Measuring Competition in the Banking Industry - A Review

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Abstract

This paper gives an overview of the existing approaches to competition measuring in the banking industry. Literature offers a great number of studies on competition. Most studies use either the approach of Panzar and Rosse or a conjectural variations model. The SCP paradigm provides a method which allows inferences from industry structure on the degree of competition. Empirical evidence of the SCP paradigm, however, is far from being unambiguous. Studying the banking sector poses specifical problems, in particular due to poor data availability and the lack of a clear definition of banks' output and input.

1 Introduction

Literature offers a great number of studies about competition. Most articles tackle the problem of competition measuring with the Panzar-Rosse or a conjectural variations model. All approaches have shortcomings. Mostly, strong assumptions have to been made and inferences about the real form of market organisation are problematic. Often, the only unambiguous proceeding is to test for one extreme case, e.g. monopoly or perfect competition. In addition, bank specific problems arise from the definition of input and output. There are four main approaches[1].

(1) The production approach views the bank as a firm producing services related to loans and deposits. Interest payments for funds are not included in the cost function. Main costs are expenditures for personnel and physical capital. This model is applied by Suominen (1994), who measures competition in the Finnish banking market.

(2) The intermediation approach assumes that banks employ labor and physical capital to produce loans. Deposits and other funds are taken as inputs. Accordingly costs consist of interest payments for funds as well as of expenses for labour and physical capital. This is the most commonly chosen model.

(3) An alternative model by Hancock (1991) regards user cost and classifies services with negative user cost (such as loans and demand deposits) as output and those with positive user cost (for instance savings deposits) as inputs. Hancock also suggests a test for input and output. Therefore banks' profits are linearly regressed on the real balances of the different items in the balance sheet. Negative coefficients indicate inputs, positive coefficients indicate output. This is intuitively plausible: an increase of output increases profit, whereas an increase of input decreases profit. Hancock finds that loans and demand deposits are output. Inputs contain labor, physical capital, materials, time deposits, and borrowed money.

(4) In a more recent study Hughes et al. (2001) introduce risk in the definition of what banks produce. Banks' business relies much on their comparative advantage

[1] cf. for example Freixas and Rochet (1998), Goddard et al. (2001) or Hempell (2002)

in monitoring and assessing risk. Hence, risk should not be neglected in banks' production and cost functions. In addition, Hughes et al. present a method of how the function of deposits can be tested. He finds that there is strong empirical evidence that deposits are input. He proceeds as follows: he differentiates an operating cost function (which includes costs of labour and physical capital, but excludes deposits) with respect to deposits. If deposits are output, an increase in the production of deposits will require more input. Hence, the above derivative should bear a positive sign, and vice versa.

In addition to the mentioned problems, a big constraint in all studies are data problems, particularly with output prices.

In the following sections I give an overview of the existing approaches to competition measuring. Each section contains a brief description of the economic background, gives an example of how the model can be described empirically and discusses advantages and shortcomings of the respective model. I also present some empirical results (focusing on studies on the German banking sector). Completeness, of course, is not assured.

2 Structural approaches

Structural approaches are based on the SCP[2] paradigm, the efficiency hypothesis and oligopoly models. The SCP paradigm posits a relationship between market structure, firm conduct and market performance. It says that in highly concentrated markets with a small number of large, dominant firms it is easy for these firms to collude and raise profits to levels not compatible with perfect competition. The bulk of studies opts for the k-firm concentration ratio (CR_k) or the Herfindahl-Hirschmann index (HHI) as a measure of market concentration. With s_i denoting the market share of firm i ($i = 1, ..., n$, $k \leq n$)these indices are defined as follows:

$$CR_k := \sum_{i=1}^{k} s_i \quad \text{where } s_i < s_j \text{ for } i < j \tag{1}$$

and

$$HHI := \sum_{i=1}^{n} (s_i)^2 \ . \tag{2}$$

The popularity of the HHI and CR_k may be due to the easy applicability of these indices as well as to the fact that attempts to derive a formal relationship between structure and performance lead directly to the HHI or the CR_k. Cetorelli (1999), however, challenges the formal derivation of the HHI since it needs far too strong assumptions. Bos (2002) or Bos (2003) enhances the SCP and creates a Cournot based model establishing a testable relationship between market share (MS_i) and profitability (cf. below). In his tests for market power he finds that, while HHI in the traditional SCP model proves not to be significant, the MS_k variable in his enhanced model does. Berger (1995) comes to a comparable result for US banks. The CR_k would be applicable for countries with a small couple of dominant banks and a competitive fringe of small institutes. This is certainly not the case in Germany.
Molyneux (1999) points out that empirical evidence for the SCP hypothesis is very weak. In addition, even if there is evidence for a relationship between structure, conduct and

[2]SCP is short for "Structure-Conduct-Performance".

performance the causality is not clear. The efficiency hypothesis proposes that high performance of dominant firms as well their dominance itself may be due to efficiency. The SCP could also give misleading signals if markets are contestable. Then, even players in highly concentrated markets may behave competitively.

As empirical results from SCP based studies are ambiguous structural approaches are not granted much space in this paper.

2.1 SCP tests

The SCP[3] model can be formulated as follows:

$$P_t = f(M_t, D_t, C_t) \,, \tag{3}$$

where t is time, P is a performance measure, M are market structure variables, D is a set of demand variables and C is a set of firm or product-specific control variables (e.g. cost variables).
Possible performance measures are return on equity (ROE) and return on assets (ROA). In his study on the Dutch banking market Bos (2002)[4] chooses ROA because it is not affected by changes in market capitalisation. Market share variables are commonly the said HHI or CR_3. Control variables in Bos (2002) are $RISK = \frac{\text{total net loans}}{\text{total assets}} \cdot 100\%$, $LIQUIDITY = \frac{\text{liquid assets}}{\text{total assets}} \cdot 100\%$, $COST = \frac{\text{total operating expenses}}{\text{total operating income}}$ and $MARKET = \text{total deposits}$.
Surprisingly both market structure variables (HHI and CR_3) carry a negative sign and are significant at the 5% level. Thus, the SCP models do not indicate any market power. This is even more astonishing regarding the fact that the Dutch CR_3 hovers around 80% in the observed period (1992-1998).

