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Journal of Banking & Finance 26 (2002) 2191–2214

Journal of BANKING & FINANCE

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Competition, concentration and their relationship: An empirical analysis of the banking industry

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Abstract

This article examines competitive conditions and market structure in the banking industry, and investigates their interrelationship. Competition is measured using the Panzar–Rosse model. In order to distinguish competitive behaviour on local, national and international markets, for each country, three subsamples are taken: small or local banks, medium-sized banks and large or international banks. For all 23 countries considered, estimations indicate monopolistic competition, competition being weaker in local markets and stronger in international markets. Subsequently, a relationship for the impact of the market structure on competition is derived and tested empirically, providing support for the conventional view that concentration impairs competitiveness.

JEL classification: F36; G2; L1
Keywords: Local and international banks; Competition; Concentration; Market structure; Panzar–Rosse model

1. Introduction

European banking markets are undergoing unprecedented changes, caused by the deregulation of financial services, the establishment of the economic and monetary union (EMU) and developments in information technology, which may well turn

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0378-4266/02/$ - see front matter
PII: S0378-4266(02)00205-4

out to be dramatic. Many of these changes will have vast implications for competition and concentration in the banking and financial sectors. One of the consequences is already apparent in the recent wave of mergers in the European banking industry. This process of concentration may affect competition, in particular on local markets for retail banking services. Questions may arise such as: Should concentration be slowed down? or Are additional measures needed to ensure sufficient competition in local retail markets? Besides, increased concentration and the size of the new global players may cause concerns about financial stability. In order to judge the implications of these developments, one has to examine the banking industry's current market structure, to determine the degree of competition, and to investigate the impact the consolidation is likely to have on the market structure and the behaviour of banks. In recent years, however, relatively few empirical studies have examined competition and concentration in European banking markets. This article seeks to measure the degree of competition in the European banking markets, and to investigate the impact of concentration on competition. Moreover, it attempts to compare the situation in Europe with that in the US and other countries.

The literature on the measurement of competition may be divided into two mainstreams, called the structural and the non-structural approach. [1] The structural approach to model competition includes the structure–conduct–performance (SCP) paradigm and the efficiency hypothesis, as well as a number of formal approaches with roots in industrial organisation theory. The SCP paradigm investigates whether a highly concentrated market causes collusive behaviour among larger banks resulting in superior market performance; whereas the efficiency hypothesis tests whether it is the efficiency of larger banks that makes for enhanced performance. In reaction to the theoretical and empirical deficiencies of the structural models, non-structural models of competitive behaviour have been developed namely the Iwata model, the Bresnahan model, and the Panzar and Rosse (P–R) model. These New Empirical Industrial Organisation approaches measure competition and emphasise the analysis of the competitive conduct of banks without using explicit information about the structure of the market. In this article we will use one of these non-structural models, the P–R model, to assess the degree of competition in a large number of countries. One of the structural approaches, the SCP paradigm, provides a theoretical relationship between market structure (concentration) and conduct (competition) which, in the empirical banking literature, is ignored. This article fills in this gap by using the P–R model's measure of competition to test this relationship empirically.

Ideally, an evaluation of competitive conditions and the degree of concentration in the banking industry should begin by rigorously defining the market under consideration. The relevant market consists of all suppliers of a particular banking service, including actual or potential competitors, and it has a product dimension and a geographical dimension. The product definition of a market is based on the equality of the products as regards their ability to fulfil specific consumer wants. The geographical boundaries of a market are determined by actual and potential contacts

[1] For an overview, see Bikker and Haaf (2001).

between actual and potential market participants. These boundaries depend on the products involved: for retail banking, the local dimension of a market is relevant while the regional or international dimension is relevant for corporate banking. The desirability to define product and (smaller-scale) geographical markets makes it harder to apply competition and concentration models to the banking industry, especially given the shortage in (European) data with respect to specific banking products or local regions.

This article attempts to solve this problem to some extent by applying the P–R model to samples of banks of various sizes, under the assumption that small banks operate mostly at a local scale and that large banks compete more than other banks at the international level, while medium-sized banks occupy an intermediate position. Furthermore, retail banking is assumed to be concentrated mostly in small banks while corporate banking occurs more at large banks. Banking behaviour in geographical markets of various sizes is observed indirectly, through the data of individual banks used in the P–R model. Of course, this is only a first step in the right direction, but we do acquire information about the effect of (the size of) geographical markets on competition.

The plan of this article is as follows. Section 2 introduces and explains the P–R approach. Section 3 applies this model to banks in 23 industrialised countries. For each country, four samples are taken: small, medium-sized and large banks and, finally, all banks. This section also displays various concentration indices and applies them to the (same) 23 industrialised countries. Finally, the relationship between competition and concentration is tested empirically. The ultimate section summarises and draws conclusions.

2. The Panzar and Rosse approach

Rosse and Panzar (1977) and Panzar and Rosse (1987) formulated simple models for oligopolistic, competitive and monopolistic markets and developed a test to discriminate between these models. This test is based on properties of a reduced-form revenue equation at the firm or bank level and uses a test statistic H, which, under certain assumptions, can serve as a measure of competitive behaviour of banks. The test is derived from a general banking market model, which determines equilibrium output and the equilibrium number of banks, by maximising profits at both the bank level and the industry level. This implies, first, that bank i maximises its profits, where marginal revenue equals marginal cost:

$$R_i'(x_i, n, z_i) - C_i'(x_i, w_i, t_i) = 0. \tag{1}$$

R_i refers to revenues and C_i to costs of bank i (the prime denoting *marginal*), x_i is the output of bank i, n is the number of banks, w_i is a vector of m factor input prices of bank i, z_i is a vector of exogenous variables that shift the bank's revenue function, t_i is a vector of exogenous variables that shift the bank's cost function. Secondly, at the market level, it means that, in equilibrium, the zero profit constraint holds:

$$R_i^*(x^*, n^*, z) - C_i^*(x^*, w, t) = 0. \tag{2}$$

Variables marked with an asterisk ($*$) represent equilibrium values. Market power is measured by the extent to which a change in factor input prices (dw_{k_i}) is reflected in the equilibrium revenues (dR_i^*) earned by bank i. Panzar and Rosse define a measure of competition H as the sum of the elasticities of the reduced-form revenues with respect to factor prices: [2]

$$H = \sum_{k=1}^{m} \frac{\partial R_i^*}{\partial w_{k_i}} \frac{w_{k_i}}{R_i^*}. \tag{3}$$

The first market model Panzar and Rosse investigated describes monopoly. The monopoly analysis includes the case of price-taking competitive firms, as long as the prices they face are truly exogenous, that is, as long as their equilibrium values are unaffected by changes in the other exogenous variables in the model. An empirical refutation of 'monopoly' constitutes a rejection of the assumption that the revenues of the banks in question are independent of the decisions made by their actual or potential rivals. Panzar and Rosse proved that under monopoly, an increase in input prices will increase marginal costs, reduce equilibrium output and subsequently reduce revenues; hence H will be zero or negative. This is a very generalised result, requiring little beyond the profit maximisation hypothesis itself. Along similar lines, Vesala (1995) proves that the same result holds for monopolistic competition without the threat of entry, i.e. with a fixed number of banks. Thus, this case also falls under what we call 'monopoly'. In the case where the monopolist faces a demand curve of constant price elasticity $e > 1$ and where a constant returns to scale Cobb–Douglas technology is employed, Panzar and Rosse proved that H is equal to $e - 1$. Hence apart from the sign, the *magnitude* of H may also be of importance, as H yields an estimate of the Lerner index of monopoly power $L = (e-1)/e = H/(H-1)$.

