4	1,9	-0,3	1.001
	0,0	*-0,7*	*-1,7*	*-1,0*	*-3,6*	*-2,1*	*0,3*	*-3,4*	*-1,1*	*3,0*	*-3,8*	*-2,6*	*-1,9*	*-0,7*	*0,0*	*-4,1*	*-0,6*	*10,3*	*2,3*	*0,3*	*-0,1*	*-0,5*	*44,7*	*-2,3*	
1988	-501,2	98,4	42,0	-174,4	-26,2	-69,3	40,3	-14,0	-4,2	4,9	-10,4	-8,7	-7,5	-5,1	-2,2	-2,9	1,7	112,3	0,4	4,3	-1,1	0,8	2,0	-0,3	985
	-0,6	*0,4*	*0,3*	*-1,3*	*-1,4*	*-1,4*	*1,6*	*-1,8*	*-0,4*	*7,1*	*-4,1*	*-3,3*	*-2,8*	*-1,9*	*-1,0*	*-3,8*	*0,3*	*8,5*	*2,1*	*1,3*	*-0,5*	*0,9*	*51,6*	*-1,9*	
1989	-37,0	-231,2	-473,6	-232,3	-100,8	-151,5	-3,2	-85,9	15,4	-1,8	-9,7	-6,2	-5,4	-0,6	-7,3	-2,7	23,7	122,5	0,4	4,1	-4,7	-0,4	2,2	-0,3	967
	-0,1	*-1,3*	*-3,9*	*-2,1*	*-3,6*	*-3,9*	*-0,2*	*-4,3*	*1,7*	*-0,5*	*-2,9*	*-1,9*	*-1,6*	*-0,2*	*-1,9*	*-2,6*	*1,8*	*10,3*	*2,1*	*1,5*	*-2,2*	*-0,4*	*53,3*	*-2,4*	
1990	796,8	37,9	-114,1	256,5	16,6	9,7	-30,3	-15,9	3,4	4,4	-11,1	-8,8	-7,1	-4,1	-6,1	-3,6	17,4	83,6	-0,2	-4,0	-0,4	-2,0	2,2	-0,2	957
	1,3	*0,2*	*-0,7*	*2,6*	*1,0*	*0,3*	*-2,3*	*-1,6*	*0,3*	*1,2*	*-4,4*	*-3,5*	*-2,8*	*-1,5*	*-2,3*	*-3,5*	*2,6*	*5,0*	*-1,4*	*-0,8*	*-0,2*	*-1,3*	*51,1*	*-1,6*	
1991	-922,3	8,8	101,9	-285,6	-25,2	-45,4	63,5	-24,3	8,8	1,3	-7,6	-4,5	-3,3	0,5	1,0	-3,4	2,6	100,6	0,1	0,1	-2,7	-1,9	2,1	-0,4	908
	-1,6	*0,0*	*0,7*	*-2,6*	*-1,2*	*-0,7*	*3,3*	*-1,3*	*0,9*	*0,7*	*-2,6*	*-1,5*	*-1,1*	*0,2*	*0,4*	*-3,2*	*0,6*	*8,2*	*0,4*	*0,0*	*-1,1*	*-1,3*	*48,6*	*-3,0*	
1992	-1.323,6	-242,6	166,4	-293,1	-5,2	25,1	72,0	-27,0	20,3	-0,9	-6,4	-3,3	-2,2	1,3	-1,8	-1,0	6,9	88,4	0,0	1,3	0,9	-2,2	2,2	0,1	906
	-2,4	*-1,3*	*1,1*	*-3,2*	*-0,2*	*0,5*	*4,0*	*-1,5*	*1,7*	*-0,2*	*-2,7*	*-1,4*	*-1,0*	*0,5*	*-0,6*	*-0,9*	*1,7*	*6,4*	*-0,2*	*0,5*	*0,3*	*-1,6*	*49,4*	*0,7*	
1993	1.038,5	547,9	-251,3	-41,1	7,5	-142,1	27,6	-16,7	-5,4	5,8	-7,0	-5,5	-3,9	0,3	4,0	-0,7	-2,7	106,3	-0,4	6,8	4,2	1,1	1,6	-0,1	870
	1,9	*2,2*	*-1,6*	*-0,7*	*0,3*	*-2,1*	*1,5*	*-0,9*	*-0,4*	*1,1*	*-2,9*	*-2,3*	*-1,6*	*0,1*	*1,5*	*-0,6*	*-0,7*	*8,4*	*-1,5*	*2,1*	*2,1*	*0,6*	*27,8*	*-0,7*	
1994	632,5	373,5	-227,9	-287,0	-55,2	-84,0	46,6	15,9	9,0	8,8	-5,0	-3,3	-1,4	0,3	10,3	-0,2	-10,8	47,7	-0,1	-6,8	9,8	2,6	0,9	0,0	821
	0,7	*1,4*	*-1,4*	*-2,0*	*-2,0*	*-1,6*	*2,4*	*1,6*	*1,1*	*1,7*	*-1,3*	*-0,9*	*-0,4*	*0,1*	*3,2*	*-0,1*	*-2,4*	*2,8*	*-0,5*	*-2,2*	*3,4*	*1,9*	*16,3*	*0,3*	
1995	-433,2	83,7	59,5	-449,9	-67,0	-17,7	62,7	2,5	3,7	-5,5	-7,7	-6,9	-4,2	-2,0	9,0	-1,8	-9,1	-3,5	-0,2	-17,5	10,3	-2,6	1,1	-0,1	772
	-0,6	*0,5*	*0,3*	*-2,6*	*-3,3*	*-0,5*	*1,8*	*0,3*	*0,2*	*-1,3*	*-1,9*	*-1,6*	*-1,0*	*-0,5*	*2,1*	*-1,3*	*-1,6*	*-0,2*	*-0,5*	*-4,7*	*2,7*	*-1,3*	*16,6*	*-0,8*	
1996	-1.271,4	-422,7	41,9	-537,9	-85,2	73,8	72,9	-5,2	38,6	-7,2	-1,7	-1,7	1,0	4,2	9,1	0,2	-9,2	3,4	-0,7	-19,9	7,7	-4,2	0,7	-0,1	761
	-2,6	*-2,0*	*0,3*	*-4,5*	*-4,8*	*1,5*	*3,2*	*-0,7*	*1,5*	*-1,6*	*-0,5*	*-0,5*	*0,3*	*1,2*	*2,3*	*0,2*	*-1,7*	*0,2*	*-2,0*	*-6,0*	*2,1*	*-2,5*	*9,6*	*-0,5*	
1997	-1.971,4	-663,5	319,0	-306,4	-15,1	174,3	67,9	3,0	36,2	0,8	-1,6	-2,2	0,8	5,6	13,5	2,7	-15,2	24,5	-0,5	-13,6	8,3	-1,0	0,6	-0,1	759
	-3,2	*-3,3*	*1,8*	*-2,7*	*-0,8*	*3,3*	*2,6*	*0,4*	*1,4*	*0,1*	*-0,4*	*-0,5*	*0,2*	*1,3*	*3,7*	*2,0*	*-3,3*	*1,7*	*-1,4*	*-7,1*	*2,6*	*-0,5*	*10,5*	*-0,7*	

(1) Coefficients are multiplied by 100; t statistics, reported in italics below each coefficient, are robust to heteroskedasticity. Column λ reports estimated differences between price and marginal cost for banks which were not involved in mergers or acquisitions over the sample period. Column $\lambda_{M\&A}$ reports the differential effect relative to λ for banks involved in such operations. The coefficient c_0 measures the cost function intercept for banks with a nation-wide reach. The system is estimated with 3SLS using a TSP program. A separate estimation is carried out for each year in the sample. The instruments used are: lagged p and q (levels and logs), current and lagged ω_1, ω_2, ω_3 (levels and logs), lagged C (levels and logs), current and lagged number of employees (levels and logs), total interbank assets, liabilities and the sum of the two (levels and logs), total assets minus real estate property and loans (a proxy for the portfolio of equity and bonds; levels and logs), four dummies for geographical areas, six for bank type, four for bank dimension.

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A NEW WAY TO MEASURE COMPETITION*

Jan Boone

This article introduces a new way to measure competition based on firms' profits. Within a general model, we derive conditions under which this measure is monotone in competition, where competition can be intensified both through a fall in entry barriers and through more aggressive interaction between players. The measure is shown to be more robust theoretically than the price cost margin. This allows for an empirical test of the problems associated with the price cost margin as a measure of competition.

A question often asked in both economic policy and research is how the intensity of competition evolves over time in a certain sector. To illustrate, a competition authority may want to monitor an industry so that it can intervene when competition slackens. Alternatively, there may have been a policy change in an industry (e.g. abolishing a minimum price or breaking up a large incumbent firm) with the goal of intensifying competition in the industry. Afterwards policy makers want to check whether the policy change had the desired effect. In economic research, there are empirical papers trying to identify the effect of competition on firms' efficiency (Nickell, 1996), on firms' innovative activity (Aghion *et al.*, 2005 and references therein) and the effects of competition on wage levels (Nickell, 1999 for an overview) and wage inequality (Guadalupe, 2003). The question is how should competition be measured for these purposes.

The price cost margin (PCM) is widely used as a measure of competition. However, the theoretical foundations of PCM as a competition measure are not robust. Theoretical papers like Amir (2002), Bulow and Klemperer (1999), Rosentahl (1980) and Stiglitz (1989) present models where more intense competition leads to higher PCM instead of lower margins. We believe that there are two reasons why PCM is still such a popular empirical measure of competition. First, we do not know how important these theoretical counterexamples are in practice. Is it the case that in 20% of an economy's industries the structure is such that more competition would lead to higher PCM or is this only the case in 1% of the industries? In the former case there would be big problems for the empirical papers mentioned above which use PCM as a measure of competition. In the latter case, the theoretical counterexamples do not seem to pose acute problems for empirical research. As long as there is no evidence that the theoretical counterexamples are important empirically, one would expect that PCM remains a popular competition measure. The second reason for the popularity of PCM is that the data needed to get a reasonable estimate of PCM are available in most datasets.[1]

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[1] Sometimes PCM is defended as measure of competition with reference to its interpretation as a welfare measure (prices closer to marginal costs lead to higher welfare). However, as shown by Amir (2002) and Mankiw and Whinston (1986) there is, in general, no simple relation between PCM and welfare. The same is true for the measure introduced here: there is no simple relation with welfare. In this sense, the measures discussed here are positive, not normative.

The idea of the current article is to develop a competition measure that is both theoretically robust and does not pose more stringent data requirements than PCM. This new measure can then be estimated in the same datasets as where PCM is estimated. This allows a comparison between the new measure and PCM for a number of industries over time. If in 99% of the industries the two measures indicate the same development in intensity of competition over time, this would indicate that the theoretical counterexamples cited above are not particularly relevant in practice. However, if in 20% of the cases the two measures diverged then one should be more careful in using PCM as a measure of competition in empirical research and policy analysis.

The measure I introduce in this article is called relative profit differences (RPD). It is defined as follows. Let $\pi(n)$ denote the variable profit level of a firm with efficiency level $n \in \mathbb{R}_+$ where higher n denotes higher efficiency (more details follow below on how variable profits and efficiency are defined). Consider three firms with different efficiency levels, $n'' > n' > n$, and calculate the following variable $[\pi(n'') - \pi(n)]/[\pi(n') - \pi(n)]$. Then more intense competition (brought about by either lower entry costs or more aggressive interaction among existing firms) raises this variable for a broad set of models. More precisely, in any model where a rise in competition reallocates output from less efficient to more efficient firms it is the case that more intense competition raises $[\pi(n'') - \pi(n)]/[\pi(n') - \pi(n)]$. Since this output reallocation effect is a general feature of more intense competition, RPD is a robust measure of competition from a theoretical point of view. Moreover, I show that the output reallocation effect is a natural necessary condition for PCM to be decreasing in intensity of competition, but it is not sufficient.

The intuition for RPD is related to the relative profits measure ($\pi(n')/\pi(n)$ is increasing in intensity of competition for $n' > n$) introduced by Boone (forthcoming). The intuition for the relative profits measure is that in a more competitive industry, firms are punished more harshly for being inefficient. However, Boone (forthcoming) analyses the relative profits measure in a number of specific examples, not in a general framework as I use here.

The intuition why RPD is increasing in intensity of competition can be stated as follows. As the industry becomes more competitive, the most efficient firm n'' gains more relative to a less efficient firm n than firm n' does (with $n'' > n' > n$). Think, for instance, of a homogeneous good market where firms produce with constant marginal costs. If these firms compete in quantities (Cournot), one would find (if n is close enough to n'') that $\pi(n'') > \pi(n') > \pi(n) > 0$. If competition is intensified by a switch to Bertrand competition, the profit levels satisfy: $\pi(n'') > \pi(n') = \pi(n) = 0$. Hence the rise in competition raises $\pi(n'') - \pi(n)$ relative to $\pi(n') - \pi(n)$.

Recent papers measuring PCM include the following. First, Graddy (1995), Genesove and Mullin (1998) and Wolfram (1999) estimate the elasticity-adjusted PCM. This yields the conduct (or conjectural variation) parameter, which can be interpreted as a measure of competition. This approach has been criticised by Corts (1999) who shows that, in general, efficient collusion cannot be distinguished from Cournot competition using the elasticity-adjusted PCM. Second, Berry *et al.* (1995) and Goldberg (1995) estimate both the demand and cost side of the automobile market. Their models can be used to simulate the effects of trade or merger policies on the industry. Using their

estimates, one can also derive firms' PCMs. Nevo (2001) uses the same methods to estimate PCMs for firms in the ready-to-eat cereal industry. He does this under three different models of firm conduct and then compares the outcomes with (crude) direct observations of PCM. In this way he is able to identify the conduct model that explains the observed values of PCM best. As I argue below, in these papers one would also have been able to derive RPD, which has a more robust relation with intensity of competition.

This article is organised as follows. The next Section introduces the model and the way that more intense competition is identified in this general set up using the (generalised) output reallocation effect. Section 2 shows that RPD is increasing in competition and Section 3 discusses which type of data are needed to estimate RPD in practice. Section 4 compares RPD and PCM and argues that both require similar data to be estimated. Further, I show that whereas the output reallocation effect is sufficient for RPD to be monotone in competition, it is only a necessary condition for PCM to be decreasing in competition, which explains the theoretical counterexamples. Finally, Section 5 concludes. The proofs of results can be found in the Appendix.

1. The Model

The aim of this Section is to introduce a general model with I firms that can enter and compete in a market. Firms are ranked such that lower i implies higher efficiency: $n_1 \geq n_2 \geq \cdots \geq n_I$. To keep things general I do not impose a certain mode of competition like either Bertrand or Cournot competition. I simply assume that each firm i chooses a vector of strategic variables $a_i \in \mathbb{R}^K$. This choice leads to output vector $q(a_i, a_{-i}, \theta) \in \mathbb{R}^L_+$ for firm i where $a_{-i} = (a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_I)$ and θ is a parameter that affects the aggressiveness of firms' conduct in the market. For instance, θ could be related to the substitution elasticity between goods from different producers or it could denote whether firms play Cournot or Bertrand competition. Further, the choices of the strategic variables also lead to a vector of prices $p(a_i, a_{-i}, \theta) \in \mathbb{R}^L_+$ for firm i's products.

Finally, we specify the costs of production for firm i as $C[q(a_i, a_{-i}, \theta), n_i]$. We say that $n_i \in \mathbb{R}_+$ measures a firm's efficiency level because of the following assumption.

ASSUMPTION 1 *For a given output vector $q \in \mathbb{R}^L_+$ we assume that*

$$\begin{aligned} \frac{\partial C(q,n)}{\partial q_l} &> 0 \\ \frac{\partial C(q,n)}{\partial n} &\leq 0 \\ \frac{\partial \left[\dfrac{\partial C(q,n)}{\partial q_l}\right]}{\partial n} &\leq 0 \end{aligned}$$

for each $l \in \{1,2,\ldots,L\}$, where the last inequality is strict for at least one combination of q and l.

That is, higher production levels lead to higher costs. Further, higher n firms produce the same output vector q with (weakly) lower costs C and (weakly) lower marginal costs for each product l. Although the efficiency levels $n_1, \ldots, n_I$ are exogenously given, the firms that are active in equilibrium are endogenously determined, as discussed below. The essential assumption here is that efficiency can be captured by a one dimensional variable n_i. This assumption is not innocuous and will be discussed further below.

Using this set up, consider the following two stage game. In the first stage, firms decide simultaneously and independently whether or not to enter. I normalise actions a_i in such a way that a firm i that does not enter has $a_i = 0$ (while firms that do enter have $a_i \neq 0$). If firm i enters it pays an entry cost γ_i. In the second stage, firms know which firms entered in the first stage and all firms that entered choose simultaneously and independently their action vectors a_i. I define an equilibrium of this game as follows.

DEFINITION 1 *The set of actions* $\{\hat{a}_1, \hat{a}_2, \ldots, \hat{a}_I\}$ *denotes a pure strategy equilibrium if the following conditions are satisfied*

$$\max_{a_i}\{p(a_i, \hat{a}_{-i}, \theta)^T q(a_i, \hat{a}_{-i}, \theta) - C[q(a_i, \hat{a}_{-i}, \theta), n_i]\} - \gamma_i < 0 \text{ implies } \hat{a}_i = 0$$

where $p(\cdot)^T$ *denotes the transpose of the column vector* $p(\cdot)$ *and*

$$\{p(\hat{a}_i, \hat{a}_{-i}, \theta)^T q(\hat{a}_i, \hat{a}_{-i}, \theta) - C[q(\hat{a}_i, \hat{a}_{-i}, \theta), n_i]\} - \gamma_i \geq 0 \text{ for } \hat{a}_i \neq 0$$

further

$$\hat{a}_i = \arg\max_{a}\{p(a, \hat{a}_{-i}, \theta)^T q(a, \hat{a}_{-i}, \theta) - C[q(a, \hat{a}_{-i}, \theta), n_i]\}.$$

Thus firm i stays out of the market if it cannot recoup its entry cost γ_i. Firms that enter choose action a_i to maximise their (after entry) profits. In other words, I consider a subgame perfect equilibrium here. The zero profit condition is only used when competition is intensified by lowering entry costs. When changing conduct (for given number of firms) it is immaterial whether the zero profit condition holds or not.

I make the following symmetry assumption on the equilibrium outcome. This assumption can also be called a level playing field assumption or an exchangeability assumption (Athey and Schmutzler, 2001). As I discuss in Section 4, neither RPD nor PCM can deal with the asymmetric case. Since the main purpose of this article is to compare the two, I leave this case for future research and focus on the broad set of models where both measures perform reasonably well.

ASSUMPTION 2 *There exist vector valued functions* $p(\cdot)$ *and* $q(\cdot)$ *such that for a firm with efficiency n equilibrium price and output vectors can be written as*

$$p(n, N, \mathcal{I}, \theta) \tag{1}$$

$$q(n, N, \mathcal{I}, \theta) \tag{2}$$

where N is an aggregate efficiency index which is a function of the efficiency levels $n_1, \ldots, n_I$ *and* $\mathcal{I}$ *is the set of firms that actually enter in equilibrium.*

I first consider an example where this assumption is satisfied and then I discuss in what circumstances it is not satisfied.

EXAMPLE 1 *Consider an industry where each firm i produces only one product, faces a demand curve of the form*

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

and has constant marginal costs $1/n_i$. *Then firm i chooses output* q_i *which solves*

$$\max_{q\geq 0}\left[\left(a - bq - d\sum_{j\neq i} q_j\right)q - \frac{1}{n_i}q\right]$$

where I assume that $a > 1/n_i > 0$ *and* $0 < d \leq b$. *Then the first order condition for a Cournot Nash equilibrium can be written as*

$$a - 2bq_i - d\sum_{j\neq i} q_j - \frac{1}{n_i} = 0. \tag{3}$$

Assuming I firms produce positive output levels, one can solve the I first order conditions (3). This yields

$$q(n_i) = \frac{\left(\frac{2b}{d} - 1\right)a - \left(\frac{2b}{d} + I - 1\right)\frac{1}{n_i} + \sum_{j=1}^{I}\frac{1}{n_j}}{[2b + d(I-1)]\left(\frac{2b}{d} - 1\right)}. \tag{4}$$

Defining the aggregate efficiency index as $N = \sum_{j=1}^{I} 1/n_j$, output can indeed be written as in Assumption 2 above. Prices can be written in a similar way as well.

Figure 1 illustrates a case that does not satisfy Assumption 2. It is an example of Salop's (1979) circle with 4 firms producing with constant marginal costs $1/n_i$. If the four firms do not have identical efficiency levels, the equilibrium output of a firm cannot be written as a function of just its own efficiency level and an aggregate efficiency index. The reason is that firms 1 and 3 face different environments. Firm 1 has a neighbour with efficiency level n_4 while firm 3 has a neighbour with efficiency

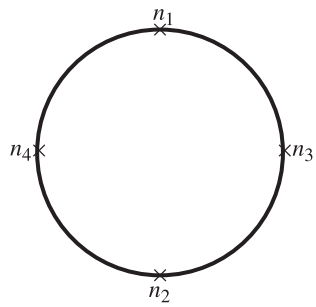

Fig. 1. *Circular Beach with Four Firms*

level n_2. As I discuss in Section 4 not only RPD but also PCM has problems in this case.

From now on I write firm i's equilibrium variable profits as

$$\pi(n_i, N, \mathcal{I}, \theta) \equiv p(n_i, N, \mathcal{I}, \theta)^T q(n_i, N, \mathcal{I}, \theta) - C[q(n_i, N, \mathcal{I}, \theta), n_i]. \tag{5}$$

Since I allow the entry cost γ_i to vary with a firm's identity i and hence with its efficiency level, it can be the case that more efficient firms face lower entry costs (γ_i increasing in i, while n_i is decreasing in i), because these firms are more efficient in both entry and production. But I also allow for the case where more efficient firms pay a higher entry cost to achieve their cost advantage (γ_i decreasing in i). For instance, this could reflect investments in R&D to develop a better production technology, investing more in capital or building a bigger factory to reap advantages of economies of scale. Thus an important distinction between $C(q, n_i)$ and γ_i is that $C(q, n_i)$ is weakly decreasing in n_i (for given q) while γ_i can both rise and fall with i.

In this framework I consider two ways in which competition can be intensified: a change in conduct and entry. The former, more aggressive interaction between players, is parameterised as $\mathrm{d}\theta > 0$. The latter is parameterised as a reduction in entry costs in the following way. Let $(\zeta_1, \ldots, \zeta_I) \in \mathbb{R}^I_+$ denote an arbitrary nonzero vector. Then we consider the following reduction in entry costs $\tilde{\gamma}_i = \gamma_i - \varepsilon\zeta_i$. The key to the analysis is the following way in which more intense competition is identified in this general framework. This is an assumption on how θ and ε affect the equilibrium outcome.

DEFINITION 2 *We say that* $\mathrm{d}\theta > 0$ *and* $\mathrm{d}\varepsilon > 0$ *increase competition if the expression*

$$\frac{\mathrm{d}\ln\left\{-\dfrac{\partial C[q(n_i, N, \mathcal{I}, \theta), n]}{\partial n}\bigg|_{n = n_i}\right\}}{\mathrm{d}\theta} \tag{6}$$

is increasing in n_i*, where the effect of* θ *is partial in the sense that the set of active firms* $\mathcal{I}$ *is taken as given; and the expression*

$$\frac{\mathrm{d}\ln\left\{-\dfrac{\partial C[q(n_i, N, \mathcal{I}, \theta), n]}{\partial n}\bigg|_{n = n_i}\right\}}{\mathrm{d}\varepsilon} \tag{7}$$

is increasing in n_i*.*

Although these conditions do not look intuitive at first sight, we view them as a generalisation of the output reallocation effect to the case where $q(\cdot, n)$ is a vector.[2] In the case where firms produce homogenous goods, Boone (forthcoming) and Vickers (1995) identify a rise in competition as a parameter change that raises output of a firm relative to a less efficient firm. Put differently, a rise in θ (or ε) raises $q(n^*)/q(n)$ for $n^* > n$. In words, if more intense competition reduces (raises) firms' output levels, the

[2] As we will show below, these conditions are also natural candidates for necessary conditions to get the result that more intense competition leads to lower PCM. However, in that case the conditions are not sufficient.

fall (rise) in output is bigger (smaller) for less efficient firms. Alternatively, the *output reallocation effect* can be stated as:

$$\frac{\mathrm{d}\ln q(n,N,\mathcal{I},\theta)}{\mathrm{d}\theta} \text{ and } \frac{\mathrm{d}\ln q(n,N,\mathcal{I},\theta)}{\mathrm{d}\varepsilon} \text{ are increasing in } n. \tag{8}$$

Note that the output reallocation effect does not assume anything about the output levels of firms (only about relative output). This is important since a change from Cournot to Bertrand competition tends to raise output of efficient firms, while it reduces output for inefficient firms. Thus there is no direct relation between intensity of competition and a firm's output level. Also, entry by new firms (as a result of a reduction in entry barriers) can both reduce every incumbent firm's output level and increase firms' output levels. See Amir and Lambson (2000) for details.

The reason why I look at the partial effect of θ, for given set of active firms $\mathcal{I}$ that participate in the market, is the well known 'topsy turvy' result. In the case where firms produce differentiated goods, it may be the case that there are twenty firms under Cournot competition while there are sixteen firms under Bertrand competition. The reason is that Bertrand competition tends to lead to lower rents and hence fewer firms enter in equilibrium. To avoid having to resolve this ambiguity (more aggressive interaction but smaller number of players), I consider the change in θ for a given set of firms in the market. Only in this clear cut case do I require the reallocation effect to hold.

If goods are not perfect substitutes, $q(n^*)/q(n)$ is not well defined ('dividing apples by oranges'). Taking this into account and allowing each firm to produce a number of products, it becomes clear that the reallocation effect has to be expressed in money terms. In principle, there are two ways to do that: costs $C(q,n)$ and revenues $p^T q$. The disadvantage of using revenues is that prices p can be affected by θ as well as output q. To illustrate, intensifying competition by making goods closer substitutes directly affects firms' demand functions and prices irrespective of a change in firms' output levels. Hence costs $C(q,n)$ seem a more natural choice here as it allows for the isolation of the effect of competition intensity on output q.

To gain further intuition for definition 2, note that the conditions above can also be stated as follows. Consider two firms i,j with $n_i > n_j$. Then the reduction in costs due to a small rise in efficiency $\mathrm{d}n > 0$ for firm i relative to j is

$$\frac{-\left.\dfrac{\partial C[q(n_i,N,\mathcal{I},\theta),n]}{\partial n}\right|_{n=n_i}}{-\left.\dfrac{\partial C[q(n_j,N,\mathcal{I},\theta),n]}{\partial n}\right|_{n=n_j}}.$$

The conditions above say that a rise in competition raises this ratio. That is, more intense competition leads to a bigger fall in costs (due to the efficiency gain $\mathrm{d}n > 0$) for the high efficiency firm i as compared to the less efficient firm j.[3] This makes sense. More intense competition tends to marginalise inefficient firms by reducing

[3] In other words, if the model would allow for firms investing in R&D to improve their efficiency n, we would see the following effect. More intense competition raises R&D investments of firms relative to less efficient firms. This is in line with results found by Aghion *et al.* (2005).

their output levels. Therefore their costs become less dependent on their efficiency level.

2. New Measure of Competition

The innovation in this article is to measure intensity of competition using RPD defined as

$$\frac{\pi(n^{**},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}{\pi(n^{*},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}>0 \tag{9}$$

for any three firms with $n^{**}>n^{*}>n$ with variable profits $\pi(\cdot)$ defined in (5). In theory there is a problem with this measure if all firms in an industry have the same efficiency level. Although a symmetry assumption is often convenient in modelling, in real world data sets there are no industries where all firms have the same efficiency level. Hence in practice this will not pose a problem. The following theorem shows that RPD is a robust measure of competition for both changes in conduct θ and entry ε.

THEOREM 1 *An increase in competition raises RPD for any three firms with $n^{**}>n^{*}>n$. That is,*

$$\frac{\mathrm{d}\left[\dfrac{\pi(n^{**},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}{\pi(n^{*},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}\right]}{\mathrm{d}\theta}>0$$

where the effect of θ is partial, i.e. taking $\mathcal{I}$ as given, and

$$\frac{\mathrm{d}\left[\dfrac{\pi(n^{**},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}{\pi(n^{*},N,\mathcal{I},\theta)-\pi(n,N,\mathcal{I},\theta)}\right]}{\mathrm{d}\varepsilon}>0.$$

To illustrate the RPD result, consider the example in Figure 2. This is based on example 1 with $a=20$, $b=2$, $N=20$ and firm $i\in\{1,2,\ldots,20\}$ has constant marginal costs equal to $i/10$ (hence efficiency of i equals $n_i=10/i$). Figure 2 has firm n's normalised efficiency level $(n-\underline{n})/(\bar{n}-\underline{n})$ on the horizontal axis and n's normalised

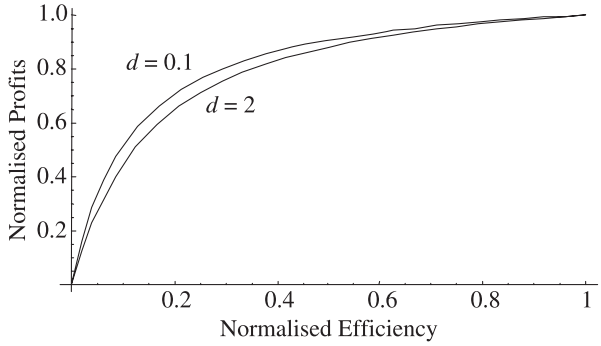

Fig. 2. *Firm n's Normalised Profits* $[\pi(n,\theta)-\pi(\underline{n},\theta)]/[\pi(\bar{n},\theta)-\pi(\underline{n},\theta)]$ *as a Function of n's Normalised Efficiency* $(n-\underline{n})/(\bar{n}-\underline{n})$

profits $[\pi(n,\theta)-\pi(\underline{n},\theta)]/[\pi(\bar{n},\theta)-\pi(\underline{n},\theta)]$ (note that this is the inverse of the expression in (9) to avoid dividing by zero for $n=\underline{n}$) on the vertical axis with $\underline{n}\leq n\leq\bar{n}$ ($\underline{n}=1,\bar{n}=10$) and where $\pi(n,\theta)$ is used as a shorthand for $\pi(n,N,\mathcal{I},\theta)$. This relation is increasing (more efficient firms make higher profits π). The more competitive the industry, the more this curve is pulled into the corner at bottom-right. This is illustrated in the graph for the case where competition is intensified by making goods closer substitutes (d increases from 0.1 to 2). Further, with Bertrand competition, homogeneous goods and constant marginal costs one finds that the curve is flat and equal to zero for all $n\in[\underline{n},\bar{n}\rangle$ and equal to 1 at $n=\bar{n}$. This corresponds to perfect competition.

How can RPD be used to measure competition in an industry? Since Theorem 1 shows that an increase in competition (either via conduct $\mathrm{d}\theta>0$ or via entry $\mathrm{d}\varepsilon>0$) raises RPD for *any three* firms, it follows that an increase in competition pulls down the curve in Figure 2. Suppose one follows an industry over time and observes that the estimated curve at time $t+1$ lies below the curve at time t. Then one can conclude that competition has become more intense in this industry. The Theorem shows that this is a robust way to measure competition.

This ordering of curves (one lying below the other) is not necessarily complete in practice (although it is in theory). The situation here is comparable to the case where income inequality is measured using Lorenz curves. If the Lorenz curve for country A lies everywhere below the curve for country B, one can rank the two countries in terms of income inequality. If one curve intersects the other, the two countries cannot be ranked. One way to make the ordering of inequality complete again is to use the Gini coefficient. Similarly, if the curve in Figure 2 for an industry at time t intersects the curve at time $t+1$, one can make the ordering complete (if one wants to) by calculating the area below the curves. This area then becomes the measure of competition. The smaller the area, the more competitive the industry is.[4] Because the Figure is normalised, the area lies between 0 and 1. In particular, in the Bertrand equilibrium with homogeneous goods and constant marginal costs, the area under the curve equals 0.

Note that this issue of completeness is also relevant for the PCM. Has competition intensified in an industry if PCM has fallen for 4 firms and risen for 2? Here the measure is often made complete by calculating the industry weighted average PCM (with firm i's weight equal to its market share). I come back to this industry average PCM below.

Note that one does not need to observe all firms in an industry to make a graph like the one in Figure 2. Indeed Figure 2 just uses a subset of the firms ($i\in\{1,\ldots,10\}$). The reason is that the result in Theorem 1 holds for *any* three firms. Hence, increasing competition pulls down the whole curve. This property of RPD is useful as it allows for the use of RPD in data sets where not all firms in the industry are sampled. Examples are balanced panel data sets and data based on information from stock exchanges that do not cover privately held firms. In such data sets RPD can still be used as a measure of

[4] One loses information by making the ordering complete in this way but sometimes having a complete ordering is convenient enough to accept this information loss.

competition. This in contrast to concentration measures which are harder to interpret if not all firms in the industry are observed.

3. Identifying Variable Profits and Efficiency in the Data

Under which conditions can RPD be estimated using firm level panel data? Broadly speaking, the better one is able to separate fixed and variable costs in the data, the more robust the competition measure will be that one can estimate.

The data I have in mind for estimating the measure in (9) is firm or plant level data that specify per firm total revenues, total wage bill (or preferably wage costs split according to production workers (blue collar) and management (white collar), see below), costs of inputs used, energy etc. Data sets like this are available in more and more countries (usually at a country's statistical office where this data forms the basis of the national accounts). Examples of papers using such data are Aghion *et al.* (2005), Bloom and Van Reenen (2007), Klette (1999), Klette and Griliches (1999), Lindquist (2001) and Nickell (1996). Further, the data should be available at the four or five digit level such that the one dimensional efficiency assumption is a decent approximation. In particular, the more aggregated the data become, say at the two digit level, the more likely it is that one firm is more efficient in producing one good and another firm more efficient in producing another good within this two digit category. In that case, efficiency is no longer a one dimensional variable. As discussed below, this one dimensional efficiency assumption is also necessary for the price cost margin to be used as a measure of competition.

Equation (5) defining variable profits $\pi(\cdot)$, states that the costs $C(q, n_i)$ should be included in calculating firm i's profits while γ_i should not be included. Hence $\pi(\cdot)$ equals total revenue for a firm minus costs $C(q, n_i)$.

The following describes how to decide which cost categories in the data should be included in $C(q, n_i)$ and which in γ_i. First, any costs, like materials and energy, that are viewed as variable costs (i.e. varying with small changes in production) should be included in $C(q, n_i)$. Second, fixed costs that are seen as being positively correlated with a firm's efficiency level should be included in γ_i because only the costs γ_i are allowed to be increasing in efficiency n_i (see Assumption 1). Examples mentioned above are investments in R&D and capital stocks, where higher investments may lead to lower marginal costs and hence higher efficiency in production. For cost categories in the data that are seen as fixed costs that do not vary with efficiency, it is immaterial whether they are included under $C(q, n_i)$ or γ_i.[5] Finally, with fixed costs that fall with efficiency, one has a choice whether to incorporate them under $C(q, n_i)$ or γ_i. Here the decision should be based on Definition 2 and the equilibrium properties of the model one has in mind to describe the sector.

If the data allow the researcher to identify different cost categories, variable costs should be calculated as the sum of labour costs (if possible only the costs of (blue collar) production workers, since (white collar) managers tend to be viewed as fixed costs), material costs, intermediate inputs and energy expenditure.

[5] To see this, note that fixed costs that do not vary with n_i have no effect on the expression $-\partial C(q, n)/\partial n$ (in Definition 2) and such fixed costs drop out when considering profit differences $\pi(n^*) - \pi(n)$ (in (9)).

Depending on the data available, efficiency n can be measured in one of the following ways. If data on output are available, efficiency can be approximated as average variable costs defined as variable costs (discussed above) divided by the output index. If there is no information on production volumes but there is a price index, then revenue divided by the price index can be seen as an approximation of output. If there is information on the number of workers, labour productivity can be used as an approximation of efficiency. The more detailed information one has on firms' revenues, costs and output levels, the better one is able to measure competition using the approach in Figure 2.