If concentration had no negative influence on competition fears of current consolidation in the European banking sector would be unfounded. Exactly these fears have contributed to boost interest in competition measuring. US anti trust authorities, however, do rely on the SCP model. Their decisions whether to accept a merger or not are based on the HHI. Cetorelli (1999) reviews the appropriateness of the use of the HHI as a main screening factor in merger analysis. In easy numerical examples he shows that the HHI can give misleading signals and indicate, for instance, higher concentration even if competitiveness would obviously be enhanced by a merger. He concludes that market structure does not allow to detect anticompetitive conditions. Cetorelli (1999) also reviews literature focusing on the SCP model and finds evidence for the SCP hypothesis[5] as well as results which suggest a non-monotonic (U-shaped) market-concentration relationship[6]. In his own study Cetorelli estimates a Bresnahan like conduct parameter and compares it with SCP paradigm based inferences from HHI in the Italian banking sector. Surprisingly, both methods yield contradictory results. Molyneux (1999) cites Gilbert's comprehensive article (Gilbert (1984)), which reviews 45 studies, just 27 of which find results supporting the SCP paradigm. As mentioned above, Berger (1995) finds that (economies of scale and)

[3] SCP is short for "Structure-Conduct-Performance".

[4] I opt for this study for two reasons: first it is one of the most recent studies applying the SCP model and second the Dutch banking sector is highly concentrated and we thus would expect the SCP hypothesis to hold.

[5] cf. Berger and Hannan (1989) and Neumark and Sharpe (1992)

[6] cf. Jackson III (1992) and Jackson III (1997)

market structure has (have) no effect on performance but that (X-efficiency and) market power does (do) have some, however weak, explanatory power for bank performance. He concludes that "it does not appear that any of the efficiency or market power hypotheses are of great importance n explaining bank profits". In line with Molyneux (1999), I claim that the SCP hypothesis has no major importance for competition measuring.

2.2 A Cournot Model

This model, developed by Cowling and Waterson (1967), is based on a Cournot model and establishes a formal relationship between industry concentration and performance[7]. A major problem of the SCP model is that the choice of the market structure measure implies an a priori assumption on the influence of different players on the market (e.g. the CR_k underestimates the competitive fringe). Thus, in order to allow for asymmetries in market structures as well as for differences in cost structures and collusive behaviour Bos (2002) modifies Cowling's model by testing a *firm* performance/market share relationship instead of an *industry* performance/market structure relationship. This proceeding might be suggested by the above mentioned results of Berger (1995) .
The model setup is based on a profit maximising collusive Cournot oligopolist and yields the following equation:

$$\frac{\Pi_i + F_i}{R_i} = \left(-\frac{1}{\eta_D}\right) \cdot (MS_i) \cdot (1 + \lambda_i) \;, \tag{4}$$

defining profit Π_i, fixed cost F_i, revenue R_i, market share MS_i, price elasticity of demand η_D, and the conjectural variation (CV) λ_i[8] respectively for firm i. For the estimation Bos assumes η_D to be constant, which is justified regarding the brevity of the analysed period. Further, he shows that, assuming collusive behaviour, λ_i is a function of MS_i. This allows interpreting the combined impact of λ_i and MS_i on profitability and omitting λ_i does not change the sign of the joint coefficient in the regression equation[9]. Thus, we get the following regression equation:

$$\ln \frac{\Pi_{i,t} + F_{i,t}}{R_{i,t}} = \beta_{0,t} + \beta_1 \ln MS_{i,t} + \epsilon \tag{5}$$

The proceeding seems to me not completely consistent, as Bos employs equation (5) to test for perfect competition. However, equation (5) has been obtained under the assumption of collusion.

Testing for perfect competition yielded the following results: The coefficient of the variable MS, although not very large, is highly significant. Thus, there is evidence for market power in the Dutch banking market. This is important since SCP tests have failed to detect it.

[7] The approach is very similar to the Bresnahan model described below.

[8] The conjectural variation is defined as $\lambda_i := \frac{\partial X}{\partial x_i} - 1 = \frac{\partial \sum_{j \neq i} x_j}{\partial x_j}$ with the firm output x_i and industry output X. The CV measures the expectations firm i has about the reaction of rivals to its own change in output. λ without subscript usually refers to the expression $\frac{\partial X}{\partial x_i}$. For further details about the CV cf. λ^* below.

[9] Bos notes that interpreting the magnitude of the coefficient, however, is no longer possible.

3 NEIO approaches

NEIO[10] approaches try to measure competitive conduct directly and do not rely on a relationship between structure, conduct and performance. They have a sound theoretical underpinning. Beyond testable hypotheses NEIO approaches provide a kind of continuous measure of competition.

3.1 A conjectural variations model ??

The conjectural variations model determines the degree of market power of the average, profit-maximising, oligopoly bank in the short run. It indirectly measures price-cost margins. The key parameter is the conjectural variations (CV) parameter, which originally is a conduct parameter giving information about the conduct of firms in the market of interest. The CV concept generalises the traditional Cournot model and makes it possible to parameterise the range between perfect competition and perfect collusion. Empirically the conduct parameter is obtained by estimating simultaneously a demand and a supply equation. Bresnahan (1989) gives a comprehensive description of this approach. This is why literature sometimes refers to this model as 'Bresnahan approach'.

If we have n banks in the industry supplying a homogenous product the first order condition for profit maximising of the average bank i, summing over all banks in the industry and dividing through n yields[11]:

$$P = -\lambda^* P'(X, EX_D)X + \frac{1}{n}\sum_{i=1}^{n} c_i'(x_i, EX_{S_i}) \quad , \tag{6}$$

where P denotes the inverse demand function, $X = \sum_{i=1}^{n} x_i$ is industry output, EX_D are exogenous variables affecting industry demand but not marginal costs, c_i' are marginal costs of bank i, EX_{S_i} are exogenous variables affecting the marginal costs of bank i but not the industry demand function and λ^* is the CV, i.e.:

$$\lambda^* := \frac{1}{n}\frac{\partial X}{\partial x_i} = \frac{1}{n}\left(1 + \frac{\partial \sum_{j \neq i} x_j}{\partial x_i}\right) \quad . \tag{7}$$

λ^* has values in the interval from 0 to 1, which have the following economic implications:

Conjectural variations parameter		
$\lambda^* = 1$	$\lambda_i = n - 1$	Monopoly or perfect collusion
$\lambda^* = \frac{1}{n}$	$\lambda_i = 0$	Cournot oligopoly
$\lambda^* = 0$	$\lambda_i = -1$	Perfect competition

λ^* has several equivalent economic interpretations which are easily seen from (6) and (7) or slightly transformed terms. (1) It represents the conjectured degree of output change of the competitors if bank i changes its output; (2) it indicates how much of the monopoly markup (which equals inverse elasticity) is actually charged by the players of the observed market; (3) alternatively λ^* can be interpreted as an elasticity adjusted Lerner index; (4) $-\lambda^*$ measures the percentage deviation of the aggregate output from the competitive equilibrium level[12].