Three other commonly employed models for an industrial market investigated by Panzar and Rosse are monopolistic competition and perfect competition and conjectural variation oligopoly, all of which happen to be consistent with positive values for H. In these models, the revenue function of individual banks depends upon the decisions made by its actual or potential rivals. For monopolistic and perfect competition, the analysis is based on the comparative statics properties of the Chamberlinian equilibrium model. This model introduces interdependence into banks' structural revenue equations via the hypothesis that, in equilibrium, free entry and exit results in zero profits. Under a set of general assumptions, [3] it can be proved that under monopolistic competition, $H \leqslant 1$. Positive values of H indicate that the data are consistent with monopolistic competition but not with individual profit maximisation as under monopoly conditions. In other words, banks produce more and the price is less than would be optimal in each individual case. A priori, monopolistic competition is most plausible for characterising the interaction between

[2] See Panzar and Rosse (1987) or Vesala (1995) for details of the formal derivation of H.

[3] One of the assumptions is that the market is in a long-run equilibrium. This assumption can be tested empirically.

banks, as it recognises the existence of product differentiation and is consistent with the observation that banks tend to differ with respect to product quality variables and advertising, although their core business is fairly homogeneous.

In the limit case of the monopolistic competition model, where banks' products are regarded as perfect substitutes of one another, the Chamberlinian model produces the perfectly competitive solution, as demand elasticity approaches infinity. In this perfect competition case, $H = 1$. An increase in input prices raises both marginal and average costs without – under certain conditions – altering the optimal output of any individual firm. Exit of some firms increases the demand faced by each of the remaining firms, leading to an increase in prices and revenues equivalent to the rise in costs.

Finally, analysing the conjectural variation oligopoly case, Panzar and Rosse show that strategic interactions among a fixed number of banks may also be consistent with positive values of H. In general, the value of H is not restricted. In the special case of *perfect* collusion oligopoly or a perfect cartel, the value of H is non-positive, similar to the monopoly model. Table 1 summarises the discriminatory power of H.

The Chamberlinian equilibrium model described above provides a simple link between H and the number of banks, so between market behaviour and market structure. The model is based on free entry of banks and determines not only the output level but also the equilibrium number of banks. Vesala (1995) proves that H is an increasing function of the demand elasticity e, that is, the less market power is exercised on the part of banks, the higher H becomes. This implies that H is not used solely to reject certain types of market behaviour, but that its magnitude serves as a measure of competition. One of the general assumptions underlying the Chamberlinian equilibrium model mentioned above is that the elasticity of perceived demand facing the individual firm, $e(x, n, w)$, is a non-decreasing function of the number of rival banks. Panzar and Rosse call this a standard assumption, eminently plausible and almost a truism. Vesala's result and this assumption together provide a positive (theoretical) relationship between H and the number of banks, or – in a more loose interpretation – an inverse relationship between H and banking concentration.

2.1. The empirical P–R model

The empirical application of the P–R approach assumes a log-linear marginal cost function (dropping subscripts referring to bank i)

Table 1
Discriminatory power of H

Values of H	Competitive environment
$H \leqslant 0$	Monopoly equilibrium: each bank operates independently as under monopoly profit maximisation conditions (H is a decreasing function of the perceived demand elasticity) or perfect cartel.
$0 < H < 1$	Monopolistic competition free entry equilibrium (H is an increasing function of the perceived demand elasticity).
$H = 1$	Perfect competition. Free entry equilibrium with full efficient capacity utilisation.

$$\ln \mathrm{MC} = \alpha_0 + \alpha_1 \ln \mathrm{OUT} + \sum_{i=1}^{m} \beta_i \ln \mathrm{FIP}_i + \sum_{j=1}^{p} \gamma_j \ln \mathrm{EX}_{\mathrm{COST}_j} \tag{4}$$

where OUT is output of the bank, FIP are the factor input prices (regarding e.g. funding, personnel expenses and other non-interest expenses) and $\mathrm{EX}_{\mathrm{COST}}$ are other variables, exogenous to the cost function C_i (t in Eq. (1)). Equally, the underlying marginal revenue function has been assumed to be log-linear of the form

$$\ln \mathrm{MR} = \delta_0 + \delta_1 \ln \mathrm{OUT} + \sum_{k=1}^{q} \zeta_k \ln \mathrm{EX}_{\mathrm{REV}_k} \tag{5}$$

where $\mathrm{EX}_{\mathrm{REV}}$ are variables related to the bank-specific demand function (z in Eq. (1)). For a profit-maximising bank, marginal costs equal marginal revenues in equilibrium, yielding the equilibrium value for output (denoted by an asterisk):

$$\ln \mathrm{OUT}^* = \left(\alpha_0 - \delta_0 + \sum_{i=1}^{m} \beta_i \ln \mathrm{FIP}_i + \sum_{j=1}^{p} \gamma_j \ln \mathrm{EX}_{\mathrm{COST}_j} - \sum_{k=1}^{q} \zeta_k \ln \mathrm{EX}_{\mathrm{REV}_k} \right) \Big/ (\delta_1 - \alpha_1). \tag{6}$$

The reduced-form equation for revenues of bank i is the product of the equilibrium values of output of bank i and the common price level, determined by the inverse-demand equation, which reads, in logarithms, as $\ln p = \xi + \eta \ln(\sum_i \mathrm{OUT}_i^*)$.

In the empirical analysis, the following operationalisation of the reduced-form revenue equation is used:

$$\ln \mathrm{INTR} = \alpha + \beta \ln \mathrm{AFR} + \gamma \ln \mathrm{PPE} + \delta \ln \mathrm{PCE} + \sum \zeta_j \ln \mathrm{BSF}_j + \eta \ln \mathrm{OI} + e \tag{7}$$

where INTR is the ratio of total interest revenue to the total balance sheet, [4] AFR is the ratio of annual interest expenses to total funds, or the average funding rate, PPE is the ratio of personnel expenses to the total balance sheet, or the (approximated) price of personnel expenses, PCE is the ratio of physical capital expenditure and other expenses to fixed assets, or the (approximated) price of capital expenditure, BSF are bank specific exogenous factors (without explicit reference to their origin from the cost or revenue function), OI is the ratio of other income to the total balance sheet, and e is a stochastic error term. AFR, PPE and PCE are the unit prices of the inputs of the banks: funds, labour and capital, or proxies of these prices. In the notation of Eq. (7), the H statistic is given by $\beta + \gamma + \delta$. In order to verify whether the competitive structure has changed over time as a result of liberalisation and deregulation, model (7) is applied to a pooled cross-section (across banks) and

[4] Here we follow the specification of the dependent variable of Molyneux et al. (1994). Other authors use unscaled revenues. Re-estimation of the equation with unscaled revenues yields similar results, particularly if one of the bank-specific factors is 'total assets'.

time-series analysis over the time span 1988–98. We are assuming that the long-term equilibrium market structure underlying the P–R analysis shifts *gradually* over time due to institutional changes (as mentioned in the introduction) not incorporated into the model equation. Ignoring market dynamics may lead to imprecise parameter estimates and biased H statistics, which could in turn result in wrong inferences about the competitive nature of the banking industry. Therefore, we multiply the elasticities of H by a continuous time-curve model $\exp(\varepsilon \mathrm{TIME})$:

$$\ln \mathrm{INTR} = \alpha + (\beta \ln \mathrm{AFR} + \gamma \ln \mathrm{PPE} + \delta \ln \mathrm{PCE})\mathrm{e}^{\varepsilon \mathrm{TIME}} + \sum \zeta_j \ln \mathrm{BSF}_j + \eta \ln \mathrm{OI} + e. \tag{8}$$

Note that $\varepsilon = 0$ indicates that H is constant over time. Without this assumption of *gradual* change, the results may be implausibly erratic, as found by Molyneux et al. (1994), who applied the P–R model to a series of subsequent years.

The dependent variable is the 'ratio of total *interest* revenue to the total balance sheet', as in Molyneux et al. (1994). The decision to consider only the interest part of the total revenue of banks is consistent with the underlying notion inherent in the P–R model, that financial intermediation is the core business of most banks. However, Shaffer (1982) and Nathan and Neave (1989) took total revenue as their dependent variable. In our sample, the share of non-interest revenues to total revenues is, on average, only 14%. However, it has increased in recent years, doubling between 1990 and 1998. In order to account for the influence exerted by the generation of other income on the model's underlying marginal revenue and cost functions, we also include the ratio of other income to the total balance sheet (OI) as an explanatory variable. Actually, the P–R model we will apply, Eq. (8), encompasses the model of Molyneux et al. ($\eta = 0$).