If, in contrast, the only data one has, are based on income statements from publicly traded firms, detailed information on cost categories will be missing. Consider the example given in Table 1. These are income statements from Coca Cola for the years 2002–5.[6] Variable profits should in this case be defined as Total Revenues minus Costs of Sales. These costs of sales are the costs directly related to the sales such as costs of inputs, labour etc. One should not subtract fixed costs like Selling, General and Administrative expense which are overhead costs. One should also not subtract costs like Depreciation and Interest. Such costs do not tend to be variable. Hence in this type of standardised Income Statement variable profits are approximated by Gross Operating Profit. Note that it is an advantage that expenditures on or depreciation of R&D,

Table 1

Income Statement Coca Cola (All numbers in $ thousands)

	Period ending			
	12/2005	12/2004	12/2003	12/2002
Income Statement				
Operating Revenue (Revenue/Sales)	23,104,000	21,962,000	21,044,000	19,564,000
Total Revenues	23,104,000	21,962,000	21,044,000	19,564,000
Cost of Sales	7,263,000	6,745,000	6,912,000	6,299,000
Cost of Sales with Depreciation	8,195,000	7,638,000	7,762,000	7,105,000
Gross Margin	14,909,000	14,324,000	13,282,000	12,459,000
Gross Operating Profit	15,841,000	15,217,000	14,132,000	13,265,000
Selling, Gen. & Administrative Expense	8,824,000	8,626,000	8,061,000	7,001,000
Operating Income	6,085,000	5,698,000	5,221,000	5,458,000
Operating Income b/f Depreciation(EBITDA)	7,017,000	6,591,000	6,071,000	6,264,000
Depreciation	932,000	893,000	850,000	806,000
Operating Income After Depreciation	6,085,000	5,698,000	5,221,000	5,458,000
Interest Income	235,000	157,000	176,000	209,000
Earnings from Equity Interest	680,000	621,000	406,000	384,000
Other Income, Net	(93,000)	(82,000)	(138,000)	(353,000)
Other Special Charges	23,000	24,000	8,000	*
Special Income/Charges	23,000	24,000	8,000	*
Total Income Avail for Interest Expense (EBIT)	6,930,000	6,418,000	5,673,000	5,698,000
Interest Expense	240,000	196,000	178,000	199,000
Pre-tax Income (EBT)	6,690,000	6,222,000	5,495,000	5,499,000
Income Taxes	1,818,000	1,375,000	1,148,000	1,523,000
Income before Income Taxes	6,690,000	6,222,000	5,495,000	5,499,000
Net Income from Containing Operations	4,872,000	4,847,000	4,347,000	3,976,000
Net Income from Total Operations	4,872,000	4,847,000	4,347,000	3,976,000

[6] Taken from http://finapps.forbes.com/finapps/jsp/finance/compinfo/IncomeStatement.jsp?tkr=KO.

advertisement and capital should not be included in the variable costs. As noted by Fisher and McGowan (1983) and Fisher (1987), getting the costs of depreciation that are economically relevant (instead of advantageous for firms from a tax point of view) is usually impossible. As they argue, this invalidates the use of accounting rates of return and profits-sales ratios to infer market power. Since RPD does not need this type of depreciation information to calculate profits, this problem is circumvented.

Once variable profits π_{it} and efficiency or productivity n_{it} have been identified for firms $i \in \{1, \ldots, N_t\}$ in year t in a certain industry, one can calculate normalised profits and efficiency. Assuming (without loss of generality) that firms are ordered such that n_{it} is decreasing in i, normalised efficiency and profits are given by $(n_{it} - n_{N_t t})/(n_{1t} - n_{N_t t})$ and $(\pi_{it} - \pi_{N_t t})/(\pi_{1t} - \pi_{N_t t})$ respectively. Plotting normalised profits against normalised efficiency gives a graph like Figure 2. For year $t + 1$ a similar plot can be made. If the area under the curve is smaller in $t + 1$ than it is in t, we say that competition has become more intense in year $t + 1$.[7]

4. Discussion

This Section compares the RPD and PCM measures of competition. I show that the generalised output reallocation effect in Definition 2 is a natural necessary condition for PCM to be monotone in competition but it is not sufficient. This explains why RPD is a theoretically robust measure of competition while there are counterexamples where a rise in competition leads to higher PCM. I further argue that the data requirements for estimating these two measures and the assumptions needed to interpret them are similar.

First, I show that the generalised output reallocation effect in Definition 2 is not a sufficient for PCM to be monotone in competition. This is the sense in which RPD is a theoretically more robust measure of competition than PCM.

I write PCM as a function of efficiency n as follows

$$PCM(n, N, \mathcal{I}, \theta) = \frac{p(n, N, \mathcal{I}, \theta)^T q(n, N, \mathcal{I}, \theta) - C[q(n, N, \mathcal{I}, \theta), n]}{p(n, N, \mathcal{I}, \theta)^T q(n, N, \mathcal{I}, \theta)} = \frac{\pi(n, N, \mathcal{I}, \theta)}{\pi(n, N, \mathcal{I}, \theta) + C[q(n, N, \mathcal{I}, \theta), n]}.$$

In order to find the effect of conduct θ and entry ε on the PCM of a firm with efficiency n in a similar way as in the Proof of Theorem 1, I fix an (arbitrary) efficiency level $\underline{n} < n$ with $\pi(\underline{n}, N, \mathcal{I}, \theta) > 0$.[8] I write

$$\pi(n, N, \mathcal{I}, \theta) = \pi(\underline{n}, N, \mathcal{I}, \theta) + \int_{\underline{n}}^{n} - \frac{\partial C[q(v, N, \mathcal{I}, \theta), t]}{\partial t}\bigg|_{t=v} \mathrm{d}v.$$

[7] A spreadsheet can be found with an example data set at http://center.uvt.nl/staff/boone/. For these data both PCM and RPD are calculated.

[8] Instead of fixing an arbitrary $\underline{n}$, one can choose $\underline{n}$ such that $\pi(\underline{n}, \cdot) = \gamma$. In that case, however, there is an additional term when differentiating with respect to θ or ε because these parameters affect the level $\underline{n}$ for which $\pi(\underline{n}, \cdot) = \gamma$ is true. Note that by looking at profit differences, this level effect of θ and ε on $\pi(\underline{n}, \cdot)$ drops out. This also explains why it is easier to derive sufficient conditions for RPD to be monotone in competition than for relative profits, $\pi(n_i, \cdot)/\pi(n_j, \cdot)$, to be monotone.

LEMMA 1 *Fix an efficiency level $\underline{n}$, then the effect of θ on PCM can be written as*

$$\operatorname{sign}\left[\frac{\mathrm{d}PCM(n,N,\mathcal{I},\theta)}{\mathrm{d}\theta}\right] = \operatorname{sign}\left(\begin{array}{l} \dfrac{\dfrac{\mathrm{d}\pi(\underline{n},N,\mathcal{I},\theta)}{\mathrm{d}\theta}}{C[q(n,N,\mathcal{I},\theta),n]} - \dfrac{\pi(\underline{n},N,\mathcal{I},\theta)}{\{C[q(n,N,\mathcal{I},\theta),n]\}^2}\dfrac{\partial C(q,n)}{\partial q}\dfrac{\mathrm{d}q(n,N,\mathcal{I},\theta)}{\mathrm{d}\theta} + \\ \displaystyle\int_{\underline{n}}^{n} \frac{\mathrm{d}\left\{\dfrac{-\dfrac{\partial C[q(v,N,\mathcal{I},\theta),t]}{\partial t}\Big|_{t=v}}{C[q(n,N,\mathcal{I},\theta),n)]}\right\}}{\mathrm{d}\theta}\mathrm{d}v \end{array}\right)$$

where the effect of θ is partial (as above). A similar expression can be derived for a change in entry $d\varepsilon > 0$.

If n is high enough that $\underline{n}$ can be chosen substantially below n (and still satisfy $\pi(\underline{n}, N, \mathcal{I}, \theta) > 0$), the term with the integral will dominate the sign of $\mathrm{d}PCM/\mathrm{d}\theta$. A natural requirement for $\mathrm{d}PCM/\mathrm{d}\theta < 0$ in this case is $\mathrm{d}\{-\partial C[q(v,N,\mathcal{I},\theta),t]/\partial t|_{t=v}/C[q(n,N,\mathcal{I},\theta),n]\}/\mathrm{d}\theta < 0$ for $n > v$. For the class of cost functions where $C(q,n) = \omega(n)c(q)$ this condition boils down to the output reallocation effect in Definition 2. However, the condition in Definition 2 is not sufficient to get $\mathrm{d}PCM(n,N,\mathcal{I},\theta)/\mathrm{d}\theta < 0$ for all n because for low n we cannot exclude the case where more intense competition leads to lower output levels for inefficient firms. Hence $\mathrm{d}q(n,N,\mathcal{I},\theta)/\mathrm{d}\theta < 0$ and $\pi(\underline{n}, N, \mathcal{I}, \theta) > 0$ works in the direction of $\mathrm{d}PCM(n,N,\mathcal{I},\theta)/\mathrm{d}\theta > 0$ and the output reallocation effect is no longer sufficient. Also, if $\underline{n}$ is rather high, we cannot exclude the the case where $\mathrm{d}\pi(\underline{n},\cdot)/\mathrm{d}\theta > 0$.[9] This, again, works in the direction of $\mathrm{d}PCM(n,\cdot)/\mathrm{d}\theta > 0$.

Coming back to estimating the two measures. Broadly speaking, there are two ways in the literature to estimate price cost margins. One is to approximate firm i's price cost margin by an expression like; see, for instance, Scherer and Ross (1990, p. 418)

$$\frac{\textit{revenue } s_i - \textit{variable cost } s_i}{\textit{revenue } s_i}. \tag{10}$$

Using this to calculate PCM requires similar data as one needs to calculate profits $\pi(\cdot)$ in (5) as revenues minus variable costs. The other way to estimate price cost margins is to use a structural approach; see Reiss and Wolak (2005) for a survey. In this case, the researcher specifies what the demand function and the cost function $C(q,n_i)$ look like and what equilibrium is played by the firms. The data are then used to identify the specified demand and cost parameters. From this PCM can be derived.

[9] As an example consider a homogenous good duopoly with linear demand, $p = 1 - q_1 - q_2$ where firm i produces with constant marginal costs $1/n_i$. Then for n_1 substantially bigger than n_2, firm 1 has higher profits under Bertrand competition than under Cournot competition, where Bertrand competition is seen as more competitive.

Note that the RPD measure is a variable that can be estimated in both ways. As described above, one can estimate RPD in an analogous way as PCM is estimated in (10). But it is also possible to use a structural approach and be more specific about the functional forms of demand and costs $C(q,n_i)$. To illustrate, table VIII in Berry *et al.* (1995) contains all the information (efficiency n_i and variable profits π_i) needed to calculate RPD. My article just offers RPD as a complementary competition measure to PCM and does not take a position on how the measures should be estimated in practice.

When PCM is used as a measure of competition, the following three assumptions (which are needed for RPD to work) are not always explicitly made:

(*i*) efficiency is one dimensional,
(*ii*) a firm's efficiency level can be observed and
(*iii*) firms compete on a level playing field.

In the discussion paper version of this article (Boone, 2004), numerical examples are given to show that PCM can be higher with more intense competition if one of these conditions is not satisfied. Intuitively, if efficiency is, say, two dimensional, an increase in competition forces a firm to focus on the activity in which it is most productive. This may raise the firm-level price cost margin. If a firm's efficiency level is not observed, an increase in efficiency (*ceteris paribus* the intensity of competition) leads to a higher price cost margin which is then (incorrectly) interpreted as reduced competition. Finally, if firms compete on an uneven playing field, changes in competition can affect the 'uneveness' of the playing field, making it hard to interpret both RPD and PCM.

Finally, Lemma 1 considers the PCM of an individual firm. However, the question of the article concerns the measurement of industry competition. Aggregating from firm level PCM to industry PCM is usually done by calculating the weighted industry average PCM, where the weight of a firm equals its market share in the industry; see, for instance, Wolfram (1999). Boone (2004) gives an example where this industry average PCM increases after competition has become more intense due the following reallocation effect. An increase in competition reallocates market share from inefficient firms to efficient firms. Since efficient firms have a higher PCM than inefficient firms, the increase in competition raises the weight in the industry average PCM of firms with a high PCM. This can raise the industry average PCM.

5. Conclusion

This article started off with the observation that PCM is often used as a measure of competition in empirical research. From a theoretical point of view, however, it is not clear what the relation between PCM and competition actually is. There are a number of theoretical papers where more intense competition leads to higher PCM. At the moment it is not known how relevant these theoretical counterexamples are from an empirical point of view.

To answer this question I have developed a new measure of competition, RPD, which has two properties. First, RPD has a robust theoretical foundation as a measure of competition. It is monotone in competition both when competition becomes more intense through more aggressive interaction between firms and when entry barriers

are reduced. Second, the data requirements to estimate RPD are the same as the requirements to estimate PCM. That implies that any firm (or plant) level data set which allows a researcher to estimate PCM should also allow for the estimation of RPD. In this way we can see in which percentage of industries both measures point in the same direction. If it turns out that the measures are congruent for more than 95% of the industries, PCM can be used as a measure of competition in empirical research without much concern for the theoretical counterexamples.

Appendix. Proof of Results

This Appendix contains the proofs of the results in the main text.

A.1. Proof of Theorem 1

First note that for any differentiable function π of n it is the case that

$$\pi(n^*) - \pi(n) = \int_n^{n^*} \frac{\mathrm{d}\pi(t)}{\mathrm{d}t}\mathrm{d}t.$$

Next note that the envelop theorem applied to

$$\pi(n_i, N, \mathcal{I}, \theta) = \max_{a_i}\Big\{p(a_i, \hat{a}_{-i}, \theta)^T q(a_i, \hat{a}_{-i}, \theta) - C[q(a_i, \hat{a}_{-i}, \theta), n_i]\Big\}$$

implies that

$$\frac{\mathrm{d}\pi(n_i, N, \mathcal{I}, \theta)}{\mathrm{d}n_i} = -\frac{\partial C[q(n_i, N, \mathcal{I}, \theta), n]}{\partial n}\bigg|_{n=n_i},$$

where $q(n_i, N, \mathcal{I}, \theta) = q(\hat{a}_i, \hat{a}_{-i}, \theta)$ is the equilibrium output vector of a firm with efficiency level n_i. Hence for any two efficiency levels n^* and n it is the case that

$$\pi(n^*, N, \mathcal{I}, \theta) - \pi(n, N, \mathcal{I}, \theta) = \int_n^{n^*} -\frac{\partial C[q(t, N, \mathcal{I}, \theta), v]}{\partial v}\bigg|_{v=t}\mathrm{d}t.$$

Therefore we can write the effect of θ on the measure $(\pi^{**} - \pi)/(\pi^* - \pi)$ as

$$\frac{\mathrm{d}\left\{\dfrac{\displaystyle\int_n^{n^{**}} -\frac{\partial C[q(\cdot), t]}{\partial t}\mathrm{d}t}{\displaystyle\int_n^{n^*} -\frac{\partial C[q(\cdot), t]}{\partial t}\mathrm{d}t}\right\}}{\mathrm{d}\theta} = \frac{\mathrm{d}\left\{1 + \dfrac{\displaystyle\int_{n^*}^{n^{**}} \frac{-\frac{\partial C[q(\cdot), t]}{\partial t}}{-\frac{\partial C[q(\cdot), t]}{\partial t}\Big|_{t=n^*}}\mathrm{d}t}{\displaystyle\int_n^{n^*} \frac{-\frac{\partial C[q(\cdot), t]}{\partial t}}{-\frac{\partial C[q(\cdot), t]}{\partial t}\Big|_{t=n^*}}\mathrm{d}t}\right\}}{\mathrm{d}\theta} > 0$$

where $\partial C[q(\cdot), t]/\partial t$ is shorthand for $\partial C[q(t, N, \mathcal{I}, \theta), v]/\partial v|_{v=t}$. The inequality follows because definition 2 implies that

$$\frac{\mathrm{d}\left\{\dfrac{-\frac{\partial C[q(\cdot), t]}{\partial t}}{-\frac{\partial C[q(\cdot), t]}{\partial t}\Big|_{t=n^*}}\right\}}{\mathrm{d}\theta} > 0$$

for $t \in \langle n^*, n^{**}]$ and

$$\frac{\mathrm{d}\left\{\dfrac{-\dfrac{\partial C[q(\cdot),t]}{\partial t}}{-\left.\dfrac{\partial C[q(\cdot),t]}{\partial t}\right|_{t=n^*}}\right\}}{\mathrm{d}\theta} < 0$$

for $t \in [n, n^*\rangle$. To see this, note that

$$\operatorname{sign}\left(\frac{\mathrm{d}\left\{\dfrac{-\dfrac{\partial C[q(\cdot),t]}{\partial t}}{-\left.\dfrac{\partial C[q(\cdot),t]}{\partial t}\right|_{t=n^*}}\right\}}{\mathrm{d}\theta}\right) = \operatorname{sign}\left(\frac{\mathrm{d}\ln\left\{-\dfrac{\partial C[q(\cdot),t]}{\partial t}\right\}}{\mathrm{d}\theta} - \frac{\mathrm{d}\ln\left\{-\left.\dfrac{\partial C[q(\cdot),t]}{\partial t}\right|_{t=n^*}\right\}}{\mathrm{d}\theta}\right).$$

The same proof applies to the case with $\mathrm{d}\varepsilon > 0$.

A.2. Proof of Lemma 1

Writing PCM as follows

$$PCM(n, N, \mathcal{I}, \theta) = \frac{1}{1 + \dfrac{C[q(n, N, \mathcal{I}, \theta), n]}{\pi(n, N, \mathcal{I}, \theta)}}$$

we find that $\mathrm{d}PCM(n, N, \mathcal{I}, \theta)/\mathrm{d}\theta < 0$ if an only if

$$\frac{\mathrm{d}\left(\dfrac{\pi(\underline{n}, N, \mathcal{I}, \theta) + \int_{\underline{n}}^{n}\left\{-\left.\dfrac{\partial C[q(v, N, \mathcal{I}, \theta), t]}{\partial t}\right|_{t=v}\right\}\mathrm{d}v}{C[q(n, N, \mathcal{I}, \theta), n]}\right)}{\mathrm{d}\theta} < 0$$

where we have written $\pi(n, N, \mathcal{I}, \theta) = \pi(\underline{n}, N, \mathcal{I}, \theta) + \int_{\underline{n}}^{n}\{-\partial C[q(v, N, \mathcal{I}, \theta], t)/\partial t|_{t=v}\}\mathrm{d}v$. Differentiating $\pi(\underline{n}, N, \mathcal{I}, \theta) + \int_{\underline{n}}^{n}\{-\partial C[q(v, N, \mathcal{I}, \theta), t]/\partial t|_{t=v}\}\mathrm{d}v/C[q(n, N, \mathcal{I}, \theta), n]$ with respect to θ (taking $\underline{n}$ as given) we get the expression in the Lemma.

We can derive a similar expression for $\mathrm{d}\varepsilon > 0$.

CentER, TILEC, NMa, ENCORE, UvA, IZA and CEPR

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Competitive analysis in banking: Appraisal of the methodologies

Nicola Cetorelli

Introduction and summary

Over the last 20 years, the U.S. banking industry has experienced significant structural changes as the result of an intense process of consolidation. From 1975 to 1997, the number of commercial banks decreased by about 35 percent, from 14,318 to 9,215. Since the early 1980s, there have been an average of more than 400 mergers per year (see Avery et al., 1997, and Simmons and Stavins, 1998). The relaxation of intrastate branching restrictions, effective to differing degrees in all states by 1992, and the passage in 1994 of the Riegle–Neal Interstate Banking and Branching Efficiency Act, which allows bank holding companies to acquire banks in any state and, since June 1, 1997, to open interstate branches, is certainly accelerating the process of consolidation.

These significant changes raise important policy concerns. On the one hand, one could argue that banks are merging to fully exploit potential economies of scale and/or scope. The possible improvements in efficiency may translate into *welfare* gains for the economy, to the extent that customers pay lower prices for banks' services or are able to obtain higher quality services or services that could not have been offered before.[1] On the other hand, from the point of view of public policy it is equally important to focus on the effect of this restructuring process on the competitive conditions of the banking industry. Do banks gain market power from merging? If so, they will be able to charge higher than competitive prices for their products, thus inflicting welfare costs that could more than offset any presumed benefit associated with mergers.

In this article, I analyze competition in the banking industry, highlighting a very fundamental issue: How do we measure market power? Do regulators rely on accurate and effective procedures to evaluate the competitive effects of a merger?

The U.S. Department of Justice, the Federal Reserve System, the Federal Deposit Insurance Corporation (FDIC), and the Office of the Comptroller of the Currency (OCC) enforce the antitrust laws in banking. The procedures to evaluate the competitive impact of a proposed merger may differ in some details among the agencies, but they all share the same approach, based on *structural analysis* of the banking market affected by the merger. The basic guideline, established by the Justice Department, requires the evaluation of the concentration of deposit market shares held by banks operating in the affected market. The importance of market concentration finds its theoretical justification in the so-called structure–conduct–performance paradigm (Bain, 1951), which postulates that fewer and larger firms (higher concentration) are more likely to engage in anticompetitive conduct. For example, a small number of large firms may be able to cooperate and act as a monopoly (*cartel*). Alternatively, one or more firms together may be large enough to set higher than competitive prices (acting as a *dominant firm*), while the other (smaller) firms would act as a *competitive fringe*, following the dominant firm's behavior.

The most common measure of concentration, and the one used by regulators, is the Herfindahl–Hirschman Index (HHI), which is defined as the sum of the squared market shares of all banks in the market (box 1 explains how the index is calculated).[2] According to the current screening guidelines, if the post-merger market HHI is lower than 1,800 points, *and* the increase in the index from the pre-merger situation is

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less than 200 points, the merger is presumed to have no anticompetitive effects and is approved by the regulators. Should those threshold values be exceeded, the regulators will check for the existence of potential *mitigating factors* that would make it unlikely that the merger could result in anticompetitive behavior. The regulators also seek to identify those extreme cases in which the potential welfare loss from the exercise of market power would be smaller than the loss produced by maintaining the status quo (for example, the merger might prevent the failure of one of the parties involved, thus preserving the stability of the market).[3] If the mitigating factors are not enough to justify the merger, the regulators may require the divestiture of some branches and offices, in order to bring the concentration indicator closer to or below the threshold level. If divestiture would not accomplish this goal, the merger application is denied.[4] If the merger does not violate the 1,800/200 rule,[5] the application is approved without further investigation.

Over the years, very few mergers have been denied. However, this fact should not lead one to conclude that the rules are not sufficiently stringent. The official statistics do not show attempts to file merger applications that were abandoned because of a voluntary decision of the banks involved or informal dissuasion by the regulators.

Does the ongoing merger and consolidation process represent a real competitive threat? A survey of local markets shows that concentration is a widespread characteristic of the banking industry. For example, in 1994, about 40 percent of metropolitan statistical areas (MSAs) had HHIs greater than 1,800 (Rhoades, 1995b). If indeed high concentration implies noncompetitive conduct, then policy concerns about the welfare effects of future mergers may be justified.

First, I review the appropriateness of the use of the HHI as a main screening factor in merger analysis. I examine the theoretical foundations of the market concentration–market power relationship and how focusing on market structure to infer firms' conduct may lead to ambiguous or even misleading conclusions about the potential effects of a merger.

Next, I survey the state of the art of the empirical literature. If there are consistent and convincing empirical results confirming the existence of the market concentration–market power relationship, then it may be appropriate to use it in policy analysis, even in the absence of a solid theoretical explanation. While

BOX 1

Calculation of the Herfindahl-Hirschman Index (HHI)

The HHI formula is

$$HHI = \sum_{i=1}^{n} MS_i^2,$$

where MS_i is the market share of bank i and n is the number of banks in the market.

Suppose a market has five banks. The share of total deposits of each bank is as follows:

	Deposit market share
Bank 1	30
Bank 2	25
Bank 3	21
Bank 4	16
Bank 5	8

The HHI = $30^2 + 25^2 + 21^2 + 16^2 + 8^2 = 2{,}286$. Suppose that banks 3 and 5 merge. After the merger, the HHI = $30^2 + 29^2 + 25^2 + 16^2 = 2{,}622$, with a post-merger increase ΔHHI = 336. In antitrust evaluation this merger may be rejected, because it violates the 1,800/200 rule.

By construction, the HHI has an upper value of 10,000, in the case of a monopolist firm with 100 percent share of the market, and tends to zero in the case of a large number of firms with very small market shares.

The HHI synthesizes information on both the distribution of market shares and the number of banks in the market. With some manipulation it could be rewritten as

$$HHI = \frac{V^2 + 1}{n},$$

where V is the coefficient of variation of deposit market shares, and n is the number of firms in the market. This feature of the HHI makes it more popular than other concentration indicators, such as the *n-firm ratio*, calculated as the sum of the market shares of the n largest firms in the market, where n is usually 3 or 4.

there have been important contributions confirming a positive and significant relationship between market concentration and the exercise of market power, other recent work has cast doubt on the overall empirical strength of such a relationship.

I then describe an alternative methodology of competitive analysis that does not infer banks' conduct through the analysis of market structure. This methodology recognizes that firms' behavior differs depending on whether they operate in a perfectly competitive market, a monopolistic market, or any other prevalent market structure. I survey the applications of this methodology, which is based on the estimation of a direct indicator of firms' behavior, for the banking industry.

Finally, I present some results of a specific empirical application of this methodology to the Italian banking industry. The analysis of Italy is relevant because the Italian banking industry has experienced a similar pattern of structural and regulatory changes as U.S. banking. In particular, as the result of an ongoing process of consolidation, the Italian HHI has been steadily increasing. The results of my empirical analysis indicate a steady convergence toward competitive conditions, providing evidence that changes in market concentration may not always provide correct information about the exercise of market power.

Theory behind the Herfindahl–Hirschman Index

As discussed above, the use of concentration ratios to evaluate competitive conditions relies on the theoretical predictions of the structure–conduct–performance paradigm. According to this paradigm, structure affects the conduct of firms, which ultimately determines their performance. Concentration of market shares will facilitate the adoption of collusive conduct and, ultimately, the setting of prices departing from the perfectly competitive benchmark. In a perfectly competitive market, firms are considered too small to have an individual impact on the price of the good they produce. From the point of view of social welfare, perfect competition represents an ideal benchmark, since consumers (in this case bank customers) pay the lowest possible price for the product they demand. Any situation in which firms command some degree of market power and are therefore able to set higher than competitive prices implies a social cost in terms of welfare loss for consumers.

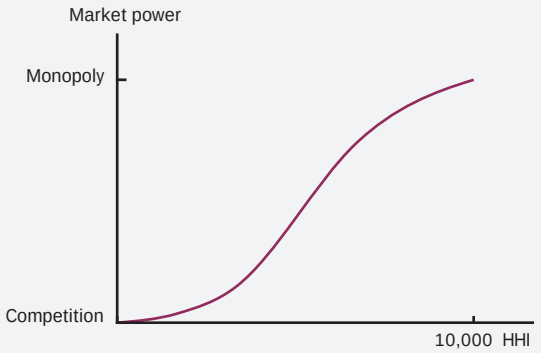
The structure–conduct–performance paradigm predicts that there is an increasing relationship between the level of market concentration and market power. Some authors are more precise in stating that the relationship, while it is increasing, may not be linear. One would expect that at low levels of concentration, conduct is close to competitive, and an increase in concentration would generate a substantial increase in market power. At high levels of concentration, conduct is already very far from the competitive benchmark, and an additional increase would not increase market power very much. Given this argument, the market concentration–market power relationship should be S-shaped, as shown in figure 1 (Carlton and Perloff, 1989).

Is it possible to derive an optimal behavior rule from a model of industrial organization theory that predicts an increasing relationship between market concentration and market power? Can we rely on such a model to find a theoretical justification for, say, the 1,800/200 rule? The answer is yes, but only if one makes strong, restrictive assumptions about firms' behavior, such as assuming that firms behave as *Cournot oligopolists*. Under Cournot conduct, a firm makes the simplistic assumption that all other firms have no reaction to a change in its behavior (see the technical appendix for the analytical derivation of this result). However, in more general (and plausible) theoretical models that allow for active interactions among firms, the market concentration–market power relationship is less obvious.

Thus, it seems that we cannot rely too much on theory to justify the postulated market concentration–market power relationship. Before surveying the approach taken in the profession, which has been to turn to a direct empirical corroboration of the postulated relationship, I present some simple numerical examples showing that, in the absence of a complete theory that can explain the market concentration–market

FIGURE 1

Theoretical relationship between market concentration and market power



Note: HHI represents the Herfindahl–Hirschman Index.

power relationship, it is possible to generate ambiguous or even incorrect predictions about the effects of a structural change on competition.

Numerical examples

These examples demonstrate the following two assertions: First, even when the 1,800/200 rule is not violated, a merger may generate anticompetitive conduct. Second, a merger may be procompetitive even when the 1,800/200 rule is violated.

In the first two examples, the basic guidelines are not violated. However, the mergers may generate the right conditions for monopoly power, not necessarily exercised only by the banks involved in the merger. Table 1 summarizes the examples.

In a pre-merger market with 20 banks, each with a 5 percent market share (see table 1, example 1), the HHI ($5^2 + 5^2 + \cdots + 5^2 = 500$) characterizes a market with a relatively large number of banks with equal and small market shares and is presumably associated with a low likelihood of anticompetitive behavior. Suppose five of the banks are involved in a series of mergers. When all the mergers are completed, the market has one bank with a 25 percent market share and 15 banks with 5 percent each. The post-merger HHI of 1,000 would still be considered (borderline) unconcentrated.[6] However, the newly created bank, with a 25 percent market share, may be able to act as a *dominant firm*, setting noncompetitive prices, with the remaining 15 banks behaving as a *competitive fringe*, adjusting to the noncompetitive choices of the dominant firm.

In the second example, the pre-merger market has 15 banks, two with 15 percent market shares, one with 10 percent, and 12 with 5 percent (see table 1, example 2). The two larger banks, B_1 and B_2, taken separately, may still be too small to behave as dominant firms. In addition, tacit or explicit collusion between them to act together as a dominant firm may still be unlikely, given the fact that the combined market share may not generate the market power and extra profits necessary to offset the costs associated with collusion.[7] The HHI of 800 may therefore be correct in characterizing a competitive market.

Suppose banks B_3 and B_{15} merge. The post-merger structure now has three banks with a 15 percent market share each and 11 banks with 5 percent each. The post-merger HHI is now 950. As in the first example, according to the guidelines the market would still be considered unconcentrated. However, the three major banks may now be able to coordinate (explicitly or tacitly) their action, thus producing adverse competitive conditions. (Note also that the two larger banks in the pre-merger market are benefiting from a merger that did not directly involve them).

The third example describes a market in which some degree of collusive behavior might have been observed prior to the merger (see table 1, example 3). The merger could create conditions under which the stable collusive agreement would break down, thus restoring market competition. However, since the basic guidelines are violated, the merger could be rejected and the exercise of market power preserved.

The pre-merger market has seven banks, three with 20 percent market shares, two with 15 percent shares, and two with 5 percent shares. The HHI of 1,700, classifying the market as moderately concentrated, may not fully account for a situation in which the three largest banks, B_1, B_2, and B_3, may be able to collude. In the event of a merger between banks B_4 and B_5, the post-merger market would have six banks, one with a 30 percent market share, three with 20 percent each, and two with 5 percent each. The post-merger HHI of 2,150 identifies this as a highly concentrated market. In addition, since the change in the HHI would be more than 200 points, there are grounds for the regulator to reject the merger application. However, the stability of a

TABLE 1

Examples of pre- and post-merger markets

Example 1

Pre-merger market (20 banks)

Bank	B_1	B_2	B_3	...	B_{20}
Market share (%)	5	5	5	...	5

Post-merger market (16 banks)

Bank	B_1	B_2	B_3	...	B_{16}
Market share (%)	25	5	5	...	5

Example 2

Pre-merger market (15 banks)

Bank	B_1	B_2	B_3	B_4	...	B_{15}
Market share (%)	15	15	10	5	...	5

Post-merger market (14 banks)

Bank	B_1	B_2	B_3	B_4	...	B_{14}
Market share (%)	15	15	15	5	...	5

Example 3

Pre-merger market (7 banks)

Bank	B_1	B_2	B_3	B_4	B_5	B_6	B_7
Market share (%)	20	20	20	15	15	5	5

Post-merger market (6 banks)

Bank	B_4	B_1	B_2	B_3	B_6	B_7
Market share (%)	30	20	20	20	5	5

collusive agreement is known to decrease with the number of participants. In the new market structure, with four large players, the collusion might break down. In that case, the merger would actually be procompetitive.

In considering whether to reject the merger application, the regulator may impose some degree of divestiture on the banks involved in the mergers. Ironically, banks B_1, B_2, and B_3, which were not involved in the merger, could benefit in this case, as the post-divestiture B_4 may not be strong enough to undermine the stability of their pre-merger collusive agreement.

The market dynamics described in these numerical examples are all hypothetical. My point is that whether a merger will generate (undetected) anticompetitive conditions or actually improve competition *cannot* be determined unambiguously just by looking at market structure. Banks' behavior can only be measured accurately through direct empirical analysis.

Empirical evidence

The empirical evidence for the existence of the market concentration–market power relationship is mixed. Some influential papers have suggested a positive relationship between concentration and the degree of market power. For example, Berger and Hannan (1989) analyze a cross-section of banking markets in 1983–85. After controlling for various factors affecting price-setting behavior, the authors find that deposit rates are significantly lower in the most concentrated markets.

Other work compares the time-series behavior of the deposit interest rate (and/or the loan rate) with the benchmark money market rate, which is not controlled by the banks. If banks have market power, they will, for example, quickly lower the deposit rate when the money market rate decreases, but the deposit rate will be sluggish when the money market rate increases. Conversely, in perfect competition one should expect quick reactivity in both cases. Hannan and Berger (1991) and Neumark and Sharpe (1992) find evidence of deposit rate rigidity and, thus, evidence of market power in the U.S. banking industry. Importantly, they find a higher level of rigidity in markets with higher HHIs.

However, recent research casts doubt on the market concentration–market power relationship. Reviewing Berger and Hannan's (1989) results, Jackson (1992b) suggests that the market concentration–market power relationship may not be monotonic. He finds that such a relationship already holds at low levels of concentration, but in markets with middle levels of concentration the relationship vanishes, and it actually changes sign in highly concentrated markets (although this is a less robust result). In other words, at higher levels of concentration, an increase in concentration may imply *less* anticompetitive behavior, as suggested in example 3 of table 1.

In another work focusing on the rigidity of deposit rates, Jackson (1997) presents additional evidence that the market concentration–market power relationship may not be monotonic. He finds that while it is true that at high levels of concentration price rigidity increases, this is also the case at low levels of concentration. This suggests a U-shaped relationship between market power and market concentration which is not consistent with the structure–conduct–performance hypothesis.

Similarly, Rhoades (1995a) observes that structural characteristics may vary widely for markets exhibiting similar HHI levels. In particular, the market share distribution may differ substantially. As shown in example 1 above, firms' conduct may be very different depending on market share distribution. Rhoades shows that market share inequality and the number of firms in the market have an effect on banks' profitability that is independent of the HHI, despite the fact that (as shown in box 1) the HHI incorporates information on both market share variability and the number of firms. Finally, in an analysis similar to Berger and Hannan's (1989), Hannan (1997) extends Rhoades's (1995a) contribution by analyzing the impact of these two factors on deposit rate levels. His results for a cross-section of banking markets using November 1993 data show, first, that the HHI was not significant in explaining deposit rates and, second, that it was not able to take into account the separate importance of market share inequality and the number of firms.

Thus, a lack of strong theoretical foundations and mixed empirical evidence motivate the search for alternative methodologies to investigate firms' competitive behavior.

Oligopoly theory and the measurement of market power

Methodologies in the "new empirical industrial organization" literature analyze firms' conduct directly, instead of relying on observation of the market structure.[8] Following this approach, the relationship between theory and firms' conduct becomes unambiguous. For instance, as mentioned earlier, if banks are behaving as Cournot oligopolists, the market concentration–market power relationship would be theoretically grounded and the use of the HHI to infer firms' conduct would be appropriate. This alternative methodology allows us to test whether indeed banks behave as Cournot oligopolists. However, the methodology is flexible enough to allow us to test for behavior that could be consistent with alternative models of

oligopoly theory. In such a case the market concentration–market power relationship would not be as clearly identified as in the Cournot case, but one would still be able to quantify the departure from perfect competition and, hence, to assess the degree of market power exercised in the industry.

The technical appendix provides details of the methodology. The following example illustrates the intuition. Suppose there is an exogenous increase in the demand for bank loans. In response, banks will take into account the cost they would incur in increasing the quantity of loans, the reactivity of demand itself to possible increases in the loan rate, and the expected reaction of the other banks in the market to their chosen course of action. In particular, the degree of interaction with the other banks in the market could differ substantially, depending on whether banks are in perfect competition with each other or enjoy some degree of market power. More precisely, the parameter of banks' interaction should be equal to 0 if the market is perfectly competitive, equal to 1 if it is monopolistic, and should take intermediate values between 0 and 1 if banks are neither perfectly competitive or monopolistic but still exercise a positive degree of market power. Using appropriate econometric modeling techniques, one can estimate this parameter of interaction and, therefore, a quantifiable measure of market power.

The advantage of this approach is that it is rigorously based on theory and does not require indirect (and perhaps ambiguous) inferences about market power through measures of market concentration. The major limitation of the approach is that it requires detailed information, mainly on cost and demand conditions at the firm level.

