

**“TRENDS IN COMPETITION AND PROFITABILITY
IN THE BANKING INDUSTRY:
A BASIC FRAMEWORK”**

by

Jacob A. Bikker and Jaap W. B. Bos

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TRENDS IN COMPETITION AND PROFITABILITY IN THE BANKING INDUSTRY: A BASIC FRAMEWORK

J. A. Bikker^{1*} and J. W. B. Bos^{2*}

Corresponding Author:

Jacob A. Bikker
Senior Economist
Supervisory Policy Division
Strategy Department
De Nederlandsche Bank
P.O. Box 98
NL-1000 AB Amsterdam
THE NETHERLANDS

Tel: +31 20 524 23 52

Fax: +31 20 524 18 85

e-mail: j.a.bikker@dnb.nl

¹ De Nederlandsche Bank.

² Department of Finance & Financial Markets, Utrecht School of Economics, Utrecht University.

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Abstract

This paper brings to the forefront the assumptions that we make when focusing on a particular type of explanation for bank profitability. We evaluate a broad field of research by introducing a general framework for a profit maximizing bank and demonstrate how different types of models can be fitted into this framework. Next, we present an overview of the current major trends in European banking and relate them to each model's assumptions, thereby shedding light on the relevance, timeliness and shelf life of the different models. This way, we arrive at a set of recommendations for a future research agenda. We advocate a more prominent role for output prices, and suggest a modification of the intermediation approach. We also suggest ways to more clearly distinguish between market power and efficiency, and explain why we need time-dependent models. Finally, we propose the application of existing models to different size classes and sub-markets. Throughout we emphasize the benefits from applying several, complementary models to overcome the identification problems that we observe in individual models.

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I. Introduction

The profitability of banks is of interest to bank management, financial markets, bank supervisors and academics. This interest is driven by increasing consolidation in the banking sector, changes in production technology and regulation, and dissolving borders, both internationally and vis-à-vis related financial products and industries. As a result, explaining (changes in) the profitability of banks is the implicit or explicit subject of much of the banking literature. When we estimate a market power model, we look for – the abuse of – market power as a means of explaining increases and differences in profitability. And when we employ an efficient frontier model, we expect sub-optimal management decisions regarding production factors to lead to differences in profitability.

Interestingly, and often implicitly, these expectations reflect important assumptions not just with respect to a bank's decision making process or its competitive behavior, but also with respect to other factors that may help explain changes and differences in profitability. For example, a market power model that assumes output price competition, thereby also assumes that products are fairly homogeneous, perhaps as a result of harmonization and liberalization of bank regulation. And by focusing on efficiency, we implicitly assume that it dominates other types of suboptimal production decisions related to for example scale (or scope). Our motivation for doing so may be the increase in average size as a result of the increasing consolidation in the banking industry.

This paper tries to bring to the forefront the assumptions that we make when focusing on a particular type of explanation for bank profitability. We attempt to evaluate a broad field of research by introducing a general framework for a profit maximizing bank and demonstrating how different types of models can be fitted into this framework. The fact that not all models introduced here are nested and the difficulties encountered in comparing past empirical evidence complicate our comparisons of empirical evidence for different models. However, we can relate the current major trends in European banking to each model's assumptions and thereby shed light on the relevance, timeliness and shelf life of different models. This way, we aim to arrive at a set of recommendations for a future research agenda that is both well-motivated and in keeping with current and future developments.

This paper continues as follows. Section 2 briefly highlights why and how banks maximize profits. Section 3 contains a basic framework for a profit maximizing bank, followed by an integrated discussion of different models and an overview of how they rivet together through the basic framework. Next, section 4 examines major trends in banking and discusses how they relate to our basic framework. In light of this discussion, some of the existing empirical evidence is reviewed in section 5. Section 6 concludes and tries to redraw the future research agenda based on lessons learned in this paper.

2. Profit maximization

A key assumption in much of the literature is that banks are profit maximizers. It is in fact one of the (few) assumptions that is shared by all models reviewed in this paper. At this point in our discussion of trends in bank profitability, it is therefore instructive to remind ourselves of exactly why banks maximize profits. To be sure, standard theory tells us that a bank's shareholders are claimants for its profits and it is thereby in their interest to maximize these profits.³ They maximize their return on investment by maximizing revenue and by minimizing costs. Depending on the market power of the bank in input and output markets respectively, it may be able to increase output prices or decrease input prices. Bank management can select the combination of inputs and outputs at which profits are maximized. In order to avoid stating the obvious, and to clarify our motivation further we therefore start by asking why a bank would *not* be able to reach maximum profits. In this section, we consider four issues related to profit maximization: (a) the role of diversification and risk preferences; (b) principal agent problems between shareholders and bank management; (c) imperfect competition; (d) inefficient use of inputs and outputs.

A first consideration relating to bank profit maximization concerns the concepts of risk and diversification. Shareholders balance their appetite for maximizing expected profits and minimizing costs with the amount of risk they are willing to take. Abstracting from speculative motives, shareholders are generally assumed to be indifferent to the distribution of profits, receiving a return on their investment in the bank either through an increase in the bank's share price or through dividends received. If all banks share the same risk-return preferences, or if the risk-return relationship can be described by some relatively simple homothetic continuous function, then there is no serious problem with the fact that we do not know how to control for a bank's risk preferences.⁴ This is different, however, in a situation where some banks (e.g. cooperative banks) are highly risk-averse and not well diversified. Such banks have different preferences, forego high-risk, high-return opportunities and optimize towards an altogether different

³ Here profits are net earnings minus any retained earnings.