The 'ratio of personnel expenses to the number of employees' (PENE) could be a plausible alternative to the 'ratio of personnel expenses to the total balance sheet' (PPE) included in our estimations. However, the former ratio is available for only a small subset of our sample. Furthermore, empirical exercises reveal that results based on PENE closely approximate those based on PPE. This is probably due to the size of the sample used, which makes the results less sensitive to measurement errors. The 'ratio of physical capital and other expenses to fixed assets' is a proxy of the price of capital. [5] In particular, the balance sheet item 'fixed assets' appears to be unrealistically low for some banks. However, the exclusion of outliers or a correction for fixed assets, such as applied by Resti (1997), did not lead to remarkable changes in the estimation results.

Bank-specific factors (BSF) are additional explanatory variables which reflect differences in risks, costs, size and structures of banks and should, at least theoretically, stem from the marginal revenue and cost functions underlying the empirical P–R Eq. (8). The risk component can be proxied by the ratio of risk capital or equity to total assets (EQ), the ratio of loans to total assets (LO) and the ratio of non-performing

[5] 'Capital expenses' includes the cost of premises, equipment and information technology.

loans to total loans (NPL). More than one variable for risk is considered, as there are cases where one of these variables may be unavailable for a particular bank. The ratio of interbank deposits to total customers and short-term funding (BDEP) and the ratio of demand deposits from customers to total customer and short-term funding (DDC) are used to capture differences in the deposit mix. Correspondent bank activities are taken into consideration when the ratio of cash and due from depository institutions (or banks) to total deposits (CDFB) is included. Total assets (TA) are used as a scaling factor.

A positive parameter for LO is expected, because more loans reflect more potential interest rate income. The coefficient for OI is probably negative as the generation of other income may be at the expense of interest income. Regarding the signs of the coefficients of the other explanatory variables, several writers hold conflicting theories [6] while others do not have a priori expectations.

3. Empirical results

3.1. Competition in the banking industry

The P–R model has been applied to banks from 23 European and non-European countries, as listed in Table 2. The data have been obtained from the database of the International Bank Credit Analysis Ltd (Fitch-IBCA), a London-based bank credit rating agency. In principle, data from individual banks are used for the years 1988–98, but the actual starting dates of the samples vary across countries. [7] For each country, Table 2 reports the number of banks and available number of observations. [8] The total number of banks is 5444 and the total number of observations is almost 29,000. Hence, on average, the sample includes more than 5 observations (in fact years) for each bank, since some of the observations are lacking due to non-reporting of (*all* relevant) data by banks in their annual report, mergers or new entries in the sample period.

For each country, the model has been adopted to a sample of all banks, as well as to subsamples of small banks, medium-sized banks and large banks, respectively. This partition into small, medium-sized and large is based on total assets of the *banks*: for each year, the smallest 50% of all banks of the world-wide sample constitute the small-banks sample, the largest 10% of all banks constitute the large-bank sample, whereas the remainder make up the medium-sized sample. The large-bank

[6] For example, Molyneux et al. (1994) expect a negative coefficient for EQ, because less equity implies more leverage and hence more interest income. However, on the other hand, capital requirements increase proportionally with the risk on loans and investment portfolios, suggesting a positive coefficient.

[7] Data of earlier years would be less useful due to serious free entry restrictions in European countries.

[8] Note that ignoring observations of non-financial institutions, which also provide financial intermediation in some subdivision of the banking market, does not distort the current analysis, as the actual (overall) competitive conditions are observed directly, irrespective of the providers of intermediation services.

Table 2
Sample period and number of observations per country

Country	Sample period	No. of years	No. of banks	No of observation per bank type			
				All	Small	Medium	Large
Australia	1991–98	8	39	185	13	115	57
Austria	1989–98	10	95	434	226	176	32
Belgium	1989–98	10	85	479	217	194	68
Canada	1988–98	11	60	363	158	140	65
Denmark	1990–98	9	96	578	466	79	33
Finland	1990–98	9	14	77	10	32	35
France	1988–98	11	393	2489	812	1334	343
Germany	1988–98	11	2219	10,987	6765	3764	458
Greece	1990–98	9	22	102	46	37	19
Ireland	1992–98	7	35	143	15	112	16
Italy	1988–98	11	365	1943	813	897	233
Japan	1989–98	10	148	1081	17	432	632
Korea (South)	1992–98	7	21	63	1	34	28
Luxembourg	1990–98	9	128	825	333	395	97
Netherlands	1991–98	8	57	307	99	145	63
New Zealand	1990–98	9	10	52	9	23	20
Norway	1989–98	10	39	220	74	120	26
Portugal	1991–98	8	41	268	70	144	54
Spain	1990–98	9	154	831	204	458	169
Sweden	1989–98	10	26	145	18	52	75
Switzerland	1988–98	11	385	1976	1414	485	77
UK	1989–98	10	213	1220	518	491	211
US	1991–98	8	799	4190	1383	2326	481
Total			*5444*	*28,958*	*13,681*	*11,985*	*3292*
In %				*100.0*	*47.2*	*41.4*	*11.4*

sample was kept relatively small to ensure that only the really large banks are included. The final numbers of *observations* are affected by the availability of data, which actually appears to be correlated with the size of the bank. Of course, the size distribution differs across the countries, see Table 2. An alternative would be to make the size subdivision per country. However, the border between small and medium-sized banks in, say, 1997 would then range from US$ 166 million in Denmark to US$ 12,660 million in South Korea and between medium-sized and large banks would range from US$ 2797 million in Germany to US$ 111,280 million in Canada. This alternative is less desirable because it makes it very hard to compare subsamples across countries [9] and, therefore, has not been considered.

Due to the small number of assumptions (mainly the cost minimisation and duality hypotheses) underlying the P–R approach, the validity of the test is fairly general. Nevertheless, a few caveats are in order. As we employ consolidated banking data, the banking market of country X is defined as the hypothetical market where banks

[9] Then, for instance, (so-called) large banks in Denmark, Germany or Switzerland could be smaller than (so-called) small banks in Finland, Japan or Korea.

from country X are active and not, say, the banking market within the national borders of that country. Moreover, banks operate in various segments of the market, both geographically and in terms of banking products and, for that matter, also in various input markets as well. This remark is particularly true of large universal banks with sizeable foreign activities. These internationally active banks are obviously confronted by other competitive forces than small regional banks. The P–R result H reflects only some kind of average over all these market segments. Finally, in certain segments of the markets, banks face competition from non-bank financial institutions. However, the P–R approach does not require observations of non-banks, as the H statistic is a direct measure of the degree of competition taking competitive effects from other institutions in its stride.

A critical feature of the H statistic is that the P–R approach must be based on observations that are in long-run equilibrium. An equilibrium test exploits the fact that in competitive capital markets, risk-adjusted rates of return will be equalised across banks. In such a case, the return rates will not be correlated with input prices. [10] We find that the hypothesis of equilibrium ($H = 0$) cannot be rejected on the 95% significance level, which justifies the applied methodology.

As an illustration, Appendix A presents tables with the estimation results of the various bank-size categories for three countries. Tables for the other countries considered can be found in Bikker and Haaf (2000). [11] For New Zealand and South Korea, the number of small banks is too small to make adequate estimations. Our basic approach was to create a model for each country and bank size combination, which included all selected bank-specific factors. Actually, for some countries, data are unavailable for part of these variables, or available only for a limited number of banks. In the latter case, we accepted only a slight reduction in the sample and otherwise disregarded that particular variable. [12] Finally, BSF were deleted, if their coefficients were not significant. This was done mainly to prevent the number of observations from being reduced by the extra explanatory variables, and also for economy's sake. For the latter reason, insignificant coefficients of the time-trend variable were also deleted. Sensitivity analyses confirm that the H estimates are only slightly, if at all, affected by the deletion of the non-significant variables.