Applications to the banking industry

Spiller and Favaro (1984) estimate the parameter of banks' interaction for the Uruguayan banking industry in a period characterized by a significant relaxation of entry regulations. They apply a refinement of the methodology proposed by Gollop and Roberts (1979) to see whether different groups of banks have different reactions to other groups' change in behavior. They reject Cournot conduct and find evidence of dominant firm–competitive fringe behavior, with a significant degree of oligopoly power, although this is substantially reduced after deregulation. Gelfand and Spiller (1987) extend the analysis of Uruguayan banks, treating the banks as multiproduct firms, the products being loans in the domestic currency and in U.S. dollars. They find evidence of noncompetitive behavior and, in particular, behavior consistent with *mutual forbearance*, whereby firms avoid changing behavior in one market fearing retaliation in another market, and with *spoiling*, whereby firms adopt predatory strategies. Applying the methodology to the Norwegian banking industry, Berg and Kim (1994) find that Cournot behavior is strongly rejected by the data and that instead banks behave as if they expect retaliation from their competitors in response to a change in their own behavior. Berg and Kim (1996) also investigate Norwegian banks as multiproduct firms, distinguishing between the retail and corporate banking markets. They find banks' degree of oligopoly power to be relatively high in the retail market and lower in the corporate market. Interestingly, the Herfindahl indicators for the two markets analyzed suggest opposite findings. Shaffer (1989), using aggregate data for the U.S. banking industry, finds no evidence of oligopoly power. Similarly, in a study of Canadian banking, Shaffer (1993a) finds that despite structural and regulatory changes, Canadian banks operate in a market exhibiting perfect competition. Shaffer and Di Salvo (1994) focus on a local market in Pennsylvania with only two banks. They find that banks' conduct is imperfectly competitive, but closer to perfect competition than one would expect, given the very high degree of concentration in that market.

Measuring market power: Results from an application to the Italian banking industry

Next, I present some results from an application of the methodology outlined above to the Italian banking industry. The remainder of the section is based on Angelini and Cetorelli (1998).

As mentioned in the introduction, there are at least two reasons the evolution of the Italian banking industry is of interest. First, the Italian banking industry is experiencing a similar pattern of regulatory and structural changes as that observed in the U.S. In the late 1980s, the requirement that Italian banks obtain a specific authorization from the central bank to open an additional branch was eliminated. Consequently, from 1983 to 1993 the number of branches increased by 67 percent. At the same time, mainly based on the anticipated opening of Italy's national borders to international competition, widespread merger activity reduced the number of banks by more than 10 percent, to a total of approximately 900. It is not clear *a priori* whether such changes have actually enhanced competition. Second, the results for Italy highlight the possibility that changes in market concentration may provide misleading information on the exercise of market power.

To determine an average indicator of banks' interaction, Angelini and Cetorelli (1998) analyze the market for commercial loans in 1983–93, pooling data

on all individual banking institutions, in substance treating the market for commercial loans as having a national dimension. It is usually argued that, especially for wholesale loans, the market boundaries are indeed very wide. Given that Italy is about as large as a mid-size U.S. state, using such a broad market definition seems appropriate. Also, performing the analysis at the national level increases the potential for finding evidence of perfect competition. This is true at least in terms of the structure–conduct–performance approach, since, as we will see below, market concentration is very low at the national level. With a possible bias in the study toward a finding of competition, therefore, evidence of noncompetitive behavior would be a strong result.

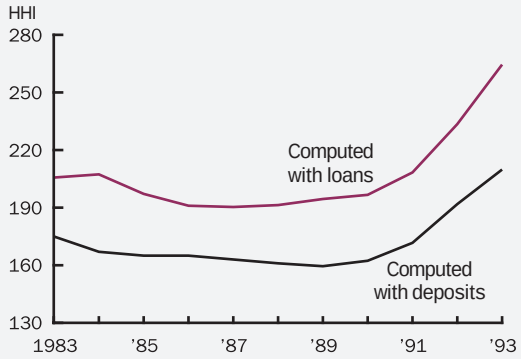
Angelini and Cetorelli (1998) make the following observations about the level of concentration of the Italian banking industry. First, the HHI, calculated on both deposits and loans, remained practically unchanged in the first part of the sample period, but increased noticeably after 1990, clearly due to the wave of bank mergers mentioned above. Second, in absolute terms the HHI remains very low, going from about 200 to 260 points over the entire period. Figure 2 plots the HHI time series for both deposits and loans. Following the predictions of the structure–conduct–performance paradigm, these two observations would imply that, given the extremely low level of concentration, the Italian banking industry should exhibit a very high degree of competition over the entire sample period, but with gradual movement toward conditions more appropriate to the exercise of market power.

In fact, the results of the econometric estimation contradict both predictions of the structure–conduct–performance paradigm. Figure 3 shows the estimates of the parameter of banks' interaction for each year between 1983 and 1993, a period including years before and after the regulatory changes. As explained earlier, the parameter should take values between 0 and 1, with 0 representing the perfectly competitive benchmark and 1 the monopolistic benchmark. However, the results show the parameter is significantly different from 0 (and from 1) for almost the entire sample period, thus rejecting the hypothesis that the Italian banking industry is perfectly competitive (as well as the hypothesis that it is a perfect monopoly). This finding contradicts the inference one would draw from the HHI. Indeed, given the very low level of concentration, one might expect the market for commercial loans at the national level to be very competitive.

A further observation is that the parameter is well above 0 in the initial part of the sample, prior to deregulation, and shows an approximately steady

FIGURE 2

Herfindahl concentration indicators for the Italian banking market



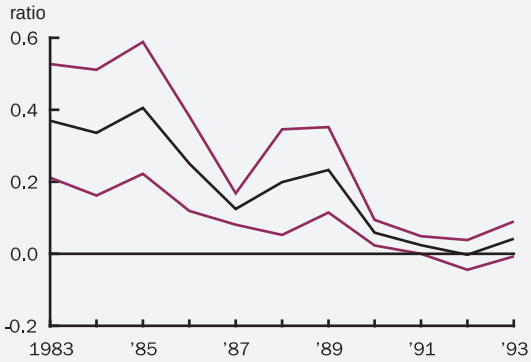
Note: HHI represents the Herfindahl–Hirschman Index.
Source: Author's calculations based on data from the Bank of Italy.

decline throughout the rest of the sample period. This can be seen as evidence that the regulatory and structural changes have indeed enhanced the overall competitiveness of the banking industry. Finally, the parameter approaches 0, suggesting the presence of perfectly competitive conditions, toward the end of the period. This represents a second element of contradiction with the information in the HHI, which is increasing in the final years of the sample period.

In addition to the estimation of the parameter of interaction, Angelini and Cetorelli (1998) estimate a parameter measuring the elasticity of demand for commercial loans. As mentioned earlier, in deciding on behavior, banks have to take into account not only the

FIGURE 3

Parameter of banks' interaction



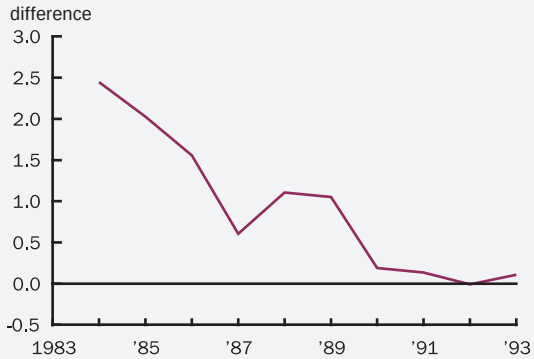
Note: The colored lines indicate 5 percent confidence bands.
Source: P. Angelini and N. Cetorelli, 1998, "Assessing competition in the Italian banking industry," Federal Reserve Bank of Chicago, mimeo.

expected reaction of other banks but also the reaction of customers. Whether the market for loans exhibits a high or low elasticity to changes in the loan rate is crucial to banks' ability to exercise market power and affect profits. The intuition is simple. Suppose the parameter of interaction is very high, close to 1, approximating ideal conditions for the exercise of market power. Banks would attempt to keep a high loan rate, or to increase it, to maximize their profits. However, if market demand elasticity is also high, borrowers are likely to reduce substantially their demand for loans in the case of a price increase. In such a case, banks will be constrained in their ability to profit from their market power. The opposite would be true in the case of a rigid demand schedule.

This consideration is important, therefore, if we are interested in exploring the actual welfare cost of market power, in terms of how high the loan rate is relative to what it would be under perfect competition. To obtain a quantifiable measure of this, Angelini and Cetorelli (1998) compute the ratio of the parameter of banks' interaction and the parameter measuring demand elasticity. When this ratio is close to 0, it means that the market exhibits competitive conditions, regardless of banks' potential ability to exercise market power. Figure 4 reports estimates for this ratio for every year in the sample period. Between 1984 and 1986, interest rates on loans charged by banks were about 2 percentage points above the level that would have been charged under competitive conditions (interest rates on loans averaged around 21 percent). This gap declined to about 1 percentage point in 1987–89, then dropped to practically 0 at the beginning of the new decade. This provides evidence that the Italian banking industry has changed substantially as a result of the process of deregulation and consolidation that began in the late 1980s.

FIGURE 4

Difference between actual interest rate on loans and "competitive" rate



Source: P. Angelini and N. Cetorelli, 1998, "Assessing competition in the Italian banking industry," Federal Reserve Bank of Chicago, mimeo.

Conclusion

This article has presented an overview of the methodologies used in competitive analysis of the banking industry. Given the ongoing process of consolidation in the U.S. banking industry, properly identifying the conditions for the exercise of banks' market power is highly relevant for policy analysis.

I have briefly outlined the antitrust analysis procedure currently followed by the regulators. Drawing on the existing literature, I have highlighted some challenges to the theoretical foundations of the current approach, which is based on the identification of an increasing, monotonic relationship between market concentration and market power. Only under rather strong, restrictive assumptions about the behavior of banking firms is this relationship identifiable. As shown in the numerical examples, relying on concentration measures alone to infer industry conduct may lead to possibly incorrect conclusions. The empirical evidence on the existence of the market concentration–market power relationship is rather mixed, in light of several recent works that cast doubt on the robustness of such a relationship.

An alternative methodology for the identification of parameters of firms' conduct and the degree of market power, which does not rely on indirect inferences of market structure analysis, requires an econometric estimation of market demand and supply conditions. The testable implications associated with this approach allow us to unambiguously identify firms' conduct. The results from an empirical application of this methodology to the Italian banking industry provide evidence that contradicts the inferences of the structure–conduct–performance approach.

Adopting this alternative methodology to identify the parameter of banks' interaction brings a higher rigor to the antitrust analysis, implicit in the econometric exercise required to extract information from industry data. This is, however, also its principal shortcoming, in terms of the need for more detailed data and the greater difficulty associated with the implementation and interpretation of the econometric work. Conversely, the main advantage of the current approach to competitive analysis is that HHI indicators are relatively easy to compute and allow the regulators to formulate objective statements (for example, setting the 1,800/200 guideline) and deliver opinions that are less subject to arbitrary judgements. Nonetheless, it is important to recognize the potential

shortcomings of the current approach and to test for accountability when developments in economic research provide the appropriate tools.

For example, the alternative methodology presented in this article could be applied to markets in which mergers have been approved to analyze banks' conduct before and after the change in market structure.[9] In addition to an "after the fact" analysis, the methodology could be used routinely to overview market conditions and to provide *ex ante* information that could be used by regulators when a merger application is filed, perhaps to resolve potential ambiguities associated with mere observation of market structure. In this way, the methodology could be adopted to complement the current procedure for antitrust analysis.

TECHNICAL APPENDIX

Details of the methodology

Estimating market power

The basic elements of the methodology can be illustrated as follows.[1] In an industry producing a single good, let p be the market price of product y and let y_j be the quantity produced by firm $j, j = 1, ..., m$, and $\sum_j y_j = y$. Let the demand function, written in inverse form, be $p = p(y, z)$, where z is a vector of exogenous variables affecting demand. In addition, let $C(y_j, \omega_j)$ be the cost function for firm j, where ω_j is the vector of the prices of the factors of production employed by firm j.

Firms in this industry behave as profit maximizers. The profit maximization problem for firm j is written as

$$1) \quad \underset{y_j}{\text{Max}}\, p(y,z)y_j - C(y_j,\omega_j).$$

If firms were in perfect competition with each other, they would set their optimal quantities at the point where the marginal cost of production would equal the market price, that is,

$$2) \quad p = C'(y_j,\omega_j),$$

where $C'(y_j, \omega_j)$, is the marginal cost of firm j.

At the opposite extreme, suppose there is only one firm in the industry, operating as a monopolist. In such a case, we know that the firm would set quantities to a level where marginal revenue equals marginal cost, or

$$3) \quad p = C'(y,\omega) - \frac{dp}{dy}y,$$

where $p + \frac{dp}{dy}y$ is the monopolist marginal revenue $\left(\frac{dp}{dy}y < 0\right)$. In intermediate oligopolistic structures, with m firms operating in the market, conduct would be summarized by the general expression

$$4) \quad p = C'(y_j,\omega_j) - \frac{dp}{dy}y_j\theta_j,$$

where the parameter θ_j is an index of oligopoly conduct, quantifying the departure from the competitive benchmark. Equation 4 is a very general expression embedding various models of oligopoly behavior, which can be estimated econometrically. To appreciate its generality, it is perhaps convenient to interpret θ_j as a parameter measuring the "conjectured" or "perceived" response of the entire industry to a change in quantity operated by firm j. Solve the maximization problem in equation 1 in more extensive form as

$$5) \quad p + \frac{\partial p}{\partial y}\frac{\partial y}{\partial y_j}y_j - C'(y_j,\omega_j) = 0.$$

Multiply and divide the second term of equation 5 by y. Then, rearranging terms, the equation can be rewritten as

$$6) \quad p = C'(y_j,\omega_j) - \frac{\theta_j}{\tilde{\varepsilon}},$$

where

$$7) \quad \tilde{\varepsilon} \equiv \frac{\partial y}{\partial p}\frac{1}{y}, \tilde{\varepsilon} < 0$$

is the semi-elasticity of demand and

$$8) \quad \theta_j \equiv \frac{\partial y}{\partial y_j}\frac{y_j}{y}$$

is the so-called conjectural elasticity, that is, the percentage variation in aggregate output due to firm j's

change in y_j. It should be clear that one does not need to impose any *a priori* restriction on θ_j, that is, any behavioral model is *a priori* plausible, and the more appropriate one can be tested and identified econometrically. For example, if firms were Cournot oligopolists, then $\frac{\partial y}{\partial y_j} = 1$. Recall that under Cournot behavior, firm *j* expects that all other firms will not adjust their quantities to a change in y_j. Therefore, since $y = \sum_j y_j$ incorporates firm *j* quantity, the total variation in output to a change in y_j must equal unity. Thus, under Cournot, θ_j would reduce to the market share of firm *j*.

If firms were instead in perfect competition, then $\frac{\partial y}{\partial y_j} = 0$, hence $\theta_j = 0$. In the case of monopoly, $\frac{\partial y}{\partial y_j} = 1$ and $y_j = y$, hence $\theta_j = 1$. Therefore, the convenient feature of this approach is that it specifies well-defined boundaries in terms of industry equilibrium conditions (perfect competition at one end and monopoly at the other), within which it is possible to identify the actual underlying characteristics of firms' conduct.

Given the generality of the methodology, one can also test whether $\theta_h \neq \theta_i$, where $h = 1, \ldots, l$ and $i = 1, \ldots, n$ and $l + n = m$. This would allow us to test, for example, whether firms behave according to dominant firm or leader–followers models.

Analytical derivation of the market concentration–market power relationship

We can also see now under what behavioral restrictions it is possible to identify a relationship between market concentration and market power.[2] Define the degree of market power of firm *j* as

$$9) \quad \alpha_j = \frac{p - C'(y_j, \omega_j)}{p} = \frac{\theta_j}{\varepsilon},$$

where $\varepsilon \equiv \frac{\partial y}{\partial p}\frac{p}{y} (\varepsilon < 0)$ is the elasticity of demand.

Now define the degree of market power of the industry as a firm average, weighted by firms' relative size,

$$10) \quad \alpha = \sum_j \left[\frac{p - C'(y_j, \omega_j)}{p} \right] \frac{y_j}{y} = \sum_j \frac{\theta_j}{\varepsilon} \frac{y_j}{y}.$$

Given the definition of θ_j we can rewrite this last expression as

$$11) \quad \alpha = \sum_j \frac{1}{\varepsilon} \frac{\partial y}{\partial y_j} \left(\frac{y_j}{y} \right)^2.$$

Assume now that all firms form the same, identical conjecture about how the rest of the industry would react to a change in their own quantities. In addition, assume that these identical conjectures will also stay the same over time and over changes in market structure (for example, distribution of market shares and number of firms). Under these conditions, $\frac{\partial y}{\partial y_j} = \gamma, \forall\ j,$ where γ is a given constant. Consequently

$$12) \quad \alpha = \frac{1}{\varepsilon} \gamma HHI.$$

The Cournot model, where $\gamma = 1$, is an example of a model that would identify a proportional relationship between market concentration and market power. However, we have already remarked that the Cournot conjecture is rather restrictive. It seems even more restrictive to assume identical conjectures equal to some arbitrary constant γ. Moreover, note the importance of the assumption that the identical conjectures will have to stay unchanged over time and in case of a change in market structure. This implies assuming that γ and *HHI* are independent from each other. Yet, as we argued earlier, a change in market structure, such as the one determined by a merger, whereby the distribution of market shares and the number of firms operating in the industry vary, will have an effect on how firms perceive the conduct of one another. This effect on conduct will not necessarily be the same for all firms (see, for example, the numerical examples section of the text). Therefore, the behavioral restrictions required to derive the market concentration–market power relationship from theory would indeed seem too strong to be accepted.

In the more general (and more plausible) case where $\frac{\partial y}{\partial y_j} \neq \frac{\partial y}{\partial y_i}, j \neq i,$ the expression for α does not allow one to derive the HHI. Therefore, under these more general conditions, we cannot rely on the HHI to make predictions regarding firms' conduct. Nonetheless, as stated above, we can test econometrically whether the Cournot or the constant γ restrictions can be rejected against alternative theoretical specifications. As Bresnahan (1989, p. 1031) stated, "Only econometric problems, not fundamental problems of interpretation, cloud this inference about what has been determined empirically."

Details of the empirical implementation

As we saw above, estimating the degree of market power means being able to identify the conduct parameter θ in equation 4, here rewritten for convenience of exposition as

$$p = C'(y_j, \omega_j) - \frac{dp}{dy} y_j \theta_j,$$

where p now indicates the interest rate on commercial loans, y indicates the quantity of commercial loans, and ω, the vector of factor prices, includes labor cost, capital expenses, and the interest rate on deposits.

For the identification of the parameter of conduct θ_j, we need information on the marginal cost function $C'(y_j, \omega_j)$ and on the inverse of the semi-elasticity on loans demand, $\frac{1}{\tilde{\varepsilon}} \equiv \frac{\partial p}{\partial y} y$. One can obtain this additional information at different degrees of refinement, depending in practice on data availability. Angelini and Cetorelli (1998) estimate the parameters of the marginal cost function using the widely used translog specification, deriving the following expression:

$$C'(y_j, \omega_j) = \frac{C_j}{y_j}\left[a_1 + a_2 \ln(y) + \sum_{i=1}^{3} b_i \ln(\omega_{ij})\right].$$

In addition, the parameter $\tilde{\varepsilon}$ is recovered by estimating simultaneously a loans demand function, specified as

$$\ln(y) = d_1 + d_2 p + d_3 \ln(z) + d_4[\ln(z) p],$$

where z is an exogenous shifter of demand, such as investments or GDP.

Finally, although it would be feasible in terms of data availability to test various models of oligopoly, thus identifying distinct parameters of conduct, $\theta_h \neq \theta_i$, Angelini and Cetorelli (1998) focus on the determination of an average indicator of conduct, θ (see Bresnahan, 1982, for details). Such an indicator gives a first approximation of the overall conditions for the exercise of market power in the industry. Since such a study has never been conducted before for the Italian banking industry, I believe there is high informational value in the average indicator θ.

[1]The remainder of the section is based on Appelbaum (1982) and Bresnahan (1989).

[2]The derivation is based on Cowling and Waterson (1976).

NOTES

[1]Examples of research work on the impact on efficiency of bank mergers include Berger and Humphrey (1992), DeYoung (1997), Hughes et al. (1996), Rhoades (1993b), and Shaffer (1993b). Other authors have sought to evaluate the impact on profitability (for example, Berger and Humphrey, 1992; Cornett and Tehranian, 1992; Pilloff, 1996; and Akhavein et al., 1997) and on production decisions, in particular on lending to small business (for example, Berger et al., 1997).

[2]An alternative measure also used in research is the sum of the market shares of the largest firms in the industry, usually the largest three or four firms.

[3]For a thorough description of the use of mitigating factors in antitrust analysis, see Holder (1993a).

[4]For a detailed description of the official guidelines for competitive analysis in banking, see, for example, Bureau of National Affairs (1984, 1992), Litan (1994), Holder (1993a, 1993b), and Di Salvo (1997).

[5]To be precise, thrift institutions are currently included in the calculation of the HHI. Their market shares, however, have only a 50 percent weight (20 percent for the Justice Department's evaluation procedure), which in any case always determines a reduction in the HHI calculated on banks only. Because of the inclusion of the thrift institutions, the 1,800/200 rule is sometimes called the 1,800/200/50 rule.

[6]The Justice Department's horizontal merger guidelines define markets with a post-merger HHI below 1,000 as unconcentrated and unlikely to present anticompetitive concerns. Markets with a post-merger HHI between 1,000 and 1,800 are defined as moderately concentrated. In such markets a variation in the HHI of less than 100 points is unlikely to present anticompetitive concerns. Markets with a post-merger HHI above 1,800 are defined as highly concentrated, and a variation of the HHI greater than 50 points is thought to have adverse competitive consequences. In the past several years, however, the Justice Department has not challenged a merger unless the post-merger HHI was at least 1,800 and the change in the HHI at least 200 points (see Litan, 1994).

[7]A firm joining a collusive agreement always has an incentive to abandon the agreement (or "cheat") and set prices and/or quantities that maximize its own profits. The costs associated with the collusive agreement are therefore expressed either in terms of the losses suffered by participants in the event that one of them cheats, or in terms of the punishment that a firm would sustain in the event it is caught cheating (for instance, all firms revert to competitive pricing forever after collusion breaks down, hence the deviating firm will no longer be able to make positive profits.)

[8]Important methodological contributions include Iwata (1974), Appelbaum (1979 and 1982), Bresnahan (1982 and 1989), Gollop and Roberts (1979), and Roberts (1984). Applications to the banking industry include Spiller and Favaro (1984), Gelfand and Spiller (1987), Berg and Kim (1994 and 1996), Shaffer (1989 and 1993a), and Shaffer and Di Salvo (1994).

[9]Prager and Hannan (1998) examine a cross-section of such markets, finding that banks operating in markets where a merger produces a substantial increase in concentration have deposit rates that are lower than those set by banks not operating in such markets. They interpret the result as evidence that these mergers lead to increased market power.

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What Drives Bank Competition?

Some International Evidence

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Abstract: Using bank-level data and applying the Panzar and Rosse (1987) methodology, we estimate the degree of competition in 50 countries' banking systems. We then relate our competitiveness measure to countries' structural and regulatory indicators and find systems with greater foreign bank entry, and fewer entry and activity restrictions to have a higher competitiveness score. We find no evidence that banking system concentration negatively relates to competitiveness. Our findings confirm that contestability determines effective competition, especially through allowing (foreign) bank entry. At the same time, our findings also suggest that competition policy in the financial sector can be more complicated than perhaps previously thought.

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INTRODUCTION

Competition in the financial sector matters for a number of reasons. As in other industries, the degree of competition in the financial sector can matter for the efficiency of the production of financial services. And, again as in other industries, it can matter for the quality of financial products and the degree of innovation in the sector. A reason specific to the financial sector why competition matters is the link between competition and stability, long recognized in theoretical and empirical research and most importantly in the actual conduct of prudential policy towards banks. The importance of these competition aspects has become further clear from recent experiences in East Asia and elsewhere when some have argued that excessive competition has been one of the factors contributing to the financial crises. It has also been shown, theoretically as well empirically, that the degree of competition in the financial sector can matter for the access of firms and households to financial services and external financing, in turn affecting overall economic growth, although not all relationships are well known. The degree of competition in and stability of the banking system will in turn depend on entry barriers, including on foreign ownership, and the severity of activity restrictions, but also on the importance of other type financial institutions (finance companies, merchant banks, insurance companies, capital markets).

While some of these relationships between competition and banking system performance and stability have been analyzed in the theoretical literature, empirical research, particularly cross-country research, on the issue of competition is still in an early stage. A hindrance for the cross-country research used to be data problems, as little bank-level data were available outside the main developed countries, but recently established databases are allowing for better empirical

work. Another hindrance on interpretation of existing empirical work has been that it did not always take into account a number of theoretical issues. The long-existing theory of industrial organization has shown that the competitiveness of an industry cannot be measured by market structure indicators alone (such as number of institutions, Herfindahl or other concentration indexes). Rather, testing for the degree of effective competition needs a structural, contestability approach. To date, few cross-country tests have taken this approach.

Empirical research on competition in the financial sector has also not yet reflected recent analysis comparing financial systems' functioning. This analysis of financial systems' functioning and performance has made clear that characterizing financial systems by the prevalence of certain type of institutions or importance of markets can be misleading. Although countries vary greatly in their financial structures, e.g., the mix between banks and markets or the concentration of their banking systems, these may not be the most important characteristics for their functioning, including competition. Research indeed has shown that what matters in the end for financial sector efficiency, access, growth and financial stability are the functions that the financial sector provides which may or may not vary by financial structure (Demirgüç-Kunt and Levine, 2001). This importance of functions rather than institutions or structures may also apply to the issue of competition, suggesting that tests focusing on how the structure of institutions may affect competition are not complete.

Finally, financial services industries have been undergoing rapid changes, in part triggered by deregulation and technological advances. These changes have led to many changes, including dis-intermediation, removal of barriers between financial products, consolidation, increased

cross-border capital flows, greater commercial presence, and more financial integration, as well as some risks and short-run costs. They have made the definition of a financial market and any particular financial service more complex. They also have increased the network properties of financial services, making competition more complex, even when a pro-competitive entry/exit regime in terms of institutions or markets for various types of financial services is in place. And it is making empirical analyses of the competitive nature of financial systems more complicated.

These considerations suggest some advantages of using a more structural approach to assessing the degree of competition in the financial sector. While one cannot expect to address all issues, a more formal test of the degree of competition will allow one to overcome some of these concerns. It will also allow a comparison of results to other approaches to measuring competition, such as using concentration ratios or the number of banks in a market. Structural competition tests have been applied to banking systems in a number of individual countries, but not on a wide cross-country basis. The purpose of this paper is to estimate and document a measure of competition for a large cross-section of countries and to try to find some factors helping explain differences. We specifically seek to analyze the role of entry and activity regulations, and the role of foreign banks in affecting the competitive conditions in banking systems. Since the importance of different size banks and the role of non-bank financial institutions in affecting the overall competition in the financial sector have received limited attention, we also study those.

Using bank-level data and applying an adapted version of the Panzar and Rosse (1987) methodology, we estimate the degree of competition in 50 countries' banking systems. We then

relate our competitiveness measure to countries' structural and regulatory indicators and find that systems with greater foreign bank entry, and lack of entry and activity restrictions have a higher competitiveness score. We find no evidence that banking system concentration negatively relates to competitiveness. Our findings confirm that contestability determines effective competition, especially through allowing (foreign) bank entry. They also suggest that competition policy in the financial sector can be more complicated than perhaps previously thought.

The paper proceeds as follows. Section 1 gives a review of related literature, both on the effects of competition in the financial sector as well as measuring competition in general and in the financial sector specifically. Section 2 discusses the methodology used to test for the degree of competition in the banking market of a particular country. Section 3 presents the data we use and the selection criteria we used for the sample we end up using. The section also presents the main empirical results and relates the measure of competition to some structural and policy variables. Section 4 reports several robustness tests. Section 5 concludes.

1. LITERATURE REVIEW

We review several, related strands of literature. We start with a short review of the growing literature on the definition and effects of competition in the financial sector. We then review the empirical literature that has investigated the relationships between structural and regulatory factors and performance, access to financing and growth, as it relates to the competitive structure of the banking system. Since these papers have mostly not attempted to test a specific structural

model, we review briefly the general theory on measuring competition and then review some of the papers that have applied competition test to the financial sector.

1.1 General Effects of Competition in Banking

As a first-order effect, one would expect increased competition in the financial sector to lead to lower costs and enhanced efficiency, even allowing for the fact that financial products are heterogeneous. In a theoretical model, Besanko and Thakor (1992), for example, analyze the allocation consequences of a relaxing of entry barriers and find that equilibrium loan rates decline and on deposit interest rates increase, even when allowing for differentiated competition. As more recent research has highlighted, the relationships between competition and banking system performance, access to financing, stability and growth are, however, more complex (for a recent review of the theoretical literature on competition and banking, see Vives 2001). Market power in banking, for example, may up to a degree be beneficial for access to financing. The view that competition policy is unambiguously good in banking is more naive than in other industries and vigorous rivalry may not be the first best for financial sector performance. Neither does necessarily technological progress lowering production or distribution costs for financial services providers lead to more or better access to external financing. A few specific examples of theoretical papers will show these specific findings.

In a dynamic world, a bank and borrower establish relationships to overcome information problems. The higher its market power, the more likely the bank invests in information gathering about firms, especially to informationally opaque firms, and the more likely it provides credit (Rajan, 1992). More competition can then undermine the incentives of banks to invest in a

relationship. But the relationship involves sunk costs and leads to a hold-up problem: the incumbent bank has more information about the borrower than its competitors. This increases the switching costs for the borrower, especially for better quality borrowers since they will face adverse conditions when trying to look for financing from another bank, as they will be perceived as a poor credit. Borrowers will be less willing to enter a relationship with a bank if they are less likely subject to a hold-up problem, for example, when the market for external financing is more competitive. The net effect of these problems can vary with the overall competitive environment. Boot and Thakor (2000), for example, show that increased interbank competition may induce banks to make not less, but more relationship loans. There can also be effects from the type of information problem on the scope for potential competition. Dell'Ariccia, Friedman and Marquez (1999), for example, show that the presence of information asymmetries in lending relationships can become a barrier to entry in the banking system.

Technological progress lowering costs can also affect the competitive structure of markets and thereby affect the access to and terms of external financing, but again not in an obvious manner. Endogenizing competition, Hauswald and Marquez (2002), for example, analyze the impact of technological progress on competition in financial services. While better information technology may lead to improved information processing, it may also lead to low costs of information or even free access to information. Better access to information can decrease interest rates, but an improved ability to process information can increase interest rates. They show that the net effects on competition hinge on the overall effect ascribed to the technological progress. Marquez (2002) analyze how information generated through the process of lending can impact the structure of the banking industry to the extent that that this information

is proprietary to the banks. He shows that in markets where new entrants have specific expertise in evaluating credit risks or in markets with high borrower turnover, entry should be easier so that incumbents' bank information advantages are reduced. Again, the preferred market structure depends on the degree of information asymmetries and the ownership of information.

Apart from its effects on access and terms of financing, the relationship between competition and stability is not obvious. Many academics and especially policy makers have stressed the importance of franchise value for banks in maintaining incentives for prudent behavior. This in turn has led banking system regulators to carefully balance entry and exit. But, this has often been a static view. Perotti and Suarez (2002), for example, draw attention to the importance of the dynamic pattern of entry and exit regulation in driving the current actions of banks. They show in a formal model that the behavior of banks today will be affected by both current and future concentration and the degree to which authorities will allow for a contestable system in the future. In a dynamic model, current concentration does not necessarily reduce risky lending, but an expected increase in future market concentration can make banks choose to pursue safer lending today.

1.2 General Empirical Studies on Banking System Performance and Structure

A number of papers have investigated the competitive conditions in banking systems. The focus of these papers has been varied. Some try to document only the degree of competition or lack thereof, others try to identify also structural and institutional factors which help explain variation in effective competition across banks, countries or over time. Some others go further and try to

establish the impact of competition or lack thereof on bank efficiency, access to financing, stability and growth. While many of these papers are not formal structure-performance-conduct tests, their results have been interpreted as indicative of the degree of competition and/or its causes and consequences in the financial sector.

Much of the literature that has (or has not) tested a specific structural model has been concerned with the US and a few developed countries. The focus has also been on the profitability of banks and efficiency with which banks operate, as it relates to factors such as the competitive structure of the market, the degree of domestic deregulation, the effects of merger and acquisitions, and the degree of consolidation in the industry. In one of the first papers, Berger and Hannan (1989) investigate the commonly observed relationship between market concentration and profitability. They try to separate the effects of non-competitive price behavior and of greater efficiency of firms with larger market shares. Using data for US banks during the period 1983-85, they find that non-competitive price behavior could explain the relationship. Berger (1995) explores also the relationship between market power and profit. He finds, however, limited evidence for any specific theory of bank profits, including the structure-conduct-performance hypothesis. Angelini and Cetorelli (2000) analyze the evolution of competitive conditions in the Italian banking industry using firm-level balance sheet data for the period 1983-1997. Regulatory reform, large-scale consolidation, and competitive pressure from other European countries have changed substantially the Italian banking environment. They find some evidence of a substantial increase in competitive conditions in the banking market after the introduction of the European Single Banking License, with a decrease in markups.

There is some empirical evidence for the U.S. and some other markets regarding the effects of concentration in the financial system on access to and costs of external financing and growth. Petersen and Rajan (1995) offer empirical evidence for the U.S. that firms are less credit constrained and face cheaper credit the more concentrated the credit market is. Degryse and Ongena (2002) show in the case of Belgium that loan rates increase in the distance between the firm and competing banks (and decrease in the distance from the lender and the firm), suggesting that increased distance relaxes price competition. Berger, Klapper and Udell (2001) investigate the effects of bank size, foreign ownership, and distress on lending to informationally opaque small firms for Argentina. Their results suggest that large and foreign-owned institutions may have difficulty extending relationship loans to opaque small firms. Collender and Shaffer (2001) document how in the U.S., non-metropolitan employment grew faster in areas where there was a more concentrated initial banking structure and where there were locally owned bank offices.

Consolidation and technology and their effects on bank lending terms have been much-researched topics and cover too large literatures to review here. Gilbert (1984) reviews the earlier studies, while Berger, Demsetz, and Strahan (1999) review more recent studies on the effects of consolidation, including some studies on the effects of consolidation on access to financing, mainly for the US. A more policy-oriented review on the effects of consolidation is G-10 (2001). More recently, technological progress and its effects in the banking industry has been more researched and Berger (2002) reviews this literature. Claessens and Klingebiel (2001) and Claessens, Dobos, Klingebiel and Laeven (2003) review the general and more recent literature on competition in the financial sector as well, trying to infer policy lessons for developing and other countries.

Most of these studies pertain to developed countries and are mostly not of a cross-country nature. There are a number of papers, however, investigating across countries the effects of specific structural or other factors presumed to relate to the competitive environment on banking performance. Claessens, Demirgüç-Kunt and Huizinga (2001) investigate the role of foreign banks in a cross-country study and show that entry by foreign banks makes domestic banking systems more efficient by reducing their margins. In a broad survey of rules governing banking systems, Barth, Caprio and Levine (2001) document for 107 countries various regulatory restrictions in place in 1999 (or around that time) on commercial banks, including various entry and exit restrictions and practices. Using this data, Barth, Caprio and Levine (2002) analyze empirically, among others, the cost and benefits of these restrictions. They find that tighter entry requirements are negatively linked with bank efficiency, leading to higher interest rate margins and overhead expenditures, while restricting foreign bank participation tends to increase bank fragility. These results are consistent with the view that tighter entry restrictions tend to limit competition and emphasize that it is not the actual level of foreign presence or bank concentration, but the contestability of a market that is positively linked with bank efficiency and stability.

Using bank level data for 77 countries, Demirgüç-Kunt, Laeven, and Levine (2003) investigate the impact of bank concentration and regulations on bank efficiency. They find that bank concentration has a negative and significant effect on the efficiency of the banking system except in rich countries with developed financial systems and more economic freedoms. Furthermore, they find bank-level based support that regulatory restrictions on entry of the new

banks, particularly concerning foreign banks, and implicit and explicit restrictions on bank activities, are associated with lower levels of bank efficiency.