⁴ Homothetic functions are characterized by the linear expansion paths that we require to be able to compare the competition proxies and efficiency measures, respectively, that we shall introduce later in this paper.

maximum profit.⁵ Although control variables aimed at proxying for this risk attitude are frequently used in the literature, comparatively little work has been done on modeling banks' risk-return tradeoff. Recent work by Hughes et al. (2000) and De Young et al. (2001) has tried to incorporate risk into a bank benchmarking exercise. Koetter (2004) has applied their model to German banks. Given that this type of work is still in its infancy, we refrain from including it in our general framework. Instead, we rely on control variables that aim to proxy for banks' risk-return preferences.

A second consideration relating to banks' profit maximization concerns incentive structures. Even risk-neutral shareholders who are well-diversified may have problems translating their claim on profits into the actions required to maximize revenue and minimize costs. In the absence of complete information, principal-agent theory states that shareholders are unable to adequately monitor bank management and that the resulting managerial discretion may induce sub-optimal behavior, i.e. profits are not maximized and/or costs are not minimized.⁶ As long as shareholders cannot monitor and penalize bank management, the latter may show expense-preference behavior or – if it is highly risk-averse – any other strategy that reduces profits.⁷ This means that the asymmetric information between principal and agent that was once used by Diamond (1984) to explain the existence of banks from the reduction in audit costs for lenders to non-financial firms, now helps explain why banks themselves may also suffer from moral hazard and other incentive problems. A vast amount of literature exists on ways to minimize the negative effects of these principal-agent problems. A detailed discussion is beyond the scope of this paper. Pecuniary and non-pecuniary incentives and yardstick competition are ways to reduce managerial slack while keeping managerial discretion intact.⁸ Discretion itself is affected by, for instance, external control mechanisms, supervisory institutions, collateralized debt and takeover bids.⁹ Price and non-price competition, the substitutability of a bank's products

⁵ See also Tirole (1993), p. 35. The same reasoning, but to a far lesser extent of course holds for risk-neutral shareholders.

⁶ This section borrows from Tirole (1993), chapters 0, 1, 6, 7 and 9, from Dewatripoint and Tirole (1994), chapters 2, 5–8 and 12, and from Freixas and Rochet (1997), chapters 2 and 3. We simplify the discussion in these references, for example by not discussing monitoring costs.

⁷ For an excellent introduction into principal-agent theory, see Arrow (1995). Seminal references for banking are Edwards and Heggstad (1973) and Edwards (1997).

⁸ See Tirole (1993), pp. 35–55. In addition, regulators have considered creating deposit insurance schemes conditional on the banks' performance (Dewatripoint and Tirole (1994) p. 129). Barnett et al. (1994) and Barnett and Hansen (1996) study the same incentive problem.

⁹ See again Tirole (1993), pp. 35–55, as well as chapters 6 and 8 of Dewatripoint and Tirole (1994).

and the contestability of its markets may also serve to ensure a bank's optimal performance by putting competitive pressure on its management, provided management compensation is performance-based.¹⁰ A similar role may be played by signaling devices such as ratings. Whether incentive problems are important in European banking is questionable. First, few studies have attempted to test empirically the impact of principal-agent conflicts on the performance of European banks. Translations into empirical tests of the situations described above where hidden action by or hidden knowledge of bank management results in suboptimal performance are rare.¹¹ Second, to the extent that the principal-agent relationship results in moral hazard conflicts, this will only create problems if the principal (i.e. the shareholder) can not insure himself against excessive risk-taking by the agent (cf. Tirole (1993), paragraph 2.1). Third, although incentive problems may lead to suboptimal performance by a bank, the extent to which this affects European banking dynamics is unclear. There is little reason to suspect that the incentive problems that can cause a bank to make less profits or experience above-minimum average costs are significantly different from bank to bank, or from country to country. The separation between ownership and control is highly similar for commercial banks across Europe, even if institutional supervision is not.¹² Summing up, even if incentive problems can help explain bank performance, empirically testing whether they can explain *differences* in bank performance is difficult and results to date have been far from conclusive.

Banks' performance is related to changes in their environment and the behavior of their competitors. Therefore, a third consideration relating to banks' profit maximization concerns market power. Economic theory also tells us that in a perfectly competitive situation, profit maximization is equivalent to cost minimization. In practice however, we do not necessarily observe maximization of profits and/or minimization of costs. Of course, exogenous factors such as regulation or (economic) shocks can cause suboptimal performance. To the extent that such factors do not have similar effects on both cost minimization and profit maximization, they can drive a wedge between the two. Imperfect competition causes a situation where profits are maximized at an output level where average costs are no longer minimized. It can thus be used to explain changes in profitability over time as well as between banks. Therefore, the first class of models considered in this paper is that of market power models.

¹⁰ For examples, see chapter 3 of Freixas and Rochet (1997).

¹¹ See Molyneux et al. (1997), pp. 82–83 for a short overview.

¹² Cf. chapter 3 of Molyneux (1997), especially table 3.20 where standard deviations for the EU area are small for all banks, and mean ownership (capital/assets) of private and cooperative banks is remarkably similar.

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A bank may also produce at lower costs and with a higher profit than other banks if it makes better use of its inputs and transforms them into outputs in the cheapest possible way. In the long run, every bank has to produce efficiently in order to survive.¹³ The fourth consideration relating to banks' profit maximization therefore concerns efficiency. For the EU, Economic Research Ltd. (1997) hypothesizes that the single market integration program (S.M.P.) "has allowed the (increased) realization of [efficiency gains] in European banking markets" (p. 187). The authors conclude that "there does appear to have been a trend for European banks, on average, to move closer to the EU cost efficiency frontier" (p. 195). Summing up, efficiency plays an important role in explaining the forces behind European bank performance. Furthermore, it can aid in measuring and interpreting the sources driving bank performance. Therefore, the second class of models considered in this paper includes various methods for the measurement and interpretation of the (relative) efficiency of European banks.