The crucial variable H is equal to $(\beta + \gamma + \delta)\exp(\varepsilon \mathrm{TIME})$ and, hence, depends on TIME, provided $\varepsilon \neq 0$. In the latter cases, H has been calculated for 1991 as well as 1997. The coefficient of the average funding rate, β, appears to be most significant and almost invariably positive and, hence, the main contributor to H. The coefficient representing labour cost, γ, is also significant and positive in most cases, but usually smaller than β. The coefficient of the price of capital expenses, δ, varies in size, sign

[10] An equilibrium test is provided by Eq. (7), after replacement of the dependent variable by the rate of return on total assets (ROA) or equity (ROE). $H = 0$ would then indicate equilibrium, whereas $H < 0$ would point to disequilibrium.

[11] These tables are available upon request from the authors.

[12] For this reason, the number of observations of small, medium-sized and large banks of a country do not necessarily add up to the number of all banks. This would only be the case if the model specification were the same for all bank-size types.

and level of significance, and is the least important component of H. The elasticity δ may also be small due to the poorer quality of capital expenses and fixed assets data, which constitute the price level of capital expenses.

Finally, the coefficient of TIME, ε, also varies in size, sign and level of significance. In fact, ε is zero (because not significant) in 53% of all cases, indicating no significant change in the competitive conditions. Where ε is non-zero, ε is positive in 34 out of the 43 cases, which indicates that competition increases over time in 80% of these cases (see Table 3, where H is shown for both 1991 and 1997 if $\varepsilon \neq 0$). In the all-bank sample, competition in 1997 was higher than in 1991 in all the 'non-zero' cases, except for Japan. However, these changes over time are fairly limited, on average 2.3 basis points (bps), which is much less than expected. Increase in competition is more often observed for medium-sized and large banks than for small banks or the all-bank sample, but with lower increases (1.6 bps versus, respectively, 2.3 and 3.3 bps). Growth in competition in EU countries has been higher than in non-EU countries for all-bank sample and small banks, but lower for large banks. The latter result is remarkable as stronger increases in competition for the EU were expected for all bank size samples. Presumably, the rise in European competition, which had been expected for 1997, has not yet materialised in that year.

Loans appear to be the most important BSF, both in terms of occurrence and level of significance. Apparently, the ratio between loans and total assets, as a proxy of risk, is an important factor in the total interest-to-income ratio. The signs of *loans* and *other income* are in line with expectation (respectively, positive and negative) for all country and sample-size combinations, apart from Greece where implausible signs are found for small and medium-sized banks. In general, the regression results are highly satisfactory, due in part to the large size of the samples: the estimation of H appears to be very robust. Its value is hardly affected by specification choices, such as those regarding the BSFs. Furthermore, the goodness of fit of the regression equations is satisfactory.

The tables in Appendix A and in Bikker and Haaf (2000) also present the estimated values for H and test results for the hypothesis $H = 0$ and 1. Table 3 reports these values for H for various bank-size samples and – where applicable ($\varepsilon \neq 0$) – for various years. The superscripts refer to the test results in the footnotes of the tables in Appendix A and Bikker and Haaf (2000). Values of H for which the hypothesis $H = 0$ is not rejected at a confidence level of 95% are in italics. Values of H for which the hypothesis $H = 1$ is not rejected at the 95% (or 99%) level of confidence are in boldface (or boldface italics, respectively). [13]

For all-banks samples of all 23 countries, both $H = 0$ (perfect cartel [14]) and $H = 1$ (perfect competition) are rejected convincingly, i.e. at the 99% level of confidence,

[13] Where the probability of the null hypothesis is 5% or more the null hypothesis is accepted or not rejected; if the probability of the null hypothesis is below 1%, the null hypothesis is rejected, and if the probability of the null hypothesis is between 1% and 5% we posit that the null hypothesis is rejected at the (stringent) 99% confidence level.

[14] In all countries, the number of banks is far greater than 1. Hence, $H = 0$ reflects perfect collusion or cartel rather than monopoly.

Table 3
Empirical results for H for various bank-size samples and various years

	All banks		Small banks		Medium-sized banks		Large banks	
	1991	1997	1991	1997	1991	1997	1991	1997
Australia	0.50^{a}	0.57^{a}	$\mathit{-0.14}^{b}$		0.67^{a}	0.70^{a}	0.63^{a}	0.68^{a}
Austria	0.87^{a}		$\mathbf{0.93}^{b}$		0.91^{a}	0.89^{a}	0.91^{c}	
Belgium	0.89^{a}		$\mathbf{0.95}^{b}$		0.88^{c}		0.86^{a}	0.88^{a}
Canada	0.60^{a}	0.62^{a}	0.74^{a}		0.63^{a}		0.56^{a}	0.60^{a}
Denmark	0.32^{a}	0.36^{a}	0.31^{a}	0.34^{a}	0.75^{a}		$\mathit{1.16}^{b}$	
Finland	0.78^{a}		$\mathit{0.67}^{b}$		0.76^{c}		0.70^{a}	
France	0.70^{a}		0.54^{a}	0.59^{a}	0.74^{a}	0.79^{a}	$\mathit{0.89}^{b}$	
Germany	0.60^{a}	0.63^{a}	0.56^{a}	0.59^{a}	0.68^{a}	0.70^{a}	$\mathbf{1.05}^{b}$	$\mathbf{1.03}^{b}$
Greece	0.76^{a}		0.41^{b}		0.66^{a}		$\mathbf{1.01}^{c}$	$\mathbf{0.94}^{c}$
Ireland	0.65^{a}		$\mathbf{0.99}^{b}$		0.63^{a}		$\mathbf{0.93}^{c}$	
Italy	0.82^{a}		0.75^{a}		0.89^{a}	0.86^{a}	0.83^{a}	0.81^{a}
Japan	0.58^{a}	0.54^{a}	$\mathbf{0.43}^{b}$		0.07^{c}	0.11^{c}	0.64^{a}	0.61^{a}
Korea (South)	0.68^{a}		–		$\mathbf{0.72}^{b}$		$\mathbf{0.77}^{c}$	
Luxembourg	0.93^{a}		0.94^{b}		0.94^{b}	0.95^{b}	0.90^{a}	0.91^{a}
Netherlands	0.75^{a}		$\mathbf{0.74}^{b}$		0.87^{a}		$\mathbf{0.91}^{c}$	$\mathbf{0.95}^{c}$
New Zealand	0.86^{a}		–		$\mathbf{1.11}^{b}$	$\mathit{1.13}^{c}$	0.86^{d}	
Norway	0.74^{a}	0.77^{a}	0.80^{a}		0.71^{a}	0.75^{a}	0.66^{a}	0.71^{a}
Portugal	0.83^{a}		$\mathit{0.84}^{b}$		0.88^{a}	0.84^{a}	$\mathit{0.91}^{c}$	
Spain	0.55^{a}	0.62^{a}	0.56^{a}	0.64^{a}	0.52^{a}	0.59^{a}	0.61^{a}	0.66^{a}
Sweden	0.80^{a}		0.84^{b}		0.69^{a}	0.76^{a}	$\mathbf{0.95}^{c}$	
Switzerland	0.55^{a}	0.58^{a}	0.51^{a}	0.54^{a}	$\mathbf{0.95}^{b}$	0.92^{c}	$\mathbf{1.01}^{d}$	
United Kingdom	0.61^{a}	0.64^{a}	0.41^{a}		0.81^{a}	0.85^{a}	1.20^{a}	
United States	0.54^{a}	0.56^{a}	0.61^{a}	0.62^{a}	0.53^{a}	0.54^{a}	0.68^{a}	0.72^{a}
Averages	*0.70*		*0.64*		*0.75*		*0.86*	
Maximum	0.93		0.99		1.12		1.20	
Minimum	0.34		−0.14		0.09		0.58	
Avgs Europe	0.72		0.68		0.79		0.91	
Avgs RoW	0.63		0.41		0.63		0.70	