There have also been papers studying the impact of the structure of banking systems on access to financing, growth and other economic variables. Using the empirical methodology of Rajan and Zingales (1998), Cetorelli and Gambera (2001) document in a cross-section study that banking sector concentration exerts a depressing effect on overall economic growth, though it promotes the growth of industries that depend heavily on external finance. Using the same data and similar methodology, Deiida and Fatouh (2002) find that banking concentration is negatively associated with per capita growth and industrial growth only in low-income countries, while there is no significant relationship between banking concentration and growth in high-income countries. Dell'Ariccia and Bonaccorsi di Patti (forthcoming) also employ this approach and find that bank competition has a positive effect on firm creation. They also find, however, that the degree of information asymmetries in the country limit the overall positive effects of bank competition on firm credit, consistent with the theories that competition may reduce credit to informationally opaque firms. Finally, Cetorelli (2001) also uses this methodology and finds that banking concentration enhances industry concentration, especially in sectors highly dependent on external finance, although these effects are less strong in countries with well-developed financial systems.

Beck, Demirgüç-Kunt and Maksimovic (2002) investigate the effects of bank competition on firm financing constraints and access to credit, also using a cross-country approach with now firm-level data. They find that bank concentration increases financing

constraints and decreases the likelihood of receiving bank finance for small and medium-size firms, but not for large firms. The relation of bank concentration and financing constraints is reduced in countries with an efficient legal system, good property rights protection, less corruption, better developed credit registries and a larger market share of foreign banks, while public bank ownership exacerbates the relation. Further, less contestability and restrictions on banks' activities exacerbate the relation, while high entry and capital requirements alleviate it.

Eschenbach and Francois (2002) investigate, using a dynamic, simultaneous system approach, the relationship between financial sector openness, competition and growth. Using a panel estimation of 130 countries, they report a strong relationship between financial sector competition/performance and financial sector openness and between growth and financial sector openness/competition. They also find evidence of the presence of economies of scale in the financial sector.

Finally, some papers have analyzed the relationship between banking concentration and banking crises. Beck, Demirguc-Kunt and Levine (2002) show, using data on 79 countries over the period 1980-1997, that crises are less likely (i) in more concentrated banking systems, (ii) in countries with fewer regulatory restrictions on bank competition and activities, and (iii) in economies with better institutions, i.e., institutions that encourage more competition and support private property rights.

1.3 Competition Testing: Theory

The papers reviewed so far did not test for the degree of competition in the banking system using a specific structural model. The general contestability literature has suggested, however, specific ways on how to go about testing for the degree of competition. Klein (1971), Baumol, Panzar, and Willig (1982) were the first to develop a formal theory of contestable markets. They draw attention to the fact that there are several sets of conditions that can yield competitive outcomes, even in concentrated systems. On the other hand, they showed that collusive actions could be sustained even in the presence of many firms. Their work has spanned a large theoretical and empirical literature covering many industries. More recently, theoretical and empirical research has focused on issues such as sunk costs, entry costs and barriers, network externalities, the effects of tying between related products or services, etc. (see Claessens et al. 2003, for a review of these issues as they may apply to finance).

Two types of empirical tests for competition can be distinguished as they have been applied to financial sector (and other industries). The model of Bresnahan (1982) and Lau (1982), as expanded in Bresnahan (1989), uses the condition of general market equilibrium. The basic idea is that profit-maximizing firms in equilibrium will choose prices and quantities such that marginal costs equal their (perceived) marginal revenue, which coincides with the demand price under perfect competition or with the industry's marginal revenue under perfect collusion. This model allows for an easy to use test statistic and a direct relationship to a natural measure of excess capacity. Specifically, a parameter, λ, can be estimated which provides a measure of the

degree of imperfect competition, varying between perfect competition ($\lambda = 0$) or market power ($\lambda = 1$). The main empirical advantage is that one only needs to use industry aggregate data (although using firm-specific data is possible as well).[1]

The alternative approach is Rosse and Panzar (1977), expanded by Panzar and Rosse (1982) and Panzar and Rosse (1987). This methodology, abbreviated here to the PR model, uses firm (or bank)-level data. It investigates the extent to which a change in factor input prices is reflected in (equilibrium) revenues earned by a specific bank. Under perfect competition, an increase in input prices raises both marginal costs and total revenues by the same amount as the rise in costs. Under monopoly, an increase in input prices will increase marginal costs, reduce equilibrium output and consequently reduce total revenues. The PR model also provides a measure ("H-statistic") between 0 and 1 of the degree of competitiveness of the industry, with 0 being a monopoly and 1 being perfect competition. The advantage of the PR model is that it uses bank-level data and allows for bank-specific differences in production function. It also allows one to study differences between types of banks (e.g., larges versus small, foreign versus domestic). Its drawback is that it assumes that the banking industry is in long-run equilibrium, but a separate test exists whether this is satisfied. As we have access to bank-level information and as we want to study differences among banks, we choose for the PR model. The empirical specification we use is explained in more detail in the next section.

[1] The Bresnahan test has been critised as suffering from a multicollinearity problem (see Perloff and Shen, 2001). The severity of this criticism is being debated.

1.4 Competition Testing: Empirical Results for Banking Systems

A number of papers have applied either the Breshnahan or the PR methodology to the issue of competition in the financial sector, although mostly to the banking system specifically.[2] The Breshnahan test has been applied in a number of papers, with one of the first papers being Shaffer (1989). She applies the methodology to a sample of US banks and finds results that strongly reject collusive conduct, but are consistent with perfect competition. Using the same model, Shaffer (1993) studies the competition conditions in Canada and finds that the Canadian banking system was competitive over the period 1965-1989, although being relatively concentrated. She also finds that the degree of competition in Canada was generally stable following regulatory changes in 1980.

Gruben and McComb (forthcoming) applied the Breshnahan methodology to Mexico before 1995 and find that the Mexican banking system was super-competitive, that is marginal prices were set below marginal costs. One of the few studies with a relatively large sample of countries is Shaffer (2001), which uses the Breshnahan model for 15 countries in North America, Europe, and Asia during 1979-91. She finds significant market power in five markets and excess capacity in one market. Estimates were consistent with either contestability or Cournot type oligopoly in most of these countries, while five countries were significant more competitive than Cournot. Since the data refer to the period before the European single banking license was adopted, the result may, however, not be reflective of the current situation.

[2] Cetorelli (1999) provides more detail on these formal tests and reviews some of the results of previous studies of empirical banking studies.

Shaffer (1982) was also one of the first to apply the PR model to banks. She estimated it for New York banks using data for 1979 and found monopolistic competition. Nathan and Neave (1989) study Canadian banks using the PR methodology. The results for Canada are consistent with the results of Shaffer (1989) using the Breshnahan methodology, in that they can also reject monopoly power for the Canadian banking system (they found perfect competition for 1982 and monopolistic competition for 1983-84). Some other studies have applied the P-R methodology to some non-North America and non-European banking systems. For Japan, for example, Molyneux, Thornton and Lloyd-Williams (1996) find evidence of a monopoly situation in 1986-1988.

A number of papers have applied the P-R methodology to European banking systems. These papers include Molyneux, Lloyd-Williams, and Thornton (1994), Vesala (1995), Molyneux, Thornton and Lloyd-Williams (1996), Coccorese (1998), Bikker and Groeneveld (2000), Bikker and Haaf (2001), De Bandt and Davis (2000), and Hempel (2002). The countries covered, the time periods and some of the assumptions used vary between the studies (Bikker and Haaf (2001) summarize the results of some ten studies). Although the findings varied somewhat consequently, generally the papers can reject both perfect collusion as well as perfect competition and find mostly evidence of monopolistic competition. Bikker and Groeneveld (2000), for example, find monopolistic competition in all of the 15 EU-countries they study.

Some of these studies find differences between types of banks. For Germany, for example, Hempel (2002) reports for 1993-1998 differences between savings and cooperative

banks on one hand and credit banks on the other hand as well as between several size categories. She cannot find clear evidence of a change in competitive behavior, however, despite a slight increase in concentration during the period studied. Others have also found differences in competitiveness between sizes of banks. De Bandt and Davis (2000), for example, find for the period 1992-96 for small banks in France and Germany monopoly while they find monopolistic competition for small banks in Italy and for the large banks in all three countries in their sample. This suggests that in these countries small banks have more market power, maybe as they cater more to local markets.

Tests on the competitiveness of banking system for developing countries and transition economies using these models are few to date. Gelos and Roldos (2002) analyze a number of banking markets using the PR-methodology, including some developing countries. They report that, overall banking markets in their sample of eight European and Latin American countries have not become less competitive, although concentration has increased. They conclude that lowered barriers to entry, such as allowing increased entry by foreign banks, appeared to have prevented a decline in competitive pressures associated with consolidation. Philippatos and Yildirim (2002) investigate 14 Central and Eastern European banking systems using bank-level data and the PR-methodology. They find, except for Latvia, Macedonia, and Lithuania, that these banking system can neither be characterized as perfectly competitive or monopolistic. Overall, they conclude that large banks in transition economies operate in a relative more competitive environment compared to small banks.[3]

[3] Their findings on differences across countries find support in the analysis of Fries, Neven and Seabright (2002). The latter investigate bank performance in 16 transition economies and find that bank performance varies significantly with progress in banking and enterprise reform as well as competitive conditions in the respective country.

Differences between assessments of the competitiveness of banking systems using the Breshnahan and the P-R methodologies appear small, as already noted for Canada. In a broad comparison, Bikker and Haaf (2001) use both the PR model as well as the Breshanan model, the latter to the market for deposit and loan facilities. They first apply the PR model to 17 European and six non-European (US, Japan, Korea, New Zealand and Canada) markets. They reject both perfect competition and perfect cartel for all markets when including all banks, but cannot reject perfect collusion for Australia and Greece when analyzing only small banks. They find some evidence that smaller banks operate in less competitive environments than larger banks do, suggesting that local markets are less competitive than national or international markets are. They also find that in general, competition appears to be less in non-European countries. Using the Breshanan model for nine EU-countries in their sample of 17 EU-countries, they find that the markets for deposit and loan facilities are probably highly competitive, a result in line with their results of the PR model, suggesting that the two methodologies lead to similar assessments.

Empirical competition tests other than using the Breshanan and the PR model have also been conducted, although few so far. Kessidis (1991) has developed a model of contestability which focuses on sunk costs. A recent study using this model on the EU-banking markets is Corvoisier and Gropp (2002). They focus on the effects of advances in information technology, given its effects on sunk costs, on competition. They find evidence for an increase in contestability in deposit markets and more moderate effects for loans markets, which they conjecture is because technology has reduced, sunk costs more in deposit than in loan markets.

2. METHODOLOGY

We use the Panzar and Rosse (1982, 1987) (henceforth PR) approach to assess the competitive nature of banking markets around the world. The Panzar-Rosse *H* statistics is calculated from reduced form bank revenue equations and measures the sum of the elasticities of the total revenue of the banks with respect to the bank's input prices. The Panzar-Rosse *H* statistic is interpreted as follows. $H<0$ indicates a monopoly; $H=1$ indicates perfect competition; and $0<H<1$ indicates monopolistic competition. Nathan and Neave (1989) point out that this interpretation assumes that the test is undertaken on observations that are in long-run equilibrium. We therefore also test whether the observations are in long-run equilibrium, which involves estimating a parameter *E,* where $E=0$ indicates equilibrium and $E<0$ indicates disequilibrium.

2.1 Competitive environment test I

We estimate the following reduced form revenue equations on pooled samples for each country:

$$\begin{aligned} \ln(P_{it}) = \alpha &+ \beta_1 \ln(W_{1,it}) + \beta_2 \ln(W_{2,it}) + \beta_3 \ln(W_{3,it}) + \\ &+ \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \\ &+ \delta D + \varepsilon_{it} \end{aligned} \qquad (1)$$

where P_{it} is the ratio of gross interest revenue to total assets (proxy for output price of loans), $W_{1,it}$ is the ratio of interest expenses to total deposits and money market funding (proxy for input price of deposits), $W_{2,it}$ is the ratio of personnel expense to total assets (proxy for input

price of labor),[4] $W_{3,it}$ is the ratio of other operating and administrative expense to total assets (proxy for input price of equipment/fixed capital). The subscript *i* denotes bank *i*, and the subscript *t* denotes year *t*.

We include several control variables. Specifically, $Y_{1,it}$ is the ratio of equity to total assets, $Y_{2,it}$ is the ratio of net loans to total assets, and $Y_{3,it}$ is the logarithm of total assets (to control for potential size effects). D is a vector of year dummies for the years 1995 through 2001 (we drop the year dummy for the year 1994). We take natural logarithms of all variables. We estimate model (1) both using OLS with time dummies and GLS with fixed bank-specific effects (in the latter case $\alpha = \alpha_i$). The *H*-statistic then equals $\beta_1 + \beta_2 + \beta_3$. We test whether $H = 1$ and whether $H = 0$ using a F-test. In what follows we refer to H1 as the H-statistic based on model (1) and estimated using OLS, and to H2 as the H-statistic based on model (1) and estimated using GLS with fixed-bank effects. Model (10) is similar to models used previously in the literature to estimate H-statistics for banking industries.

2.2 Equilibrium test I

Since the PR-model is only valid if the market is in equilibrium, we also estimate the following equation for each country:

[4] Due to lack of data on total employees, we do not express the unit cost of labor in terms of total employees but in terms of total assets.

$$\ln(ROA_{it}) = \alpha + \beta_1 \ln(W_{1,it}) + \beta_2 \ln(W_{2,it}) + \beta_3 \ln(W_{3,it}) + \\ + \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \\ + \delta D + \varepsilon_{it} \qquad (2)$$

where ROA is the pre-tax return on assets (pre-tax profits to total assets). Because return on assets can take on (small) negative values, we compute the dependent variable as *ROA'*=ln(1+*ROA*) where *ROA* is the unadjusted return on assets. We define the equilibrium *E*-statistic as $\beta_1 + \beta_2 + \beta_3$. We test whether $E = 0$, again using a F-test. If rejected, the market is assumed not to be in equilibrium. In what follows we refer to E1 as the E-statistic based on model (2) and estimated using OLS, and to E2 as the E-statistic based on model (2) and estimated using GLS with fixed-bank effects. The idea behind model (2) is that, in equilibrium, returns on bank assets should not be related to input prices. This approach for testing whether the observations are in long-run equilibrium has previously been used in the literature (see, for example, Shaffer 1982 and Molyneux et al. 1996). Model (2) is similar to the models used in those papers.

2.3 Competitive environment test II

For robustness, we estimate the following alternative reduced revenue equations:

$$\ln(Pa_{it}) = \alpha + \beta_1 \ln(Wa_{1,it}) + \beta_2 \ln(Wa_{2,it}) + \beta_3 \ln(Wa_{3,it}) + \\ + \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \\ + \delta D + \varepsilon_{it} \qquad (1a)$$

where Pa_{it} is the ratio of total revenue to total assets (where total revenue is calculated as gross interest revenue plus other operating revenues, such as fee income, commission income, etc.), $Wa_{1,it}$ is the ratio of interest expenses to total deposits and money market funding plus total other funding (including bonds, subordinated debt and hybrid capital), $Wa_{2,it}$ is the ratio of personnel expense to total deposits plus money market instruments plus net loans, $Wa_{3,it}$ is the ratio of other operating and administrative expense to fixed assets. The dependent variable now includes non-interest revenues. The *H*-statistic equals $\beta_1 + \beta_2 + \beta_3$. We test again whether $H = 1$ and whether $H = 0$ (F-tests). In what follows we refer to H3 as the H-statistic based on model (1a) and estimated using OLS, and to H4 as the H-statistic based on model (1a) and estimated using GLS with fixed-bank effects.

2.4 Equilibrium test II

We estimate the following equation for each country:

$$\begin{aligned} \ln(ROA_{it}) = \alpha &+ \beta_1 \ln(Wa_{1,it}) + \beta_2 \ln(Wa_{2,it}) + \beta_3 \ln(Wa_{3,it}) + \\ &+ \gamma_1 \ln(Y_{1,it}) + \gamma_2 \ln(Y_{2,it}) + \gamma_3 \ln(Y_{3,it}) + \\ &+ \delta D + \varepsilon_{it} \end{aligned} \qquad (2a)$$

We define the equilibrium *E*-statistic as $\beta_1 + \beta_2 + \beta_3$. We then test whether $E = 0$ (F-tests). If rejected, the market is not in equilibrium. In what follows we refer to E3 as the E-

statistic based on model (2a) and estimated using OLS, and to E4 as the E-statistic based on model (2a) and estimated using GLS with fixed-bank effects.

3. DATA AND EMPIRICAL RESULTS

3.1 Data

We use bank-level data from BANKSCOPE, a database containing bank financial statements used in a number of other cross-country studies. We have panel data for the years 1994-2001 and we include all banks (commercial banks, savings banks, cooperative banks, and bank holding companies). We use data from consolidated accounts if available, and otherwise from unconsolidated accounts (to avoid double-counting).

We start with the complete sample of banks in BANKSCOPE, resulting in a total number of bank-year observations of 54,038 (on average 6,755 banks per year). The sample we end up using is smaller, however, as we apply some selection criteria. First, we apply a number of outlier rules to the main variables (roughly corresponding to the 1st and 99th percentiles of the distributions of the respective variables). We also delete countries with less than 50 bank-year observations (we need a reasonable number of bank-year observations for each country to estimate the H-statistic; we set the minimum number of observations to 50). This reduced sample consists of 37,107 bank-year observations. We also delete countries with data for less than 20 banks since we need at least 20 observations per country to get reasonable accurate H estimates for each country. Furthermore, some countries in Bankscope do not have adequate coverage of

banks and only include the very large banks in the country.[5] Table 1 provides for a detailed overview of how the various outlier rules affect the sample we end up using.

The final sample consists of 35,834 bank-year observations (4,479 banks on average per year). It is an unbalanced panel with the largest number of 5,002 banks observations for the year 1999.[6] The final sample we use consists of 50 countries.[7] Table 2 reports the summary statistics of each of explanatory variables by country (country averages). In terms of number of banks, banks from Germany, United States, Italy, France and Switzerland dominate the sample. In each of these countries we have more than 1,000 bank-year observations (see also Table 3).

3.2 Competitive environment tests

We estimate the *H*-statistics on the basis of four models. The four estimates vary as follows in terms of estimation technique, Pooled OLS with time dummies vs. Fixed effects with time dummies, and in terms of dependent variable, Gross interest revenue as dependent variable vs. Total revenues as dependent variable. The results are reported in Table 3. Out of the 200

[5] We therefore drop observations from the following countries (with number of bank-year observations between brackets): Bahrain (55), Bolivia (100), Cayman Islands (52), Cyprus (51), El Salvador (62), Ireland (80), Israel (91), Jordan (59), Kazakhstan (60), Republic of Korea (59), Nepal (50), Puerto Rico (US) (55), Saudi Arabia (70), Slovak Republic (80), Slovenia (90), Sweden (73), Thailand (61), United Arab Emirates (66), and Vietnam (59).

[6] The distribution of the sample across years is as follows: 3,934 banks in 1994, 4,327 banks in 1995, 4,633 banks in 1996, 4,731 banks in 1997, 4,852 banks in 1998, 5,002 banks in 1999, 4,741 banks in 2000, and 3,614 banks in 2001. The total number of bank-year observations is 35,834.

[7] These countries are (with number of bank-year observations between brackets): Argentina (278), Australia (126), Austria (760), Bangladesh (132), Belgium (371), Brazil (248), Canada (224), Chile (148), Colombia (167), Costa Rica (111), Croatia (196), Czech Republic (90), Denmark (646), Dominican Republic (121), Ecuador (106), France (1,926), Germany (13,015), Greece (95), Honduras (68), Hong Kong, China (243), Hungary (112), India (399), Indonesia (353), Italy (2,508), Japan (100), Kenya (106), Latvia (85), Lebanon (371), Luxembourg (277), Malaysia (228), Mexico (58), Netherlands (227), Nigeria (86), Norway (259), Pakistan (148), Panama (88), Paraguay (92), Peru (132), Philippines (237), Poland (138), Portugal (213), Russian Federation (232), South Africa (186), Spain (839), Switzerland (1,048), Turkey (69), Ukraine (71), United Kingdom (569), United States (7,261), and Venezuela (171).

estimates, there are only two inconsistent estimates. Specifically, using the fixed effects with total revenues as the dependent variable estimator, the estimate of 1.08 observed for Honduras and the estimate of –0.02 for Japan are both theoretical impossible.[8] Otherwise, we find that the four measures generally provide close estimates of the H-statistic for each country. The correlations between the estimates are between 0.14 and 0.40 (see also Table 5). Excluding the 10 countries with the largest absolute differences among each of the four estimates,[9] the correlations between the estimates are higher, between 0.23 and 0.61. This suggests that the methods are quite robust. The average H-statistic varies between the four estimation techniques from 0.60 to 0.70, suggesting that monopolistic competition is the best description of the average degree of competition. There do not appear to be any strong patterns among type of countries, although it is interesting that some of the largest countries (in terms of number of banks and general size of their economy) have relatively low values for the H-statistics. The U.S., for example, has an H1 of 0.15 and Germany has an H1 of 0.39, much below the overall averages.

3.2 Equilibrium tests

Conducting the equilibrium tests we find that the banking systems of most countries are in "equilibrium" (Table 4). Although the F-tests indicate disequilibria for many countries from a statistical point of view, in the sense that the tests reject that the parameter E equals zero, the absolute levels of the equilibrium-*E*-statistics are so close to zero that we can argue that the

[8] However, both estimates are not statistically significantly different from 1 respectively 0 (and very close to 1 and 0 in economic terms).
[9] These countries are: Bangladesh, Greece, Hong Kong (China), Hungary, Japan, Mexico, Paraguay, South Africa, Turkey, and Ukraine.

systems are in "equilibrium" from an economic point of view. We therefore proceed with using all the observations.

3.3 Determinants of the *H*-Statistic

We next try to identify factors that can explain the assessment of the competitiveness of the banking system across countries. To do so, we regress each of the four *H*-statistics on a number of country characteristics. The regression model is as follows:

$$H_i = \alpha + \beta \mathrm{B}_i + \varepsilon_i$$

where H_i is the *H*-statistic for country *i*, based on individual bank data for the period 1994-2001, and B_i is a vector of country characteristics. Since there is some variation between the four measures, we also conduct the regressions using the average of the four *H*-statistics as dependent variable as a robustness test.

We run the cross-country regressions for our regular sample of 50 countries that includes only countries with at least 50 bank-year observations and at least 20 banks. We also run the cross-country regressions using a smaller sample of 39 countries that includes only countries with at least 100 bank-year observations and at least 20 banks.

As explanatory variables we use a number of variables also used in other cross-country studies to explain banking system performance and stability. From the date base established by

Barth, Caprio, and Levine (2001), we use two regulatory variables, the Entry fit test variable, an indicator of the severity of the entry regime with higher scores indicating less severe restrictions; and the Activity restrictions variable, indicating the limits imposed on commercial banks to engage in securities markets, insurance and real estate activities. The Entry fit variable refers to the actual practices of the supervisory agencies in the country, while the Activity variable refers to the legal rules in place. We also use from the Barth, Caprio, and Levine data base a number of banking system structure variables: the share in assets/numbers of banks which are foreign-controlled, the Foreign bank ownership variable; the density of bank banks, the Logarithm of the number of banks per million inhabitants in a particular country; and a measures of banking system concentration, the 5-bank concentration ratio. Data typically refer to the situation as of end-1999, which is towards the end of our data period. As in other studies, we rely on the relative stability of the regulation and supervision indicators.

We furthermore use a number of other data to describe the structure of the banking system, the competition coming from the non-banking sector, the macro-economic conditions, and the overall development of the country. To investigate the impact of the degree of competition banks face from non-bank financial institutions, we use a measure on the overall size of the other financial services that has been collected by Beck, Demirguc-Kunt and Levine (2000). We also use data on the importance of the insurance industry, specifically we use life insurance penetration, defined as the amount of annual life insurance premiums collected divided by GDP. These data refer to the year-end 1994. We expect to find a positive coefficient for both indicators as the greater these other parts of the financial sector are the more competitive pressure there will be on the banking system.

Finally, we control for macro-economic stability and the general economic development as these can be expected to affect banking system performance. As an indicator for macro-economic stability, we use the inflation rate in 1995. We expect that it will be less likely that a banking system will be more competitive when it is subject to high inflation as prices of financial services, such as interest rates, will be less informative. As proxy for the general level of development of the country, we use the logarithm of per capita GDP in 1995. Others have found that the general level of development can affect how the structure of the banking system, including its concentration, affects it performance and competitiveness. We expect that in more developed countries banking system structure indicators have a less close relationship with competitiveness indicators. Both data come from the World Development Indicators (WDI).

Table 5 reports the matrix of correlations between and among the dependent and independent variables. As a start, it is useful to note that many of the correlations are not statistically significant, out of the 55 correlations only 18 are significant at the 10% level. As noted, the four competitiveness indicators are positively correlated among each other, although only half of the correlations are not statistically significant at the 10% level. There are positive correlations between the competitiveness indicators and the banking systems concentration variables, although many are not statistically significant. The correlations between the competitiveness indicators and the number of banks per population, log of per capita GDP and inflation are mostly not statistically significant. The most consistency in the correlations is for the foreign bank ownership and activity restrictions where both two of the four correlations with the competitiveness indicators are statistically significant at the 10% or better level. In terms of

correlations among the independent variables, the bank density variable is significantly negatively related to the activity restriction and inflation variables and significantly positively to the general development variable. Activity restrictions are significantly negatively related the general development and significantly positively to inflation, while inflation and general level of development are significantly negatively related, which is to be expected.

Table 6 reports the base regression results regarding the cross-country determinants of our PR's *H*-statistic. The results are presented in panels, depending on the number of independent variables included. All regressions include the two macro-economic variables we have, GDP per capita and inflation, to control for differences in economic development. Besides these two macro variables, Panel A includes only the entry fit test and foreign ownership variables. Panel B includes besides these two variables also the bank concentration and the density of banks variables. Panel C investigates specifically the impact of restrictions on the activities of banks, in terms of providing other types of financial services. Panel D investigates the role of both entry fit test and foreign ownership as well as restrictions on the activities of banks. Panel E investigates directly the impact of competition from other financial services industries (inter-industry competition) on margins by adding variables on the size of other financial services industries. Since the variables we have on these other industries are correlated (see Beck et al. 2001), we enter the non-bank financial development variables one at a time.

There are many coefficients that are not statistically significant and results that vary between the different regression specifications, in part because the number of observations varies between the regressions. There is some consistency, however, across the results. Of the

variables we use, we find that cross-country variations in bank competition are best explained by differences in the degree of foreign bank ownership. More foreign bank ownership seems to improve the level of competition in the home market, a result we find in most of our specifications. Next, we find that less severe entry fitness tests and fewer activity restrictions also positively affect banking system competition in a quite consistent way. The general level of development and the inflation rate are most often not statistically significant and the sign of the coefficients are not obvious. When significant, GDP per capita has once a negative sign and twice a positive sign, and when significant, the inflation rate has twice a negative sign and twice a positive sign.

Besides the foreign bank ownership variable, we find little evidence that variables describing the banking system structure can help explain its measured competitiveness, or at least in the way typically posed. We find that bank concentration and none of the four *H*-statistics are negatively correlated as may be expected, but rather we find some positive relationship, that is, more concentrated banking systems seem to face a greater degree of competition. It may be that the *H*-statistic and the bank concentration measure are two different concepts that measure different concepts, that is, bank concentration may not be a good summary statistic for bank competitive environment. Similarly, the number of banks variable is never significantly positively related to the competition indicator, and, although not statistically significant, has sometimes even a negative sign, that is the less banks, the more competitive the system is (Panel B). In summary, it appears that assuring a contestable system is the most important to assure a competitive banking system.

4. ROBUSTNESS TESTS

We want to conduct a number of robustness checks to verify that our results are not affected by the specific measure we developed for the competitiveness of the banking system, or the type of banks or the sample of countries we focus on in the regressions. We start with a different measure of the degree of competitiveness. Specifically, we use a partial H statistic, which is only based on the elasticity-component of deposit prices, i.e., the estimates of β_1 in equation (1). Arguably, this part of the *H*-statistic is estimated most precisely as the data on deposits are very reliable, while we often lack good data on the unit cost of labor and fixed capital. We use the same sample as before and report the partial H-statistics in Table 7. As will be obvious, the partial H-statistic is always smaller than the total statistic reported before. It also takes on values that are more consistent than before across the four estimation techniques, with the correlations between 0.42 and 0.66. This may be because the data on deposits are more reliable.

Table 8 reports regression results with this partial H statistics as dependent variable, where we only report those regression panels where we found meaningful results before. We find again many insignificant coefficients and variation in results across regression specifications. There is consistency, however, across the results and with the earlier results. The degree of foreign bank ownership continues to exert a positive effect on bank competition and is even more often statistically significant. This is shown in panel A and B where more foreign bank ownership seems to improve the level of competition in the home market when controlling not only for the level of general development and inflation, but also for some of the industrial organization regulations in place. We again find that less severe entry fitness tests

positively affect banking system competition. Fewer activity restrictions only have a significantly negative sign for one of the partial H-statistics. When significant, GDP per capita has twice a negative sign, suggesting somewhat surprisingly that more developed countries have less competitive banking system, and inflation rate has twice a negative sign, suggesting that lack of macroeconomic stability has a negative effect on banking system competitiveness.

As a second robustness test, we differentiate between small banks and large banks in countries with a large cross-section of banks. Small banks can be assumed to operate predominantly at a local scale whereas large banks can be assumed to compete at both national and international levels, with medium banks taking intermediate positions. Indeed, as mentioned, others have found that measures of competitiveness can differ depending on whether small and large banks are studied (Hempel 2002 and De Bandt and Davis 2000). These tests have, however, been done for either one country or for economies which were comparable in size, e.g., some of the largest EU-countries.

We can differentiate between small banks and large banks only in countries with a large cross-section of banks. First, for these countries the difference between measures of competitiveness for the two different groups of banks is expected to be largest due to the presence of a large number of small banks that do not compete at national levels. Second, on a cross-country basis, the problem arises with the definition of small and large banks. If this is done relative to the country's market, e.g., the largest five banks in the country, then it will capture banks of very different asset size across countries. It will have the advantage that we can assume that the largest banks in a country have nation-wide coverage and do compete with each

other, assuming the national market is the relevant market. It will be hard to argue, however, that it is a size effect since a large bank in one country can be a very small bank in another country. At the same time, an absolute measure of a large bank has some advantages as it allows for easier comparison across markets. We may have also better quality of data, as large banks may have better reporting standards. Furthermore, even if it are the small banks that are more important in affecting the competitive environment in the country, we would still see that reflected in our competitiveness indicators for the large banks.

For countries with a large cross-section of banks, i.e., France, Germany, Italy, and the U.S., we include only banks with at least US$ 5 billion in total assets (in any period). Estimated H-statistics and E-statistics for these four countries based on the sub-sample of large banks are reported in Table 9. The table shows that the number of large banks in each of these countries is considerably less, in case of Germany only 76 banks instead of 2,226 banks for the full sample. As can be seen from a comparison with Table 3, for the largest banks in these countries the competitiveness indicators are almost all larger than the ones for the whole sample (the one exception is the H2 measure for the U.S which is slightly lower). This suggests that in these countries large banks operate in a more competitive environment, possibly because they are less locally oriented.

For the other countries, the H-statistics are unchanged and identical to those reported in Table 3. We then combine the new H-statistics for the four countries with those of the other countries and rerun the same regressions as in Table 6, differing in independent variable only for the four countries with a large number of banks. The regression results are reported in Table 10.

We find that there are again a few statistically significant variables with these alternative H-statistics. Basically only the entry fit test, the activity restrictions and the foreign bank ownership variables are statistically significant, although not always. The signs are the same: fewer restrictions on entry and activities and more foreign bank ownership lead to a higher of competitiveness in the banking system. It also seems that more developed, higher income countries have less competitive banking systems. Finally, higher inflation seems to have a negative effect, but the variable is only twice statistically significant. The role of non-bank financial institutions in terms of competition is unclear as none of the coefficients are statistically significant.

As a third robustness check, we run the regressions on a smaller sample of 39 countries that includes countries with at least 100 bank-year observations and at least 20 banks (i.e., at least five year-observations on average per bank). This rule leads us to exclude the following countries: Bangladesh, Czech Republic, Greece, Honduras, Japan, Latvia, Mexico, Panama, Paraguay, Turkey, and Ukraine. This rules also leads us to remove those countries with "invalid" *H*-statistic estimates (i.e., above 1) (probably due to lack of observations). The regression results based on this smaller set of countries are reported in Table 11, where we follow the specifications used in Table 8.

We find that the entry fit test and the foreign bank ownership variables are statistically significant, with the foreign bank ownership more often than the entry fit tests. The signs remain the same: fewer restrictions on entry and more foreign bank ownership lead to more competition. It also seems that the larger the number of banks, the less competitive the system is. This is

somewhat surprising but consistent with the sign for the banking system concentration variables, which is positive (although the variable is never statistically significant). Finally, the inflation variable is never statistically significant.

5. CONCLUSIONS

Using a structural model, we estimate competitiveness indicators for a large cross-section of countries. When we relate our competitiveness indicator to a number of country characteristics, we find that lack entry restrictions in the banking sector and greater foreign bank presence can make for more competitive banking systems. We also find that activity restrictions on commercial banks can reduce competition. This suggests that being open to new entry is the most important competitive pressure. We find no evidence that banking system concentration is negatively associated with competitiveness. At the opposite, we find some evidence that more concentrated banking systems are more competitive. Similarly, we have some, although not strong evidence that the competitiveness of banking systems relates negatively to the number of banks in the country. We find that many of these results remain using a number of robustness tests.

While our results confirm much of traditional industrial organization theory that contestability rather than structure is the most important for competition, the fact that the structure matters so little, or even in opposite ways to expectations, might surprise many involved with competition policy in the financial sector. It suggests at the minimum that competition policy in the financial sector is more complicated than perhaps previously thought.

Competition policy in the financial sector has traditionally centered on balancing franchise value, important for prudential concerns and related to the so-called special nature of banks, with allowing more competition forces with greater entry. This tradeoff implied that the preferred solution often was though to be a more concentrated system with less entry that was less competitiveness. Changes in the production and distribution of financial services, altering industrial structures and large deregulations, including the removal of barriers between markets and products, may have made for new industrial structures that require a different competition policy paradigm. Some of the elements of this new paradigm for the financial sector can be borrowed from traditional industrial organization research. It will need to be adapted, however, to take into account the increased importance of networks and network externalities in financial services industries.

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Table 1 Sample and Outlier rules

	Number of bank-year observations
All banks for the years 1994-2001	54,038
-/- Observations for which:	
Interest income to total assets (P)<2%	843
Interest income to total assets (P)>30%	756
Interest expense to total deposits plus money market funding (W1)<1%	2,461
Interest expense to total deposits plus money market funding (W1)>20%	1,806
Personnel expense to total assets (W2)<0.5%	3,631
Personnel expense to total assets (W2)>20%	3,958
Other operating and administrative expenses to total assets (W3)<0.1%	170
Other operating and administrative expenses to total assets (W3)>20%	179
Equity to total assets (Y1)<1%	232
Equity to total assets (Y1)>50%	310
Net loans to total assets (Y2)<1%	862
Net loans to total assets (Y2)>100%	37
Pre-tax profits to total assets (ROA)<-10%	72
Pre-tax profits to total assets (ROA)>20%	23
	38,698
-/- Observations from countries with less than 50 bank-year observations	1,591
	37,107
-/- Observations from countries with data on less than 20 banks	1,273
	35,834

Table 2 Summary statistics

Summary statistics: Country averages for the years 1994-2001.
Y3 is expressed in billions of U.S. dollars. All other variables are expressed as percentages.