¹³ Cf. Hanweck and Rhoades (1984).

3. Methodology

Now that we have defined two broad classes of interest when analyzing bank profitability, we look more closely at the concept of a profit maximizing bank. Section 3.1 introduces a general model of a profit maximizing bank. Next, section 3.2 presents a number of market power models and shows how they fit into the basic model. Section 3.3 does the same for efficiency models. Finally, section 3.4 works out a synthesis of all models.

3.1. Basic model

This section develops a basic model of a profit maximizing bank.¹⁴ Equilibrium conditions from this model can be used to test more extreme models, namely perfect competition and myopic oligopoly behavior (the classic Cournot model). We assume all costs to be variable costs (in the long run), and all outputs to be perfect complements with zero cross-price elasticity. For now, banks are also assumed to be myopic (we will later relax this assumption). For a bank i , we define profit Π_i , the output vector Y_i , the input vector X_i , the output price vector p_i , and the input price vector w_i . Each bank i maximizes profit using transformation function T and pricing opportunity set H , which captures the bank's assessment of its competitive position and concomitant willingness of customers to pay the prices charged by the bank. Part of the pricing opportunity set is Z , the level of equity. For now we drop subscripts that denote different inputs, outputs, input prices or output prices, for ease of exposition. All variables used in this section are therefore vectors, and a subscript i always refers to individual banks, whereas a variable without a subscript denotes the aggregate vector for all banks in a market.¹⁵

Since we use duality (and thus do not have to estimate input-demand and output-supply functions), there is no need to further specify the transformation function T or the opportunity set H .¹⁶ For each output in the

¹⁴ The model described here is derived from Cowling (1976), Cowling and Waterson (1976), and Stigler (1964). The model by Cowling describes a relationship between industry performance and market concentration, both over time (intra-industry) and between industries (inter-industry).

¹⁵ See Hughes and Mester (1993) and Mester (1996).

¹⁶ See Coelli et al. (Chapter 3, 1998).

output vector Y_i , bank i sets the price p_i based on the inverse demand function $f(X)$. Bank i then maximizes:

$$\begin{aligned} \Pi_i &= p_i Y_i - w_i X_i, \text{ subject to} \\ T(X_i, Y_i) &= 0 \\ H(p_i, Y_i, w_i, Z_i) &= 0 \\ p_i &= f\left(\sum_{i=1}^N Y_i\right) = f(Y) \end{aligned}$$

where $f(Y)$ is inverse market demand and N the number of banks. The corresponding Lagrangian system can be written as:

$$L\Pi_i = p_i Y_i - w_i X_i - \xi T(\bullet) - \theta H(\bullet) \quad (1)$$

Solving for p and X simultaneously yields the optimal output prices and input quantities (denoted by asterisks):

$$\begin{aligned} p_i^* &= p_i^*(Y_i, w_i, Z_i) \\ X_i^* &= X_i^*(Y_i, w_i, Z_i) \end{aligned}$$

Profits are maximized if:

$$\frac{d\Pi_i}{dY_i} = p_i^* + Y_i f'(Y) \frac{dY}{dY_i} - w_i^*(Y_i) X_i^* = 0 \quad (2)$$

Multiplying by Y_i yields:

$$p_i^* Y_i - w_i^*(Y_i) X_i^* Y_i = - \left((Y_i)^2 f'(Y) \left(\frac{dY}{dY_i} \right) \right) = 0 \quad (3)$$

where revenue is denoted by $p_i Y_i$. Marginal costs, $w_i'(Y_i)$, depend on the price of inputs, which in turn depends on the demand for outputs. Here, banks are assumed to face perfectly competitive input markets, but operate in output markets where price differentiation is potentially possible. Thus, banks may compete via their output pricing strategies, by adjusting prices and fees according to market conditions.¹⁷ The extent to which they can influence prices depends on output quantities, input prices and other factors, all of which are given at the time of price setting. In the empirical analysis, we can

¹⁷ Note that on the markets for inputs, banks are assumed to be price-takers. Therefore, they face exogenously determined market input prices (cf. Berger and Mester (2003)). In many studies based on (a derivation of) this basic framework, input prices are essentially wrongly specified, since they are calculated for each individual bank instead of at the market level.

disregard output prices, which are subject to severe measurement problems according to Berger and Mester (1997) and Vander Venet (1997), are not required for the empirical analysis.

We further rewrite and rearrange equation 3, in order to arrive at an equation that is more closely in line with what is found in the empirical literature on bank performance. We start by defining:

$$\frac{dY}{dY_i} = 1 + \frac{d \sum_{j \neq i} Y_j}{dY_i} = 1 + \lambda_i \quad (4)$$

where λ_i is known as the conjectural variation of firm i 's output.¹⁸ Substitution of λ_i in equation 3 and multiplying by Y_i gives:

$$p_i^* Y_i - w_i'(Y_i) X_i^* Y_i = -(Y_i)^2 f'(Y) (1 + \lambda_i) = 0 \quad (5)$$

Dividing both sides by $p_i Y_i$ and rearranging gives:

$$\frac{p_i^* Y_i - w_i'(Y_i) X_i^*}{p_i^* Y_i} = - \frac{Y_i}{Y} \frac{f'(Y) Y}{p_i^*} (1 + \lambda_i) = 0 \quad (6)$$

The left-hand side of equation 6 is the bank's mark-up over its total costs. This mark-up can be decomposed into three parts, equivalent to the right-hand side of equation 6:

1. (Y_i/Y) is firm i 's market share, with $0 < MS \leq 1$.
2. $f'(Y)Y/p$ is the inverse of the market price elasticity of demand, $1/\eta_D$. Since the main prices for banks in the context of this analysis are interest rates, η_D is referred to as the interest elasticity of demand.
3. $1 + \lambda_i$ measures firm i 's expectations about the reactions of its rivals dY/dY_i , with $-1 \leq \lambda \leq 1$.