For each country, the superscripts refer to the acceptance or rejection of the null hypothesis $H = 0$ and $H = 1$, as is explained in the footnotes of the respective tables in Appendix A and Bikker and Haaf (2000). Averages: Where the underlying model includes a time trend, averages are taken over H-values of 1991 and 1997. Subsequently, averages are taken over the 23 countries.

and for nearly all countries even at the 99.9% level. This would imply monopolistic competition in all countries, without exception. However, this uniform picture becomes more diversified when the banking market is split into segments: the market for (i) small banks operating mostly on a local scale, (ii) middle-sized banks operating both locally and nationally, and (iii) large banks which also operate internationally. For small banks in one country, Australia, the hypothesis $H = 0$ cannot be rejected, which suggests that this market is characterised by perfect collusion. Note, however, that this result is based on an unusually small sample size of 13 observations. In any case, this result suggests a lower level of competition. For a number of bank-size and country combinations, the hypothesis $H = 1$ cannot be rejected,

implying that these markets may be characterised by perfect competition. This holds in particular for a number of the large-bank markets. For Danish large banks, H is significant larger than 1, which may indicate a deviating market structure, such as conjectural variation oligopoly (see Section 2).

A shortcoming of the P–R test may be the fact that it is single-tailed, in the sense that a positive value rejects any form of imperfect competition (under the assumption of profit-maximising behaviour and at least short-term competition), whereas a negative value is consistent with various types of market power. [15] However, this shortcoming is of little consequence for this article, as $H \leqslant 0$ is rejected in all cases but one.

Based on the result of Vesala (1995, p. 56), we interpret H between 0 and 1 as a continuous measure of the level of competition, in the sense that higher values of H indicate stronger competition than lower values. The values of H are comparable across national or bank-size markets if the revenue equation, the perceived demand elasticity and its sensitivity to the number of banks ($\partial e/\partial n$) are identical for the various markets. [16] In particular, the latter cannot be observed, so the following conclusions are under reservations that the necessary assumptions hold. The averages across all countries (bottom rows of Table 3) make clear that H is substantially below average for small-bank markets (0.64), somewhat greater for medium-sized bank markets (0.75) and greatest for large-bank markets (0.86). Apparently, in line with expectations, smaller banks operate in a less competitive environment than larger banks, or, put differently, local markets are less competitive than national and international markets. The 0.64–0.86 spread should be seen as the *lower limit* of the actual difference in competition between local and international markets, as small banks do not solely operate on local markets but may also be active on the national markets; similarly large banks do not exclusively operate on international markets. The difference in the degree of competition between local and international markets is not only reflected in the overall averages, but also in many of the national figures. The values of H for small-bank markets range from -0.14 to 0.99, whereas for large banks they range from 0.58 to above 1.

In Europe, all large banks appear to operate in a highly competitive environment. Exceptions are two Scandinavian countries (Finland and Norway) and Spain with H values around 0.7. Competition among smaller banks is weak in Greece, Denmark and the UK, and limited in France, Germany, Spain and Switzerland. In general, competition seems to be weaker in non-European countries. In the US, Canada and Australia, for instance, H ranges from 0.5 to 0.7, and in Europe from 0.7 to 0.9. Of course, this conclusion does not necessarily hold for all market segments. In Japan competition is, in fact slightly weaker while in New Zealand and South Korea it is somewhat stronger. It should be kept in mind, however, that these comparisons of H across countries are based on more far-reaching assumptions than are made in the standard P–R test (see above). The structure of the European banking

[15] See e.g. Bresnahan (1989), Shaffer and DiSalvo (1994) and Toolsema (2002).

[16] These are sufficient but not necessary requirements.

industry has altered during the 1980s mostly as in response to domestic deregulation and in anticipation of EU-wide regulatory changes. One of the major consequences has been increased competition, see Gual and Neven (1993) and Molyneux et al. (1996). Gardener and Molyneux (1990) explained how mergers in Europe often contributed to the forming of groups of local and regional based banks that could compete effectively with the large, dominant banks. In a number of countries outside Europe, liberalisation and deregulation took place somewhat later, e.g. in the US, where the 1994 Riegle–Neal Act ending a ban on lending and branch operations across state borders, and where in 1999, the Glass–Steagall Act was repealed, which has prevented firms from combining banking and insurance activities. These trends may well have contributed to the observed differences in degrees of competition inside and outside Europe.

In order to show what effect our choice for interest revenue as dependent variable in the P–R model had on the outcome, Appendix B contrasts our results with those based on total revenue as dependent variable for the Netherlands, where the share of non-interest revenue in total revenue averages 16%. As the financial intermediation model underlying the P–R theory does not apply to the activities generating non-interest revenues, it comes as no surprise that the fit of the P–R model (measured by $\overline{R}^2$) is much lower for total revenue (0.60) than for interest revenue (0.90). In the total-revenue variant, the estimated value of H is substantially lower, which is plausible because the input price 'funding costs' is generally not relevant for the non-interest revenue activities. Nevertheless, this value of H still points to the same conclusion that the market is characterised by monopolistic competition. Inclusion of 'other income' as an independent variable hardly affects the outcome. Similar results are obtained for other countries. All in all, this sensitivity analysis confirms that total revenue is less appropriate as input for the P–R model than interest revenue.

A comparison between our results and those in the literature is shown in Table 4, which summarises the results of other studies applying the P–R model. Shaffer (1982), in his pioneering study on New York banks, observed monopolistic competition. For Canadian banks, Nathan and Neave (1989) found perfect competition for 1982 and monopolistic competition for 1983, 1984. Lloyd-Williams et al. (1991) and Molyneux et al. (1996) revealed perfect collusion for Japan. Molyneux et al. (1994) obtained values for H which, for 1986–89, are significantly different from both zero and unity for France, Germany (except for 1987 when 'monopoly' was found), Spain and the UK, indicating monopolistic competition. For Italy during 1987–89, the 'monopoly' hypothesis could not be rejected. The strong shifts in H over the years are less plausible, let alone those in market structure. Our pooled time series cross-section approach ensures less volatile results. Unlike Molyneux et al., Coccorese (1998), who also analysed the Italian banking sector, obtained values for H which were at the least non-negative and even significantly different from zero. The value of H also differed significantly from unity, except in 1992 and 1994.

For the Finnish banking industry in the years 1985–92, Vesala (1995) found consistently positive values of H, which differed significantly from zero and unity in 1989 and 1990 only. De Bandt and Davis (2000) investigated banking markets in France, Germany and Italy for groups of large and small banks. They obtained estimates of

Table 4
P–R model results in other studies

Authors	Period	Countries considered	Results
Shaffer (1982)	1979	New York	Monopolistic competition
Nathan and Neave (1989)	1982–84	Canada	1982: perfect comp.; 1983, 1984: monopolistic competition
Lloyd-Williams et al. (1991)	1986–88	Japan	Monopoly
Molyneux et al. (1994)	1986–89	France, Germany, Italy, Spain and United Kingdom	Mon.: Italy; mon. comp.: France, Germany, Spain, UK
Vesala (1995)	1985–92	Finland	Monopolistic competition for all but two years
Molyneux et al. (1996)	1986–88	Japan	Monopoly
Coccorese (1998)	1988–96	Italy	Monopolistic competition
Rime (1999)	1987–94	Switzerland	Monopolistic competition
Bikker and Groeneveld (2000)	1989–96	15 EU countries	Monopolistic competition
De Bandt and Davis (2000)	1992–96	France, Germany and Italy	Large banks: mon. comp. in all countries; small banks: mon. comp. in Italy, monopoly in France, Germany

H which were significantly different from zero and unity for large banks in all three countries. The H statistics estimated for the small-banks sample indicate monopolistic competition in Italy, and monopoly power in France and Germany. The latter results are in flat contradiction to our findings. For Switzerland, Rime (1999) observed monopolistic competition. Like Rime, Bikker and Groeneveld (2000) applied the P–R method to 15 EU-countries without, however, distinguishing between size classes. Their results are rather similar to ours, except for the larger countries, where they used smaller samples of (only) the largest banks. Their H-values for these countries may therefore be regarded as overestimations.