[10] NEIO is short for "New Empirical Industrial Organisation".
[11] For details cf. Appendix.
[12] For details cf. Appendix.

Sticking to the CV language (which corresponds to interpretation (1)) the above listed implications can easily be derived from economic intuition. Therefore it is important to remember that λ^* says something about the *expectations* of firms. A Cournot oligopolist assumes by definition that the other players won't change their output. Thus $\frac{\partial X}{\partial x_i} = 1$. In perfect competition price is exogenously given. Thus industry output is expected to remain constant and $\frac{\partial X}{\partial x_i} = 0$. In a perfectly collusive oligopoly each player wants to maintain its market share $\frac{1}{n}$. Hence an output increase by player i will cause a proportional increase in output of each "partner". Thus industry output X increases proportionally and $\frac{\partial X}{\partial x_i} = n$. Some articles present equation (6) in a more "purist" form without deriving it from a Cournot first order condition:

$$P = -\lambda^* P' X + c \,, \tag{8}$$

where c denotes average marginal cost. Of course, (8) is equal to (6). The implication λ^* as a parameter representing the degree of competition is even more obvious[13].

The empirical model shall now briefly be exemplified following Bresnahan (1982) and Bikker (2003): Bikker chooses a one-product banking model. However, he considers two products in this sense that he first tests for the hypothesis with deposits as "the" product (or rather the services attributed to deposits approximated by the real value of total deposits) and later with loans as "the" product. Of course costs are different in both cases. For deposits the equations estimated are:

$$DEP_t = \alpha_{0,t} + \alpha_{1,t} 1 r_{dep,t} + \alpha_{2,t} EX_{D,t} + \alpha_{3,t} EX_{D,t} r_{dep,t} + \epsilon_t \text{ and} \tag{9}$$

$$r_{dep,t} = -\lambda^* \frac{DEP_t}{\alpha_{1,t} + \alpha_{3,t} EX_{D,t}} + \beta_{0,t} + \beta^*_{1,t} DEP + \beta^*_{2,t} EX_{S,t} + \nu_t \,. \tag{10}$$

These equations yield the conduct parameter λ^*. The cross term in (9) must be included for reasons of identification. The variables are defined as follows:

DEP = the real value of deposits

r_{dep} = the market deposit rate

EX_D = exogenous variables affecting industry demand for deposits but not marginal costs, such as disposable income, unemployment, interest rates for alternative investments and the number of branches

ϵ = error term

EX_S = exogenous variables influencing the supply of deposits, such as costs of input factors for the production of deposits($wagesetc.$)

ν = error term

Substituting $LOANS$ and DEP for r_{lend} and r_{dep} yields (9) and (10) for loans.

Bikker (2003) cannot reject perfect competition for almost all countries. For those countries, where it is rejected, he finds a very low degree of collusion only. The results are very similar for deposit and for loan markets.[14]

[13] which is the reason why I present this equation as well.

[14] This may be astonishing because Germany is among those countries where perfect competition can be rejected (even if the actual market equilibrium seem snot be too far away from it). On the other hand concentration measures unanimously yield comparatively low levels of concentration. SCP thus would predict exactly the opposite of what Bikker (2003) found with Bresnahan's model.

Suominen (1994) extends the Bresnahan model to a two product model and thus can apply the production approach.

We now come to the problems associated with the CV model. At first glance, the above interpretation of the CV parameter might seem very accessible and beyond doubts. This is right for perfect competition and Cournot oligopoly. For monopoly or perfect collusion, however, there is some inconsistency. The question is: which inferences can we draw from the estimation result if $\lambda^* = 1$? It is right to say that in perfect collusion one player *expects* its partners to proportionally match its increase in quantity. As all firms act as one monopolist collusive output maximises every one firm's profit. If one firm deviates from common optimum output others will perfectly match this deviation and profits will drop. Thus, as firms *expect* retaliation (with negative consequences for their profits) they actually will never deviate from collusive output[15]. But this means that the econometrician will never observe deviations from the collusive output. The expected matching behaviour described by λ^* therefore will remain unobserved. Returning to the above question, the observed value of λ^* cannot be seen as result of the "collusive expectation". Since, if the incumbent firms had theses expectations we should not observe $\lambda^* = 1$. Theses considerations do not cast a good light on the "conjectural variations interpretation". As a solution to this problem literature tends to interpret the parameter λ^* as an "as-if" parameter who tells us that the degree of competition is as high "as if" it was produced in a conjectural variations market with this level of competition. Corts (1999) notes: "The as-if interpretation of the conduct parameter is based on the observation that, for given demand and cost conditions, one can compute the conjecture that would yield the observed price-cost margins if firms were playing a conjectural variations equilibrium, even if observed behavior is in fact generated by some other oligopoly game." The "conjectural variations problem" might be evaded by just taking λ^* as an elasticity-adjusted Lerner index[16].
Another question is: in which cases is '$\lambda^* = 1$' consistent with a stable equilibrium? Obviously equilibrium is just guarantied if the incentive to collude is compatible with market conditions. However, transitory demand shocks and low discount factors might disturb the equilibrium[17].