We can now write equation 6 as:

$$\frac{p_i^* Y_i - w_i'(Y_i) X_i^*}{p_i^* Y_i} = (MS_i) \left(-\frac{1}{\eta_D} \right) (1 + \lambda_i) \quad (7)$$

After multiplying by $p_i^* Y_i$ we have:

¹⁸ A high λ_i means a firm has a high awareness of its interdependence with other firms. If firms are indeed myopic, their λ_i is zero.

$$\Pi_i^* = p_i^* Y_i - w_i' (Y_i) X_i^* = \left(MS_i \right) \left(-\frac{1}{\eta_D} \right) (1 + \lambda_i) p_i^* Y_i \quad (8)$$

Therefore optimal profits Π_i^* go up with an increase in the market share MS_i , with a decrease in the price elasticity of demand η_D , with an increase of the conjectural variation λ_i , an increase in the price of outputs p_i^* , and an increase in demand for Y_i . As we shall see in the remainder of this section, many models that study competition and efficiency can be classified according to this basic framework. All models contain a partial analysis, and focus on a single right-hand variable in equation 8, or a combination of two of these variables.

3.2. Market power

This section summarizes the various approaches to measuring competition and profitability, and how they are related to the framework presented above. In the context of the models discussed here, there may be circumstances where banks can increase their prices and be rewarded by higher profits. They can do so because the drop in demand that would normally result from such an increase is not entirely offset by the extra marginal revenue gained by the price increase. These circumstances are broadly defined as market power. In light of equation 8 above, market power is derived from MS_i , η_D , or λ_i , or a combination of these variables.

3.2.1. Iwata

In the Iwata model (Iwata, 1974), the right-hand side of equation 8 is written as:

$$\lambda_i = \eta_D \left((w_i' (Y_i) X_i - p) / p \right) / MS_i - 1 \quad (9)$$

Thus, the model allows for the estimation of conjectural variation values for individual banks supplying a homogeneous product in an oligopolistic market. Although, to the best of our knowledge, this measure has been applied only once to the banking industry, it is included in the present overview for completeness' sake.

A general problem with these models, which we will see again in the subsections below, is the fact that some of the determinants of profitability that we have identified so far are interrelated and/or cannot be observed in practice. In order to solve a possible identification problem, in particular

when applying these models empirically, these models therefore generally begin by defining a set of limiting assumptions. In this case, the Iwata model assumes that p and MS_i are strict functions of exogenous variables, and that η_D , the elasticity of demand, is constant. Now we can derive an indirect estimate of the conjectural variation λ by estimating a market demand function and cost functions for individual banks to quantify the conjectural variation for each bank. Applying this model to the banking industry is difficult, particularly for the European industry, where micro data for the structure of cost and production for homogeneous products are scarce or lacking altogether.

3.2.2. Bresnahan

Contrary to Iwata (1974), Bresnahan (1982) and Lau (1982) assume that all banks are equal and identical and make an aggregate analysis. In this short-run model, they thereby determine the level of market power in the banking market and take averages over equation 8 thus obtaining:

$$p + f'(Y) \sum_i (dY/dY_i)(1/n)Y_i - \sum_i (w'_i(Y_i)X_i)/n = 0 \quad (10)$$

This is equal to:

$$p = -\lambda f'(Y)Y + (\bar{w}(\bar{Y})\bar{X}) \quad (11)$$

if we define λ as $(dy/dY_i)/n = (1 + d\sum_{i \neq j} Y_j/dY_i)/n$ and assume that all banks are equal (so that the definition of λ holds for each i). The bars in equation 11 refer to average values; \bar{w} , \bar{Y} and \bar{X} represent the average cost function, average output and average input, respectively.

Banks maximize their profits by equating marginal cost and perceived marginal revenue. The perceived marginal revenue coincides with the demand price in competitive equilibrium and with the industry's marginal revenue in the collusive extreme (Shaffer, 1993). Based on time-series of industry data, the conjectural variation parameter, λ , is now equal for all banks and determined by simultaneous estimations of the market demand and supply curves.

For the average bank in a *perfectly competitive* market, the restriction $\lambda = 0$ holds, as, in a competitive equilibrium, price equals marginal cost. Since prices are assumed to be exogenous to the firm in a perfectly competitive market, an increase in output by one firm must lead to an analogous decrease

in output by the remaining firms, in line with equation 11. The *Cournot equilibrium* describes non-cooperative optimization, where agents who mutually influence each other act without explicit cooperation. Under that type of equilibrium, the conjectural variation ($d\sum_{i \neq j} Y_j / dY_i$) for firm i would equal zero. The Cournot equilibrium assumes that a firm does not *expect* retaliation from other firms in response to changes in its own output, so that $\lambda = 1/n$ and $p + h(\cdot)/n = (\bar{w}(\bar{Y})\bar{X})$, with $h(\cdot) = f'(Y)Y$, represent the semi-elasticity of market demand. Under *perfect collusion*, an increase in output by one of the colluders leads to a proportional increase in output by all other colluders, yielding $\lambda = \left(1 + d\sum_{i \neq j} Y_j / dY_i\right) / n = \left(1 + (Y - Y_i) / Y_i\right) / n = Y / (Y_i n) = 1, \forall i$,¹⁹ so that $p + h(\cdot) = (\bar{w}(\bar{Y})\bar{X})$. Hence, under normal conditions, the parameter λ takes values between zero and unity.