In some respects, the empirical P–R studies present far from uniform outcomes. Yet except in the case of Japan and, according to some authors, Italy, they all point to the existence of monopolistic competition in the countries considered.

3.2. Market structure and competition

Given the current wave of mergers in the EU banking market and the expectation of continued or even accelerating consolidation, concerns have been voiced as to competitive conditions in the EU banking markets, especially in some market segments, such as local and retail markets. More precisely, the question emerges whether market concentration might affect the conduct of banks or the degree of competition. Theoretically, the existence of a relationship between market structure and banks' behaviour is indicated by, among others, the P–R model. Where, in the literature, the impact of the banking market structure on bank performance has been examined exhaustively – employing the SCP paradigm – the relevance of market

structure for conduct or competitive conditions has been almost entirely ignored. [17] The present section aims at examining this disregarded relationship and seeks to assess a possible impact of the number of banks and the banking market concentration on competition.

As was observed above, the P–R approach provides a link between number of banks and competition. However, as a description of the market structure, the number of banks is a rather limited concept. For instance, it fully ignores the size distribution of banks (or inequality) in a given market. As concentration indices, weighted averages of banks' market shares, take both the size distribution and the number of banks into account, they are often used as a simple proxy of the market structure. Apart from the number of banks itself, we also use two-frequently applied-types of such indices as a proxy. [18] The first is the so-called k-bank concentration ratio (CR_k) which takes the market shares of the k largest banks in the market and ignores the remaining banks in that market. This index is based on the idea that the behaviour of a market is dominated by a small number of large banks. The second index we use is the Herfindahl index (HI), which takes market shares as weights, and stresses the importance of larger banks by assigning them a greater weight than smaller banks. It includes each bank separately and differently, and thereby avoids an arbitrary cut-off and insensitivity to the share distribution.

Table 5 presents the 1997 HI and CR_k, for $k = 3$, 5 and 10, for all 23 countries analysed earlier. Total assets have been taken as the measure of bank size. The value of the k-bank concentration ratios (for various values of k) always exceeds the value of the HI, since the latter gives less prominence to the markets shares (the weights again being market shares) than the former (unit weights). The results for the various index values are rather similar, displaying a high degree of correlation. The strongest correlations are found between CR_3 and CR_5, CR_5 and CR_{10}, and, surprisingly, HI and CR_3. In terms of ranking, the correlation between HI and CR_3 is, at 98%, by far the strongest. This demonstrates that the HI is determined mainly by (the squares of the market shares of) the large banks, which puts into perspective the alleged drawback of the CR_k indices vis-à-vis the HI, i.e. that they ignore the influence of smaller banks.

For countries where the number of banks in the available sample is low, as in Finland, Korea and New Zealand, results are less reliable. High concentration rates are found in Denmark, Greece, the Netherlands and Switzerland, where the largest three banks take more than two-thirds of the total market in terms of total assets. In Canada, concentration is high only when at least five banks are taken into consideration. Switzerland is the most highly concentrated country according to HI, which may seem remarkable given the large number of banks in that country. Increasing the sample of Swiss banks to more than three hardly increases the concentration rate. Concentration appears to be low in France, Germany, Italy, Luxembourg and the

[17] See Calem and Carlino (1991) for an example of the empirical approximation of conduct.

[18] Both indices, CR_k and HI, can be derived as proxies for market structure in theoretical SCP relationships, see Bikker and Haaf (2001).

Table 5
Concentration indices for 23 countries, based on total assets (1997)

	Herfindahl index	CR_3	CR_5	CR_{10}	No. of banks
Australia	0.14	0.57	0.77	0.90	31
Austria	0.14	0.53	0.64	0.77	78
Belgium	0.12	0.52	0.75	0.87	79
Canada	0.14	0.54	0.82	0.94	44
Denmark	0.17	0.67	0.80	0.91	91
Finland	0.24	0.73	0.91	1.00	12
France	0.05	0.30	0.45	0.64	336
Germany	0.03	0.22	0.31	0.46	1803
Greece	0.20	0.66	0.82	0.94	22
Ireland	0.17	0.65	0.73	0.84	30
Italy	0.04	0.27	0.40	0.54	331
Japan	0.06	0.39	0.49	0.56	140
Korea (South)	0.11	0.45	0.68	0.96	13
Luxembourg	0.03	0.20	0.30	0.49	118
Netherlands	0.23	0.78	0.87	0.93	45
New Zealand	0.18	0.63	0.90	n.a.	8
Norway	0.12	0.56	0.67	0.81	35
Portugal	0.09	0.40	0.57	0.82	40
Spain	0.08	0.45	0.56	0.69	140
Sweden	0.12	0.53	0.73	0.92	21
Switzerland	0.26	0.72	0.77	0.82	325
United Kingdom	0.06	0.34	0.47	0.68	186
United States	0.02	0.15	0.23	0.38	717
Averages/total	*0.12*	*0.49*	*0.64*	*0.73*	*4645*
Standard deviations	*0.07*	*0.18*	*0.20*	*0.18*	

US, where the largest three have a combined share of less than one-third. By all measures, concentration is lowest in the US. Germany, where the number of banks in our sample is largest, takes the last place but one in concentration.

All types of indices appear to be inversely correlated to the number of banks. This is owing to a well-known weakness of concentration indices, namely their dependency on the size of a country or banking market. The smaller the country or the number of its banks, the larger its measure of concentration. In the empirical analysis below, we attempt to solve this problem by taking the number of banks into account explicitly. Table 5 is based on the Fitch-IBCA data set, used for the P–R analysis in Section 3.1. This sample does not include all banks, which for some countries might distort the concentration index value. However, this effect is limited as the ignored market segment consists mainly of the smallest banks. This problem, too, is considered in the empirical analysis below. Another shortcoming of concentration indices is that non-bank financial institutions are ignored. As competition from non-banks is mainly related to some segments of the banking market, such as mortgage lending, it is difficult to correct for that in the present broad 'total assets' measure of concentration. Finally, the Fitch-IBCA data set consists of consolidated figures and does not distinguish between domestic and foreign operations. For that

Table 6
Market shares of the ten largest banks in the sample (1997)

Bank	Country	Market shares			National	
		Total assets	Loans	Deposits	H	CR_3
1. UBS AG	Swi	0.36	0.46	0.45	1.01	0.72
2. Deutsche Bank AG	Ger	0.09	0.09	0.12	1.03	0.22
3. HSBC Holdings Plc	UK	0.14	0.14	0.15	1.20	0.34
4. Bayerische Hypo- und Vereinsbank[a]	Ger	0.09	0.07	0.04	1.03	0.22
5. Crédit Agricole CA	Fra	0.14	0.11	0.13	0.89	0.30
6. Dai-Ichi Kangyo Bank Ltd DKB	Jap	0.17	0.14	0.12	0.61	0.39
7. ABN Amro Holding N.V.	Neth	0.34	0.39	0.41	0.95	0.78
8. Société Générale	Fra	0.10	0.10	0.11	0.89	0.30
9. Norinchukin Bank	Jap	0.08	0.13	0.11	0.61	0.61
10. Sakura Bank Limited	Jap	0.16	0.13	0.12	0.61	0.61

[a] Pro forma.

reason, the concentration index values for small countries with large international banks are overestimated. [19] This is illustrated in Table 6, where market shares for total assets, loans and non-bank deposits are presented for the ten banks with the largest balance-sheet total in the sample.