Country	P	Pa	W1	Wa1	W2	Wa2	W3	Wa3	Y1	Y2	Y3	ROA
Argentina	9.79%	14.15%	5.76%	5.45%	3.97%	3.12%	3.57%	111.40%	15.30%	48.49%	2.22	0.59%
Australia	7.25%	9.07%	6.44%	5.46%	1.22%	0.84%	1.71%	268.30%	7.19%	73.39%	28.90	1.31%
Austria	5.61%	7.14%	3.73%	3.39%	1.50%	1.11%	1.22%	135.96%	6.91%	57.37%	1.85	0.66%
Bangladesh	6.25%	8.40%	5.40%	5.21%	1.14%	0.81%	0.98%	171.97%	4.90%	54.35%	0.59	1.39%
Belgium	6.53%	7.39%	5.20%	4.66%	1.17%	0.95%	1.02%	281.94%	7.25%	42.91%	17.30	0.74%
Brazil	15.99%	20.64%	13.91%	12.83%	3.75%	3.70%	4.93%	434.57%	12.86%	37.97%	9.09	1.84%
Canada	6.66%	8.28%	5.54%	5.27%	1.35%	1.00%	1.44%	399.61%	8.77%	65.74%	11.30	0.61%
Chile	10.45%	11.53%	8.71%	7.72%	1.68%	1.30%	1.36%	68.45%	14.66%	59.88%	2.89	0.97%
Colombia	15.68%	21.39%	12.49%	11.95%	3.49%	2.52%	5.10%	186.44%	13.67%	61.37%	0.99	0.94%
Costa Rica	12.48%	14.90%	10.43%	10.20%	2.43%	1.74%	2.63%	173.47%	15.89%	63.14%	0.21	1.52%
Croatia	8.02%	10.86%	5.31%	4.69%	2.28%	2.01%	2.64%	60.76%	17.46%	47.06%	0.48	0.82%
Czech Republic	8.12%	10.29%	6.77%	6.45%	0.91%	0.76%	2.40%	115.25%	8.74%	42.76%	3.94	0.43%
Denmark	7.59%	8.80%	3.37%	3.23%	2.17%	1.58%	1.63%	107.87%	12.53%	55.35%	3.29	1.60%
Dominican Rep.	13.34%	16.15%	10.04%	8.79%	2.74%	2.13%	3.40%	92.12%	12.81%	58.29%	0.46	2.26%
Ecuador	13.71%	18.05%	10.35%	9.99%	3.23%	2.70%	4.35%	120.61%	14.49%	49.04%	0.31	1.76%
France	6.69%	8.27%	4.95%	4.70%	1.76%	1.33%	1.45%	323.05%	7.32%	56.19%	14.70	0.72%
Germany	6.35%	7.26%	4.01%	3.78%	1.50%	1.01%	1.10%	111.98%	5.05%	61.14%	1.75	0.71%
Greece	9.47%	11.95%	7.71%	7.73%	1.89%	1.45%	1.49%	88.14%	9.45%	43.99%	9.95	1.62%
Honduras	15.26%	16.38%	10.82%	9.61%	3.03%	2.33%	3.26%	87.50%	12.09%	56.65%	0.16	1.65%
Hong Kong	7.60%	8.61%	6.17%	6.09%	1.05%	0.83%	0.82%	131.70%	13.18%	56.01%	11.10	1.48%
Hungary	11.43%	13.84%	9.45%	8.59%	1.54%	1.26%	2.81%	462.20%	10.03%	47.29%	1.41	1.70%
India	9.73%	11.14%	7.76%	7.67%	1.79%	1.37%	0.86%	88.50%	5.00%	43.74%	3.82	0.86%
Indonesia	13.11%	14.23%	11.31%	10.52%	1.29%	0.91%	1.67%	189.61%	10.65%	62.56%	1.73	1.55%
Italy	7.23%	8.30%	5.06%	4.34%	1.90%	1.57%	1.52%	116.90%	10.91%	50.47%	6.21	1.12%
Japan	3.55%	3.91%	1.73%	1.71%	1.01%	0.65%	0.80%	53.28%	4.48%	69.22%	37.90	-0.26%
Kenya	14.07%	16.85%	9.68%	9.58%	2.70%	2.25%	3.19%	109.05%	17.51%	50.01%	0.12	2.07%
Latvia	8.15%	12.50%	4.20%	4.06%	2.54%	2.28%	4.12%	99.18%	11.99%	35.77%	0.17	1.10%
Lebanon	10.04%	11.16%	7.90%	7.88%	1.65%	1.43%	1.26%	79.54%	9.80%	32.88%	0.58	1.20%
Luxembourg	6.06%	8.39%	5.75%	5.71%	1.18%	1.09%	1.20%	389.11%	6.55%	26.54%	3.93	1.03%
Malaysia	7.11%	8.21%	4.82%	4.79%	0.87%	0.61%	0.87%	125.70%	9.25%	59.92%	4.86	1.53%
Mexico	15.92%	17.90%	14.02%	13.64%	1.96%	1.43%	3.13%	640.54%	15.03%	60.83%	7.73	0.77%
Netherlands	6.22%	8.14%	5.40%	5.27%	1.38%	1.08%	1.21%	194.32%	7.81%	56.52%	38.40	1.08%
Nigeria	12.13%	18.13%	7.65%	7.53%	2.41%	2.43%	5.73%	126.17%	11.40%	33.21%	0.44	3.95%
Norway	7.13%	8.31%	5.49%	4.82%	1.20%	0.75%	1.42%	161.21%	8.39%	84.68%	4.23	1.31%
Pakistan	9.17%	10.93%	7.50%	7.49%	1.38%	1.06%	1.46%	97.74%	7.33%	44.82%	1.28	1.27%
Panama	8.40%	9.48%	6.59%	6.08%	1.07%	0.74%	1.38%	125.83%	9.57%	62.78%	0.57	1.44%
Paraguay	15.24%	17.98%	10.06%	10.21%	3.71%	2.79%	3.59%	166.56%	15.47%	55.42%	0.14	2.59%
Peru	11.56%	13.64%	7.57%	7.42%	2.87%	2.15%	3.88%	82.93%	10.74%	58.46%	0.76	0.80%
Philippines	9.10%	11.00%	7.77%	7.62%	1.45%	1.13%	2.49%	108.49%	16.72%	62.19%	1.75	1.17%
Poland	13.49%	16.40%	10.61%	10.57%	2.29%	1.82%	0.76%	46.23%	11.83%	49.09%	1.92	2.06%
Portugal	7.41%	8.79%	6.07%	5.81%	1.42%	1.15%	1.41%	86.93%	8.17%	51.06%	9.25	0.54%

Country	P	Pa	W1	Wa1	W2	Wa2	W3	Wa3	Y1	Y2	Y3	ROA
Russian Federation	12.00%	19.98%	8.42%	8.12%	3.16%	2.76%	5.26%	192.91%	18.39%	42.98%	0.85	3.98%
South Africa	13.34%	16.05%	11.32%	10.24%	2.11%	1.48%	2.07%	189.70%	10.84%	71.99%	8.68	1.96%
Spain	6.74%	7.77%	4.23%	4.13%	1.64%	1.20%	1.18%	68.05%	8.81%	56.67%	12.20	1.10%
Switzerland	4.43%	8.27%	3.86%	3.33%	2.09%	1.95%	1.98%	290.41%	13.59%	59.94%	9.96	1.50%
Turkey	19.33%	19.62%	12.73%	12.64%	2.51%	2.23%	3.30%	118.05%	11.77%	37.65%	2.13	2.94%
Ukraine	14.89%	22.66%	10.27%	10.07%	3.37%	2.95%	5.32%	131.04%	21.53%	47.07%	0.12	3.81%
United Kingdom	7.54%	9.94%	5.66%	5.23%	1.75%	1.52%	1.89%	221.12%	12.09%	50.58%	43.50	1.68%
United States	6.89%	8.33%	4.79%	4.71%	1.48%	1.11%	1.62%	145.91%	9.03%	63.12%	10.80	1.59%
Venezuela	18.13%	20.12%	8.40%	8.12%	3.90%	3.11%	5.09%	526.08%	12.53%	45.18%	0.78	2.99%
Total	7.30%	8.80%	5.07%	4.77%	1.67%	1.26%	1.56%	150.65%	8.21%	58.12%	6.64	1.13%

Table 3 H-statistics

The table displays estimated H-statistics for each country in the sample based on the Panzar and Rosse (1987) approach. The H-statistics are based on a sample that includes observations from countries with a total number of at least 50 bank-year observations and observations on at least 20 banks. H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. Standard errors of the H-statistics are reported between brackets.

Country	H1	H2	H3	H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
Argentina	0.71	0.78	0.62	0.80	105	278
	(0.06)	(0.07)	(0.05)	(0.07)		
Australia	0.43	0.86	0.94	0.98	26	126
	(0.19)	(0.05)	(0.13)	(0.05)		
Austria	0.48	0.70	0.75	0.71	160	760
	(0.04)	(0.03)	(0.04)	(0.03)		
Bangladesh	0.88	0.84	0.66	0.39	28	132
	(0.12)	(0.11)	(0.17)	(0.12)		
Belgium	0.54	0.58	0.87	0.91	76	371
	(0.05)	(0.04)	(0.06)	(0.05)		
Brazil	0.92	0.85	0.79	0.74	96	248
	(0.05)	(0.08)	(0.04)	(0.05)		
Canada	0.62	0.61	0.83	0.60	49	224
	(0.06)	(0.06)	(0.09)	(0.06)		
Chile	0.76	0.68	0.64	0.57	31	148
	(0.07)	(0.07)	(0.09)	(0.06)		
Colombia	0.76	0.57	0.68	0.63	39	167
	(0.08)	(0.08)	(0.07)	(0.09)		
Costa Rica	0.89	0.92	0.92	0.95	30	111
	(0.06)	(0.03)	(0.05)	(0.04)		
Croatia	0.52	0.58	0.58	0.57	45	196
	(0.07)	(0.08)	(0.10)	(0.09)		
Czech Republic	0.56	0.80	0.56	1.00	25	90
	(0.08)	(0.10)	(0.18)	(0.18)		
Denmark	0.41	0.53	0.52	0.53	100	646
	(0.05)	(0.03)	(0.06)	(0.06)		
Dominican Republic	0.46	0.85	0.73	0.83	27	121
	(0.10)	(0.09)	(0.11)	(0.07)		
Ecuador	0.36	0.81	0.72	0.81	35	106
	(0.11)	(0.08)	(0.07)	(0.08)		
France	0.59	0.63	0.81	0.71	355	1,926
	(0.03)	(0.02)	(0.02)	(0.02)		
Germany	0.39	0.60	0.65	0.69	2,226	13,015

Country	H1	H2	H3	H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
	(0.02)	(0.01)	(0.02)	(0.01)		
Greece	0.89	0.84	0.55	0.77	21	95
	(0.06)	(0.06)	(0.07)	(0.10)		
Honduras	0.70	0.71	0.76	1.08	21	68
	(0.09)	(0.12)	(0.08)	(0.14)		
Hong Kong, China	0.75	0.72	0.86	0.47	44	243
	(0.06)	(0.08)	(0.07)	(0.08)		
Hungary	0.83	0.48	0.86	0.84	26	112
	(0.06)	(0.09)	(0.06)	(0.08)		
India	0.52	0.53	0.50	0.55	60	399
	(0.04)	(0.04)	(0.04)	(0.04)		
Indonesia	0.66	0.56	0.59	0.66	97	353
	(0.04)	(0.06)	(0.06)	(0.08)		
Italy	0.48	0.58	0.68	0.67	472	2,508
	(0.03)	(0.02)	(0.03)	(0.02)		
Japan	0.53	0.82	0.53	-0.02	44	100
	(0.13)	(0.17)	(0.10)	(0.28)		
Kenya	0.41	0.69	0.53	0.67	34	106
	(0.14)	(0.09)	(0.09)	(0.10)		
Latvia	0.58	0.42	0.86	0.79	24	85
	(0.11)	(0.16)	(0.13)	(0.14)		
Lebanon	0.67	0.75	0.61	0.73	63	371
	(0.06)	(0.04)	(0.05)	(0.05)		
Luxembourg	0.77	0.86	0.88	0.75	76	277
	(0.03)	(0.03)	(0.04)	(0.04)		
Malaysia	0.70	0.72	0.62	0.66	41	228
	(0.06)	(0.04)	(0.07)	(0.05)		
Mexico	0.91	0.89	0.73	0.60	27	58
	(0.10)	(0.10)	(0.09)	(0.10)		
Netherlands	0.68	0.92	0.94	0.90	44	227
	(0.04)	(0.06)	(0.06)	(0.07)		
Nigeria	0.62	0.74	0.66	0.67	42	186
	(0.06)	(0.07)	(0.05)	(0.06)		
Norway	0.05	0.59	0.91	0.72	48	259
	(0.12)	(0.05)	(0.09)	(0.04)		
Pakistan	0.39	0.51	0.47	0.55	21	148
	(0.19)	(0.11)	(0.12)	(0.08)		
Panama	0.59	0.69	0.70	0.97	32	88
	(0.07)	(0.10)	(0.11)	(0.07)		
Paraguay	0.50	0.93	0.64	0.32	23	92
	(0.06)	(0.12)	(0.16)	(0.55)		
Peru	0.76	0.73	0.69	0.71	24	132
	(0.06)	(0.06)	(0.08)	(0.07)		
Philippines	0.60	0.75	0.59	0.70	45	237
	(0.05)	(0.04)	(0.06)	(0.05)		

Country	H1	H2	H3	H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
Poland	0.77	0.79	0.71	0.82	40	138
	(0.05)	(0.05)	(0.06)	(0.07)		
Portugal	0.53	0.72	0.69	0.74	37	213
	(0.07)	(0.05)	(0.06)	(0.05)		
Russian Federation	0.60	0.55	0.54	0.46	106	232
	(0.06)	(0.09)	(0.05)	(0.09)		
South Africa	0.81	0.96	0.67	0.95	45	186
	(0.07)	(0.03)	(0.07)	(0.04)		
Spain	0.35	0.61	0.59	0.58	157	839
	(0.04)	(0.02)	(0.03)	(0.02)		
Switzerland	0.59	0.62	0.74	0.74	227	1048
	(0.03)	(0.02)	(0.03)	(0.03)		
Turkey	0.58	0.30	0.67	0.28	34	69
	(0.12)	(0.20)	(0.11)	(0.40)		
Ukraine	0.61	0.91	0.90	0.31	30	71
	(0.10)	(0.21)	(0.10)	(0.17)		
United Kingdom	0.60	0.73	0.78	0.84	106	569
	(0.04)	(0.03)	(0.04)	(0.03)		
United States	0.15	0.49	0.47	0.52	1,135	7,261
	(0.01)	(0.01)	(0.01)	(0.01)		
Venezuela	0.67	0.77	0.72	0.80	55	171
	(0.09)	(0.06)	(0.06)	(0.06)		

Table 4 Equilibrium tests

The table displays estimated E-statistics for the different countries in our sample using alternative specifications and estimation techniques, as well as the p-values of a test that E equals zero. The E-statistics E1 and E2 are estimated using our base specification. The E-statistics E3 and E4 are estimated using our alternative specification. E1 and E3 are estimated using pooled OLS, while E2 and E4 are estimated using fixed effects. All regressions include time dummies.

Country	E1	E1=0	E2	E2=0	E3	E3=0	E4	E4=0	Number of banks	Number of observations
	Pooled OLS	p-value	Fixed effects	p-value	Pooled OLS	p-value	Fixed effects	p-value		
Argentina	-0.01	0.07	-0.03	0.00	-0.01	0.02	-0.03	0.01	105	278
Australia	0.01	0.92	-0.00	0.67	0.00	0.97	-0.00	0.71	26	126
Austria	-0.00	0.29	-0.01	0.02	-0.00	0.43	-0.01	0.01	160	760
Bangladesh	-0.00	0.83	-0.02	0.04	-0.01	0.35	-0.03	0.02	28	132
Belgium	0.01	0.02	0.01	0.16	0.01	0.09	0.01	0.25	76	371
Brazil	-0.00	0.54	-0.02	0.03	0.01	0.36	-0.02	0.09	96	248
Canada	-0.01	0.02	-0.03	0.00	-0.02	0.03	-0.03	0.00	49	224
Chile	-0.01	0.04	-0.03	0.00	-0.01	0.04	-0.02	0.01	31	148
Colombia	-0.02	0.08	-0.04	0.01	-0.02	0.06	-0.03	0.02	39	167
Costa Rica	0.00	0.66	0.00	0.19	0.00	0.96	0.00	0.36	30	111
Croatia	-0.01	0.12	-0.00	0.89	-0.00	0.76	-0.00	0.85	45	196
Czech Republic	-0.02	0.00	-0.00	0.72	-0.01	0.05	0.01	0.27	25	90
Denmark	-0.01	0.26	-0.02	0.00	0.00	0.84	-0.01	0.03	100	646
Dominican Republic	-0.03	0.00	-0.02	0.09	-0.04	0.01	-0.01	0.44	27	121
Ecuador	-0.01	0.20	0.03	0.02	0.00	0.93	0.03	0.01	35	106
France	-0.00	0.01	-0.01	0.00	-0.00	0.15	-0.01	0.01	355	1,926
Germany	-0.01	0.00	-0.01	0.00	-0.00	0.01	-0.01	0.00	2,226	13,015
Greece	-0.00	0.83	-0.01	0.58	-0.00	0.74	0.00	0.77	21	95
Honduras	-0.01	0.20	0.02	0.20	-0.01	0.14	0.03	0.10	21	68
Hong Kong, China	0.01	0.10	0.01	0.37	0.00	0.73	0.01	0.17	44	243
Hungary	-0.00	0.55	-0.01	0.18	0.00	0.84	0.00	0.84	26	112
India	-0.03	0.00	-0.03	0.00	-0.02	0.00	-0.02	0.00	60	399
Indonesia	-0.01	0.01	-0.01	0.43	-0.01	0.14	-0.01	0.36	97	353
Italy	-0.01	0.00	-0.01	0.00	-0.00	0.04	-0.00	0.41	472	2,508
Japan	-0.03	0.02	-0.13	0.00	-0.02	0.07	-0.07	0.09	44	100
Kenya	-0.03	0.14	-0.04	0.13	-0.01	0.59	-0.02	0.54	34	106
Latvia	0.01	0.60	-0.01	0.72	0.01	0.39	0.01	0.56	24	85
Lebanon	-0.02	0.00	-0.02	0.00	-0.01	0.04	-0.03	0.00	63	371
Luxembourg	0.00	0.21	0.00	0.96	0.00	0.39	-0.00	0.47	76	277
Malaysia	-0.00	0.52	-0.01	0.52	-0.00	0.57	-0.00	0.76	41	228
Mexico	0.03	0.03	-0.05	0.00	-0.00	0.60	-0.04	0.01	27	58
Netherlands	0.01	0.00	0.01	0.02	0.01	0.00	0.01	0.02	44	227
Nigeria	-0.01	0.36	-0.02	0.02	0.01	0.43	-0.01	0.39	42	186
Norway	0.02	0.01	-0.00	0.65	0.02	0.01	-0.00	0.85	48	259
Pakistan	-0.00	0.66	-0.00	0.96	-0.00	0.72	0.01	0.15	21	148
Panama	-0.00	0.89	0.02	0.10	-0.02	0.05	0.03	0.03	32	88
Paraguay	-0.04	0.00	-0.05	0.03	-0.04	0.06	-0.19	0.37	23	92
Peru	-0.02	0.01	-0.01	0.04	-0.02	0.02	-0.01	0.05	24	132

Country	E1	E1=0	E2	E2=0	E3	E3=0	E4	E4=0	Number of banks	Number of observations
	Pooled OLS	p-value	Fixed effects	p-value	Pooled OLS	p-value	Fixed effects	p-value		
Philippines	-0.02	0.00	-0.01	0.22	-0.01	0.14	-0.00	0.81	45	237
Poland	0.00	0.78	0.02	0.01	0.00	0.50	0.03	0.00	40	138
Portugal	-0.02	0.02	-0.01	0.02	-0.01	0.03	-0.01	0.00	37	213
Russian Federation	-0.01	0.36	-0.01	0.23	-0.01	0.49	-0.02	0.25	106	232
South Africa	-0.01	0.39	0.01	0.13	-0.00	0.40	0.01	0.03	45	186
Spain	-0.02	0.00	-0.02	0.00	-0.02	0.00	-0.02	0.00	157	839
Switzerland	0.01	0.05	0.01	0.00	0.00	0.10	0.01	0.01	227	1048
Turkey	-0.02	0.00	-0.06	0.07	-0.02	0.04	-0.07	0.12	34	69
Ukraine	-0.01	0.12	-0.01	0.62	0.01	0.36	-0.02	0.36	30	71
United Kingdom	0.01	0.00	-0.00	0.14	0.01	0.05	-0.00	0.91	106	569
United States	-0.00	0.00	-0.01	0.00	-0.00	0.01	-0.00	0.00	1,135	7,261
Venezuela	-0.01	0.41	0.01	0.22	-0.00	0.65	0.01	0.16	55	171

Table 5 Correlation matrix

H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. All H-statistics are based on the Panzar-Rosse (1987) approach. p-values below correlation coefficients.

	H1	H2	H3	H4	Concentration ratio	Log(Number of banks/population)	Entry fit test	Foreign bank ownership	Activity restrictions	Log of Per capita GDP	Inflation
H1	1.00										
H2	0.40	1.00									
	0.00										
H3	0.21	0.26	1.00								
	0.15	0.07									
H4	0.14	0.20	0.38	1.00							
	0.32	0.16	0.01								
5-bank Concentration ratio	0.34	0.26	0.26	0.23	1.00						
	0.04	0.11	0.11	0.17							
Log(Number of banks/population)	-0.38	-0.10	0.25	0.19	-0.26	1.00					
	0.02	0.53	0.11	0.22	0.12						
Entry fit test	0.03	0.22	0.18	0.34	0.31	0.14	1.00				
	0.84	0.17	0.26	0.03	0.05	0.37					
Foreign bank ownership	0.30	-0.06	0.45	0.10	-0.08	0.23	0.02	1.00			
	0.09	0.74	0.01	0.59	0.68	0.20	0.90				
Activity restrictions	0.17	-0.07	-0.39	-0.43	-0.10	-0.55	-0.17	-0.05	1.00		
	0.28	0.68	0.01	0.01	0.54	0.00	0.30	0.79			
Log of Per capita GDP	-0.22	-0.01	0.35	0.01	-0.07	0.69	0.04	0.16	-0.45	1.00	
	0.13	0.92	0.01	0.95	0.66	0.00	0.81	0.38	0.00		
Inflation	0.28	-0.11	-0.11	-0.01	0.25	-0.54	0.12	0.10	0.42	-0.66	1.00
	0.06	0.46	0.47	0.96	0.14	0.00	0.47	0.60	0.01	0.00	

Table 6 Cross-Country Determinants of H-statistics

H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. All H-statistics are based on the Panzar-Rosse (1987) approach. Havg is the average of H1 though H4. All regressions are estimated using OLS with heteroskedasticity-consistent standard errors. A constant was added, but is not reported. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Entry and foreign ownership

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
Entry fit test	0.009	0.035*	0.025*	0.074*	0.036**
	(0.021)	(0.019)	(0.013)	(0.036)	(0.017)
Foreign bank ownership	0.003**	0.000	0.002***	0.001	0.002**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Log of Per capita GDP	-0.050*	-0.027	0.005	-0.034	-0.026
	(0.029)	(0.023)	(0.015)	(0.036)	(0.017)
Inflation	0.005	-0.047	-0.004	-0.035	-0.020
	(0.026)	(0.029)	(0.013)	(0.040)	(0.022)
Observations	32	32	32	32	32
R-squared	0.28	0.17	0.30	0.18	0.23

Panel B. Bank concentration, number of banks, entry and foreign ownership

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
5-bank Concentration ratio	0.344**	0.303**	0.110	0.337	0.273**
	(0.159)	(0.138)	(0.099)	(0.226)	(0.114)
Log(Number of banks/population)	-0.021	-0.027	0.009	0.050	0.003
	(0.022)	(0.018)	(0.018)	(0.051)	(0.020)
Entry fit test	0.002	0.028*	0.020	0.051	0.025
	(0.018)	(0.014)	(0.013)	(0.032)	(0.016)
Foreign bank ownership	0.003**	0.001	0.002**	0.001	0.002*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Log of Per capita GDP	-0.033	-0.005	-0.001	-0.069	-0.027
	(0.030)	(0.023)	(0.020)	(0.058)	(0.021)
Inflation	-0.019	-0.066**	-0.009	-0.040	-0.034
	(0.022)	(0.029)	(0.016)	(0.047)	(0.022)
Observations	31	31	31	31	31
R-squared	0.43	0.40	0.29	0.27	0.38

Panel C. Activity restrictions

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
Activity restrictions	-0.000	-0.001	-0.019**	-0.051**	-0.018*
	(0.014)	(0.011)	(0.009)	(0.021)	(0.009)
Log of Per capita GDP	-0.018	-0.016	0.025	-0.030	-0.010
	(0.031)	(0.023)	(0.017)	(0.031)	(0.019)
Inflation	0.030	-0.032	0.020	0.012	0.007
	(0.024)	(0.027)	(0.015)	(0.041)	(0.021)
Observations	39	39	39	39	39
R-squared	0.13	0.06	0.19	0.25	0.10

Panel D. Activity restrictions, Entry, and Foreign Ownership

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
Activity restrictions	0.006	0.004	-0.009	-0.045*	-0.011
	(0.014)	(0.012)	(0.007)	(0.022)	(0.009)
Entry fit test	0.015	0.037*	0.020*	0.056**	0.032*
	(0.022)	(0.020)	(0.011)	(0.027)	(0.017)
Foreign bank ownership	0.003**	0.000	0.002***	0.001	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of Per capita GDP	-0.058*	-0.027	0.006	-0.051	-0.033
	(0.033)	(0.027)	(0.017)	(0.037)	(0.020)
Inflation	-0.002	-0.050*	0.002	-0.013	-0.016
	(0.025)	(0.028)	(0.014)	(0.043)	(0.021)
Observations	31	31	31	31	31
R-squared	0.31	0.17	0.33	0.35	0.27

Panel E. Activity restrictions and competition from other financial services industries

	(1) H3	(2) H3	(3) H3	(4) H3
Activity restrictions	-0.028**	-0.015	-0.019*	-0.018*
	(0.012)	(0.010)	(0.009)	(0.009)
Other FIs assets to total financial assets	0.062			
	(0.164)			
Private credit by other FIs to GDP		-0.076		
		(0.106)		
Stock market capitalization to GDP			0.003	
			(0.019)	
Life insurance penetration				0.097
				(0.590)
Log of Per capita GDP	0.023	0.027	0.029*	0.042**
	(0.019)	(0.018)	(0.017)	(0.016)
Inflation	0.042***	0.016	0.020	0.026*
	(0.013)	(0.016)	(0.015)	(0.015)
Observations	20	38	35	36
R-squared	0.34	0.18	0.25	0.26

Table 7 Partial H-statistics

This table displays estimated *partial* H-statistics for each country in the sample. The partial H-statistics relate to the deposit input price effect only (rather than the sum of the different input price effects), but otherwise follow the Panzar and Rosse (1987) approach. The partial H-statistics are based on a sample that includes observations from countries with a total number of at least 50 bank-year observations and observations on at least 20 banks. Partial H1 is the partial H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. Partial H2 is the partial H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. Partial H3 is the partial H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. Partial H4 is the partial H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. Standard errors of the partial H-statistics are reported between brackets.

Country	Partial H1	Partial H2	Partial H3	Partial H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
Argentina	0.40	0.44	0.23	0.52	105	278
Australia	0.32	0.65	0.74	0.61	26	126
Austria	0.46	0.59	0.40	0.50	160	760
Bangladesh	0.75	0.67	0.44	0.38	28	132
Belgium	0.43	0.49	0.43	0.61	76	371
Brazil	0.66	0.58	0.45	0.50	96	248
Canada	0.51	0.53	0.51	0.40	49	224
Chile	0.48	0.59	0.36	0.43	31	148
Colombia	0.41	0.45	0.39	0.41	39	167
Costa Rica	0.61	0.78	0.51	0.68	30	111
Croatia	0.30	0.32	0.24	0.34	45	196
Czech Republic	0.42	0.63	0.30	0.50	25	90
Denmark	0.21	0.37	0.14	0.31	100	646
Dominican Republic	0.32	0.44	0.46	0.49	27	121
Ecuador	0.14	0.58	0.39	0.50	35	106
France	0.46	0.58	0.45	0.52	355	1,926
Germany	0.28	0.49	0.30	0.42	2,226	13,015
Greece	0.71	0.75	0.35	0.46	21	95
Honduras	0.43	0.52	0.43	0.55	21	68
Hong Kong, China	0.61	0.43	0.60	0.58	44	243
Hungary	0.65	0.63	0.63	0.67	26	112
India	0.43	0.47	0.43	0.44	60	399
Indonesia	0.39	0.38	0.39	0.41	97	353
Italy	0.28	0.34	0.41	0.45	472	2,508
Japan	0.29	0.38	0.17	0.28	44	100
Kenya	0.36	0.60	0.31	0.51	34	106
Latvia	0.28	0.18	0.35	0.23	24	85
Lebanon	0.58	0.62	0.47	0.58	63	371
Luxembourg	0.79	0.76	0.52	0.57	76	277
Malaysia	0.56	0.53	0.44	0.50	41	228
Mexico	0.71	0.59	0.66	0.53	27	58
Netherlands	0.70	0.68	0.51	0.55	44	227

Country	Partial H1	Partial H2	Partial H3	Partial H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
Nigeria	0.35	0.39	0.24	0.27	42	186
Norway	0.25	0.46	0.51	0.51	48	259
Pakistan	0.35	0.38	0.40	0.37	21	148
Panama	0.43	0.37	0.61	0.69	32	88
Paraguay	0.47	0.51	0.46	0.37	23	92
Peru	0.48	0.59	0.49	0.59	24	132
Philippines	0.36	0.40	0.34	0.41	45	237
Poland	0.66	0.64	0.55	0.62	40	138
Portugal	0.35	0.59	0.43	0.49	37	213
Russian Federation	0.41	0.35	0.31	0.27	106	232
South Africa	0.67	0.79	0.36	0.60	45	186
Spain	0.33	0.48	0.30	0.46	157	839
Switzerland	0.49	0.52	0.21	0.32	227	1048
Turkey	0.33	0.29	0.52	0.29	34	69
Ukraine	0.34	0.55	0.48	0.22	30	71
United Kingdom	0.47	0.58	0.42	0.56	106	569
United States	0.09	0.30	0.10	0.19	1,135	7,261
Venezuela	0.33	0.41	0.34	0.36	55	171

Table 8 Robustness: Cross-Country Determinants of Partial H-statistics

The partial H-statistics relate to the deposit input price effect only (rather than the sum of the different input price effects), but otherwise follow the Panzar and Rosse (1987) approach. The partial H-statistics are based on a sample that includes observations from countries with a total number of at least 50 bank-year observations and observations on at least 20 banks. Partial H1 is the partial H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. Partial H2 is the partial H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. Partial H3 is the partial H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. Partial H4 is the partial H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. Partial Hag is the average of partial H1 through partial H4. All regressions are estimated using OLS with heteroskedasticity-consistent standard errors. A constant was added, but is not reported. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Entry and foreign ownership

	(1) Partial H1	(2) Partial H2	(3) Partial H3	(4) Partial H4	(5) Partial Havg
Entry fit test	0.023	0.013	0.023	0.027*	0.022*
	(0.017)	(0.017)	(0.014)	(0.014)	(0.012)
Foreign bank ownership	0.003*	0.002*	0.003***	0.003**	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of Per capita GDP	-0.035	0.003	-0.019	-0.028	-0.020
	(0.031)	(0.028)	(0.023)	(0.021)	(0.020)
Inflation	-0.014	0.026	0.006	-0.037*	-0.005
	(0.030)	(0.023)	(0.023)	(0.020)	(0.018)
Observations	32	32	32	32	32
R-squared	0.17	0.19	0.26	0.26	0.27

Panel B. Activity restrictions, entry and foreign ownership

	(1) Partial H1	(2) Partial H2	(3) Partial H3	(4) Partial H4	(5) Partial Havg
Activity restrictions	-0.004	-0.025**	0.001	-0.011	-0.010
	(0.013)	(0.012)	(0.011)	(0.010)	(0.010)
Entry fit test	0.025	0.005	0.029*	0.028**	0.022*
	(0.019)	(0.017)	(0.017)	(0.014)	(0.012)
Foreign bank ownership	0.003*	0.002*	0.003***	0.002**	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of Per capita GDP	-0.047	-0.013	-0.032	-0.046**	-0.034*
	(0.034)	(0.029)	(0.022)	(0.019)	(0.019)
Inflation	-0.016	0.036	0.000	-0.036*	-0.004
	(0.030)	(0.024)	(0.023)	(0.020)	(0.017)
Observations	31	31	31	31	31
R-squared	0.20	0.30	0.30	0.35	0.34

Table 9 Competition and equilibrium test statistics: Banks with over US$ 5 billion in total assets

This table presents the H-statistics and E-statistics for four countries in our sample with a large number of banks: France, Germany, Italy and the US. The reported statistics are based on the sub-sample that includes banks with at least US$ 5 billion in total assets. H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. All H-statistics are based on the Panzar-Rosse (1987) approach. For other countries than those reported here, the statistics are identical to those reported in Table 3 and 4.

Panel A. H-statistics based on large banks only

Country	H1	H2	H3	H4	Number of banks	Number of observations
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects		
France	0.74	0.84	0.91	0.79	95	495
Germany	0.50	0.60	0.98	0.84	76	407
Italy	0.68	0.82	0.79	0.82	65	373
US	0.23	0.46	0.56	0.49	350	1,810

Panel B. E-statistics and p-values for a test of E equals zero based on large banks only

Country	E1	E1=0	E2	E2=0	E3	E3=0	E4	E4=0	Number of banks	Number of observations
	Pooled OLS	p-value	Fixed effects	p-value	Pooled OLS	p-value	Fixed effects	p-value		
France	0.00	0.23	-0.00	0.64	0.01	0.02	0.00	0.57	95	495
Germany	0.00	0.21	-0.00	0.89	0.01	0.05	-0.00	0.11	76	407
Italy	-0.00	0.08	0.00	0.87	-0.00	0.70	0.00	0.61	65	373
US	0.00	0.01	-0.01	0.00	0.00	0.03	-0.01	0.00	350	1,810

Table 10 Robustness: Cross-Country Determinants of H-statistics and Large Banks

H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. All H-statistics are based on the Panzar-Rosse (1987) approach. Havg is the average of H1 though H4. For four countries in our sample with a large number of banks, i.e., France, Germany, Italy and the US, the four H-statistics (H1 through H4) are based on the sub-sample that *excludes banks with less than US$ 5 billion* in *total assets*. All regressions are estimated using OLS with heteroskedasticity-consistent standard errors. A constant was added, but is not reported. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Entry and ownership

	(1) H1 Large Banks	(2) H2 Large Banks	(3) H3 Large Banks	(4) H4 Large Banks	(5) Havg Large Banks
Entry fit test	0.004	0.039*	0.002	0.066	0.028
	(0.018)	(0.020)	(0.026)	(0.040)	(0.018)
Foreign bank ownership	0.002**	-0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Log of Per capita GDP	-0.037	-0.022	0.026	-0.024	-0.014
	(0.028)	(0.024)	(0.020)	(0.039)	(0.019)
Inflation	0.009	-0.046	0.004	-0.032	-0.016
	(0.025)	(0.028)	(0.015)	(0.041)	(0.022)
Observations	32	32	32	32	32
R-squared	0.22	0.19	0.18	0.13	0.12

Panel B. Controlling for bank concentration and the number of banks.