Empirical applications of the Bresnahan model are scarce. The model has been estimated by Shaffer (1989 and 1993) for, respectively, the US loan markets and for the Canadian banking industry. Suominen (1994) applied the model in its original one-product version to the Finnish loan market for the period 1960–84. An adapted two-product version is applied to the period after deregulation (September 1986–December 1989). Suominen finds zero λ 's for the period with regulated interest rates in both markets, and values of λ indicating use of market power after the deregulation of the loan market. Swank (1995) estimated Bresnahan's model to obtain the degree of competition in the Dutch loan and deposit markets over the period 1957–90, and found that both markets were significantly more oligopolistic than under Cournot equilibrium. Bikker (2003) presents applications of the Bresnahan model to loans markets and deposits markets in nine European countries over the last two or three decades. Where values of λ appear to be significantly different from zero, so that perfect competition should be rejected, they are nevertheless close to zero. In many submarkets, the hypothesis $\lambda = 0$ (that is, perfect competition) can not be rejected.

3.2.3. Panzar-Rosse

Most of the models we derive here assume Cournot competition. In fact, this is the assumption in the model by Cowling (1976) from which our basic framework is derived. An important exception is the Panzar-Rosse model.

¹⁹ The assumptions underlying the Cournot oligopoly theory according to Hause (1977) are: homogeneous products, n firms with strictly increasing marginal cost functions (which need not be identical), independent (non-cooperative) behaviour of firms to maximize their own profits, no entry, and industry demand is strictly decreasing.

Aside from the fact that price information is notoriously scarce and unreliable for banking markets, not much is known about the role of Cournot and Bertrand competition respectively in banking. However, with quantity precommitments the Panzar-Rosse model reduces to a basic Cournot model.²⁰ Therefore, we include it in the present analysis.

The method developed by Panzar and Rosse (1987) estimates competitive behavior of banks on the basis of the comparative static properties of reduced-form revenue equations based on cross-section data. Panzar and Rosse (P–R) show that if their method is to yield plausible results, banks need to have operated in a long-term equilibrium (that is to say, the number of banks needs to be endogenous to the model) while the performance of banks needs to be influenced by the actions of other market participants. Furthermore, the model assumes a price elasticity of demand, η_D , greater than unity, and a homogeneous cost structure. To obtain the equilibrium output and the equilibrium number of banks, profits are maximized at the bank as well as at the industry level when marginal revenue equals marginal cost (cf equation 8). Let w_i be a vector of K input prices (for K inputs). In equilibrium, the zero profit constraint holds at the market level:

$$\Pi^* = p^*Y - w'(Y)X^* = \left(MS_i \right) \left(-\frac{1}{\eta_D} \right) (1 + \lambda) p^*Y = 0 \quad (12)$$

which is equal to equation 8, aggregated over all firms i (MS_i is now the average MS). Variables marked with an asterisk represent equilibrium values. Now we assume that MS_i and λ are strict functions of exogenous variables. Market power is then measured by the extent to which a change in factor input prices (∂w_k) is reflected in the equilibrium revenues (∂R_i^*) earned by bank i . Panzar and Rosse define a measure of competition, the ‘ H -statistic’ as the sum of the elasticities of the reduced-form revenues with respect to the K input prices:²¹

$$H = \sum_{k=1}^K \left(\partial p^*Y / \partial w_k \right) (w_k / p^*Y) \quad (13)$$

The estimated value of the H -statistic ranges between $-\infty$ and 1. H is smaller than zero if the underlying market is a monopoly, it ranges between zero and unity for other types of competition such as oligopoly, and an H of one indicates perfect competition. Shaffer (1983) demonstrated formal linkages

²⁰ On a more theoretical level, our basic framework can lead to the same 2–player competitiveness that we find in many (simple) Bertrand models.

²¹ See Panzar and Rosse (1987) or Vesala (1995) for details of the formal derivation of the H -statistic.

between the Panzar–Rosse H -statistic, the conjectural variation elasticity and the Lerner index. Table 3.5 in Bikker (2004) provides an overview of studies which test the P–R method for the banking industry.

3.2.4. Structure-Conduct-Performance

The Structure-Conduct-Performance (SCP) model assumes that market structure affects bank behavior (conduct) which in turn influences bank performance. In a market with a higher concentration, banks are more likely to show collusive behavior, and their oligopoly rents increase performance (profitability). Here, conduct is an unobservable and is measured indirectly through market concentration.

Although the SCP hypothesis lacks a formal underpinning, we can use our basic profit model to derive the SCP relationship. We start by deriving our basic framework by summing equation 7 over N firms:

$$\frac{p^*Y - w'(Y)X^*}{p^*Y} = (\Sigma(Y_i/Y)^2) \left(-\frac{1}{\eta_D} \right) \left(1 + (\Sigma\lambda_i Y_i) / (\Sigma Y_i^2) \right) \quad (14)$$

Multiplying by p^*Y gives us:

$$\Pi^* = p^*Y - w'(Y)X^* = \left(HHI \right) \left(-\frac{1}{\eta_D} \right) (1 + \mu) p_i^* Y_i \quad (15)$$

where $HHI = \Sigma(Y_i/Y)^2$, i.e. the Hirschman-Herfindahl index, and $\mu = (\Sigma\lambda_i Y_i) / (\Sigma Y_i^2)$.