The market shares of even the largest banks in France, Germany, Japan and the UK are modest, suggesting that, on a national or market-wide scale, these banks have limited market power. Of course, the situation may be different in particular market segments or local areas. Large banks in small countries, such as UBS of Switzerland and ABN-Amro of the Netherlands, do command substantial market shares, although in the case of ABN-Amro, for instance, domestic business is less than half of total business, while for UBS the ratio is even less than one in four. After correction for foreign operations (which, by the way, affects both the denominator and the numerator of the shares), the market shares for ABN-Amro are almost 30% smaller, [20] though still sizeable. To some extent, the indices (such as CR_3) do indeed reflect the higher concentration in the Netherlands and Switzerland. At the same time, ABN-Amro and UBS may be facing stiff competition on other (foreign) markets.

In order to investigate the relationship between competition and market structure in the banking industry, we related the H statistic for all banks, [21] a measure of competition, to the concentration index (CI) and the logarithm of the number of banks in the markets ($\log n$) as representatives of the market structure. Despite the various shortcomings, already noted, which concentration index may have as a proxy of

[19] A similar distortion does not occur in the P–R analysis, where any link to national borders is absent. There, the level of competition of a country is the average level of competition on the markets where its banks operate.

[20] Not in the 50% region lower, due to the denominator effect.

[21] It would not be sensible to split the concentration index into indices for small, medium-sized and large banks. Hence the analysis is based on the all-banks sample of H and the concentration indices.

the market structure, we nevertheless, for want of anything better, examined how it acts in the empirical relationship in question. The estimated values of H were taken from the 'all-bank' sample. Concentration indices are one-dimensional measures taking account of two dimensions, i.e. the number of banks, indicating the 'density' of the banking market, and their size distribution, indicating skewness. Some concentration indices can be rewritten as measures of the distribution and the number of banks. For instance, the Herfindahl index can be rewritten as [22]

$$\mathrm{HI} = (\eta_0^2 + 1)/n \tag{9}$$

where η_0^2 is the variation coefficient of the bank-size distribution. In our empirical analysis, we restore this two-dimensionality, describing the market structure by both the CI and the number of banks. Here we have used logarithms to scale the variable n. There is another reason why inclusion of the number of banks makes sense. Below Table 5, we recorded the dependency of concentration indices on the size of a country or banking market. By including the number of its banks (as proxy of the banking market size) in the regression equation, we correct for this distortion. At the same time, the effect on the CI of a limited sample size (as is the case for some countries) is compensated for. Hence, the estimated regression is given by

$$H = \alpha_0 + \alpha_1 \mathrm{CI} + \alpha_2 \log n + \alpha_3 \mathrm{dummy\ (Europe)}. \tag{10}$$

A dummy variable 'Europe' is included because H is substantially higher for Europe than for non-European banking markets, which may be due to economic and institutional conditions. The upper part of Table 7 presents regression results for Eq. (10) for four CIs. [23] For all four regressions, the coefficient of the concentration index shows the expected negative sign, indicating that competition is decreasing with increasing market concentration. The significance of CR_3 is highest (highest t-value), while the effect of CR_{10} on competition is strongest (taking into account the indices' standard deviation). The results support the view that the share of the k largest banks (k being 3, 5 or 10) rather than the entire size distribution of banks in a market, is the strongest determinant for the competitive conditions in a market.

In principle, a larger number of banks indicates more potential for competition. For that reason, one would expect to see a coefficient with a positive sign. Yet, wherever the size distribution is heavily skewed and just a few banks dominate the market, a large number of banks merely indicates that there is a broad fringe of powerless dwarfs. The larger the number of banks, the less opportunity each

[22] See Bikker and Haaf (2001, Eq. (2.5)).

[23] Alternatively, the observations for the 23 countries could also be weighted by $\log n$ as a measure (or proxy) of the respective banking-market size. In this way, we could take account of the magnitude of the banking market in each country, weighting Germany, France and Italy heavier than, say, Greece, Ireland and Sweden. At the same time, lower weights would be allocated to countries where the sample size is limited and the variables are therefore somewhat less reliable, as is the case for Finland, South Korea and New Zealand. Incidentally, the weighted regression results appear to be similar to the unweighted outcomes of Table 7, while the level of significance is even substantial higher for CI and $\log(n)$.

Table 7
Relationship between competition and concentration for the all-bank sample

	HI	CR_3	CR_5	CR_{10}
Constant	1.01 (7.0)	1.23 (7.1)	1.31 (5.5)	1.54 (4.6)
Concentration Index	−0.93 (1.9)	−0.53 (2.9)	−0.47 (2.3)	−0.65 (2.5)
Log n	−0.07 (2.8)	−0.09 (3.6)	−0.10 (3.2)	−0.11 (3.0)
Dummy (Europe)	0.15 (2.3)	0.16 (2.8)	0.14 (2.3)	0.17 (2.9)
$\overline{R}^2$	0.25	0.37	0.30	0.35
Constant	0.90 (7.0)	1.05 (6.6)	1.14 (5.3)	1.33 (4.5)
Concentration Index	−0.71 (1.8)	−0.38 (2.4)	−0.37 (2.1)	−0.51 (2.4)
Log n	−0.07 (3.1)	−0.08 (3.6)	−0.09 (3.3)	−0.10 (3.1)
Share of bank deposits	0.85 (3.6)	0.83 (3.7)	0.80 (3.5)	0.89 (4.0)
$\overline{R}^2$	0.42	0.48	0.45	0.50

Note: T-values in parenthesis. The critical value of the one sided t-value test is 1.73 and that of the two-sided t-value test is 2.09.

has to assert its influence and increase competition. The latter effect appears to be dominant, as the net effect of the number of banks on competition is negative. [24] Obviously, in situations, typically measured by the CR_k indices, where a few large banks occupy a large share of the market, market power is exercised more heavily. The dummy variable for Europe proves to be significant for all four regression equations, indicating the different institutional and economic conditions faced by European banks, which are disregarded by the other explanatory variables.

It is no easy task to find out which differences cause the diverging levels of competition between European and non-European banks. We found that if the share of bank demand deposits in total assets is included in Eq. (10), the Europe dummy becomes insignificant and may be dropped, see the lower part of Table 7. This share reflects an aspect of banks' average funding habits: European banks make more extensive use of the interbank market for funding. We may have hit on an important variable here, [25] but a convincing theoretical explanation is lacking. One possible explanation is that where banking and financial markets are more developed, (i) the interbank market is more developed and (ii) competition is more intense. If this is true, then the share of bank deposits acts as an indicator of financial sophistication.

The above provides evidence that conduct such as competitive behaviour may indeed be related to characteristics of the market structure such as concentration and number of banks. A Wald test, which assesses the significance of the coefficients of the CI and the number of banks simultaneously, confirms this conclusion. [26]

[24] An alternative formulation is that the effect of the number of banks, as taken into account by the CI, is overestimated (implying low values for the CI value in large countries and vice versa).

[25] As suggested, for instance, by the better fit in Table 7, when the share of interbank deposits is included.

[26] For all (eight) equations in Table 7, and also in the weighted regressions (not shown), a hypothetical value of zero for both coefficients is rejected at the 95% level of confidence.

The evidence is only modest, however, as Eq. (10) is not very robust. For instance, if the Europe dummy is deleted, the significance of the other parameters drops dramatically. Nevertheless, the continuing process of consolidation in the banking industry may raise the policy makers' concern about competitive conditions in the banking markets. This concern, however, is very often related not so much to entire markets as to market segments, such as, for instance, deposits or certain geographical areas. Unfortunately, the limited availability of data makes it impossible to make more refined analyses.

4. Conclusions

The ongoing dramatic structural changes in the banking industry, particularly in Europe, may affect competition, especially on local markets and for bank's retail services. This article sought to assess competitive conditions and concentration in the banking markets of as many as 23 industrialised countries inside and outside Europe over approximately 10 years. In addition, it investigated the interaction between competition and concentration. The Panzar–Rosse approach has been applied to obtain a measure of competitive conditions in to 23 countries over a time span of more than 10 years. The resulting H statistic provides strong evidence that the banking markets in the industrial world are characterised by monopolistic competition, but perfect competition cannot be ruled out in some cases.