Apart from the theoretical interpretation of the conduct parameter Corts (1999) challenges its *estimation.* Corts proves that the estimated parameter is biased as soon as the actual underlying behaviour is not the result of a conjectural variations equilibrium and establishes a formal sufficient and necessary condition for the "as-if" interpretation being correct. He simulates an efficient supergame collusion and shows that, if the demand shocks the market undergoes are not permanent, the estimated conduct parameter underestimates the actual degree of collusion. If the demand shocks are completely transitory it may not detect any market power even if there are monopolistic price-cost margins. One may argue that the model can at least be used to test for extreme behaviour (e.g. perfect competition) instead of being used to measure the degree of market power. However Corts shows that $\lambda = 1$ may be consistent with any level of

[15] This is right provided that perfect collusion is a stable, efficient equilibrium. If the game allows for the possibility that cheating will raise profits despite retaliation in the periods to come (a possible retaliation might be: playing a Cournot game from the respective round on) the "monopolistic" equilibrium may break down. Corts (1999) simulates an efficient supergame where exactly this happens.

[16] Appendix A shows how this interpretation can easily be derived from equation (6).

[17] cf. again Corts (1999) for details on this topic

market power and a rejection of this hypothesis may actually not allow any inference. The intuition behind Corts' argumentation is easy: the framework of CV analysis is based on the *static* first-order condition of a profit-maximising Cournot oligopolist. In a *dynamic* setting, however, the first-order condition may depend as well on the incentive compatibility constraint associated with collusion. After a demand shock a player might find that cheating (despite retaliation by rivals) would earn him higher profits. Such behavior can bias the estimated conduct parameter.
The criticism in Corts (1999) somewhat relativises the outcome of CV studies. Since the late nineties a couple of articles have been published, which try to "test" the accuracy of CV methods. They focus on industries with virtually perfect data availability, where markups can be measured directly. The "direct" results are compared with the outcome of CV estimates. Genesove and Mullin (1998) concentrate on the US sugar industry between 1890 and 1914. They find that the CV model provide a quite correct estimate of market conditions; deviation from the actual degree of competition are is not large. Kim and C.R. (2003) studies the Californian electricity market covering the period from 1998 to 2000. Their result is that the accuracy of the parameter estimate depends on the functional form of demand (e.g. linear or loglinear).

Finally it is worth pointing to the article of Ribon and Yosha (1999), which analyses if competition had been affected by financial liberalisation in Israel. Ribon and Yosha introduce a couple of new features into the Bresnahan approach. First they simultaneously determine the competitive conduct in an input market (deposits) and an output market (loans). Second they allow for dynamics, i.e. the conduct parameters are not assumed to be constant over time. This is achieved by either interacting the conduct parameters with time dummies or by modelling the conduct parameters as functions of time. Third, they extensively include alternative funding sources, as central bank sealed bid auctions, and also account for additional aspects, e.g. reserve rates regulated by the Bank of Israel or the inflation rate. Ribon and Yosha use marginal cost, which are specified as the marginal cost of funding from the central bank. Data needed to compute the industry average of these cost can easily be obtained. The authors further note that identification of the conduct parameters needs varying inflation rates. Unfortunately, this point might make the approach - in the form used by Ribon and Yosha - inapplicable to the German banking sector. Nevertheless, this approach to the Bresnahan concept is very worth reading as it introduces a couple of aspects other studies omit.

I will shortly report the outcome of Bikker (2003), the only Bresnahan-based study of competition in German banking, which is available to me. For the deposit market[18] the hypothesis $\lambda^* = 0$ (attributed to perfect competition) can be rejected on a 95%-level of significance. Nevertheless the deviation from zero is not great. Testing for Cournot equilibrium ($\lambda^* = 1/n$) the hypothesis cannot be rejected. On the German loans market both perfect competition and Cournot equilibrium can be rejected. The estimated value of λ^* lies somewhere in between.
Apart from Germany, Spain was the only country for which the hypothesis "perfect competition in the deposit market" could be rejected[19]. For all other countries it could not be rejected (Bikker notes, however, that taking perfect competition as hypothesis implies an a priori bias towards perfect competition.). The result is somewhat astonishing.

[18] where deposits are the only product

[19] The sample contains Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden and the UK.

At least for countries with a very high concentration ratio, like the Netherlands, we would have expected evidence supporting some abuse of market power. On the other hand, in Germany, which has a relatively low concentration, the Bresnahan model detects collusion. In the loan market nonperfect competition is found in Portugal, Spain, Sweden and the UK (and Germany).

3.2 The Panzar-Rosse (P-R) approach

Originally[20] Panzar and Rosse develop a testable implication of monopolistic profit-maximisation. The model is then extended to other market equilibria. They therefore analyse the comparative static properties of the reduced form revenue equation at the firm level. The key parameters are the factor price elasticities of the reduced form revenue equation. Data requirements are relatively modest. Output price data are not required.
The model is based on the reduced form revenue function $R^* = R^*(w, z, t)$, where z are exogenous variables shifting the firm's revenue function, t are exogenous variables shifting the firm's cost function and w are factor prices. The key parameter is the H-statistic which is defined as follows:

$$H := \sum_{i=1}^{n} \frac{\partial R^*}{\partial w_i} \frac{w_i}{R^*} \tag{11}$$

We need the following assumptions:

1. linearly homogenous cost functions (or homothetic production function)
2. factor prices exogenous to the individual firm
3. free market entry and exit
4. long-run equilibria[21]
5. the elasticity of perceived demand facing the individual firm is a nondecreasing function of the number of symmetric rivals
6. $\frac{\partial P}{\partial y}, \frac{\partial P}{\partial n} < 0$ with the inverse demand function P and the number of symmetric rivals n.

The following table shows the implications of different values of H:

Competitive environment test	
$H \leq 0$	Monopoly or perfect collusion
$H \leq 1$	Symmetric Chamberlinian equilibrium
$H = 1$	Long-run competitive equilibrium

It is important to note that in the literature this classification is not completely consistent. For example Hempell (2002) does not allow equality for monopolistic competition. Therefore I have sticked to the original article of Panzar and Rosse (Panzar and Rosse (1987)). The intuitive derivation of this classification is easy:
Monopoly: An increase in input factor prices produces an upward shift of cost functions. Thus prices rise and output falls. As monopolists produce on the elastic portion of the inverse demand schedule this has a negative total effect on revenues. Hence an increase in input factor prices causes a decrease in revenues.

[20] cf. Panzar and Rosse (1987)
[21] This is not necessary if one just wants to test for monopoly.