To arrive at the basic SCP relationship, we have to make two additional assumptions. The first is that η_D , the price elasticity of demand is constant. If not, the interpretation of a coefficient for MS_i – in the absence of a proxy for η_D – could be biased downward (upward) by increases (decreases) in the interest elasticity of demand over time. The second assumption concerns the individual firm's conjectural variation λ_i , the extent to which it expects other firms to react to a change in output. Here, there are two options. The first is to assume that λ_i is constant and equal across firms, in which case it drops out of the above equation and we are left with a relationship between performance and market share.²² The second option is to formalize the relationship between λ_i and MS_i , under the presumption of collusive behavior.

²² Not surprisingly, this is also a necessary condition for the myopic Cournot oligopolist, who is ignorant of the impact of his actions on his competitors and therefore not prone to collusive behavior.

Following Stigler (1964), we can show that an increase in market share MS_i is expected to increase awareness (λ_i) and thereby lead to more collusive behavior (for proof, see the appendix). Although this still leaves us without a direct measure of λ_i , it does allow us to capture its impact through MS_i . After all, the collusive oligopolist realizes a more than proportional increase in performance as a result of an increase in market share. Alternatively, the penalty for uncollusive behavior increases with market size.

All in all, if we take η_D to be constant and λ_i (or λ) to be an implicit function of HHI we have developed a basic relationship between performance and structure that is consistent with the SCP relationship.²³ The basic equation (without control variables) is then:

$$\Pi^* = ((HHI)(1 + \lambda)) p^* Y \quad (16)$$

The model amounts to interpreting the combined impact of λ and HHI on performance. In two extreme cases, interpretation of the coefficient $\frac{\partial \Pi^*(Y, w)}{\partial (HHI)}$ is straightforward. The Cournot oligopoly prediction is $\frac{\partial \Pi^*(Y, w)}{\partial (HHI)} = 1$, since $\lambda = 0$ and impact of HHI is exactly proportional. If collusive behavior exists, $\lambda > 0$ and the impact of market share is more than proportional, and $\frac{\partial \Pi^*(Y, w)}{\partial (HHI)} > 1$. Finally, in the case of perfect competition an increase in market share has no impact on performance and since $\lambda = -1$, this means that $\frac{\partial \Pi^*(Y, w)}{\partial (HHI)} = 0$.

Summing up, we have derived a relationship between market structure and performance, allowing us to test the SCP hypothesis (cf. Bos (2004) for an overview and a critical analysis).

3.2.5. Cournot model

In deriving the SCP model in the previous subsection, we have assumed that all banks react similarly to an increase in market concentration, and that they benefit equally. Thereby we have implicitly addressed one of the major weaknesses of the SCP hypothesis: the choice of a measure for market concentration.

²³ As explained, for the collusive oligopoly we assume a λ_i that is not constant but unmeasurable – except through MS_i . In the collusive Cournot oligopoly an increase in output Y_i by a bank i has the consequence that all banks in the market increase their output proportionally. This is consistent with a dynamic Cournot equilibrium.

It became the reason why the SCP model became subject to criticism. For example, the idea that all banks benefit equally from a high level of market concentration runs counter to much of the theoretical literature that identifies strategic group behavior and more elegantly translates asymmetric market structures into performance differences. In section 3.1, we have developed a model that also describes a relationship between *industry* performance and market concentration. In fact, the model described in section 3.1 is the disaggregated version of the basic framework that we used to derive the SCP model. As we will see in the present subsection, this modification makes it easier to accommodate asymmetric market structures, differences in cost structures and collusive behavior.

As in section 3.2.4, we start from equation 8, assume that η_D is constant and arrive at:

$$\Pi_i^* = ((MS_i)(1 + \lambda_i))p_i^*Y_i \quad (17)$$

Following the proof in the appendix, we can again show that an increase in market share MS_i is expected to increase awareness (λ_i) and hence to lead to more collusive behavior. We can therefore model λ_i as an implicit function of MS_i and have now arrived at the same relationship as in equation 16, but on a disaggregated level.²⁴

Although all coefficients can be interpreted in the same way as those in equation 16, this Cournot model does not measure exactly the same relationship as the SCP model. Whereas the latter concentrates on the impact of market structure, the former focuses on individual banks' market share. However, in doing so it more accurately captures asymmetric market structures, differences in cost structures and collusive behavior. In fact, Bos (2004) has shown empirically that estimates of equation 17 are consistent with the model's assumptions, whereas the same does not always hold for equation 16.

3.3. Efficiency

In all models introduced so far, we assume that banks choose the optimal output prices p and inputs x that maximize profits, *given* existing market power. Therefore, any deviations from the profits that would prevail under

²⁴ As argued by Cowling (1976), firms could need time to adjust to the new competitive situation and the impact of an increase in market share on performance may therefore involve a lag. In empirical applications, a one-year lag is therefore applied to MS_i .

perfect competition are entirely attributed to (changes in) the degree of competition in the market.

In practice, of course, banks may choose suboptimal combinations of output prices and inputs. They may produce an output at suboptimal scale, produce a suboptimal combination of outputs, or select a suboptimal combination of inputs (or input prices) to produce outputs. In short, banks may be inefficient.²⁵ The general concept of efficiency refers to the difference between observed and optimal values of inputs, outputs, and input/output combinations. In this section, we therefore introduce a second class of models that attempt to measure the extent to which firms may realize suboptimal profits. As it has been shown by Berger and Humphrey (1991) to dominate other inefficiencies, we start with X-efficiency in section 3.3.1. Next, we introduce scale and scope economies in section 3.3.2. Of course, as is already clear from this short introduction, the effects of efficiency and competition on profitability are not always easy to distinguish. Therefore, in section 3.3.3, we present a discussion of the efficiency hypothesis as an example of the relationship between both classes of models.