We have attempted to take account of the geographical and even the product dimension of banking operations by defining three sub-markets in terms of bank sizes for each country and have estimated their degree of competition. Competition is stronger among large banks – operating predominantly in international markets – and weaker among small banks – operating mainly in local markets – while medium-sized banks take an intermediate position. In some countries, perfect competition has been found among large banks. For a number of countries, estimates of the H statistic over time indicate a significant increase in competition. Competition seems to be somewhat stronger in Europe than in countries like the US, Canada and Japan. Thanks to the large sample and the pooled regression approach, our results are fairly robust. Generally speaking, our findings are in keeping with comparable studies in the literature, which also point to monopolistic competition in most countries.

Concentration in the banking markets of 23 industrialised countries was measured using various k-bank concentration ratios and the Herfindahl index. Empirical studies concerning the impact of market structure on banks' conduct are rare. In order to investigate this relationship, the estimated H-values indicating competition are used as proxies of conduct and are related both to the concentration indices considered and to the absolute number of banks operating in these markets, acting together as a proxy of the market structure. The impact of both market structure measures on competition appears to be significant, most markedly so when the k-bank concentration indices are used. The latter confirms the observation that a few large (cartel) banks can restrict competition and that a multitude of fringe competitors is unable to engender competition.

Appendix A. Estimation results of the P–R models for four countries and various size classes (Tables 8–10)

Table 8
Empirical results for Germany (1988–98)

	All banks		Small banks		Medium-sized banks		Large banks	
	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values
Funding rate	0.45	*74.1*	0.39	53.7	0.50	*50.9*	0.92	*28.1*
Wage rate	0.13	*35.9*	0.13	27.5	0.16	*25.4*	0.14	*17.2*
Capital price	0.00	*0.3*	0.01	*4.8*	−0.01	*2.3*	0.00	*0.1*
Time	7.07	*19.0*	9.68	*18.8*	4.72	*9.3*	−2.32	*2.6*
Loans ratio	0.07	*32.0*	0.09	*33.0*	0.04	*10.0*		
Other income	−0.05	*23.6*	−0.06	*21.0*	−0.05	*13.7*		
Total assets	−0.01	*8.9*					−0.03	*4.7*
Bank deposits	−0.01	*6.8*	−0.00	*2.1*	−0.01	*6.0*	−0.12	*12.5*
Equity	−0.04	*12.5*	−0.02	*5.3*	−0.03	*5.4*	−0.22	*18.5*
Dem. Dep. C.	0.01	*4.5*	0.02	*8.2*				
Cash & DFB	0.01	*7.3*	0.01	*7.0*	0.01	*5.4*		
Intercept	−0.64	*26.3*	−0.83	*27.6*	−0.45	*11.2*	1.05	*8.8*
Adj. R^2	0.69		0.69		0.71		0.84	
No. of observations	10 513		6523		3672		458	
H (1991–97)	**0.60**[a]	**0.63**[a]	**0.56**[a]	**0.59**[a]	**0.68**[a]	**0.70**[a]	**1.05**[b]	**1.03**[b]

[a] $H = 0$ and $H = 1$ rejected (level of confidence 99.9%).
[b] $H = 1$ not rejected (level of confidence 95%).

Table 9
Empirical results for the Netherlands (1991–98)

	All banks		Small banks		Medium-sized banks		Large banks	
	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values
Funding rate	0.75	*48.5*	0.70	*23.1*	0.85	*48.9*	0.67	*19.1*
Wage rate	0.08	*5.0*	−0.01	*0.2*	0.06	*4.7*	0.09	*9.2*
Capital price	−0.07	*2.9*	0.05	*0.3*	−0.05	*2.2*	0.12	*4.3*
Time							6.80	*4.4*
Loans ratio	0.04	*3.4*			0.04	*4.76*	0.27	*4.8*
Other income	−0.05	*5.1*	−0.06	*3.1*	−0.03	*2.9*		
Total assets	0.01	*2.3*			0.03	*3.2*	0.02	*3.1*
Equity	0.12	*8.7*	0.14	*5.6*	0.07	*4.5*		
Intercept	−0.73	*8.8*	−1.31	*7.9*	−0.44	*4.5*	−0.20	*1.6*
Adj. R^2	0.90		0.90		0.95		0.95	
No. of observations	296		96		139		61	
H (1991–97)	**0.75**[a]		**0.74**[b]		**0.87**[a]		**0.91**[c]	**0.95**[c]

[a] $H = 0$ and $H = 1$ rejected (level of confidence 99.9%).
[b] $H = 1$ not rejected (level of confidence 95%); the F-statistic is 2.33 and the probability level (of the null hypothesis) is 13.0%.
[c] $H = 1$ not rejected (level of confidence 95%); the F-statistic is, respectively, 2.72 and 0.92, and the probability level (of the null hypothesis) is, respectively, 10.5% and 34.1%.

Table 10
Empirical results for the United States (1991–98)

	All banks		Small banks		Medium-sized banks		Large banks	
	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values
Funding rate	0.40	*46.7*	0.40	*29.0*	0.40	*35.8*	0.43	*19.6*
Wage rate	0.07	*13.7*	0.18	*16.1*	0.06	*8.4*	0.13	*8.7*
Capital price	0.06	*19.7*	0.02	*3.2*	0.06	*14.1*	0.10	*15.4*
Time	3.62	*4.4*	3.08	*2.9*	3.52	*3.0*	8.01	*4.8*
Loans ratio	0.12	*20.0*	0.09	*11.2*	0.12	*14.1*	0.21	*18.3*
Other income			−0.04	*6.4*				
Total assets	−0.02	*10.1*			−0.02	*4.5*		
Equity	0.06	*7.4*	0.03	*2.5*	0.05	*4.7*		
Non-performing loans	0.01	*4.3*			0.01	*3.7*		
Cash & DFB	0.03	*11.9*	0.02	*5.2*	0.04	*9.6*		
Intercept	−0.76	*16.3*	−0.63	*8.3*	−0.76	*11.2*	−0.02	*2.6*
Adj. R^2	0.51		0.48		0.52		0.70	
No. of observations	3835		1350		2216		463	
H (1991–97)	**0.54**[a]	**0.56**[a]	**0.61**[a]	**0.62**[a]	**0.53**[a]	**0.54**[a]	**0.68**[a]	**0.72**[a]

[a] $H = 0$ and $H = 1$ rejected (level of confidence 99.9%).

Appendix B. The dependent variable: Interest revenue versus total revenue (Table 11)

Table 11
Empirical results for the Netherlands for interest revenue and total revenue (all banks; 1991–98)

	Interest revenue				Total revenue			
	Including other income		Excluding other income		Including other income		Excluding other income	
	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values	Coefficient	*t*-values
Funding rate	0.75	*48.5*	0.76	*47.8*	0.48	*17.6*	0.47	*17.0*
Wage rate	0.08	*5.0*	0.01	*2.0*	0.07	*2.5*	0.16	*13.3*
Capital price	−0.07	*2.9*	−0.01	*1.6*	0.01	*0.7*	0.02	*1.3*
Time								
Loans ratio	0.04	*3.4*	0.04	*3.4*	0.04	*1.6*	0.02	*1.0*
Other income	−0.05	*5.1*			0.06	*3.5*		
Total assets	0.01	*2.3*	0.01	*1.4*	−0.01	*1.1*	−0.00	*0.4*
Equity	0.12	*8.7*	0.11	*7.6*	0.07	*2.9*	0.08	*3.3*
Intercept	−0.73	*8.8*	−0.67	*8.0*	−0.51	*3.5*	−0.50	*34*
Adj. R^2	0.90		0.90		0.59		0.57	
No. of observations	296		296		296		296	
H (1991–97)	**0.75**[a]		**0.77**[a]		**0.56**[a]		**0.65**[a]	

[a] $H = 0$ and $H = 1$ rejected (level of confidence 99.9%).

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