Perfect competition: Suppose all input factor prices rise by 1%. As we have assumed linear homogeneous cost functions the average total costs curve shifts upward by 1% for all output levels. Thus prices increase by 1% as well. As the minimum point of the average total cost curve does not move optimum output remains constant. Thus revenues rise by 1%. The effect of a 1% increase of factor input prices is a 1% increase in revenues.
There is no easy intuitive explanation for the H values in the case of Chamberlinian monopolistic competition.
Molyneux et al. (1994) points out that there is a second interpretation of the H-statistic which allows to test for equilibrium. In this case one has to substitute elasticities of *returns* for elasticities of *revenues*. Since the P-R approach is based on comparative static models inferences from the H-statistic are actually not possible if markets are not in a long-run equilibrium. Hence, testing for equilibrium should precede testing for market power.

Equilibrium test	
$H < 0$	Disequilibrium
$H = 0$	Equlibrium

Again, economic intuition can illuminate these interpretations of H: In competitive capital markets risk-adjusted rates of return must be equal for all banks. Thus, in equilibrium rates of return should not be statistically correlated with input prices.
In the regression equation, returns have to be substituted for revenues as the left-hand variable.

We will now shortly discuss the pros and cons of the P-R approach. The most striking advantage are the limited data requirements. Output prices are not required. In addition we have a sound theoretical underpinning and with some additional assumptions H can be interpreted as a continuous measure of competition[22]. As we use firm-level data it is possible to differentiate between different markets. Hempell (2002), for instance, classifies banks into big, small and medium-sized ones or she tests savings banks, cooperative banks, credit banks and foreign banks separately. At last, the disaggregation of the H-statistic can give insight into which factor contributed most to the total effect.
Problems arise from the fact that the model (if applied to test other scenarios than monopoly) works for long-run equilibria only. The model does not allow for differences in maturity structure of banks' asset portfolio. This might cause a downward bias as longer maturities prevent banks from direct price adjustments. In addition P-R do not account for multi-product banks. Maybe the most problematic aspect of the model is the assumption that banks are price takers on input markets.[23]
The "one-product constraint" is sometimes solved by running the tests for two product bundles separately. Rime (1999) in his study of the Swiss banking market, for instance, takes two pairs of products: (1) loans and bonds and (2) total assets and service fees. Of course costs have to be adapted adequately.

The estimation equation is a loglinear reduced form revenue equation. We cite the version used by Hempell (2002):

$$\begin{aligned} \ln TIN1tTA_{i,t} &= a_1 + b_1 \ln IETF2_{i,t} + b_2 \ln wage1_{i,t} + b_3 \ln aCEtFA_{i,t} + c_1 LtTL_{i,t} \\ &\quad + c_2 IDtTD_{i,t} + c_3 lmab1t_{i,t} + c_4 cashi_{i,t} + d_1 t + \lambda_t + \mu_i + u_{i,t} \;, \quad (12) \end{aligned}$$

[22] Bikker and Haaf (2000a)

[23] (Bikker (2003))finds a quite high degree of competition in deposit markets. In addition, if more and more substitutes for traditional deposits are offered there may also be a positive effect on the competition in this segment. Thus, at least one of the input markets might be highly competitive.

where

$TIN1tTA$	=	total income to total assets
$IEtF2$	=	interest expenses to total funds
$wage1$	=	personnel expenses to total assets
$CEtFA$	=	capital expenses to fixed assets
$LtTL$	=	customer loans to total loans
$IDtTD$	=	interbank deposits to total deposits
$lmab11$	=	maturity structure of customer loan portfolio
$cashi$	=	cash flow to business volume by sector of the borrower, weighted with the portfolio of loans to enterprises.

Hempell estimates (12) with a fixed effect panel regression. λ_t represents the time specific constant accounted for by including time dummies and μ_i the bank specific constant. $u_{i,t}$ are the error terms corresponding to the endogenous variable[24]. The vast majority of studies estimates a loglinear revenue function. Perrakis (1991) criticises this functional form. Lang (1997) therefore applies a translog function. Molyneux et al. (1994) also try a translog model but drop it because of massive problems with collinearity of explanatory variables.
In the estimation equation for the equilibrium test Molyneux et al. (1994) choose 'return on assets' (ROA) as left-hand variable[25].

Most studies using the P-R statistic find different degrees of monopolistic competition. For the German banking sector the reviewed studies have the following results: As mentioned above Hempell (2002) runs her test for the whole sample as well as for different subgroups. The period covered is 1993 - 1998. She finds monopolistic competition for all groups. However, cooperative banks, savings banks, credit banks and foreign banks have increasing H-values. Distinguishing between small, medium-sized and large banks[26] H increases with size. Thus bigger banks operate in a more competitive environment than small banks.
Lang (1997) analyses data from the period between 1988 and 1992 to get virtually the same results as Hempell, i.e. monopolistic competition and a higher H value for credit banks than for savings and cooperative banks.
Bikker and Haaf (2000a) study the period from 1988 to 1998. They find that competitive behaviour increases with size. For small and medium-sized banks both hypotheses $H = 0$ and $H = 1$ can be rejected (level of confidence: 99.9%). This indicates monopolistic competition. For large banks however they obtain $H = 1.05$ and thus cannot reject the hypothesis that this group operates in a perfectly competitive environment (level of confidence: 95%). The following table gives an overview of which hypotheses could not

[24] Hempell (2002) also gives a good overview of the variables other studies employed.

[25] The right-hand variables differ as well, but this is not due to the equilibrium test.

[26] "small" includes all banks with assets below 1 billion DM, "medium-sized" means banks with assets between 1 and 5 billion DM and "large" covers the remainder.

be rejected[27] in the countries analysed in Bikker and Haaf (2000a):

country	$H = 1$ **not rejected** (group)	$H = 0$ **not rejected** (group)
Austria	small	
Belgium	small	
Denmark	large	
Finland	small	
Germany	large	
Greece	large	small
Ireland	small, large	
Japan		small
South Korea	medium, large	
Netherlands	small, large	
New Zealande	medium	
Sweden	large	
Switzerland	medium, large	

This shows that the German result "the larger the bank the more competitive its environment" cannot easily be generalised. However, monopoly seems to be very scarce. The whole sample includes 23 countries. In almost half of them there are no indications at all for either perfect competition or monopoly.
Molyneux et al. (1994) studies competitive conditions in various European banking markets between 1986 and 1989. He also runs an equilibrium test. For Germany he finds equilibrium for the whole period. In the competition test for Germany both perfect competition and monopoly can be rejected for 1986, 1988 and 1989. The 1987 data suggest perfect competition.