	(1) H1 Large Banks	(2) H2 Large Banks	(3) H3 Large Banks	(4) H4 Large Banks	(5) Havg Large Banks
5-bank Concentration ratio	0.234	0.229	-0.011	0.267	0.180
	(0.170)	(0.155)	(0.123)	(0.245)	(0.137)
Log(Number of banks/population)	-0.020	-0.030	0.018	0.053	0.005
	(0.021)	(0.018)	(0.023)	(0.053)	(0.022)
Entry fit test	0.000	0.036**	-0.001	0.045	0.020
	(0.020)	(0.016)	(0.025)	(0.036)	(0.020)
Foreign bank ownership	0.003*	0.001	0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Log of Per capita GDP	-0.021	0.002	0.013	-0.061	-0.017
	(0.032)	(0.025)	(0.025)	(0.060)	(0.024)
Inflation	-0.010	-0.062**	0.007	-0.034	-0.025
	(0.023)	(0.030)	(0.020)	(0.048)	(0.024)
Observations	31	31	31	31	31
R-squared	0.30	0.36	0.19	0.22	0.18

Panel C. Activity restrictions, Entry and Ownership

	(1) H3 Large Banks	(2) H4 Large Banks	(5) H3 Large Banks	(6) H4 Large Banks
Activity restrictions	-0.021**	-0.053**	-0.017	-0.049**
	(0.009)	(0.021)	(0.011)	(0.024)
Entry fit test			-0.009	0.045
			(0.024)	(0.028)
Foreign bank ownership			0.001	0.001
			(0.001)	(0.002)
Log of Per capita GDP	0.034**	-0.026	0.028	-0.042
	(0.016)	(0.031)	(0.021)	(0.038)
Inflation	0.018	0.011	0.015	-0.008
	(0.015)	(0.041)	(0.019)	(0.044)
Observations	39	39	31	31
R-squared	0.27	0.26	0.28	0.33

Panel D. Activity restrictions, Inter-industry characteristics, Entry and Ownership

	(1) H3 Large Banks	(2) H3 Large Banks	(3) H3 Large Banks	(4) H3 Large Banks
Activity restrictions	-0.034***	-0.017*	-0.022**	-0.020**
	(0.010)	(0.009)	(0.009)	(0.009)
Other FIs assets to total financial assets	-0.012			
	(0.145)			
Private credit by other FIs to GDP		-0.095		
		(0.093)		
Stock market capitalization to GDP			-0.015	
			(0.018)	
Life insurance penetration				-0.141
				(0.612)
Log of Per capita GDP	0.042**	0.038**	0.038**	0.054***
	(0.019)	(0.018)	(0.017)	(0.015)
Inflation	0.042***	0.013	0.016	0.023
	(0.010)	(0.016)	(0.016)	(0.014)
Observations	20	38	35	36
R-squared	0.46	0.27	0.34	0.35

Table 11 Robustness: Cross-Country Determinants of H-statistics and Countries with at least 100 bank-year observations

Dependent variable is the H-statistic. The regression results are based on a sample of countries that excludes countries with an estimated H-statistic that is based on a sample of less than 100 bank-year observations. H1 is the H-statistic estimated using pooled OLS with time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H2 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with gross interest revenues as dependent variable in the reduced form revenue equations. H3 is the H-statistic estimated using pooled OLS with time dummies and with total revenues as dependent variable in the reduced form revenue equations. H4 is the H-statistic estimated using pooled GLS with bank-specific fixed effects and time dummies and with total revenues as dependent variable in the reduced form revenue equations. All H-statistics are based on the Panzar-Rosse (1987) approach. Havg is the average of H1 though H4. All regressions are estimated using OLS with heteroskedasticity-consistent standard errors. A constant was added, but is not reported. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Panel A. Entry and ownership

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
Entry fit test	0.004	0.030*	0.024**	0.027*	0.021*
	(0.018)	(0.016)	(0.011)	(0.015)	(0.011)
Foreign bank ownership	0.005***	0.002	0.002***	0.002	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of Per capita GDP	-0.047*	-0.022	0.026	0.001	-0.011
	(0.027)	(0.022)	(0.021)	(0.022)	(0.019)
Inflation	0.020	-0.028	0.007	-0.014	-0.004
	(0.024)	(0.027)	(0.021)	(0.030)	(0.018)
Observations	24	24	24	24	24
R-squared	0.50	0.17	0.44	0.19	0.33

Panel B. Controlling for bank concentration and the number of banks

	(1) H1	(2) H2	(3) H3	(4) H4	(5) Havg
5-bank Concentration ratio	0.248	0.152	0.095	0.135	0.158
	(0.179)	(0.135)	(0.100)	(0.132)	(0.111)
Log(Number of banks/population)	-0.011	-0.036*	-0.020	-0.055**	-0.031
	(0.032)	(0.019)	(0.023)	(0.022)	(0.018)
Entry fit test	-0.004	0.023*	0.024*	0.029	0.018
	(0.016)	(0.012)	(0.013)	(0.019)	(0.012)
Foreign bank ownership	0.005***	0.003***	0.002**	0.002*	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of Per capita GDP	-0.030	0.029	0.049	0.065*	0.028
	(0.048)	(0.031)	(0.039)	(0.032)	(0.027)
Inflation	0.009	-0.016	-0.003	-0.024	-0.008
	(0.030)	(0.020)	(0.021)	(0.023)	(0.018)
Observations	23	23	23	23	23
R-squared	0.54	0.48	0.48	0.46	0.51

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banking industry

The distinctive function of banks is the transformation of short-term deposits into longer-term, less liquid and riskier loans (Fama, 1980; 1985; Diamond and Rajan, 2001; Gorton and Winton, 2003). By raising funds from depositors and providing credit, banks avoid the duplication of monitoring, which reduces the overall cost of transferring funds from capital suppliers to its users (Leland and Pyle, 1977; Diamond, 1984). At the same time, however, the greater liquidity of liabilities than of assets, which are typically longer-term and riskier, makes bank balance sheets vulnerable. Not only may banks fail if they are unable to obtain repayment of their loans, but depositors might even decide to withdraw their assets simply anticipating that others will do so. Such a 'bank run' can drive an otherwise sound bank to insolvency (Diamond and Dybvig, 1983). The need to protect depositors and so guarantee a stable monetary transaction system explains why the banking industry is so heavily regulated. It is harder for a depositor to protect his interests than for an average investor, because judging the financial condition of a bank is difficult and costly, even for specialists. For this reason, the typical instruments adopted by bank regulators include restrictions on the amount of risk that a bank can take, and compulsory deposit insurance schemes that prevent runs.

Regulatory intervention affects the shape of the banking industry and its degree of competition. Until the mid-1960s, governments deliberately limited competition in the interest of 'safety and soundness' by regulating deposit rates, entry, branching and mergers. The traditional view is of a trade-off between soundness and competition, with more intense competition reducing franchise values and increasing incentives to take on risky projects, since forgone future profits in the case of bankruptcy are lower (Keeley, 1990). By increasing the equity at risk, capital controls reduce (although perhaps not entirely) excessive risk-taking (Hellman, Murdock and Stiglitz, 2000).

Recently, a more comprehensive view has been put forward, suggesting that regulation interacts dynamically with pervasive information asymmetries, and that the relationship between competition and stability is accordingly complex and multifaceted (Allen and Gale, 2003). The cost of acquiring information in order to mitigate moral hazard and adverse selection is a strong endogenous barrier to the entry of new banks, allowing incumbents to gain monopoly rents (Broecker, 1990), making competitive equilibria unsustainable (Dell' Ariccia, 2001; Dell'Ariccia, Friedman and Marquez, 1999), and forcing new entrants to take a higher-risk clientele (Shaffer, 1998).

The problems of information asymmetries can be attenuated if a bank deals repeatedly with the same customer, a practice known as 'relationship lending'. However, as Sharpe (1990) and Rajan (1992) show, this gives relationship banks a monopoly on information about their borrowers, further reducing competition, especially in the short run (Petersen and Rajan, 1995). In this case, deregulation aimed at fostering inter-bank competition in transaction lending could have the effect of augmenting the scope for relationship banking, which permits banks to retain some monopoly power. As Boot and Thakor (2000) show, this is not the case if stronger competition comes from capital market financing, which drives some banks out of the market, reducing competition and consequently relationship lending.

Since the mid-1980s, the banking industry has been transformed by a series of events: deregulation of deposit accounts, which forced US banks to compete on interest rates; branching liberalization, which led to a sharp decline in the number of banks; the changes in capital requirements introduced with the Basel accords of 1988, which pushed banks towards newer and less regulated off-balance-sheet activities; the introduction of the euro, which created a unique wholesale banking market within Europe (Berger, Kashyap and Scalise, 1995); and the substantial repeal of the Glass–Steagall Act of 1933, allowing banks to supply financial services previously offered only by other intermediaries, such as investment firms and insurance companies.

One of most important consequences of deregulation has been the unprecedented numbers of mergers and acquisitions during the 1990s, which sharply reduced the number of banks in many industrial countries and often heightened concern over possible anti-competitive effects. However, there is no clear evidence that the consolidations have harmed consumers or diminished competition, as would have been predicted from the observed negative correlation between the degree of concentration in local banking markets and the level of deposit rates (Berger and Hannan, 1989). Rather, the available evidence indicates a positive effect stemming from the larger and more efficient banks taking over the smaller and less efficient (Berger, Kashyap and Scalise, 1995; Focarelli, Panetta and Salleo, 2002). And while there may be some contraction of credit to smaller clients due to consolidation, this effect appears to be largely offset by increased lending by other banks (Berger et al., 1998). Indeed, there is evidence that in the medium term mergers increase the efficiency of the target bank, benefiting depositors (Focarelli and Panetta, 2003).

The future of the banking industry is likely be determined by the interaction of three major forces: international competition, innovation in information technology and regulation. At present, all three factors are heightening competition in banking. International competition, while still limited, tends to display the same pattern as domestic consolidation, with larger and more efficient banks in more developed countries taking over less efficient banks in financially less developed areas (Focarelli and Pozzolo, 2005). Technological innovation is lessening the importance of close lending relationships, enlarging the size of local credit markets and further reducing the role of small banks (Petersen and Rajan, 2002). Worldwide regulatory systems are moving to allow more competition and to assign a more important role to market evaluation (Basel Committee on Banking Supervision, 2005).

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See also **agency problems; banking crises; financial intermediation; market structure; merger analysis (United States); micro-credit; payment systems.**

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Banking School, Currency School, Free Banking School

Historians of economic thought conventionally represent British monetary debates from the 1820s on as centred on the question of whether policy should be governed by rules (espoused by adherents of the Currency School), or whether authorities should be allowed discretion (espoused by adherents of the Banking School). In fact many other questions were in dispute, including those raised by neglected or misidentified participants in the debates – adherents of the Free Banking School.

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Abstract. Great strides have been made in the theory of bank technology in terms of explaining banks' comparative advantage in producing informationally intensive assets and financial services and in diversifying or offsetting a variety of risks. Great strides have also been made in explaining sub-par managerial performance in terms of agency theory and in applying these theories to analyze the particular environment of banking. In recent years, the empirical modeling of bank technology and the measurement of bank performance have begun to incorporate these theoretical developments and yield interesting insights that reflect the unique nature and role of banking in modern economies. This chapter gives an overview of two general empirical approaches to measuring bank performance and discusses some of the applications of these approaches found in the literature.

Keywords: Bank, efficiency, risk, cost, profit, agency costs, X-inefficiency

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Introduction

What do commercial banks do? What are the key components of banking technology? What determines whether banks operate efficiently? The literature on financial intermediation suggests that commercial banks, by screening and monitoring borrowers, can solve potential moral hazard and adverse selection problems caused by the imperfect information between borrowers and lenders. From the information obtained from checking account transactions and other sources, banks assess and manage risk, write contracts, monitor contractual performance, and, when required, resolve nonperformance problems. (Bhattacharya and Thakor (1993) review the modern theory of financial intermediation.)

Banks' ability to ameliorate informational asymmetries between borrowers and lenders and their ability to manage risks are the essence of bank production. These abilities are integral components of bank output and influence the managerial incentives to produce financial services prudently and efficiently. That banks' liabilities are demandable debt gives banks an incentive advantage over other intermediaries. The relatively high level of debt in a bank's capital structure disciplines managers' risk-taking and their diligence in producing financial services by exposing the bank to an increased risk of insolvency. The demandable feature of the debt, to the extent it is not fully insured, further heightens performance pressure and safety concerns by increasing liquidity risk. These incentives tend to make banks good monitors of their borrowers. Hence, the banking relationship can improve the financial performance of bank customers and increase access to credit for firms too informationally opaque to borrow in public debt and equity markets. The uniqueness of bank production, in contrast to the production of other types of lenders, is derived from the special characteristics of banks' capital structure: the funding of

informationally opaque assets with demand deposits.[1] (For a discussion of the optimal capital structure of commercial banks, see Calomiris and Kahn (1991) and Flannery (1994).)

But banks' ability to perform efficiently – to obtain accurate information concerning its customers' financial prospects and to write effective contracts and to enforce them – depends in part on the property rights, legal, regulatory, and contracting environments in which they operate. Such an environment includes accounting practices, chartering rules, government regulations, and the market conditions (e.g., market power) under which banks operate. Differences in these features across political jurisdictions can lead to differences in the efficiency of banks across jurisdictions.[2] The operating environment can also influence the external and internal mechanisms that discipline bank managers. Internal discipline might be induced or reduced by organizational form, ownership and capital structure, governing boards, and managerial compensation. External discipline might be induced or reduced by government regulation and the safety net, capital market discipline (takeovers, cost of funds, stakeholders' ability to sell stock (stock price)), managerial labor market competition, outside blockholders (equity and debt), and product market competition.[3]

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[1] Berlin and Mester (1999) find empirical evidence of an explicit link between banks' liability structure and their distinctive lending behavior. As discussed in Mester (2007), relationship lending is associated with lower loan rates, less stringent collateral requirements, a lower likelihood of credit rationing, contractual flexibility, and reduced costs of financial distress for borrowing firms. Banks' access to core deposits, which are rate inelastic, enable banks to insulate borrowers with whom they have durable relationships from exogenous credit shocks. Mester, Nakamura, and Renault (2007) also find empirical evidence of a synergy between the liability and asset sides of a commercial bank's balance sheet, showing that information on the cash flows into and out of a borrower's transactions account can help an intermediary monitor the changing value of collateral that a small-business commercial borrower has posted.

[2] Demirgüç-Kunt, Kane, and Laeven (2007) use a sample of 180 countries to study the external and internal political features that influence the adoption and design of deposit insurance, which, in turn, affect the efficiency of the domestic banking system.

[3] LaPorta, Lopez-de-Silanes, and Shleifer (2002) examine banking systems in 92 countries and find that government ownership is correlated with poorer countries and countries with less developed financial systems, poorer protection of investors' rights, more government intervention, and poorer performance of institutions. They also find that government ownership is associated with higher cost ratios and wider interest rate margins. Aghion, Alesina, and Trebbi (2007) provide evidence that democracy has a positive impact on productivity growth in more advanced sectors of the economy, possibly by fostering entry and competition.

I. Banking Technology and Performance

I.A. The empirical measurement of banking technology and performance

There are two broad approaches to measuring technology and explaining performance: nonstructural and structural. Using a variety of financial ratios that capture various aspects of performance, the nonstructural approach compares performance among banks and considers the relationship of performance to investment strategies and other factors such as characteristics of governance. For example, the nonstructural approach might investigate technology by asking how performance ratios are correlated with such investment strategies as growing by asset acquisitions and diversifying or focusing the bank's product mix. It looks for evidence of agency problems in correlations of performance ratios and variables characterizing the quality of banks' governance. While informal and formal theories may motivate some of these investigations, no general theory of performance provides a unifying framework for these studies.

The structural approach is choice-theoretic and, as such, relies on a theoretical model of the banking firm and a concept of optimization. The older literature applies the traditional microeconomic theory of production to banking firms. The newer literature views the bank as a financial intermediary that produces informationally intensive financial services and diversifies risks, and combines the theory of financial intermediation with the microeconomics of bank production. This helps guide the choice of outputs and inputs in the bank's production structure. For example, as discussed in Mester (forthcoming), the standard application of efficiency analysis to banking does not allow bank production decisions to affect bank risk. This rules out the possibility that scale- and scope-related improvements in diversification could lower the cost of borrowed funds and induce banks to alter their risk exposure. Also, much of the earlier literature does not account for the bank's role in producing information about its borrowers in its

underwriting decisions when specifying the bank's outputs and inputs. An exception is Mester (1992), which directly accounted for banks' monitoring and screening role by measuring bank output treating loans purchased and originated loans as separate outputs entailing different types of screening, and treating loans held on balance sheet and loans sold as separate outputs entailing different types of monitoring.

Banks make choices about their capital structure and the amount of risk to assume, which should be taken into account when modeling bank production. Part of the input and output prices a bank faces are not exogenous – the bank makes strategic decisions regarding asset quality and capital structure, which affect the risk premium in its output and input prices. These decisions also relate to how one should view bank performance. In the standard efficiency literature, the bank is assumed to choose a production plan that minimizes costs given its output mix and input prices or that maximizes profits given the prices of its inputs and outputs. In newer research (e.g., Hughes, Lang, Mester, and Moon, 2000; Hughes, 1999; Hughes, Lang, Mester, and Moon, 1999; and Hughes, Mester, and Moon, 2001) bank managers are modeled as maximizing their utility, which is a function of market value and risk. To the extent that production decisions affect bank risk, they also affect the discount rate applied to evaluating the present value of costs and profit streams. Production decisions that increase expected profit but also increase the discount rate applied to that profit may not increase the bank's market value. In addition, managers may trade off expected return and risk, so that production choices that maximize managers' utility depend not only on the expected profits they generate but also on the variability of the profit stream they generate. Banks with high levels of agency problems between owners and managers might choose utility-maximizing production plans, but these need not be value-maximizing plans if the risk-return tradeoffs being made are not efficient.

How one gauges performance in structural models, then, depends on whether one views the bank as minimizing cost, maximizing profits, or maximizing managerial utility. In the latter case, one would want to gauge the trade-offs between risk and expected return being made in banks with minimum agency problems between owners and managers, i.e., banks with strong corporate controls (see Hughes, Mester, and Moon, 2001). In both the structural and nonstructural approaches, the performance metric and the specification of the performance equation reflect implicitly or explicitly an underlying theory of managerial behavior.

As a general specification of the structural and nonstructural approaches, let y_i represent the measure of the i^{th} bank's performance. Let $\boldsymbol{z}_i$ be a vector of variables that capture key components of the i^{th} bank's technology (e.g., output levels and input prices) and $\boldsymbol{\tau}_i$ be a vector of variables affecting the technology (e.g., the ratio of nonperforming to total loans). Jensen and Meckling (1979) add a vector, $\boldsymbol{\theta}_i$, of characteristics of the property-rights system, contracting, and regulatory environment in which the i^{th} firm operates (e.g., whether the country has a deposit insurance scheme and the degree of investor protection) and a vector, $\boldsymbol{\phi}_i$, of characteristics of the organizational form and the governance and control environment of the i^{th} firm (e.g., whether the bank is organized as a mutual or stock-owned firm, the degree of product market concentration, and the number of outside directors on its board). When the sample of banks used in the estimation includes financial institutions located in environments with different property rights and contracting environments or with different governance and control structures, estimating this model permits one to investigate how these differences are correlated with differences in bank performance.

Allowing for random error, the performance equation to be estimated takes the form,

$$(1) \qquad y_i = f(\boldsymbol{z}_i, \boldsymbol{\tau}_i, \boldsymbol{\phi}_i, \boldsymbol{\theta}_i \mid \boldsymbol{\beta}) + \varepsilon_i.$$

The specification of the vectors z_i and τ_i differs between the structural and nonstructural approaches.

I.B. The structural approach to bank efficiency measurement: cost minimization, profit maximization, and managerial utility maximization

The *structural approach* usually relies on the economics of cost minimization or profit maximization, where the performance equation denotes a cost function or a profit function. Occasionally, the structural performance equation denotes a production function. While estimating a production function might tell us if the firm is *technically efficient*, i.e., if managers organize production so that the firm maximizes the amount of output produced with a given amount of inputs (so that the firm is operating on its production frontier), we are more interested in *economic efficiency*, i.e., whether the firm is correctly responding to relative prices in choosing its inputs and outputs, which subsumes technical efficiency.

In the newer literature, the optimization problem is managerial utility maximization, where the manager trades off risk and expected return. The vector z includes input prices and output prices in a profit function. In the cost function and the nonstandard profit function (Humphrey and Pulley, 1997), the vector contains input prices and output levels. In all of these cases, τ might include controls like nonperforming loans to total loans or off-balance-sheet assets to total assets.

These functions can also differ by the definition of cost they use: accounting (cash-flow) cost excludes the cost of equity capital, while economic cost includes it. The theoretically proper specification of accounting cost is addressed in section I.E. The challenge of specifying economic cost is estimating the cost of equity capital. McAllister and McManus (1993) arbitrarily pick the required return and assume it is uniform across banks. Clark (1996) and

Fiordelisi (2007) use the Capital Asset Pricing Model to estimate it. Fiordelisi (2007) describes the resulting profit function as "Economic Value Added."

The structural performance equation can be fitted to the data as an average relationship, which assumes that all banks are equally efficient at minimizing cost or maximizing profit, subject to random error, ε_i, which is assumed to be normally distributed. Alternatively, the structural performance equation can be estimated as a *stochastic frontier* to capture best-practice and to gauge inefficiency, the difference between the best-practice performance and achieved performance. Berger and Mester (1997) review the estimation methods. Note that best-practice performance is sometimes called potential performance. However, this is somewhat of an abuse of terms since the best-practice performance does not necessarily represent the best possible practice, but merely the best practice observed among banks in the sample (see Berger and Mester, 1997, and Mester, forthcoming).

In the stochastic frontier, the error term, ε_i, consists of two components; one is a two-sided random error that represents noise (v_i), and one is a one-sided error representing inefficiency (μ_i). The stochastic frontier approach disentangles the inefficiency and random error components by making explicit assumptions about their distributions. The inefficiency component measures each bank's extra cost or shortfall of profit relative to the frontier – the best practice performance observed in the sample.[4] Let y_i denote either the cost or profit of firm i. The stochastic frontier gives the highest or lowest potential value of y_i given $\boldsymbol{z}_i$, $\boldsymbol{\tau}_i$, $\boldsymbol{\phi}_i$, and $\boldsymbol{\theta}_i$,

$$(2) \qquad y_i = F(\boldsymbol{z}_i, \boldsymbol{\tau}_i, \boldsymbol{\phi}_i, \boldsymbol{\theta}_i \mid \boldsymbol{\beta}) + \varepsilon_i,$$

[4] Leibenstein (1966) called such inefficiency, which can result from poor managerial incentives or the failure of the labor market to allocate managers efficiently and to weed out incompetent managers, *X-inefficiency*. Jensen and Meckling (1976) called such inefficiency *agency costs* and provided a theoretical model of managerial utility maximization to explain how, when incentives between managers and outside stakeholders are misaligned, managers may trade off the market value of their firm to enjoy more of their own private benefits, such as

where $\varepsilon_i \equiv \mu_i + v_i$ is a composite error term comprising v_i, which is normally distributed with zero mean, and μ_i, which is usually assumed to be half-normally distributed and negative when the frontier is fitted as an upper envelope in the case of a profit function and positive when the frontier is fitted as a lower envelope as in the case of a cost function. $\boldsymbol{\beta}$ are parameters of the deterministic kernel, $F(\boldsymbol{z}_i, \boldsymbol{\tau}_i, \boldsymbol{\phi}_i, \boldsymbol{\theta}_i \mid \boldsymbol{\beta})$, of the stochastic frontier. The i^{th} bank's inefficiency is usually estimated by the mean of the conditional distribution of μ_i given ε_i, i.e., $E(\mu_i|\varepsilon_i)$. The difference between best-practice and achieved performance gauges managerial inefficiency in terms of either excessive cost – *cost inefficiency* – or lost profit – *profit inefficiency*. Expressing the shortfall and excess as ratios of their frontier (best-practice) values yields profit and cost inefficiency ratios. While the fitted stochastic frontier identifies best-practice performance of the banks in the sample, it cannot explain the behavior of inefficient banks. A number of papers have surveyed investigations of bank performance using these concepts: for example, Berger and Humphrey (1997), Berger and Mester (1997), and Berger (2007).

As discussed in Mester (forthcoming), since inefficiency is derived from the regression residual, selection of the characteristics of the banks and the environmental variables to include in the frontier estimation is particularly important. These variables define the peer group that determines best-practice performance against which a particular bank's performance is judged. If something extraneous to the production process is included in the specification, this might lead to too narrow a peer group and an overstatement of a bank's level of efficiency. Moreover, the variables included determine which type of inefficiency gets penalized. If bank location, e.g., urban vs. rural, is included in the frontier, then an urban bank's performance would be judged against other urban banks but not against rural banks, and a rural bank's performance would be

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consuming perquisites, shirking, discriminating prejudicially, taking too much or too little risk to enhance their

judged against other rural banks. If it turned out that rural banks are more efficient than urban banks, all else equal, the inefficient choice of location would not be penalized. An alternative to including the variable in the frontier regression is to measure efficiency based on a frontier in which it is omitted and then to see how it correlates with efficiency. Several papers have looked at the correlations of efficiency measures and exogenous factors, including Mester (1993), Mester (1996), Mester (1997), and Berger and Mester (1997). Mester (1997) shows that estimates of bank cost efficiency can be biased if bank heterogeneity is ignored. See also Bos, Heid, Koetter, Kolari, and Kool (2005) on the issue of whether certain differences in the economic environment belong in the definition of the frontier.

Either the average cost function or cost frontier can be used to measure *scale economies*, which refer to how the bank's scale of operations (its size) is related to cost and give a measure of whether the bank is operating at an optimal scale. A bank is operating with scale economies if a one percent increase in scale leads to a less than one percent increase in cost; it is operating with scale diseconomies if a one percent increase in scale leads to a greater than one percent increase in costs; it is operating with constant returns to scale if a one percent increase in scale leads to a one percent increase in cost. *Scope economies* refer to whether the bank is producing the optimal combination of products to minimize cost (or maximize profits). In particular, a bank is operating with scope economies if the cost of producing the bank's product bundle is less than the cost of separating the bundle into specialized firms. The bank is operating with scope diseconomies if specialized banks could produce the product mix more cheaply.

Typically in the literature, the cost and profit functions or frontiers are measured without considering the bank's capital structure or bank's choice of risk. This is a serious omission since both are important parts of banking technology. Banks' production technologies embody their

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control.

ability to diversify and offset a variety of risks, and the production decisions managers make reflect their incentives to take on risks as well as to diversify them. Modern banking theory emphasizes managers' contrasting incentives for risk-taking. On the one hand, increased risk-taking exploits the risk-taking subsidy of explicit and implicit, mispriced deposit insurance, while, on the other hand, reduced risk-taking protects a bank from costly episodes of financial distress involving liquidity crises, regulatory intervention, and even forfeiture of the bank's valuable charter. For most banks, valuable investment opportunities make trading profitability for reduced risk a value-maximizing strategy. Reducing risk can involve not just producing assets with lower expected profit, but also incurring higher costs to manage risks.

When market-priced risk varies across production plans, the discount rate on profit will also vary across firms so that the production plan that maximizes expected profit may not maximize the discounted value of expected profit. Modeling the behavior of value-maximizing managers requires a more general objective function than profit maximization. Hughes, Lang, Mester, and Moon (1996, 1999, 2000) incorporate risk into managers' choice of production plans by defining managerial utility as a function of profit and the production plan (i.e., the choice of inputs and outputs). Technology defines all feasible production plans. The utility function ranks feasible production plans according to the utility the managers derive from each production plan. Each production plan is linked to a subjective probability distribution of profit by managers' beliefs about the probability distribution of future economic states and how these states interact with feasible production plans to determine profit. Thus, managerial utility expressed as a function of profit and the production plan is equivalent to utility expressed as a function of subjective, conditional probability distributions of profit. Hence, it allows managers to rank

production plans not just by their expected profit, the first moment of their distribution, but also by higher moments that capture the risk of production plans.

This managerial utility function is also sufficiently general that it can also account for rankings of production plans that reflect agency problems. To the extent that managers are able to pursue personal objectives that sacrifice firm value, such as empire building and risk avoidance, maximizing utility need not be the same as maximizing value, and the utility function can represent such rankings. Thus, unlike the standard maximum profit function and minimum cost function, this utility framework is able to explain *inefficient* as well as efficient managerial decisions.

To specify the performance equation (1), Hughes, Lang, Mester, and Moon (1996, 1999, 2000) adapt the Almost Ideal Demand System to derive a *utility-maximizing* profit equation and its associated input demand equations. This profit function does not necessarily maximize profit, since it follows from managers' assessment of risk and risk's effect on asset value and perhaps their job security. The profit function also might not represent value-maximizing output production plans or risk-expected return choices, to the extent that there are agency costs and managers are able to pursue non-value-maximizing objectives. Profit maximization (cost minimization) can be tested by noting that the standard translog profit (cost) function and share equations are nested within the model and can be recovered by imposing the parameter restrictions implied by profit maximization (cost minimization) on the coefficients of this adapted system. Hughes, Lang, Mester, and Moon (1996, 1999, 2000) test these restrictions and reject the hypothesis of profit maximization (and cost minimization) in their applications.

Since the utility-maximizing profit function explains inefficient as well as efficient production, it cannot be fitted as a frontier. To gauge inefficiency, Hughes, Lang, Mester, and

Moon (1996) and Hughes, Mester, and Moon (2001) estimate a best-practice risk-return frontier and measure inefficiency relative to it. The estimated utility-maximizing profit function yields a measure of expected profit for each bank in the sample, and, when divided by equity capital, the expected profit is transformed into expected return on equity, $E(\pi_i / k_i)$. Each bank's expected (or, predicted) return is a function of its production plan and other explanatory variables. When the estimation of the profit function allows for heteroscedasticity, the standard error of the predicted return (profit), σ_i, a measure of econometric prediction risk, is also a function of the production plan and other explanatory variables and varies across banks in the sample.[5] The estimation of a stochastic frontier similar to (2) gives the highest expected return at any particular risk exposure:

(3) $$E(\pi_i / k_i) = \alpha_0 + \alpha_1 \sigma_i + \alpha_2 \sigma i^2 - \mu_i + \nu_i ,$$

where ν_i is a two-sided error term representing noise, and μ_i is a one-sided error term representing inefficiency. A bank's *return inefficiency* is the difference between its potential return and its noise-adjusted expected return, gauged among its peers with the same level of return risk. (Note, however, that if a bank's managers are taking too much or too little risk relative to the value-maximizing amount, this inappropriate level of risk is not taken into account by this measure of inefficiency.)

Koetter (2006) uses the model of managerial utility maximization and the associated measure of risk-return efficiency developed in Hughes, Lang, Mester, and Moon (1996, 1999, 2000) to investigate the efficiency of universal banks in Germany between 1993 and 2004. He

[5] Note that the estimated profit (or return) function resembles a multi-factor model where the factors are the explanatory variables in the profit function. The regression coefficients can be interpreted as marginal returns to the explanatory variables, and the standard error of the predicted return, a function of the variance-covariance matrix of the estimated marginal returns, resembles the variance of a portfolio return. Hughes (1999) and Hughes, Mester, and Moon (2001) report that the regression of *ln*(market value of equity) on *ln*($E(\pi_i / k_i)$) and *ln*(σ_i) for 190 publicly

compares the measure of return efficiency with cost and profit efficiency estimated by standard formulations and finds evidence that *efficient* banks using a low-risk investment strategy score poorly in terms of standard profit efficiency measures, since they also expect lower profit.

Hughes, Mester, and Moon (2001) take this a step further by recognizing that the utility-maximizing choices of bank managers need not be value maximizing to the extent that there are agency problems within the firm and managers are able to pursue their own, non-value-maximizing objectives. To identify the value-maximizing banks among the set of all banks, they select the quarter of banks in the sample that have the highest predicted return efficiency. These banks are the mostly likely group to be maximizing value or, at least, producing with the smallest agency costs. One can use this set of efficient banks to gauge characteristics of the value-maximizing production technology. For example, mean scale economies across this set of banks would indicate whether there were scale economies as banks expand output along a path that maximizes value. In contrast, mean scale economies across *all* banks would indicate whether there were scale economies as banks expand output along a path that maximizes managers' utility, but this can differ from the value-maximizing expansion path to the extent that managers are able to pursue their own objectives and these objectives differ from those of outside owners.

While the model of managerial utility maximization yields a structural utility-maximizing profit function that includes as special cases the standard maximum profit function and a value-maximizing profit function, it is, nevertheless, based on accounting measures of performance. An alternative model developed by Hughes and Moon (2003) gauges performance using the market value of assets. They develop a *utility-maximizing q-ratio function* derived from a model where managers allocate the potential (frontier) market value of their firm's assets between their

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traded bank holding companies has an R-squared of 0.96, which implies that the production-based measures of expected return and risk explain a large part of a bank's market value.

consumption of agency goods (market-value inefficiency) and the production of market value, which, given their ownership stake, determines their wealth. The utility function is defined over wealth and the value of agency goods and is conditioned on capital structure, outside blockholder ownership, stock options held by insiders, and other managerial incentive variables. The authors derive a utility-maximizing demand function for market value and for agency goods (inefficiency). Hence, their *q*-ratio equation is *structural* and, consequently, enjoys the properties of a well-behaved consumer demand function. The authors use these properties to analyze the relationship between value (or inefficiency) and the proportion of the firm owned by insiders, which is their opportunity cost of consuming agency goods.

I.C. The nonstructural approach to bank efficiency measurement

The *nonstructural approach* to bank performance measurement usually focuses on achieved performance and measures y_i, in equation (1) by a variety of financial ratios, e.g., return-on-asset, return-on-equity, or the ratio of fixed costs to total costs. However, some applications have used measures of performance that are based on the market value of the firm (which inherently incorporates market-priced risk), e.g., Tobin's q-ratio (which is the ratio of the market value of assets to the book value of assets), the Sharpe ratio (which measures the ratio of the firm's expected excess return over the risk-free return to the volatility of this excess return (as measured by the standard deviation of the excess return)), or an event study's cumulative abnormal return, or CAR (the cumulative error terms of a model predicting banks' market return around a particular event). Other applications have measured performance by an inefficiency ratio obtained by estimating either a nonstructural or structural performance equation as a frontier. The nonstructural approach then explores the relationship of performance to various bank and environmental characteristics, including the bank's investment strategy, location,

governance structure, and corporate control environment. For example, the nonstructural approach might investigate technology by asking how performance ratios are correlated with asset acquisitions, the bank's product mix, whether the bank is organized as a mutual or stock-owned firm, and the ratio of outside to inside directors on its board. While informal and formal theories may motivate some of these investigations, no general theory of performance provides a unifying framework for these studies.

Using the frontier methods in a nonstructural approach, Hughes, Lang, Moon, and Pagano (1997) proposed a proxy for Jensen and Meckling's agency cost: a frontier of the market value of assets fitted as a potentially nonlinear function of the book-value investment in assets and the book value of assets squared. This frontier gives the highest potential value observed in the sample for any given investment in assets. For any bank, the difference between its highest potential value and its noise-adjusted achieved value represents its lost market value – a proxy for agency cost (*X*-inefficiency). Several studies have used either this systematic lost market value or the resulting noise-adjusted q-ratio to measure performance: Baele, DeJonghe, and Vennet (2006), Hughes, Lang, Mester, Moon, and Pagano (2003), DeJonghe and Vennet (2005), Hughes and Moon (2003), Hughes, Lang, Mester, and Moon (1999), and Hughes, Mester, and Moon (2001).

Habib and Ljungqvist (2005) specified an alternative market-value frontier as a function of a variety of managerial decision variables, including size, financial leverage, capital expenditures, and advertising expenditures. Thus, the peer grouping on which the frontier is estimated is considerably narrower than the wide grouping based on investment in assets, and inefficient choices of these conditioning values are not accounted for in the measurement of agency costs.

I.D. Specifying outputs and inputs in structural models of production

In estimating the standard cost or profit function or the managerial utility maximization model, one must specify the outputs and inputs of bank production. The intermediation approach focuses on the bank's production of intermediation services and the total cost of production, including both interest and operating expenses. Outputs are typically measured by the dollar volume of the bank's assets in various categories. (As mentioned above, an exception is Mester (1992), which to account for the bank's screening and monitoring activities, measured outputs as loans previously purchased, which require only monitoring, loans currently originated for the bank's own portfolio, loans currently purchased, and loans currently sold.) Inputs are typically specified as labor, physical capital, deposits and other borrowed funds, and, in some studies, equity capital. While the intermediation approach treats deposits as inputs, there has been some discussion in the literature about whether deposits should be treated as an output since banks provide transactions services for depositors. Hughes and Mester (1993) formulated an empirical test for determining whether deposits act as an input or output. Consider variable cost, VC, which is the cost of nondeposit inputs and is a function of the prices of nondeposit inputs, $\boldsymbol{w}$, output levels, $\boldsymbol{q}$, other variables affecting the technology, $\boldsymbol{\tau}$, and the level of deposits, x. If deposits are an input, then $\partial VC/\partial x < 0$: increasing the use of some input should decrease the expenditures on other inputs. If deposits are an output, then $\partial VC/\partial x > 0$: output can be increased only if expenditures on inputs are increased. Hughes and Mester's empirical results indicate insured and uninsured deposits are inputs at banks in all size categories.

I.E. Specifying capital structure in performance equations

As discussed above, typically, cost and profit functions are measured without considering the bank's capital structure. However, the newer literature recognizes the importance of bank

managers' choice of risk and capital structure on bank performance. Some of the first structural models to include equity capital as an input are Hancock (1985, 1986), McAllister and McManus (1993), Hughes and Mester (1993), Clark (1996), and Berger and Mester (1997).

As discussed in Hughes and Mester (1993), Hughes (1999), Mester (forthcoming), and Berger and Mester (1997), a bank's insolvency risk depends not only on the riskiness of its portfolio but on the amount of financial capital it has to absorb losses. Insolvency risk affects bank costs and profits via the risk premium the bank has to pay for uninsured debt, through the intensity of risk management activities the bank undertakes, and through the discount rate applied to future profits. A bank's capital level also directly affects costs by providing an alternative to deposits as a funding source for loans.

Most studies use the cash-flow (accounting) concept of cost, which includes the interest paid on debt (deposits) but not the required return on equity, as opposed to economic cost, which includes the cost of equity. Failure to include equity capital among the inputs can bias efficiency measurement. If a bank were to substitute debt for some of its financial equity capital, its accounting (cash-flow) costs could rise, making the less-capitalized bank appear to be more costly than a well-capitalized bank. To solve this problem, the level of equity capital can be included as a quasi-fixed input in the cost function. The resulting cost function captures the relationship of cash-flow cost to the level of equity capital, and the (negative) derivative of cost with respect to equity capital – the amount by which cash-flow cost is reduced if equity capital is increased – gives the shadow price of equity. The shadow price of equity will equal the market price when the amount of equity minimizes cost or maximizes profit. Even when the level of equity does not conform to these objectives, the shadow price nevertheless provides a measure of its opportunity cost. Hughes, Mester, and Moon (2001) find that the mean shadow price of

equity for small banks is significantly smaller than that of larger banks. This suggests that smaller banks over-utilize equity relative to its cost-minimizing value, perhaps to protect charter value. On the other hand, larger banks appear to under-utilize equity relative to its cost-minimizing value, perhaps to exploit a deposit subsidy and the subsidy due to the Too-Big-To-Fail Doctrine.