3.3.1. X-Efficiency

Berger, Hunter and Timme (1993) define X-efficiency as the economic efficiency of any single firm minus scale and scope efficiency effects.²⁶ Berger and Humphrey (1991) report that scale and scope inefficiencies (amounting to about 5 percent) are less important in the banking industry than X-inefficiencies (in the range of 20–25 percent).²⁷

This paper uses stochastic frontier models to measure X-efficiency (as well as scale and scope economies). In light of the framework presented here, stochastic frontier models have the advantage that they use the same elementary set of assumptions about bank production as our basic model, and can thus be easily fitted into this framework.²⁸ Related, by using stochastic

²⁵ In our use of wording, we shall be relatively lighthearted about the precise distinction between productivity and efficiency. For a more formal treatment of the topic, see Coelli et al. (1998).

²⁶ Economic efficiency is the sum of technical and allocative efficiency. Technical efficiency is a measure of a bank's distance from the frontier, minimizing inputs given outputs or vice versa. Allocative efficiency measures the extent to which a bank is able to use inputs and outputs in optimal proportions given prices and the production technology.

²⁷ See also Berger and Humphrey (1997) and Molyneux, Altunbas and Gardener (1997).

²⁸ Cf. in this respect deterministic models with for example Data Envelopment Analysis.

frontiers, we recognize the fact that in measuring bank profitability as we do with our basic model, we also experience some measurement error as not all deviations from optimal (predicted) profit may be due to inefficiency. A final, but less specific, advantage that has been widely used in the literature, is the fact that stochastic frontier models generate bank-specific efficiency estimates, which allow us to test for differences in efficiency among banks in different countries as well as to measure the scale and scope economies of banks that operate close to the frontier.

Stochastic frontier models have been estimated most frequently for *cost minimization* models. In fact, most of the empirical evidence we present in this paper refers to cost efficiency estimations. Here, however, we make a case for *profit maximization* models. In particular, we build on our basic model from section 3.1 to arrive at the alternative profit model by Humphrey and Pulley (1997), Berger and Mester (1997), and DeYoung and Hassan (1998). In this model, banks are assumed to face perfectly competitive input markets but operate in output markets where price differentiation is potentially possible. Thus, the model allows for market power. Banks can compete via their output pricing strategies by adjusting prices and fees according to market conditions. The extent to which they can influence prices depends on output quantities, input prices, and other factors, all of which are given at the time of price setting. Additional features of the profit model are that it can account for differences in the quality of outputs (to the extent that it is reflected in prices) as well as correct for scale bias. Also, output prices, which are subject to severe measurement problems according to Berger and Mester (1997) and Vander Venet (1997), are not required for the empirical analysis.²⁹ The same holds, of course, for our basic model from section 3.1. Let us therefore start by making that model stochastic. In line with the literature, we assume for now that η_D is constant, and we ignore λ_i and MS_i .³⁰

$$\Pi_i^* = \left(p_i^* Y_i - w_i' (Y_i) X_i^* \right) * \exp(\varepsilon_i) \quad (18)$$

We assume that ε_i can be decomposed into a noise component v_i , and an efficiency component u_i , where $\varepsilon_i = v_i - u_i$. Here, v_i is normally distributed, i.i.d. with $v_i \sim N(0, \sigma_v^2)$. The inefficiency term u_i is drawn from a non-negative half-normal distribution truncated at μ and i.i.d. with $u_i \sim |N(\mu, \sigma_u^2)|$. It carries a negative sign because all inefficient firms will operate *below* the efficient

²⁹ For a theoretical framework for the Stochastic Frontier models used here, see Coelli, Prasado Rao, and Battese (1998) and Bos (2002).

³⁰ For a description of the functional form and empirical specification used to estimate this model see section 5.2.

profit frontier. Profit efficiency for bank i is defined as:

$$PE_i = E[\exp(-u_i) | \varepsilon_i] \quad (19)$$

This measure takes on a value between 0 and 1, where 1 indicates a fully efficient bank. The frontier functions are estimated through maximum likelihood methods. In the estimation, the terms σ_u^2 and σ_v^2 are reparameterized by $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_v/\sigma_u$. If the parameter γ is close to zero, little structural inefficiency exists and standard OLS estimation may be appropriate. Extremely large parameter values of γ suggest a deterministic frontier.³¹ We can of course apply the same logic to a cost minimization model, considering that $\varepsilon_i = v_i + u_i$ since inefficient banks now operate *above* the minimum cost frontier.

3.3.2. Scale and scope economies

X-inefficiency results from a suboptimal *choice* of output prices and inputs. Hence it is also frequently referred to as managerial efficiency. Although, when measuring performance, it is sometimes difficult to disentangle endogenous factors from exogenous factors, there is evidence that X-efficiency captures the former, far more fully than the latter. E.g., Bos and Kool (2004) find that exogenous, environmental factors explain no more than 20% of the differences in X-efficiency of a group of relatively homogenous banks.

There are, however, other types of efficiency (or economies) that – although much more exogenous to the firm – can have a significant impact on bank performance. Banks may be operating at a suboptimal scale, or with a suboptimal mix of outputs. Here, we therefore briefly discuss economies of scale and economies of scope, respectively.³²

We define output-specific economies of scale as the *ceteris paribus* increase in profits that results from an increase in output Y_k . To this purpose we take equation 8 and calculate the derivative respect to Y_k :

³¹ Note that the hypothesis we present in section 3.4, $(1 - \frac{\Pi'_i(Y_i, w_i) \exp(v_i)}{\Pi'_i(Y_i, w_i)} > 0)$, should be tested conditional on the fact that $\gamma > 0$.