The above mentioned problems all arise from the theoretical framework of the P-R model itself. There is, however, another flaw associated with the empirical setup, which shall now shortly be described: Input factor prices entering the estimation equation always include personnel expenses, costs of physical capital and costs of deposits. Equity capital as input factor and costs of equity capital, however, are neglected. This might be due to problems associated with measuring costs of equity capital. The gravity of this problematic might be demonstrated by means of the following example: Hempell (2002) classifies deposits as input. Consequently she accounts for interest expenses in the calculation of costs. These funding costs are approximated by $IEtF2$, which is defined as "interest expenses to total funds". Assume that the bank in question substitutes risky loans for, say, government securities. In this case, the bank has to increase its equity capital to account for the higher risk in its portfolio. As a certain amount of equity capital will be substituted for debts and liabilities interest expenses will fall. The nominator of the proxy for funding costs will decrease (since: funds = deposits + equity capital). Thus, the proxy for input costs will fall. This might produce a paradoxical effect: if costs for equity capital are higher than costs of foreign capital funding costs will rise. The cost measure, however, will indicate lower costs[28]. Appendix B describes how a shadow price for equity capital could be estimated.

[27] The levels of confidence are always over 95%. See Bikker and Haaf (2000a), Appendix 1

[28] Of course, the example is very rough. If the bank takes higher risks it might have to pay higher rates on deposits, which also affect the new funding costs. The scenario shall just demonstrate the general problem.

3.3 An approach by Hannan and Liang

Hannan and Liang (1993) have developed a method to test for price-taking behavior in the deposit market. They apply it to the US banking market. The method has been adopted by Ashton (1999) in a study on competition in the UK retail banking sector. In addition, it allows to test the SCP hypothesis. Hannan and Liang note that testing for perfect collusion would need unacceptable assumptions, such as product homogeneity. However, the parameter they estimate enables to draw ordinal conclusions about the degree of competition. Thus, it is possible to compare competition in different product markets. The test requires time-series information on bank deposit rates, security rates, and bank marginal costs. The main outcome of the study is that perfect competition can be rejected and that the degree of competition is lower for money market deposit accounts (MMDA) than for two-year certificates of deposits (2YCD) and three-year certificates of deposits (3YCD). The theoretical background relies on the analysis of the margin between exogenous gouvernment securities rates and deposits rates of respective maturities. Comparison of a market where individual banks might exercise some price-setting power and a market where an individual bank is price-taker allows inferences on the level of market power. The estimated parameter measures the supply elasticity. It gives information on both a bank's conjecture on how rivals will react to its interest rate change and the degree of product differentiation. Defining r_d^i bank i's deposit rate, c_d^i bank i's marginal cost of employing a dollar of deposits to fund securities, r_s the security rate and e_d^i bank i's perceived deposit-supply elasticity[29] the profit-maximising rate for each type of deposit must satisfy the following equation:

$$r_d^i \cdot \left(1 + \frac{1}{e_d^i}\right) = r_s - c_d^i \Longleftrightarrow r_d^i = \underbrace{\frac{e_d^i}{1 + e_d^i}}_{=:\, \alpha^i} \cdot (r_s - c_d^i) \ . \qquad (13)$$

In words: the additional expenses due to an an additional dollar "produced" must equal the marginal net gain from investing that dollar in securities.

In the absence of market power the perceived supply elasticity is infinite. As $\alpha^i \overset{e_d^i \to \infty}{\longrightarrow} 1$, perfect competition is equivalent with $\alpha^i = 1$. Thus, if time-series regression of r_d^i on $r_s - c_d^i$ yields values for α^i significantly less than unity perfect competition can be rejected. Further, we can note that α_i is an isotonic function of elasticity and, hence, a lower degree of competition coincides with lower values of α^i.

Some attention should be paid to the choice of the three deposit categories. MMDAs require frequent contact between customers and banks and thus they may be competed for on an local basis. The market for 2YCDs and 3YCDs is likely to be geographically broader. This approach to distinction of different markets (where 'different' mainly refers to the geographic dimension) is similar to our proceeding in the Bresnahan and the P-R model where market delineation has been achieved by product differentiation (deposits and loans) and separation of different banking groups (large, medium-sized and small or savings, cooperative, credit and foreign banks).

The variable c_d^i in equation (13) cannot be measured directly . Hannan and Liang derive it from a multi-product cost function following Berger (1995). Ashton (1999) show the procedure for a couple of UK banks.

[29] Deposit-supply elasticities are bank specific since Hannan and Liang allow for the existence of product differentiation. Thus, elasticity is affected by the reactions of rivals as well as by the degree of product differentiation

The time series estimation equation is specified as follows:

$$r_d^i = \alpha_0 + \alpha_1^i(r_s - c_d^i) + \text{error term} \tag{14}$$

The estimation results[30] show that 94% respectively 80% and 77% of α^i were significantly (95% level of confidence) less than one in the MMDA, the 2YCD and the 3YCD case.

As the Hannan/Liang approach also provides a test for the SCP paradigm we will briefly return to this model. The above discussion of the coefficient α^i suggests that it can be interpreted as a rough measure of market power. Thus, a negative relationship between α^i and market concentration could be interpreted as evidence for the SCP paradigm. Therefore Hannan and Liang run cross-section regressions of α_1^i on a concentration measure and other explanatory variables. The estimation equation is of the form:

$$\tilde{\alpha}_1^i = \gamma_0 + \gamma_1 CR_i + \gamma X_i + u_i \ , \tag{15}$$

where $\tilde{\alpha}_1^i$ is the estimated value of α_1^i, CR_i represents the 3-firm concentration index of bank i's market, X_i is a vector of explanatory variables, e.g. bank size, and u_i is an error term[31]. The regressions results are not surprising: for the MMDA market, which is a relatively local market, Hannan and Liang find a negative relationship between $\tilde{\alpha}_1^i$ and CR_i. For the CDs the coefficients of CR_i are not significant. This is in line with the notion that in broader geographic markets market power associated with concentration is not perceivable[32]. The result may be interpreted in this sense that the SCP paradigm generally is plausible, but contestability matters.