I.F. Specifying output quality in the performance equation

In measuring efficiency, one should control for differences in output quality to avoid labeling unmeasured differences in product quality as differences in efficiency. Controls for loan quality, e.g., nonperforming loans to total loans by loan category or loan losses, are sometimes included in the cost or profit frontier as controls (see Mester, forthcoming, for further discussion). As discussed in Berger and Mester (1997), whether it is appropriate to include nonperforming loans or loan losses in the cost or profit function depends on the extent to which these variables are exogenous. They would be exogenous if caused by economic shocks (bad luck), but could be endogenous to the extent that management is inefficient or has made a conscious decision to cut short-run expenses by cutting back on loan origination and monitoring resources. Berger and Mester (1997) attempt to solve this problem by using the ratio of nonperforming loans to total loans in the bank's state as a control variable. This state average would be nearly entirely exogenous to any one bank, but can control for negative shocks that affect bank output quality.

The variable, nonperforming loans, can also play a role as a quasi-fixed "input" whose quantity rather than price is included in the performance equation. As such, its "cost" is excluded from the performance metric, either cost or profit. Its price is the expected loan-loss rate. Hence, when the cost of nonperforming loans, i.e., loan losses, is excluded from the

performance measure, a case can be made for including the level of nonperforming loans, and when the performance measure is net of loan losses, the logic suggests that the loss rate be included in the specification of the performance equation.

II. Applications of the structural approach

II.A. Performance in relation to organizational form, governance, regulation, and market discipline

An increasing number of papers using structural models are exploring the importance of governance and ownership structure to the performance of banks. The structural model is first used to obtain a frontier-based measure of inefficiency. Then inefficiency is regressed on a set of explanatory variables.

Using confidential regulatory data on small, closely held commercial banks, DeYoung, Spong, and Sullivan (2001) use a stochastic frontier to measure banks' profit efficiency. They find banks that hire a manager from outside the group of controlling shareholders perform better than those with owner-managers; however, this result depends on motivating the hired managers with sufficient holdings of stock. They calculate an optimal level of managerial ownership that minimizes profit inefficiency. Higher levels of insider holdings lead to entrenchment and lower profitability.

Berger and Hannan (1998) consider the relationship of bank cost efficiency, estimated by a stochastic frontier, to product market discipline, gauged by a Herfindahl index of market power. They find that the reduced discipline of concentrated markets is associated with a loss of cost efficiency far more significant than any welfare loss due to monopoly pricing.

DeYoung, Hughes, and Moon (2001) use the model of managerial utility maximization developed by Hughes, Lang, Mester, and Moon (1996, 2000) to estimate expected return and return risk. Using these values, they estimate a stochastic risk-return frontier as in equation (3)

to obtain each bank's return inefficiency. They consider how banks' supervisory CAMEL ratings are related to their size, their risk-return choice, and their return inefficiency. They find that the risk-return choices of efficient banks are not related to their supervisory rating, while higher-risk choices of inefficient banks are penalized with poorer ratings. Moreover, the risk-return choices of large inefficient banks are held to a stricter standard than smaller banks and large efficient banks.

Two studies by Mester (1991, 1993) investigate differences in scale and scope measures for stock-owned and mutual savings and loans by estimating average cost functions. She finds evidence of agency problems at mutual S&Ls, as evidenced by diseconomies of scope, prior to the industry's deregulation, and evidence that these agency costs were lessened after the deregulation in the mid-1980s.

Using data for the period 1989-1996, Altunbas, Evans, and Molyneux (2001) estimate separate and common frontiers for three organizational forms in German banking: private commercial, public (government-owned) savings, and mutual cooperative banks. They argue that the same technology of intermediation is available to all so that the choice of technology is a management decision whose efficiency should be compared among all types of forms. The private sector appears to be less profit and cost efficient than the other two sectors. These results are especially clear in the case of the common frontier, but they are also obtained from the estimation of separate frontiers.

II.B. Uncovering evidence of scale economies by accounting for risk and capital structure

Berger and Mester (1997) use data on the almost 6000 U.S. commercial banks that were in continuous existence over the six-year period 1990-1995. They estimate scale economies, cost X-efficiency, and profit X-efficiency for banks in different size categories based on their

preferred model that incorporates asset quality, financial capital, and off-balance-sheet assets and based on several alternative specifications. In the preferred model, which includes financial capital, they find significant cost scale economies for banks in each size class: the typical bank would have to be two to three times larger in order to maximize cost scale efficiency for its product mix and input prices.

Hughes and Mester (1998) use 1989 and 1990 data on U.S. banks with assets over $1 billion and estimate cost function conditioned on the level of financial capital. They find that banks do not hold the cost-minimizing level of capital and that the level of capitalization increases less than proportionately with assets. They find significant scale economies across banks of all size in the sample.

Hughes, Mester, and Moon (2001) apply a model of managerial utility to data on U. S. bank holding companies to consider how incorporating capital structure and endogenous risk-taking into the production model affects the ability of the empirical investigator to detect scale economies. For example, better diversification may lead to a lower cost of risk and an incentive to increase risk-taking for greater profitability. The increased risk-taking may be costly. If larger banks are better diversified and more risky than smaller banks, this source of scale economies may be hard to detect without accounting for endogenous risk-taking: the increase in cost due to the increased risk-taking can lead to the conclusion that there are no economies of scale. The authors provide evidence that better diversification is associated with larger scale economies, and increased risk-taking and inefficiency are related to smaller scale economies.

Bossone and Lee (2004) use the Hughes and Mester (1998) and Hughes, Mester, and Moon (2001) methodologies to study the relationship between productive efficiency and the size of the financial system. Using data on 875 commercial banks from 75 countries, they estimate a

cost function and measure scale economies allowing for banks' endogenous choice of risk and financial capital. Consistent with the results from Hughes and Mester (1998) and Hughes, Mester, and Moon (2001), they find significant scale economies that are increasing with the size of the financial system. They also find that small banks in larger financial systems are more cost efficient than those in small financial systems. They interpret their findings as evidence of what they call "systemic scale economies."

Berger and Mester (2003) investigate cost and profit productivity, where productivity is measured as a combination of technological change (i.e., changes in the best-practice frontier) and changes in inefficiency, holding constant the exogenous environmental variables. (This discussion is taken largely from Mester (forthcoming).) They find that during 1991-1997, cost productivity in the banking industry worsened while profit productivity improved substantially and concluded this was because revenue-based productivity changes are not accounted for in measuring cost productivity. Banks have been offering wider varieties of financial services and have been providing additional convenience, which may have raised costs but also raised revenues by more than the cost increases. They also found that banks involved in merger activity might be responsible for their main findings. The merging banks had greater cost productivity deterioration and profit productivity improvements than other banks. Merging banks may have also improved their profit performance, on average, by shifting their portfolios into investments with higher risk and higher expected return to take advantage of the diversification gains from mergers, as suggested by the work of Hughes, Lang, Mester, and Moon (1996) and Hughes, Mester, and Moon (2001).

III. Applications of the nonstructural approach

III.A. Measuring the value of investment opportunities ("charter value")

The value of a bank's investment opportunities is often measured by Tobin's q-ratio; however, in the presence of agency cost the q-ratio captures only the ability of the incumbent managers to exploit these opportunities. Ideally, the value of investment opportunities should be gauged independently of the ability and actions of the current management. Hughes, Lang, Moon, and Pagano (1997) and Hughes, Lang, Mester, Moon, and Pagano (2003) propose a measure based on fitting a stochastic frontier to the market value of assets as a function of the book value of assets and variables characterizing the market conditions faced by banks. These conditions include a Herfindahl index of market power and the macroeconomic growth rate. The fitted frontier gives the highest potential value of a bank's assets in the markets in which it operates. Thus, this potential value is conditional on the location of the bank and represents the value the bank would fetch in a competitive auction. Hughes, Lang, Moon, and Pagano (1997) define this value as the bank's "charter value" – its value in a competitive auction.

III.B. Measuring the performance of business and capital strategies

Several papers have used the nonstructural performance equation to examine the relationship between bank value and bank capital structure. Hughes, Lang, Moon, and Pagano (1997) regress performance measured by Tobin's q-ratio and market-value inefficiency on a number of variables characterizing bank production. Calomiris and Nissim (2007) regress the ratio of the market value of equity to its book value on a similar list of variables. De Jonghe and Vennet (2005) apply the market-value frontier of Hughes, Lang, Moon, and Pagano (1997) to derive a noise-adjusted measure of Tobin's q, which they use to evaluate how leverage and market power are related to value. All three studies find evidence that banks follow dichotomous strategies for enhancing value as predicted by Marcus (1984): a lower risk, lower leverage strategy and a higher risk, higher leverage strategy.

III.C. Relationship of ownership structure to bank value

Jensen and Meckling (1976) defined agency cost as the difference in value of a firm owned entirely by its manager (so that there are no agency problems) and one where the manager does not own all of the firm. Since firms with no agency costs should out-perform those with agency problems, some studies have sought evidence of agency costs by looking for a correlation between firm value measured by Tobin's q-ratio and variables characterizing potential agency problems, such as the proportion of the firm owned by managers and the proportion owned by outside blockholders.

In an influential study, Morck, Shleifer, and Vishny (1988) hypothesized that managerial ownership creates two contrasting incentives: a higher ownership stake, first, better aligns the interests of managers and outside owners and, second, enhances managers' control over the firm and makes it harder for managers to be ousted when they are not efficient. Measuring performance by Tobin's q, these authors provide evidence that the so-called alignment-of-interests effect dominates the entrenchment effect at lower levels of managerial ownership, while the entrenchment effect dominates over a range of higher levels.

Studies that attempt to measure the *net* effect of the alignment and entrenchment effects on firm valuation cannot identify these effects individually – only their sum in the form of the sign of a regression coefficient or a derivative of a regression equation. Adams and Santos (2006) cleverly isolate the entrenchment effect by considering how the proportion of a bank's common stock controlled but not owned by the bank's own trust department is statistically related to the bank's economic performance. The voting rights exercised by management through the trust department enhance management's control over the bank but do not align their

interests with outside shareholders', since the beneficiaries of the trusts, not the managers, receive the dividends and capital gains and losses.

Caprio, Laeven, and Levine (2003) study the effect of ownership, shareholder protection laws, and supervisory and regulatory policies on the valuations of banks around the world. The authors construct a database of 244 banks – in each of 44 countries. They measure performance by Tobin's q-ratio and by the ratio of the market value of equity to the book value of equity. They find evidence that banks in countries with better protection of minority shareholders are more highly valued; bank regulations and supervision have no significant effect on bank value; the degree of cash-flow rights of the largest owner has a significant positive effect on bank value; and an increase in ownership concentration has a larger positive effect on valuation when the legal protection of minority shareholders is weak.

III.D. Relationship of mergers and takeovers to bank value

Brook, Hendershott, and Lee (1998) examine the stock market reaction to the passage of the Interstate Banking and Branching Efficiency Act (IBBEA) of 1994. They find significantly positive abnormal returns that are negatively related to a bank's prior performance. Apparently, the increased probability of a takeover following the passage of IBBEA improves the value of underperforming banks more than better performing banks. This increase in value is offset among banks whose managers show evidence of entrenchment, such as higher insider ownership, lower outside blockholder ownership, and less independent boards.

If the threat of a takeover disciplines managers and improves profitability, differences in takeover restrictions across states imply differences in the threat of a takeover. Schranz (1993) finds that banks in states with a more active takeover market are more profitable than banks in states restricting takeover activity.

Hughes, Lang, Mester, Moon, and Pagano (2003) examine U.S. bank holding companies and find evidence of managerial entrenchment among banks with higher levels of insider ownership, more valuable growth opportunities, poorer financial performance, and smaller asset size. When managers are not entrenched, asset acquisitions and sales are associated with reduced market value inefficiency. When managers are entrenched, sales are associated with smaller reductions in inefficiency, while acquisitions are associated with greater inefficiency.

DeLong (2001) studies 280 domestic U.S. bank mergers from 1988 through 1995. Gauging performance by the CARs of the mergers, she finds that mergers that focus activity and geography increase shareholder value, while diversifying mergers do not.

IV. Conclusions

Great strides have been made in the theory of bank technology in terms of explaining banks' comparative advantage in producing informationally intensive assets and financial services and in diversifying or offsetting a variety of risks. Great strides have also been made in explaining sub-par managerial performance in terms of agency theory and in applying these theories to analyze the particular environment of banking. In recent years, the empirical modeling of bank technology and the measurement of bank performance have begun to incorporate these theoretical developments and yield interesting insights that reflect the unique nature and role of banking in modern economies.

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IMPACT OF BANK COMPETITION ON THE INTEREST RATE PASS-THROUGH IN THE EURO AREA

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Abstract

This paper analyses the impact of loan market competition on the interest rates applied by euro area banks to loans and deposits during the 1994-2004 period, using a novel measure of competition called the Boone indicator. We find evidence that stronger competition implies significantly lower spreads between bank and market interest rates for most loan market products. Using an error correction model (ECM) approach to measure the effect of competition on the pass-through of market rates to bank interest rates, we likewise find that banks tend to price their loans more in accordance with the market in countries where competitive pressures are stronger. Further, where loan market competition is stronger, we observe larger bank spreads (implying lower bank interest rates) on current account and time deposits. This would suggest that the competitive pressure is heavier in the loan market than in the deposit markets, so that banks compensate for their reduction in loan market income by lowering their deposit rates. We observe also that bank interest ratesin more competitive markets respond more strongly to changes in market interest rates. These findings have important monetary policy implications, as they suggest that measures to enhance competition in the European banking sector will tend to render the monetary policy transmission mechanism more effective.

JEL classification: D4, E50, G21, L10.

Keywords: Monetary transmission, banks, retail rates, competition, panel data.

1 Introduction

This paper discusses the effects of bank competition on bank loan and deposit rate levels as well as on their responses to changes in market rates and, hence, on the monetary policy transmission mechanism. Given the prominent role of the banking sector in the euro area's financial system, it is of significant importance for the ECB to monitor the degree of competitive behaviour in the euro area banking market. A more competitive banking market is expected to drive down bank loan rates, adding to the welfare of households and enterprises. Further, in a more competitive market, changes in the ECB's main policy rates supposedly will be more effectively passed through to bank interest rates.

This study extends the existing empirical evidence, which suggests that the degree of bank competition may have a significant effect on both the level of bank rates and on the pass-through of market rates to bank interest rates. Understanding this pass-through mechanism is crucial for central banks. However, most studies that analyse the relationship between competition and banks' pricing behaviour apply a concentration index such as the Herfindahl-Hirschman index (HHI) as a measure of competition. We question the suitability of such indices as measures to capture competition. Where the traditional interpretation is that concentration erodes competition, concentration and competition may instead increase simultaneously when competition forces consolidation. For example, in a market where inefficient firms are taken over by efficient companies, competition may strengthen, while the market's concentration increases at the same time. In addition, the HHI suffers from a serious weakness in that it does not distinguish between small and large countries. In small countries, the concentration ratio is likely to be higher, precisely because the economy is small.

The main contribution of this paper is that it applies a new measure for competition, called the Boone indicator [see also Boone (2001); Bikker and Van Leuvensteijn (2008); Van Leuvensteijn *et al.* (2007)]. The basic notion underlying this indicator is that in a competitive market, more efficient companies are likely to gain market shares. Hence, the stronger the impact of efficiency on market shares is, the stronger is competition. Further, by analyzing how this efficiency-market share relationship changes over time, this approach provides a measure which can be employed to assess how changes in competition affect the cost of borrowing for both households and enterprises, and how it affects the pass-through of policy rates into loan and deposit rates.

Our study contributes also to the pass-through literature in the sense that it applies a newly-constructed data set on bank interest rates for eight euro area countries covering the January 1994 to March 2006 period. We include data for Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal and Spain.[1] Further, we consider four types of loan products (mortgage loans, consumer loans and short and long-term loans to enterprises) and two types of deposits (time deposits and current account deposits). We apply recently developed dynamic panel estimates of the pass-through model. Our approach is closely related to that of Kok Sørensen and Werner (2006), on which it expands by linking the degree of competition directly to the pass-through estimates.

1. For other euro area countries we had insufficient data to estimate the Boone indicator.

Against this background, we test the following three hypotheses:

I) Are loan interest rates lower, and are deposit interest rates higher, in more competitive loan markets than in less competitive loan markets?
II) Are long-run loan and deposit interest rate responses to corresponding market rates stronger in more competitive loan markets than in less competitive loan markets?
III) Do bank interest rates in more competitive markets adjust faster to changes in market interest rates than in less competitive markets?

This paper uses interest rate data that cover a longer period and that are based on more harmonised principles than those used by previous pass-through studies for the euro area. We find that stronger competition implies significantly lower interest rate spreads for most loan market products, as we expected. Using an error correction model (ECM) approach to measure the effect of competition on the pass-through of market rates to bank interest rates, we likewise find that banks tend to price their loans more in accordance with the market in countries where competitive pressures are stronger. Furthermore, where loan market competition is stronger, we observe larger spreads between bank and market interest rates (that is, lower bank interest rates) on current account and time deposits. Lower time deposit rates in countries with stronger bank competition are confirmed by the ECM estimates. Apparently, the competitive pressure is heavier in the loan market than in the deposit markets, so that banks under competition compensate for their reduction in loan market income by lowering their deposit rates. Furthermore, in more competitive markets, bank interest rates appear to respond more strongly and sometime more rapidly to changes in market interest rates.

The structure of the paper is as follows. Section 2 discusses the literature on both measuring competition and the bank interest rate pass-through. Section 3 describes the Boone indicator of competition and Section 4 the employed interest rate pass-through model of the error-correction type and the applied panel unit root and cointegration tests. Section 5 presents the various data sets used. The results on the various tests and estimates of the spread model and the error correction model equations are shown in Section 6. Finally, Section 7 summarises and concludes.

2 Literature review

2.1 Measuring competition

Competition in the banking sector has been analysed by, amongst other methods, measuring market power (i.e. a reduction in competitive pressure) 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 strong conjectural variation implies that a bank is highly aware of its interdependence (via the demand equation) with other banks in terms of output and prices. 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. In principle, this H-statistic ranges from -∞ 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 (old) EU countries by Bikker and Haaf (2002) and to 101 countries by Bikker *et al*. (2006).

A third indicator for market power is the Herfindahl-Hirschman 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.[2] 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. 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 has been mentioned above, the Boone indicator can be seen as an elaboration on the assumptions underlying this efficiency hypothesis (EH). This EH test is based on estimating an equation which explains profits from both market structure variables and measures of efficiency. The EH 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 EH test suffers from a multicollinearity problem if the EH holds.

Market power may also be related to profits, 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 the output price minus marginal costs, divided by output price. The PCM is frequently used in the empirical industrial organization literature as an empirical approximation of the theoretical Lerner index.[3] In the literature banks'

2. Bikker and Bos (2005), pp. 22 and 23.

3. 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 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).

efficiency is often seen as proxy of competition. The existence of scale and scope economies has in the past been investigated thoroughly. It is often assumed that, under strong competition, unused scale economies would be exploited and, consequently, reduced.[4] 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 (imperfect) competition [Bikker and Van Leuvensteijn (2008)]. 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 place new firms in 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. X-efficiency of firm *i* is defined as the difference in cost levels 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).

2.2 Relationship between competition and monetary transmission

According to the seminal papers by Klein (1971) and Monti (1972) on banks' interest rate setting behaviour, banks can exert a degree of market pricing power in determining loan and deposit rates. The Monti-Klein model demonstrates that interest rates on bank products with smaller demand elasticities are priced less competitively. Hence, both the levels of bank interest rates and their changes over time are expected to depend on the degree of competition. With respect to the level of bank interest rates, Maudos and Fernández de Guevara (2004) show that an increase in banks' market power (i.e. a reduction in competitive pressure) results in higher net interest margins.[5] In addition, Corvoisier and Gropp (2002) explain the difference between bank retail interest rates and money market rates by bank's product-specific concentration indices. They find that in concentrated markets, retail lending rates are substantially higher, while deposits rates are lower.

Regarding the effect of competition on the way banks adjust their lending and deposit rates, Hannan and Berger (1991) find that deposit rates are significantly more rigid in concentrated markets. Especially in periods of rising monetary policy rates, banks in more consolidated markets tend not to raise their deposit rates, which may be indicative of (tacit) collusive behaviour among banks. In a cross-country analysis, both Cottarelli and Kourelis (1994) and Borio and Fritz (1995) find a significant effect of constrained competition on the monetary transmission mechanism. Thus, lending rates tend to be stickier when banks operate in a less competitive environment, due to, *inter alia,* the existence of barriers to entry. This finding was confirmed in an Italian setting by Cottarelli *et al.* (1995). Reflecting the existence of bank market power and collusive behaviour as well as potential switching costs for bank customers (or other factors affecting demand elasticities), the degree of price stickiness is likely to be asymmetric over the (monetary policy) interest rate cycle.[6] Against this background, Mojon (2001) tests for the impact of banking competition on the

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4. This interpretation would be different in a market numbering only a few banks. It would also be different in a market where many new entries incur unfavourable scale effects during the initial phase of their growth path.

5. Of course, competition is not the only factor determining the level of bank interest rates. Factors such as credit and interest risk, banks' degree of risk aversion, operating costs, and bank efficiency are also likely to impact on bank margins. See, for example, Maudos and Fernández de Guevara (2004).

6. See, for example, Neuwark and Sharpe (1992) and Mester and Saunders (1985) for empirical evidence of asymmetric interest rate pass-through effects among US banks.

transmission process related to euro area bank lending rates, using an index of deregulation, constructed by Gual (1999). He finds that higher competition tends to put pressure on banks to adjust lending rates quicker when money market rates are decreasing. Furthermore, higher competition tends to reduce the ability of banks to increase lending rates (although not significantly), when money market rates are moving up — and *vice versa* for deposit rates.[7] Similar findings of asymmetric pass-through effects have been found by Scholnick (1996), Heinemann and Schüler (2002), Sander and Kleimeier (2002 and 2004) and Gropp *et al.* (2007).[8] Moreover, De Bondt (2005) argues that stronger competition from other banks and from capital markets has helped to speed up the euro area banks' interest rate adjustments to changes in market rates.

A number of country-specific studies also provide evidence of sluggish pass-through from market rates into bank rates when competition is weak. For example, Heffernan (1997) finds that British banks' interest rate adjustment is compatible with imperfect competition whereas Weth (2002), by using various proxies for bank market power, provides evidence of sluggish and asymmetric pass-through among German banks. De Graeve *et al.* (2004) estimate the determinants of the interest rate pass-through on Belgian banks and find that banks with more market power pursue a less competitive pricing policy. In a microeconomic analysis of Spanish banks, Lago-González and Salas-Fumás (2005) provide evidence that a mixture of price adjustment costs and bank market power causes price rigidity and asymmetric pass-through. In a cross-country study, Kok Sørensen and Werner (2006) show that differences in the pass-through process across the euro area countries may to some extent be explained by national differences in bank competition. Finally, in another euro area based study, Gropp *et al.* (2007) provide evidence that the level of banking competition has a positive impact on the degree of bank interest rate pass-through.

7. In addition to bank competition, switching costs and other interest rate adjustment costs, bank rate rigidity may also be due to credit risk factors. For example, in a situation of credit rationing banks may decide to leave lending rates unchanged and to limit the supply of loans instead; see, for example, Winker (1999). Banks may also choose to provide their borrowers with 'implicit interest rate insurance' by smoothing bank loan rates over the cycle; see Berger and Udell (1992). Finally, sometimes banks give customers an interest rate option for a given period. These banks have to recoup the costs of their options which may reduce the speed of the interest rate pass through for outstanding clients.

8. Sander and Kleimeier (2002 and 2004) differ from others studies in that they also modelling asymmetries the severity of the interest rate shock (rather than merely its direction). This approach aims to take into account menu cost arguments implying that banks tend to pass on changes in market rates of a minimum size only.

3 The Boone indicator as measure of competition

Boone's indicator assumes that more efficient firms (that is, firms with lower marginal costs) will gain higher market shares or profits, and that this effect will be stronger the heavier competition in that market is. In order to support this 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 indicator and to examine its properties compared to common measures such as the HHI and the PCM. 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:

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

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:

$$a - 2\ b\ q_i - d \sum_{i\neq j} q_j - mc_i = 0 \qquad (2)$$

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

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

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. Competition in this market increases as the produced (portfolios of) services of the various banks become closer substitutes, that is, as d increases (with d kept below b). Further, 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 *mc)* 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 $s_i = q_i / \sum_j q_j$:

$$\ln s_i = \alpha + \beta \ln mc_i \qquad (4)$$

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 β 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

interpretation, particularly across equations.[9] The choice of functional form is not essential, as the log-linear form is just an approximation of the pure linear form.

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 homogenous 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 instead of lowering it. 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 the part of profits that stems 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 affects the annual estimates β_t more strongly 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). An absolute benchmark for the level of β is not available. We only know that more negative betas reflect stronger competition. Comparing the indicator across countries or industries helps to interpret estimation results. For that reason, Boone and Weigand in CPB (2000) and Boone *et al.* (2004) apply the model to different manufacturing industries. Since measurement errors —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.

We improve on Boone's approach in two ways. First, we calculate marginal costs instead of approximating this variable with average costs. We are able to do so by estimating

9. The few existing empirical studies based on the Boone indicator all use a log linear relationship. See, for example, Bikker and Van Leuvensteijn (2008).

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 our dependent variable instead of profits. The latter is, by definition, the product of market shares and profit margin. We have views with respect to 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 more important advantage of 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 be ignored.

In order to be able to calculate marginal costs, we estimate, for each country, a translog cost function (TCF) using individual bank observations. This function assumes that the technology of an individual bank can be described by a single 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. Our TCF has different marginal costs for different types of banks, resulting in 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 (commercial, savings 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. Another dummy variable is d_t,, 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 $(K\text{-}K_1\text{-}K_2)$ 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 impose 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:

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

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 symmetry restrictions $\gamma_{j,k} = \gamma_{k,j}$ for $j, k = 1, .., K$.[10] As Equation (5) expresses that we assume different cost functions for each type of banks, the restrictions (6) likewise 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 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:

$$mc_{i1t}^h = c_{it}^h / x_{i1t} \, (\beta_{1h} + 2 \, \gamma_{1lh} \ln x_{ilt} + \sum_{k=1,..,K;\, k \neq l} \gamma_{1kh} \ln x_{ikt} \,) \, d_l^h \qquad (8)$$

10. The restrictions are imposed on Equation (5), so that the equation is reformulated in terms of a lower number of parameters.

4 The interest rate pass-through model

Our analysis of the pass-through of market rates to bank interest rates takes into account that economic variables may be non-stationary.[11] The relationship between non-stationary but cointegrated variables should preferably be based on an error-correction model (ECM), which allows disentangling the long-run co-movement of the variables from the short-run adjustment towards the equilibrium. Accordingly, most of the pass-through studies conducted in recent years apply an ECM, as it allows testing for both the long-run equilibrium pass-through of bank rates to changes in market rates and the speed of adjustment towards the equilibrium.[12] Using a panel-econometric approach, we test for the impact of banking competition (measured by the Boone indicator) on the long-run bank interest rate pass-through.

4.1 Estimation of the long-run relationship

If bank interest rates and their corresponding market rates are cointegrated, we may analyse their long-run relationship in an error-correction framework. Hereby, we test for the three hypotheses by estimating the following two equations for each of the six considered interest rates:[13]

$$BR_{i,t} = \alpha BI_{i,t} + \beta_i MR_{i,t} + \gamma BI_{i,t} MR_{i,t} + \delta_i D_i + u_{i,t} \quad (9.a)$$

$$\Delta BR_{i,t} = \theta_i u_{i,t-1} + \eta_i \Delta MR_{i,t} + \varphi BI_{i,t} \Delta MR_{i,t} + v_{i,t} \quad (9.b)$$

Equation (9.a) reflects the long-run equilibrium pass-through, while Equation (9.b) presents the short-term adjustments of bank interest rates to their long-run equilibrium. $BR_{i,t}$ and $MR_{i,t}$ are the bank interest rate and the corresponding market rate, respectively, in country i (for $I = 1,\ldots, N$) at time t (for $t = 1,\ldots, T$), observed at a quarterly basis. $BI_{i,t}$ is the Boone indicator of country i at time t. For convenience's sake, the Boone indicator is redefined in positive terms, so that an increase in the Boone indicator reflects stronger competition (hence $BI = -\beta$). In all estimations, we include the market interest rates for the different countries separately ($\beta_i MR_{i,t}$ and $\eta_i \Delta MR_{i,t}$, respectively, in the long and short run), in order to observe country-specific effects, as well as multiplied by the Boone indicator ($\gamma BI_{i,t} MR_{i,t}$ and $\varphi BI_{i,t} \Delta MR_{i,t}$, respectively, in the long and short run), in order to capture the (overall) impact of competition on the pass-through. Furthermore, in the long-run model we account for country effects, by using country dummies (D_i). The short-run model includes the error-correction term ($\theta_i u_{i,t-1}$), the effects of competition on short-term adjustments in market rates ($\varphi BI_{i,t} \Delta MR_{i,t}$) for all countries simultaneously and the change in the market interest rate for each country separately ($\eta_i \Delta MR_{i,t}$).

In Equations (9.a) and (9.b), we estimate European-wide (or panel) parameters for the various competition effects (α, γ and φ), because the Boone indicator varies insufficiently over time to estimate reliable country-specific effects. The other parameters (β_i, η_i and θ_i)

11. In order to avoid spurious results, see Granger and Newbold (1974).

12. See, for example, Mojon (2001), De Bondt (2002 and 2005), Sander and Kleimeier (2004), and Kok Sørensen and Werner (2006).

13. Namely, four types of loan products (mortgage loans, consumer loans and short and long-term loans to enterprises) and two types of deposits (time deposits and current account deposits).

remain country-specific, unless restrictions that these parameters are equal across all countries considered would be accepted by a Wald test.

The three hypotheses to be tested are:

I) Are loan interest rates lower, and are deposit interest rates higher, in more competitive loan markets than in less competitive loan markets?
H_0: $\alpha + \gamma MR_{i,t} < 0$ and H_1: $\alpha + \gamma MR_{i,t} \geq 0$;[14]
(and H_0: $\alpha + \gamma MR_{i,t} > 0$ and H_1: $\alpha + \gamma MR_{i,t} \leq 0$, respectively, for deposit rates).

II) Are long-run loan and deposit interest rates responses to the corresponding market rates stronger in more competitive loan markets than in less competitive loan markets? H_0: $\gamma > 0$ and H_1: $\gamma \leq 0$.

III) Do more competitive markets adjust faster, in the short run, to changes in market interest rates than in less competitive markets?
H_0: $\varphi > 0$ and H_1: $\varphi \leq 0$.

As we measure competition on the loan market, the competition effects on the deposit-rate pass-through may be less reliable. Loan market competition might have a positive impact on deposit markets also, implying $\alpha_1 + \gamma_1 MR_{i,t} > 0$. Alternatively, banks may try to compensate for strong loan market competition by exploiting their market power in the deposit market, in which case $\alpha_1 + \gamma_1 MR_{i,t} < 0$.

4.2 Unit root and panel cointegration tests

UNIT ROOT TESTS

As a first preparatory step, we investigate the unit root properties of the variables.[15] We apply two types of tests based on two different null hypotheses. The Im, Pesaran and Shin (2003) test (henceforth the IPS test) is a panel version of the Augmented Dickey Fuller (ADF) test on unit roots. It is based on the following regression equation:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_j} \beta_{i,j} \Delta y_{i,t-j} + \varepsilon_{i,t} \tag{10}$$

The interest rate series under investigation is $y_{i,t}$ and it must be observable for each country i and each month t. The autoregressive parameter ρ_i is estimated for each country separately, which allows for a large degree of heterogeneity. The null hypothesis is, H_0: $\rho_i = 0$ for all i, against the alternative hypothesis H_1: $\rho_i > 0$ for some countries. The test statistic Z_{t_bar} of the IPS test is constructed by cross-section-averaging the individual t-statistics for ρ_i. Rejection of the null hypothesis indicates stationarity.

As a cross-check, we add results based on Hadri's (2000) test, which is a panel version of the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, testing the null hypothesis of stationarity. The model underlying the Hadri test can be written as:

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14. Note that competition causes a downwards shift to the level of bank interest rates (that is, $\alpha_1 < 0$) as well as a change in the relationship between market rates and bank rates (expressed by $\gamma_1 MR_{i,t}$).

15. For a survey of panel unit root tests, see Banerjee (1999). For a more detailed description and application to a similar set of data, see also Kok Sørensen and Werner (2006).

$$y_{i,t} = \alpha_i + \sum_{\tau=1}^{t} u_{i,\tau} + \varepsilon_{i,t} \tag{11}$$

The time series $y_{i,t}$ are broken down into two components, a random walk component $\sum_\tau u_{i,\tau}$ and a stationary component $\varepsilon_{i,t}$. The test statistic Z_τ is based on the ratio of the variances $\sigma^2_u / \sigma^2_\varepsilon$. The null hypothesis of the test assumes that this ratio is zero, which implies that there is no random walk component. Rejection of this test's null hypothesis indicates the presence of unit root behaviour of the variable under investigation. Both panel series test statistics are asymptotically normal.

COINTEGRATION TESTS

In a second preliminary step, we test for cointegration using panel cointegration tests by Pedroni (1999 and 2004) which are based on the following regression models:

$$y_{i,t} = \alpha_i + \sum_{j=1}^{K} \beta_{j,i} x_{j,i,t} + \varepsilon_{i,t} \tag{12}$$

The long-run coefficients $\beta_{i,j}$ may be different across the euro area countries. We use the group mean panel version of the Pedroni test. The null hypothesis of this test assumes a unit root in the residuals of the cointegration regression, which implies absence of cointegration. The alternative hypothesis assumes a root less than one, but allows for different roots in different countries.[16] We use three different types of test statistics: an ADF type which is similar to the ADF statistic used in univariate unit-root tests, a nonparametric Phillips-Perron (PP) version, and a version which is based directly on the autoregressive coefficient (ρ-test).

16. In the panel versions of the tests the alternative hypothesis assumes a root which is less than one but is identical between the countries. Hence, the group mean versions allow for stronger heterogeneity. As a result, we focus on the test's group mean version.

5 The data

5.1 The Boone indicator

This paper uses the Bankscope database of banks from eight euro area countries during 1992-2004, namely Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal and Spain. Our choice of countries was limited by the availability of (usable) data. For countries such as Finland, Greece and Ireland not enough data are available. Luxembourg is excluded from our sample because its figures presumably do not reflect local market conditions due to the high international profile of its banks. We focus on commercial banks, savings banks, cooperative banks and mortgage banks, ignoring the 25% more specialized institutions such as investment banks, securities firms, long-term credit banks and specialized governmental credit institutions. An exception is made for Germany in order to achieve a more adequate coverage of the national banking systems: specialized German governmental credit institutions, comprising mainly the major Landesbanken, are included. In addition to certain public finance duties, the Landesbanken also offer banking activities in competition with private sector banks, and thus should be included to ensure adequate cover of the competitive environment in the German banking system [see Hackethal (2004)]. The appendix provides a detailed description of the data; see also Van Leuvensteijn *et al.* (2007). Table 5.1 presents summary statistics of the estimated Boone indicator.[17] Over the 1994-2004 period we observe that, on average, banking competition is heaviest in Spain, Germany and Italy. Competition appears to be less strong in Belgium, the Netherlands and Austria, and is found to be weakest in France and Portugal. At the same time, Boone indicators for many countries vary considerably over time.[18]

Table 5.1 Summary statistics of the Boone indicator (1994-2004)

	AT	BE	DE	ES	FR	IT	NL	PT
Average	-1.5	-2.6	-4.0	-4.8	-0.6	-4.0	-2.5	-0.9
Standard deviation	2.3	0.7	1.5	1.8	0.5	1.8	1.5	1.2
Maximum	4.3	-1.5	-2.5	-2.7	0.3	-1.6	1.0	1.6
Minimum	-4.0	-3.4	-7.1	-9.6	-1.3	-7.3	-4.4	-2.4

5.2 Bank interest rates and market rates

Our bank loan interest rates are from the ECB's MFI Interest Rate (MIR) statistics, which since January 2003 have been compiled on a harmonised basis across all euro area countries. Prior to January 2003 the series have been extended backwards to January 1994 using the non-harmonised national retail interest rate (NRIR) statistics compiled by the national central

17. The Boone indicator results in this paper may seem different from those in Van Leuvensteijn *et al.* (2007). However, both working papers use identical estimates of the Boone indicator. The estimates in the appendix of the present paper are exactly equal to the estimates in Table 5.4 in Van Leuvensteijn *et al.* (2007). However, the presentation of the results differs in two respects from Table 5.3 in Van Leuvensteijn *et al.* (2007). First, in this paper we present three additional euro-area countries, namely Austria, Belgium and Portugal. Second, in Table 5.3 of Van Leuvensteijn *et al.* (2007) we compare the average Boone indicator across the European countries by estimating a single parameter for each country over the entire sample period. In this way, we obtain a weighted average of the Boone indicator over the entire period instead of an unweighted average of the annually (time dependent) estimates as in Table 5.1. See the appendix for the yearly estimates of the Boone indicator.

18. For more details, see Van Leuvensteijn *et al*. (2007).

banks of the (later) Eurosystem.[19] The MIR statistics consist of more detailed breakdowns than the NRIR statistics, particularly with respect to the size of loans and the rate fixation periods. In order to link the two sets of statistics, the MIR series have been aggregated (using new business volumes as weights) to the broader product categories of the NRIR statistics, which include rates on mortgage loans, rates on consumer loans, rates on short-term loans to non-financial corporations (≤1 year), rates on long-term loans to non-financial corporations (>1 year), rates on current account deposits and rates on time deposits. The data period covers 147 monthly observations ranging from January 1994 to March 2006.

We select market rates which correspond to these bank interest rates in terms of the rate fixation period. Hence, a three-month money market rate is selected to correspond with bank rates that are either floating or fixed for short periods (below one year), while longer-term government bond yields are selected for long-term fixed bank rates.[20] Table 5.2 presents the data availability of bank interest rates in each country and for each product category together with the corresponding market rates. Note that there is strong variation in interest rate fixation periods across both products and countries. For instance, in many of the considered euro area countries the predominant fixation period for mortgages is rather short, proxied by three months. For Germany and France, however, the typical fixation period on consumer loans is quite long, approximated here by five years.

Table 5.2 Availability of bank interest rates and corresponding market rates

	Mortgage loans	Consumer loans	Short-term enterprise loans	Long-term enterprise loans	Current account deposits	Time deposits
AT	April 1995 3M MR	April 1995 3M MR	April 1995 3M MR		April 1995 3M MR	April 1995 3M MR
B0E	Jan. 1994 3M MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Jan. 1994 5Y MR		Jan. 1994 3M MR
DE	Jan. 1994 10Y MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Nov. 1996 5Y MR		Jan. 1994 3M MR
ES	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR
FR	Jan. 1994 10Y MR	Jan. 1994 5Y MR	Jan. 1994 3M MR	Jan. 1994 5Y MR		Jan. 1994 3M MR
IT	Jan. 1995 3M MR		Jan. 1994 3M MR	Jan. 1995 3M MR	Jan. 1994 3M MR	Feb. 1995 3M MR
NL	Jan. 1994 10Y MR		Jan. 1994 3M MR		Jan. 1994 3M MR	Jan. 1994 3M MR
PT	Jan. 1994 3M MR	Jan. 1994 3M MR	Jan. 1994 3M MR			Jan. 1994 3M MR

Sources: ECB and Bloomberg.

Note: Date indicates: 'available since'; '3M MR' is the 3-month money market rate (MR). '5Y MR' is the 5-year government bond yield. '10Y MR' is the 10-year government bond yield, all for the respective country.

19. For some bank products in some countries, it is not possible (due to insufficient data being available) to extend interest rates series all the way back to 1994. Hence, we use unbalanced samples for some bank products.

20. The market rates have been chosen to best match bank interest rates on the basis of information from the Methodological Notes for the NRIR statistics and from the volume weights of the MIR statistics.

Table 5.3 Summary statistics of the various bank interest rates (1994-2004; in %)

	AT	BE	DE	ES	FR	IT	NL	PT
	Mortgage rates							
Average	5.6	5.9	6.4	6.6	6.1	7.0	5.7	7.6
Standard deviation	1.0	1.2	1.1	2.7	1.5	3.2	1.0	3.5
Maximum	7.9	8.8	9.1	11.5	8.9	13.0	8.0	14.5
Minimum	3.8	3.8	4.5	3.1	3.9	3.7	3.8	3.4
	Consumer lending rates							
Average	6.6	8.1	7.5	10.4	8.8			13.1
Standard deviation	1.1	0.5	1.0	2.8	1.7			3.6
Maximum	9.5	9.1	10.2	16.2	12.1			19.6
Minimum	5.0	7.3	6.3	7.1	6.2			8.6
	Rates on short-term loans to enterprises							
Average	4.8	4.6	4.0	5.9	4.5	6.7	4.2	8.8
Standard deviation	1.0	1.1	0.7	2.2	1.5	2.8	1.0	3.8
Maximum	7.2	7.6	5.8	10.5	7.8	11.7	6.5	16.8
Minimum	2.9	2.9	3.1	3.2	2.6	3.3	2.8	4.4
	Rates on long-term loans to enterprises							
Average		5.1	5.2	5.7	5.9	6.3		
Standard deviation		1.1	0.5	2.4	1.4	2.7		
Maximum		8.2	6.1	10.4	8.8	11.8		
Minimum		3.4	4.2	3.0	4.0	3.1		
	Current account deposit rates							
Average	1.3			1.8		2.6	1.7	
Standard deviation	0.2			1.2		1.8	0.3	
Maximum	1.7			4.6		5.7	2.0	
Minimum	1.0			0.5		0.7	1.1	
	Time deposit rates							
Average	3.5	3.4	4.4	3.8	4.0	3.3	4.1	3.4
Standard deviation	1.0	0.9	2.1	1.3	2.3	0.9	2.2	0.8
Maximum	6.3	5.4	8.9	8.0	9.1	5.4	8.7	5.1
Minimum	1.9	2.0	1.9	2.0	1.6	2.0	1.8	2.0

Table 5.3 shows summary statistics of the bank interest rate data. Bank interest rates differ substantially across countries, across products and over time. On average, over the 1994-2004 period, mortgage rates and consumer lending rates were highest (lowest) in Portugal (Austria). Regarding short-term loans to enterprises rates were on average highest (lowest) in Portugal (Germany), whereas regarding long-term loans to enterprises rates were highest (lowest) in Italy (Belgium). On the deposit side, current account deposit rates were lowest (highest) in Austria (Italy), while time deposit rates were lowest (highest) in Italy (Germany). Regarding developments over time, it may be noted that the variation of bank interest rates was highest in the Mediterranean countries reflecting the particular strong decline in the overall level of interest rates in those countries.

Table 5.4 details the market interest rates for the considered countries. We find that Italy has, on average, the highest three-month money market rate and the Netherlands the lowest. The same picture arises for the 5-year government bond yield. The minima for the three-month money market rates and the two government bond yields with, respectively, a 5 and 10 year fixation period are very similar across all countries: these minima where reached after the introduction of the euro in 1999.

Table 5.4 Summary statistics of the various market rates (1994-2004; in %)

	AT	BE	DE	ES	FR	IT	NL	PT
	3-month money market rate							
Average	3.6	3.6	3.6	4.9	3.9	5.4	3.5	5.3
Standard deviation	0.9	1.1	1.0	2.3	1.4	2.8	1.0	2.9
Maximum	5.5	7.0	5.9	9.7	8.1	11.0	5.4	12.7
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	5-year government bond yield							
Average	4.7	4.8	4.5	5.7	4.8	6.1	4.6	5.9
Standard deviation	1.1	1.2	1.0	2.6	1.3	2.9	1.1	2.7
Maximum	7.3	8.0	7.1	12.2	7.9	13.4	7.3	12.2
Minimum	2.8	2.9	2.8	2.7	2.7	2.9	2.8	2.7
	10-year government bond yield							
Average			5.2		5.4		5.3	
Standard deviation			1.0		1.2		1.0	
Maximum			7.6		8.2		7.7	
Minimum			3.6		3.6		3.6	

Table 5.5 presents the spreads between the various bank and market rates. We present the spreads on deposits as a negative number as the market interest rates are higher than the bank lending rates on these products. On average, the spreads are narrow ranging from 0.5% to 2.0%, with the notable exception of consumer loans where bank interest rates often include very high risk premiums.

Table 5.5 Summary statistics of the various bank-rate spreads (1994-2004; in %)

	AT	BE	DE	ES	FR	IT	NL	PT
	Mortgage rates							
Average	2.1	2.2	1.8	1.6	1.3	1.9	1.1	2.2
Standard deviation	0.6	0.6	0.3	0.5	0.7	0.7	0.2	1.0
Maximum	3.6	3.5	2.4	2.9	3.8	3.7	1.7	4.5
Minimum	0.8	0.3	1.0	0.8	0.1	0.7	0.6	0.5
	Consumer lending rates							
Average	3.2	4.2	3.1	5.5	4.0			7.7
Standard deviation	0.7	0.9	0.8	0.6	0.9			1.3
Maximum	5.1	6.5	5.2	7.2	7.0			10.2
Minimum	2.1	2.6	1.4	4.2	2.3			4.4
	Rates on short-term loans to enterprises							
Average	1.3	1.0	0.5	1.0	0.6	1.3	0.7	3.4
Standard deviation	0.6	0.2	0.6	0.2	0.8	0.5	0.3	1.1
Maximum	2.9	1.5	1.6	2.0	2.8	2.5	1.3	6.7
Minimum	0.4	0.4	-0.4	0.5	-1.8	-0.4	-0.1	1.9
	Rates on long-term loans to enterprises							
Average		0.4	1.1	0.9	1.1	1.3		
Standard deviation		0.4	0.2	0.4	0.7	0.4		
Maximum		1.2	1.8	1.8	2.2	3.3		
Minimum		-0.3	0.5	0.1	-0.4	-0.5		
	Current account deposit rates							
Average	-2.0			-2.9		-2.7	-1.7	
Standard deviation	0.7			1.2		1.1	0.8	
Maximum	-1.0			-1.4		-1.3	-0.8	
Minimum	-3.8			-5.9		-6.0	-3.5	
	Time deposit rates							
Average	-0.4	-0.1	-0.2	-0.5	-0.1	-0.9	-0.2	-1.1
Standard deviation	0.4	0.2	0.2	0.3	0.1	0.5	0.4	0.9
Maximum	0.6	0.2	0.2	0.1	0.2	-0.2	0.6	-0.1
Minimum	-1.5	-0.7	-0.6	-1.1	-0.3	-2.6	-1.1	-4.7

6 Empirical results

Estimates of the Boone indicator for the loan markets in the euro area countries are presented in the appendix. This approach is similar to the procedure applied in Van Leuvensteijn *et al*. (2007). We obtain annual estimates of the Boone indicator. As the regressions in this section are based on monthly data, we calculate 'smoothed' Boone indicator values using moving averages over six months.

6.1 Unit root and cointegration

Table 6.1 reports the panel unit root tests for the bank and market interest rate series of the considered eight euro area countries simultaneously. The outcomes indicate non-stationarity at the 5% significance level for all the bank and market interest rate series used. The IPS test on the null hypothesis of a unit root cannot be rejected at the 5% significance level for either the bank rates or the market rates, suggesting non-stationary interest rates. While the IPS test indicates stationarity of the Boone indicator, the null hypothesis of non-stationarity cannot be rejected at the 5% significance level for the product of the Boone indicator and the market rates for three of the six categories, namely mortgage loans, consumer loans and time deposits. However, the Hadri-test on the null hypothesis of stationarity is clearly rejected in all cases. Furthermore, we apply the panel unit root tests for the first differences in interest rates to test on second order non-stationarity. The results reject I(2) and, hence, support the conclusion that the interest rate series are integrated of order 1, so that I(1) holds. Given these findings, we proceed to test on cointegration between bank interest rates and the corresponding market rates.

Table 6.1 Panel unit root tests on model variables applied to all countries

	Im, Pesaran and Shin test		**Hadri test**	
	Z_{t_bar} [a]	*p-value*	Z_τ	*p-value*
	Boone-indicator			
Boone-indicator	-2.16	0.02	10.67	0.00
	Bank interest rates			
Mortgage loans	0.98	0.84	18.78	0.00
Consumer loans	-0.89	0.19	16.59	0.00
Short-term loans to enterprises	-0.68	0.25	18.83	0.00
Long-term loans to enterprises	0.40	0.66	13.10	0.00
Current account deposits	1.64	0.95	13.86	0.00
Time deposits	-0.72	0.24	16.03	0.00
	Market interest rates [b]			
Mortgage loans	0.04	0.52	17.08	0.00
Consumer loans	0.34	0.64	15.21	0.00
Short-term loans to enterprises	-0.68	0.25	17.23	0.00
Long-term loans to enterprises	0.94	0.83	13.39	0.00
Current account deposits	0.38	0.65	12.60	0.00
Time deposits	-1.56	0.06	16.46	0.00
	Boone indicator times market interest rates [a]			
Mortgage loans	-2.16	0.01	15.76	0.00
Consumer loans	-1.88	0.03	12.64	0.00
Short-term loans to enterprises	-1.44	0.08	17.46	0.00
Long-term loans to enterprises	-1.38	0.08	13.74	0.00
Current account deposits	-1.60	0.06	12.65	0.00
Time deposits	-2.46	0.01	15.70	0.00

[a] The test statistics are explained in Section 4.2; [b] Market rates are approximated according to Table 5.2.

Table 6.2 shows the results for Pedroni's three panel cointegration tests as applied to the long-run models of the six bank rates.[21] For bank interest rates on consumer loans and current account deposits, the null hypothesis of no cointegration cannot be rejected. Apparently, therefore, the adjustment of interest rates on consumer loans and current account deposits to changes in market rates is so sluggish that even a long-run relationship cannot be detected in our sample.[22] Consequently, the results of the error-correction model on consumer loans and current account deposits, presented in Section 6.2 below, have to be interpreted with caution. For the other four long-run bank rate models, the null hypothesis of no cointegration has been rejected (for two of the three tests), indicating a long-run equilibrium relationship between bank rates, market rates and the Boone indicator.

Table 6.2 Pedroni cointegration tests on the six long-run bank interest rates models

Bank interest rates	Group mean panel cointegration tests[a]		
	ρ-statistic	*PP-statistic*	*ADF-statistic*
Mortgage loans	-3.19 (0.00)	-3.56 (0.00)	-0.07 (0.53)
Consumer loans	0.73 (0.77)	0.19 (0.57)	0.05 (0.52)
Short-term loans to enterprises	-5.79 (0.00)	-4.75 (0.00)	-1.50 (0.07)
Long-term loans to enterprises	-2.68 (0.00)	-2.91 (0.00)	-0.75 (0.22)
Current account deposits	1.14 (0.87)	1.29 (0.90)	0.66 (0.75)
Time deposits	-8.28 (0.00)	-7.08 (0.00)	-0.43 (0.33)

[a] P-values in parentheses.

6.2 Competition and the bank interest-rate pass-through

As a first investigation into the impact of competition on the bank interest rate pass-through, we analyse the effect of competition on the various spreads between bank and market interest rates (see Table 6.3). The main finding is that competition tends to keep bank loan rates more closely in line with the corresponding market rates (implying that they are lower). Moreover, the results in Table 6.3 show that competition significantly diminishes the bank rate spreads for three out of four loan products, namely for mortgages, consumer loans and short-term loans to enterprises. No significant effect is found for long-term loans to enterprises. The Boone indicator's elasticities of the first three loan products indicate that mortgage loans are least affected by competition while short-term loans to enterprises are influenced most strongly.

For the two deposit categories, competition in the loan market seems to increase the (negative) spread between bank and market rates. Hence, deposit rates become lower where there is fierce competition in the loan market. This could reflect that the competitive pressure is heavier in the loan market than in the deposit markets, so that banks under competitive pressure compensate for their decline in loan market income by lowering their deposit rates.

21. P-values of the various test statistics have been derived using the standard normal distribution, which is a valid assumption for cointegration tests; see Pedroni (1999).

22. Data on interest rates on consumer loans and current account deposits prior to January 2003 are only available for six and four countries, respectively, which somewhat limits the analysis of these rates.

Table 6.3 Effect of competition on the spreads between bank and market rates

	Mortgage loans		**Consumer loans**		**Short-term loans to enterprises**	
	parameter	*z-value*[1)]	*parameter*	*z-value*	*parameter*	*z-value*
Boone indicator	-0.030	**-2.12	-0.075	***-3.03	-0.128	***-6.72
Constant	1.357	***5.54	5.818	***16.91	0.736	***3.02
Country dummies [2)]	$X^2(7)=498$		$X^2(5)=3095$		$X^2(7)=911$	
Monthly dummies[2)]	$X^2(119)=693$		$X^2(119)=766$		$X^2(119)=223$	
R-squared, centred	0.687		0.907		0.793	
Number of observations	957		717		957	
	Long-term loans to enterprises		**Current account (sight) deposits**		**Time deposits**	
	parameter	*z-value*	*parameter*	*z-value*	*parameter*	*z-value*
Boone indicator	0.003	0.15	-0.154	***-8.26	-0.036	***-3.06
Constant	1.114	***4.26	-3.496	***-12.30	-0.655	***-2.80
Country dummies	$X^2(4)=240$		$X^2(3)=141$		$X^2(7)=640$	
Monthly dummies	$X^2(119)=1084$		$X^2(119)=1499$		$X^2(119)=389$	
R-squared, centred	0.670		0.832		0.691	
Number of observations	578		477		956	

Two and three asterisks indicate a level of confidence of 95% and 99%, respectively. [1)] The z-value indicates whether the parameter significantly differs from 0 under the normal distribution with mean zero and standard deviation one. [2)] Chi-squared distributed Wald tests on H_0 'all country dummy coefficients are zero' and 'all monthly time dummy coefficients are zero', respectively. The null hypotheses are rejected for all loan and deposit types.

Table 6.4 presents the estimated long-run relationship of the error-correction model (ECM) described in Section 4.1 [Equation (9.a)], in order to test the three hypotheses mentioned in that section. This model explains bank interest rates from the Boone indicator and the market interest rates. We use Newey-West's kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations to correct for heteroskedasticity and autocorrelation, where the bandwidth has been set on two periods. We observe that the impact of market rates on bank interest rates is highly significant for all six interest rates considered and in all eight euro area countries. Moreover, in line with the existing literature, we find that the country-specific long-run pass-through coefficients (β_i) differ considerably across product categories (and across countries) for both the long and short term. The adjustment of bank interest rates to changes in market rates is highest for mortgage loans, loans to enterprises and time deposits.[23]

The first hypothesis is: are loan interest rates lower, and are deposit interest rates higher, in more competitive loan markets than in less competitive loan markets? Contrary to the estimations of the spreads presented above, the ECM long-run equation does not assume full pass-through of market rates within one month. Table 6.4 shows that the effect of the interaction terms with the Boone indicator of competition and the market rate is (slightly) positive for all four considered loan products.[24] But the Chi-squared distributed Wald tests on H_0: $\alpha+\gamma MR_{i,t}=0$ also shows that the combined effects of $\alpha+\gamma MR_{i,t}$ on bank rates are not significant. This outcome does not confirm our earlier finding of significantly lower loan market spreads under competition. Apparently, the simple spread

23. See also Mojon (2001), De Bondt (2005) and Kok Sørensen and Werner (2006).

24. When tested, one single EU-wide parameter for market interest rates was rejected in favour of separate country-specific parameters for market interest rates.

model is a more successful tool to observe the competition effect than the more complicated ECM.[25]

The second hypothesis is: do bank interest rates in more competitive markets show stronger long-run responses to the corresponding market rates compared to less competitive markets? Our results suggest that all four bank loan rates do indeed respond significantly more strongly to market rates when competition is high, as reflected by the significant positive coefficient γ of the product terms of indicator and market rates for all loan categories. We find that competition in the loan market contributes also to a more complete pass-through of interest rates on current accounts.[26] All in all, we observe that, generally, competition does make for stronger long-run bank rate responses to corresponding market rates.

The third hypothesis is: do more competitive markets adjust faster in the short run to changes in market interest rates than in less competitive markets? To test this hypothesis, we estimate Equation (9.b). The results in Table 6.5 indicate that the immediate responses of banks' interest rates on loans to changes in market rates tend indeed to be higher in more competitive markets (see the coefficient φ of the product terms).[27] However, the effect is not statistically significant. All in all, we find only limited evidence to support the third hypothesis.

25. We have tested on a single EU-wide parameter for market interest rates in the long-run ECM model. This null hypothesis was rejected for all loan and deposit categories in favour of separate country-specific parameters for market interest rates.

26. As mentioned in Section 4, the estimated long-run relationship between interest rates on consumer loans and current account deposits and corresponding market rates may be spurious owing to the lack of a statistically significant cointegration relationship.

27. We have tested on one single EU-wide parameter for market interest rates and for one single EU-wide parameter for residuals in the short-run ECM model. The null hypotheses of a single EU-wide parameter were rejected for most loan and deposit categories in favour of separate country-specific parameters.

Table 6.4 Estimates of the long-run ECM models for the six bank interest rates

	Mortgage loans		**Consumer loans**		**Short-term loans to enterprises**	
	parameter	*z-value*	*parameter*	*z-value*	*parameter*	*z-value*
Boone indicator (α)	-0.198	***-3.32	-0. 196	**-2.39	-0.153	**-3.39
Market interest rate AT	0.843	***8.02	0.824	***6.15	0.937	***8.76
Market interest rate BE	0.913	***12.26	1.000	***5.98	0.892	***23.05
Market interest rate DE	0.923	***14.88	0.312	**2.41	0.325	***6.22
Market interest rate ES	0.777	***10.89	0.785	***7.63	0.725	***10.90
Market interest rate FR	0.989	***12.85	1.093	***13.38	0.877	***13.04
Market interest rate IT	0.870	***16.07			0.807	***16.90
Market interest rate NL	0.784	***18.11			0.879	***20.11
Market interest rate PT	1.274	***24.63	1.336	***23.06	1.344	***37.41
Market int. r.*Boone ind. (γ)	0.053	***4.29	0.057	***3.21	0.039	***3.47
Constant	1.951	***9.74	5.679	***11.21	2.813	***13.62
R-squared, centred	0.940		0.927		0.952	
Number of observations	957		717		957	
$\alpha+\gamma MR_{i,t}$	0.034		0.055		0.002	
x^2 H_0: $\alpha+\gamma MR_{i,t}=0$ [1)]	2.92, p-value = 0.09		2.39, p-value =0.12		0.01, p-value = 0.92	
	Long-term loans to enterprises		**Current account (sight) deposits**		**Time deposits**	
	parameter	*z-value*	*parameter*	*z-value*	*parameter*	*z-value*
Boone indicator (α)	-0.181	***-3.59	-0.146	***-5.75	-0.001	-0.60
Market interest rate AT			0.063	***2.28	0.616	***10.17
Market interest rate BE	0.808	***16.79			0.921	***39.45
Market interest rate DE	0.615	***11.48			0.894	**33.03
Market interest rate ES	0.691	***10.89	0.259	***6.75	0.925	***26.99
Market interest rate FR	0.982	***14.42			0.997	***137.37
Market interest rate IT	0.745	***18.84	0.433	***18.09	0.856	***26.99
Market interest rate NL			0.083	***2.19	0.831	***12.41
Market interest rate PT					0.798	***38.33
Market int. r.e*Boone-ind. (γ)	0.046	***4.48	0.037	***5.86	-0.015	-0.60
Constant	2.591	***11.58	1.457	***10.43	0.302	**3.15
R-squared, centred	0.956		0.966		0.972	
Number of observations	578		477		956	
$\alpha+\gamma MR_{i,t}$	0.028		0.005		-0.024	
x^2 H_0: $\alpha+\gamma MR_{i,t}=0$ [1)]	2.26, p-value=0.13		0.53, p-value=0.47		4.29, p-value =0.04	

Note: One, two and three asterisks indicate levels of confidence of 90%, 95% and 99%, respectively. Country dummies are included but not shown.

[1)] Chi-squared distributed Wald tests on H_0 '$\alpha+\gamma MRi,t=0$'. The null hypothesis is not rejected for any of the loan and for current account deposits.

Table 6.5 The short-term ECM model of bank interest rates

	Mortgage loans		**Consumer loans**		**Short-term loans to enterprises**	
	parameter	*z-value*	*parameter*	*z-value*	*parameter*	*z-value*
ΔMarket interest rate AT	0.2272	***3.15	0.203	*1.84	0.275	***3.41
ΔMarket interest rate BE	0.207	*1.73	0.358	1.32	0.408	***2.49
ΔMarket interest rate DE	0.511	***4.33	-0.267	-1.30	0.159	1.20
ΔMarket interest rate ES	0.217	*1.75	0.041	0.10	0.573	***3.36
ΔMarket interest rate FR	-0.025	-0.58	-0.005	-0.09	0.079	0.73
ΔMarket interest rate IT	0.156	1.11			0.066	0.42
ΔMarket interest rate NL	0.262	***2.79			0.464	***3.01
ΔMarket interest rate PT	0.173	*1.88	0.001	0.00	0.159	0.87
ΔMarket interest rate*Boone-ind. (φ)	0.020	0.86	0.071	1.52	0.050	*1.66
Residual AT (-1) [a]	-0.005	***-3.10	-0.004	***-2.89	-0.005	***-3.00
Residual BE (-1)	-0.007	**-2.20	-0.003	-1.09	-0.005	-1.52
Residual DE (-1)	-0.003	-1.56	-0.003	**-2.07	-0.001	-0.23
Residual ES (-1)	-0.006	***-2.80	-0.003	-0.86	-0.000	-0.03
Residual FR (-1)	-0.006	***-3.45	-0.004	***-3.25	-0.003	-0.44
Residual IT (-1)	-0.006	**-1.96			-0.004	*-1.64
Residual NL (-1)	-0.004	-1.63			-0.000	-0.10
Residual PT (-1)	-0.009	***-3.89	-0.006	-1.50	-0.011	**-2.28
R-sq centred	0.19		0.03		0.19	
Number of observations	949		711		949	
	Long-term loans to enterprises		**Current account (sight) deposits**		**Time deposits**	
	parameter	*z-value*	*parameter*	*z-value*	*parameter*	*z-value*
ΔMarket interest rate AT			0.107	***3.05	0.229	***2.90
ΔMarket interest rate BE	0.987	***6.97			0.532	****6.02
ΔMarket interest rate DE	0.657	***3.56			0.587	****6.27
ΔMarket interest rate ES	0.994	***3.67	0.374	***3.90	0.344	**2.09
ΔMarket interest rate FR	0.162	1.47			0.972	***38.82
ΔMarket interest rate IT	0.744	***3.34	0.312	***3.68	0.146	1.28
ΔMarket interest rate NL			0.099	**2.45	0.463	***4.95
ΔMarket interest rate PT					0.281	***3.37
ΔMarket interest rate*Boone-ind. (φ)	0.070	1.41	-0.033	**-2.47	0.020	0.92
Residual AT (-1)			-0.004	**-2.16	-0.004	*-1.69
Residual BE (-1)	0.001	0.31			-0.004	-1.58
Residual DE (-1)	-0.001	-0.80			-0.001	-0.64
Residual ES (-1)	-0.005	-1.51	-0.010	**-2.13	-0.006	**-2.03
Residual FR (-1)	-0.004	-1.36			0.000	0.24
Residual IT (-1)	-0.004	-1.33	-0.007	-1.41	-0.009	**-2.33
Residual NL (-1)			-0.003	**-2.18	-0.005	-1.46
Residual PT (-1)					-0.009	***-3.39
R-squared centred	0.27		0.18		0.63	
Number of observations	573		473		948	

Note: One, two and three asterisks indicate a level of confidence of, respectively, 90%, 95% and 99%.
[a] See Equation (9.b).

7 Conclusions

This paper analyses the effects of loan market competition on bank interest rates on loans and deposits, measuring competition by a new approach, called the Boone indicator. Our results show that, in the euro area countries, bank interest rate spreads on mortgage loans, consumer loans and short-term loans to enterprises are significantly lower in more competitive markets. This result implies that bank loan rates tend to be lower under heavier competition, thus improving social welfare. Banks compensate for stronger loan market competition by lowering their deposit rates. Furthermore, evidence is found for all four loan categories that, in the long run, bank loan rates are closer in line with market rates where competition is higher. These results show that stronger loan market competition reduces bank loan rates while changes in market rates are transmitted more rapidly to bank rates. These findings underline that bank competition may have a substantial impact on the monetary policy transmission mechanism.

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APPENDIX: THE ESTIMATION OF THE BOONE INDICATOR MODEL

Description of the data used

The Boone indicator model uses Bankscope data of banks from eight euro area countries during 1992-2004.[28] This model is based on marginal costs which are derived from a translog cost function with output components and input prices. 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 0.20; 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 0.01 and 0.50. As a result, our final data set totals 520 commercial banks, 1506 cooperative banks, 699 savings banks, 28 special governmental credit institutions (Landesbanken) and 62 real estate banks (see Table A.1).

Table A.1 Number of banks by country and by type

Country	Commercial banks	Cooperative banks	Real estate banks	Savings banks	Specialized governmental credit institutions	Total
AT	52	54	10	65	0	181
BE	24	6	0	5	0	35
DE	130	867	44	501	28	1570
ES	61	17	0	43	0	121
FR	115	83	2	30	0	230
IT	105	476	1	52	0	634
NL	24	1	4	1	0	30
PT	9	2	1	2	0	14
Total	520	1506	62	699	28	2815

Table A.2 provides a short description of the model variables. To grasp the relative magnitude of the key variables, such as costs, loans, security investment and other services, we present them as shares of corresponding balance sheet items. Total costs are defined as total expenses. They vary between 6.3% and 8.6% of total assets, whereas market shares in the loan market vary between 0.06% and 5.8%. Loans and securities are in the range of, respectively, 35%-60% and 4%-37% of total assets. One of the output components we distinguish is other services. For lack of direct observations, this variable is proxied by non-interest income. Non-interest income ranges from 12%-20% of total income. Wage rates are proxied as the ratio of personnel expenses and total assets, since for many banks the number of staff is not available. Wages vary across countries between 0.9% and 1.7% of total assets. The input price of capital is proxied by the ratio of other expenses and fixed assets. Finally, interest rates are proxied by dividing interest expenses by total funding and range from 3.2% to 5.9%.

28. See also Van Leuvensteijn *et al.* (2007), where a similar approach has been used.

Table A.2 Mean values of key variables for various countries (in %)

	Boone model	Translog cost function						
Country code	*Average loans market shares in %*	*Total costs as % of total assets*	*Loans as % of total assets*	*Securities as % of total assets*	*Other services as % of total income*	*Other expenses as % of fixed assets*	*Wages as % of total assets*	*Interest expenses as % of total funding*
AT	0.87	6.34	56	22	20	229	1.4	3.2
BE	2.27	6.49	35	37	16	594	1.0	4.5
DE	0.06	6.44	60	22	12	227	1.5	3.7
ES	0.98	6.63	58	14	16	167	1.5	4.1
FR	0.41	7.42	54	4	20	537	1.5	4.8
IT	0.22	6.67	53	26	16	261	1.7	3.5
NL	3.02	6.59	54	15	13	340	0.9	5.4
PT	5.83	8.62	52	8	18	191	1.3	5.9

Estimation results for marginal costs

We estimate a translog cost function for each separate country and take the first derivative of loans to derive the marginal costs of lending, see Equations (5) and (8), respectively.[29] Table A.3 shows the marginal costs of loans across countries and over time. Marginal costs decline over time, reflecting the significant decreases in funding rates during 1992-2004 and possibly also technological improvements. Germany, France and Spain have relatively high marginal costs compared to the Netherlands and Belgium. Apart from differences in funding rates, this may be explained also by lower efficiency in the former countries.[30]

Table A.3 Marginal costs of loans across countries and over time (in %)

	AT	BE	DE	ES	FR	IT	NL	PT
1992	10.3	7.1	10.2	15.9	13.8	13.2	9.2	21.3
1993	9.4	6.9	9.4	17.2	13.4	12.0	8.1	18.8
1994	7.1	6.4	9.2	14.3	11.9	12.2	7.4	16.6
1995	7.3	5.8	8.9	15.4	11.7	11.8	7.1	15.4
1996	7.1	5.2	8.5	14.3	10.9	11.3	6.3	13.4
1997	6.1	4.6	7.4	11.7	10.9	9.7	6.4	12.3
1998	6.0	3.6	7.1	11.1	11.2	7.5	7.4	9.4
1999	5.5	3.2	6.4	8.8	10.0	6.7	6.4	6.1
2000	6.1	3.3	7.1	9.9	11.2	6.7	6.5	6.3
2001	6.1	3.1	7.3	9.6	11.7	6.6	6.4	5.9
2002	5.7	3.1	7.1	7.8	10.7	6.1	5.7	5.2
2003	5.5	2.7	6.4	5.9	8.9	5.3	4.9	5.3
2004	5.2	2.5	6.0	4.8	7.9	4.9	4.6	5.5

Estimation results for the Boone indicator

Table A.4 shows the estimates of the Boone indicator across countries and over time (usually 1994-2004, depending on the respective country). The results are based on the following model:

29. See also Section 3.1 in Van Leuvensteijn *et al.* (2007).

30. Another explanation is lower population density in the former countries. Low population density may raise operating costs, as it makes retail distribution of banking services more costly.

$$\ln ms_{i,t} = \alpha + \sum_{t=1,..,T} \beta_t \ln mc_{i,t} + \sum_{t=1,..,(T-1)} \gamma_t d_t + u_{i,t} \quad \text{(A.1)}$$

explaining loans market shares of bank *i* in year *t* ($ms_{i,t}$) by marginal costs ($mc_{i,t}$) and country dummies (d_t). Note that the Boone indicator, β_t, is time dependent. The estimations are carried out using the Generalized Moment Method (GMM) with as instrument variables the one-, two- or three-year lagged values of the explanatory variable, marginal costs, or average costs. To test on overidentification of the instruments, we apply the Hansen J-test for GMM [Hayashi (2000)]. The joint null hypothesis is that the instruments are valid as such, *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. Furthermore, 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 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.

Over the sample period, the Boone indicator for Belgium, Germany, and Italy are highly significant, except for one or two years, suggesting stronger loan market competition then elsewhere in the euro area.[31] The Dutch and Spanish loan markets take up an intermediate position with significant Boone indicators for at least a number of years. For France, the degree of competition declined over the years, where the reverse development is observed for Austra and Portugal. If, for each country, we had estimated only one beta for the full-sample period instead of annual ones (that is, $\beta_t = \beta$ for all *t*), we would have obtained significant values for all countries (except Portugal), reflecting a certain degree of competition in the whole area [see Van Leuvensteijn *et al.* (2007)].

31. Most likely, the favourable result for Germany hinges in part on the special structure of its banking system, being built on three pillars, *i.e.* the commercial banks, the publicly-owned savings banks and the cooperative banks [see Hackethal (2004)].

Table A.4. The Boone indicator over time and across various countries[2)]

	Germany[1)]		**France**		**Italy**[1)]	
	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	*-0.7	-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		5.01		13.23	
Anderson canon corr. LR-test	185.20		1023.66		300.34	
Hansen J-test (p-value)	0.00		19.69 (0.48)		0.00	
Number of observations	14 534		918		4918	
	Spain[1)]		**Netherlands**		**Belgium**	
	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	-1.48	-1.59
1996	-9.61	-0.67	**-2.09	-2.58	**-1.74	-2.93
1997	-4.36	-1.78	-3.57	-1.70	**-2.02	-3.78
1998	-5.40	-0.86	1.04	0.38	**-1.98	-3.19
1999	*-5.46	-2.21	-1.44	-0.85	**-2.62	-4.65
2000	-3.44	-1.93	**-3.26	-3.00	**-3.41	-6.10
2001	**-4.38	-2.55	**-3.91	-4.71	**-3.00	-4.51
2002	*-3.88	-2.09	*-2.45	-2.44	**-3.42	-4.34
2003	-3.42	-1.20	-2.22	-1.80	**-2.79	-3.18
2004	**-2.69	-5.62	**-3.09	-2.85	**-3.12	-4.02
F-test	3.33		3.90		6.35	
Anderson canon corr. LR-test	38.78		31.71		178.10	
Hansen J-test (p-value)	0.00		20.5 (0.039)		8.34 (0.60)	
Number of observations	1015		241		269	
	Austria		**Portugal**			
	β_t	*z-value*	β_t	*z-value*		
1994	11.2	1.01	0.05	0.05		
1995	-4.03	-0.94	1.57	0.91		
1996	*-2.31	-1.93	0.09	0.16		
1997	4.25	0.93	-0.04	-0.08		
1998	-0.91	-0.52	-0.55	-0.76		
1999	-2.98	-0.73	-1.51	-1.40		
2000	-2.31	-0.50	**-2.43	-4.03		
2001	-0.96	-1.30	**-1.92	-3.77		
2002	*-1.49	-1.97	**-2.16	-7.33		
2003	**-1.26	-3.52	*-1.74	-2.05		
2004	**-2.99	-2.23	-1.53	-1.69		
F-test	2.21		3.94			
Anderson canon corr. LR-test	28.89		77.92			
Hansen J-test, (p-value)	9.308 (0.59)		11.71 (0.38)			
Number of observations	988		134			

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 (A.1) is estimated with the GMM.

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