3.4 The Iwata model

Iwata (1974) has developed another model which is based on an oligopolistic market and measures the conjectural variation. According to the Cournot and the Bresnahan model, it is derived from the first order conditions of a profit-maximising oligopolist. Bikker and Haaf (2000b) note that this model has apparently been applied only once to the banking industry by Shaffer and DiSalvo (1994) to a duopoly. Iwata himself applies it to the Japanese flat glass industry. A shortcoming of the model is that it requires micro-data for the structure of cost and production for homogenous products. This is why I will not go into further detail and just present the term which determines the conjectural variation:

$$\lambda_i = \eta_D \cdot \frac{c'(x_i) - p}{p} \cdot \frac{X}{x_i} - 1 \ , \tag{16}$$

where η_D is the price elasticity of demand, x_i individual firm output, X industry output and p price. To obtain λ_i one has to estimate a market demand function and individual cost functions. Therefore one has to assume that p and x_i/X are strict functions of exogenous variables and that the price elasticity of demand is constant.

4 Conclusion

The paper has presented an overview of the existing approaches to the measurement of competition. It shows that bank specific problems are not yet resolved perfectly. In

[30]Hannan and Liang excluded those banks from the sample, for which α^i proved to be not constant over time.

[31]Markets are defined as Metropolitan Statistical Areas (MSAs) or counties in the case of banks located outside of MSAs.

[32]This is kind of a contestability argument.

particular the question of how to introduce risk and equity capital , at least in the papers I reviewed, remains unanswered. Structural approaches to the measurement of competition seem not reliable. Thus recent literature has focussed on NEIO models, mainly the conjectural variations approach and the Panzar-Rosse approach. The latter seems to be the most applicable model. The empirical outcome is more or less similar in all studies indicating a relatively high degree of competition.

References

J. Ashton. A test of perfect competition in the uk retail-banking deposit market. Bournemouth University, School of Finance & Law, Working Paper Series, No. 15, 1999.

A. Berger and T. Hannan. The price-concentration relationship in banking. *Review of Economics and Statistics*, 71:291–299, 1989.

A.N. Berger. The profit-structure relationship in banking - tests of market power and efficient structure hypothesis. *Journal of Money, Credit and Banking*, 27(2):404–431, 1995.

J.A. Bikker. Testing for imperfect competition on EU deposit and loan markets with Bresnahan's market power model. De Nederlandsche Bank, Research Series Supervision, vol. 52, 2003.

J.A. Bikker and K. Haaf. Competition, concentration and their relationship: An empirical analysis of the banking industry. De Nederlandsche Bank, Research Series Supervision, vol. 30, 2000a.

J.A. Bikker and K. Haaf. Measures of competition and concentration in the banking industry: a review of the literature. De Nederlandsche Bank, Research Series Supervision, vol. 27, 2000b.

J. Bos. *European Banking: Market Power and Efficiency*. Universitaire Pers Maastricht, Maastricht, 2002.

J.W.B. Bos. Improving market power tests: Does it matter for the dutch banking market? De Nederlandsche Bank, Research Series Supervision, vol. 56, 2003.

T.F. Bresnahan. The oligopoly solution concept is identified. *Economics Letters*, 10:87–92, 1982.

T.F. Bresnahan. Empirical studies of industries with market power. *Handbook of Industrial Organization*, 2:1011–1055, 1989.

N. Cetorelli. Competitive analysis in banking: Appraisal of the methologies. 1999.

K.S. Corts. Conduct parameters and the measurement of market power. *Journal of Econometrics*, 88(2):227–250, 1999.

W. Cowling and M Waterson. Price-cost margins and market structure. *Economica*, 43: 267–274, 1967.

X. Freixas and J.-C. Rochet. *Microeconomics of Banking*. The MIT Press, Cambridge, Mass., 1998.

D. Genesove and W.P. Mullin. Testing static oligopoly models: conduct and cost in the sugar industry, 1890-1914. *RAND Journal of Economics*, 29(2):355–377, 1998.

R.A. Gilbert. Bank market structure and competition - a survey. *Journal of Money, Credit and Banking*, 16(2):617–645, 1984.

J. Goddard, P. Molyneux, and Wilson J.O.S. *European banking*. Finance. Wiley, Chichester, 2001.

T.H. Hannan and J.N. Liang. Inferring market power from time-series data, the case of the banking firm. *International Journal of Industrial Organization*, 11:205–218, 1993.

H. Hempell. Testing for competition among german banks. Economic Research Centre of the Deutsche Bundesbank, Discussion paper 04/02, 2002.

J.P. Hughes, W.W. Lang, L.J. Mester, and C.G. Moon. Are scale economies in banking elusive or illusive? evidence obtained by incorporating capital structure and risk-taking into models of bank production. *Journal of Banking and Finance*, 25:2169–2208, 2001.

G. Iwata. Measurement of conjectural variations in oligopoly. *Econometrica*, 42(5):947–966, 1974.

W. Jackson III. The price-concentration relatioship in banking: A comment. *Review of Economics and Statistics*, 74:373–376, 1992.

W. Jackson III. Market structure and the speed of adjustment: Evidence of non-monotonicity. *Review of Industrial Organization*, 71:291–299, 1997.

D.-W. Kim and Knittel C.R. Biases in Static Oligopoly Models?: Evidence from the Californian Electricity Market. University of California, Davis, 2003.

G. Lang. Wettbewerbsverhalten deutscher Banken. eine Panelanalyse auf Basis der Rosse-Panzar Statistik. *Jahrbuch für Wirtschaftswissenschaften - Review of Economics*, 48(1): 21–38, 1997.

P. Molyneux. Increasing concentration and competition in European banking: The end of anti-trust? *EIB Papers, European banking after EMU*, 4(1):127–136, 1999.

P. Molyneux, D.M. Lloyd-Williams, and Thornton J. Competitive conditions in European banking. *Journal of Banking and Finance*, 18:445–459, 1994.

D. Neumark and S. Sharpe. Market structure and the nature of price rigidity: Evidence from the market for consumer deposits. *Quartely Journal of Economics*, 107:656–680, 1992.

J.C. Panzar and J.N. Rosse. Testing for "monopoly" equilibrium. *The Journal of Industrial Economics*, XXXV(4):443–456, 1987.

S. Perrakis. Assesing competition in Canada's finacial system: A note. *Canadian Journal of Economics*, 223(3):727–732, 1991.

S. Ribon and O. Yosha. Financial Liberalization and Competition in Banking: An Empirical Investigation. The Eitan Berglas School of Economics, Tel-Aviv University, Working Paper No. 23-99, 1999.

B. Rime. Mesure du degré de concurrence dans le système bancaire suisse à l'aide du modèle de Panzar et Rosse. *Revue suisse d'Economie politique et de Statistique*, 135(1): 21–40, 1999.

S. Shaffer. A test of competition in canadian banking. *Journal of Money, Credit and Banking*, 25(1):49–61, 1993.

S. Shaffer and J. DiSalvo. Conduct in a banking duopoly. *Journal of Banking & Finance*, 18:1063–1082, 1994.

M. Suominen. Measuring competition in banking: A two-product model. *Scandinavian Journal of Economics*, 96:95–110, 1994.

Appendix

A The formal framework of the conjectural variations approach

We assume n banks in an oligopolistic market supplying one homogenous product. Profit of bank i is given by:

$$\pi_i = P(X, EX_D)x_i - c_i(x_i, EX_{S_i}) - F_i \ , \tag{17}$$

where P is price, c_i is the marginal cost of bank i, x_i is the output of bank i, X is industry output, EX_{S_i} are exogenous factors affecting bank i's cost but not industry demand, EX_D are exogenous factors affecting industry demand but not marginal cost and F_i is bank i's fixed cost. Defining c_i' the marginal cost of bank i, the first-order condition for profit-maximisation is:

$$0 = P(X, EX_D) + x_i \frac{\partial P}{\partial X}\frac{\partial X}{\partial x_i} - c_i' \ . \tag{18}$$

Summing over all banks and dividing through n yields:

$$0 = P + \frac{1}{n} X P' \frac{\partial X}{\partial x_i} - \frac{1}{n}\sum_{i=1}^{n} c_i' \ ; \tag{19}$$

hence,

$$P = -\lambda^* X P' + \frac{1}{n}\sum_{i=1}^{n} c_i' \ . \tag{20}$$

With the semi-elasticity of demand η_D^* and average marginal cost c one has:

$$P = \lambda^*(\eta^*)^{-1} + c \ . \tag{21}$$

This relationship reflects how prices are affected by demand elasticities and costs where the oligopolist is assumed to maximise perceived profits through consideration of the reaction of other players.

Another re-arrangement illuminates the interpretation of λ^* as part of the Lerner index $L := \frac{P-c}{P}$ which measures the markup:

$$L = \frac{P-c}{P} = \lambda^* \frac{1}{\eta^*} \ . \tag{22}$$

In a monopoly the Lerner index equals inverse elasticity. This is consistent with assigning the value 1 to λ^* in case of monopoly as done in sub-section 3.1.

Dividing through L and defining the elasticity-adjusted Lerner index L_η yields:

$$\lambda^* = \eta \frac{P-c}{P} =: L_\eta \ . \tag{23}$$

Sometimes the CV parameter even *is defined* as the elasticity-adjusted Lerner index. The elasticity adjusted Lerner index has an important feature: it differentiates whether high price-cost margins are due to the abuse of market power or to low elasticities.

At last, Shaffer (1993) presents the interpretation of the CV parameter as the percentage deviation from competitive output. This goes as follows:

$$\underbrace{P \cdot \frac{\mathrm{d}X}{\mathrm{d}P}}_{\text{equlibrium output}} \quad - \quad \underbrace{c \cdot \frac{\mathrm{d}X}{\mathrm{d}P}}_{\text{competitive output}} \quad = \ \text{deviation} \ . \tag{24}$$

Re-arrangement and devising through X produces:

$$\frac{P \cdot \frac{\mathrm{d}X}{\mathrm{d}P} - c \cdot \frac{\mathrm{d}X}{\mathrm{d}P}}{X} = -\lambda^* \,. \tag{25}$$

B The cost of equity capital

Hughes et al. (2001) offers an interesting method how to derive the shadow price of equity capital. He also estimates the mean shadow price for different size groups of US banks (where size refers to asset size). Starting point of the formal derivation is the cash-flow cost function

$$C_{CF}(\mathbf{y}, n, p, \mathbf{w_p}, \mathbf{w_d}, k) = \min_{\mathbf{x_p}, \mathbf{x_d}} (\mathbf{w_p x_p} + \mathbf{x_d w_d}) \text{ s.t. } T(\mathbf{y}, n, p, \mathbf{x}, k) \leq 0 \text{ and } k = k^0 \,, \tag{26}$$

with the transformation function T; $\mathbf{y}$, information-intensive loans and financial services; k, equity capital; $\mathbf{x_d}$, demandable debt and other types of debt; $\mathbf{x_p}$, labour and physical capital; $\mathbf{x} = (\mathbf{x_p}, \mathbf{x_d})$; and w_i, the price of the i-th type of input. In order to allow for the asset quality two controls are included: the amount of nonperforming loans, n, and the average contractual interest rate on loans, p. Then, economic cost can be described as follows:

$$C(\mathbf{y}, n, p, \mathbf{w_p}, \mathbf{w_d}, w_k) = C_{CF}(\mathbf{y}, n, p, \mathbf{w_p}, \mathbf{w_d}, k) + w_k k \,, \tag{27}$$

The first-order condition for cost minimisation yields:

$$w_k = -\frac{\partial C_{CF}}{\partial k} \,. \tag{28}$$

If the shadow price equals the market price it reflects the marked-priced risk of a bank's portfolio[33]. But, besides possible problems with estimating $-\partial C_{CF}/\partial k$, it is not assured that the level of equity observed minimises cost. If not, the estimated shadow price may not equal the market price. Regulation, for instance, might demand levels of equity capital, which exceed cost-minimising levels. Another incentive for banks to hold more equity capital may be the signalling function of equity capital.

The outcome of the estimations in Hughes et al. (2001) suggest that banks do not minimise cost. Shadow price values for small banks seem to be smaller than market prices, those of large banks seem to exceed market prices.

[33] Higher risks increase the required return on equity.