³² We shall refrain from discussing the relationship of both types of efficiency with X-efficiency.

$$\frac{\partial \Pi_i^*}{\partial Y_{i,k}} \quad (20)$$

A value larger (smaller) than one indicates increasing (decreasing) returns to scale, and unity indicates constant returns to scale. Overall economies of scale are simply the sum of output-specific economies of scale.

Berger, Hunter, and Timme (1993) identified four aspects of the measurement of economies of scale that are relevant to our analyses. First and foremost, research has confirmed that banks have U-shaped cost curves. Economies of scale increase up to a relatively modest size, often estimated in the range of \$100–\$500 million in total assets, after which they tend to decrease (albeit slowly). Second, risk variables are often excluded when measuring economies of scale. Following Mester (1996) and Berger and Mester (1997), this problem can be resolved by including an equity/total assets ratio that enters scale measures via interaction terms in e.g. a translog specification.

Third, many studies base their scale measures on averages, thereby including observations that do not lie on or close to the efficient frontier. In this case economies of scale will be biased to the extent that banks do not lie on or close to the efficient frontier.³³ Fourth, the most reliable measure of economies of scale is an overall estimate, defined as the sum of output-specific economies of scale. The sum of the partial derivatives of each output is less dependent on changes and differences in the output mix.

The extent to which that output mix itself is optimal is measured by calculating scope economies. Unfortunately, calculating scope economies is not as straightforward as calculating scale economies. The derivation itself is straightforward, and analogous to equation 20:

$$\frac{\partial \Pi_i^*}{\partial Y_{i,k} \partial Y_{i,l}}, \text{ for } k \neq l \quad (21)$$

The main problem with this method lies in the fact that, at least theoretically, we require banks with zero outputs for specific outputs Y_k (cf. Berger and Humphrey (1994)). However, the models we have discussed so far are usually estimated using logarithmic (semi-)flexible forms and thereby cannot handle these zero outputs. In addition, Berger, Hanweck, and Humphrey (1987) observed that for translog functions complementarities cannot exist at all

³³ This is reflected by a significantly positive value for μ/σ_u .

levels of output. Finally, in many cases there is an extrapolation problem as well. Given a sample containing both universal banks and other banks, only the former banks typically offer the full range of financial services. Consequently, the economies of scope derived from the cost (or profit) function tend to overestimate the true economies of scope among most sample banks. A further problem is that the measurement of *average* economies of scope yields values that are biased due to the inclusion of X-(in)efficiencies. In the search for a better functional form, some researchers have used a Box-Cox transformation for outputs, while others have used a composite function with a separate fixed-costs component of scope economies.

For cost models Molyneux, Altunbas, and Gardener (1997) proposed a comparison of the separate cost functions for individual outputs with the joint cost of production. However, the plant and firm level data required for this type of analysis are often not available. An alternative method is suggested in Bos and Kolari (2005). They specify a model with three outputs, Y_1 , Y_2 , and Y_3 , which sum to Y . They start by defining $Y_1/Y = a$, $Y_2/Y = b$ and $Y_3/Y = c$. If such a ratio is high, a bank is relatively highly specialized. For overall scope economies, they therefore calculate $d = a^2 + b^2 + c^2$. This measure is bounded by $1/3$ (not specialized) and 1 (specialized). Define 'high' [H] as referring to the upper 25th percentile, and 'low' [L] for the remainder of the observations. Now, the ratio $(\Pi_L^* - \Pi_H^*)/\Pi_H^*$ can be calculated for Y_1 , Y_2 , Y_3 , and Y . Profits Π_i^* are divided by total revenues to adjust for the possibility that banks in high and low bank groups may have different size. If scope economies exist, the ratio is greater than 0. Note that these ratios can only be constructed using averages; as such, the scope measure itself does not have a standard deviation. This is a common problem, as recognized by Berger and Humphrey (1991). Instead, Bos and Kolari (2004) report a t-value for an independent samples test for $\Pi_L^* - \Pi_H^*$. Note that by varying the cut-off point to more or less than the 25th percentile, it is possible to check for extrapolation problems.

3.3.3. Efficiency hypothesis

An important critique of both classes of models discussed so far is the fact that they focus on one half of the story (market power or efficiency, respectively), without being able to control adequately for the other half. For example, in the Cournot model discussed in section 3.2.5 we consider market power to be the sole explanation for differences in market share. The Efficiency hypothesis has been developed as an important alternative

explanation. This section provides a critical review of the way the Efficiency hypothesis can be tested against the market power hypothesis and proposes an alternative test of the Efficiency hypothesis that resolves identification problems when using market power *and* efficiency to explain bank performance.³⁴

The Efficiency hypothesis attributes differences in performance to differences in efficiency (Goldberg and Rai (1996)), Smirlock (1985)). According to the Efficiency hypothesis, both a high market share and relatively good performance result from high efficiency. Thus, whereas according to the traditional SCP hypothesis and the above Cournot model a high degree of market concentration, or respectively, a high market share is an explanatory variable for above average performance, within the Efficiency hypothesis it is seen as, at most, the result of a higher efficiency. Testing the Efficiency hypothesis against the SCP hypothesis therefore generally involves including both market shares and a market structure variable in the estimated equations. The premise is that if the Efficiency hypothesis holds, once individual banks' market share is controlled for, overall market concentration does not explain profits (cf. Demsetz (1973)).

Tests aimed at setting off both hypotheses against each other tend to suffer from identification problems, since the same market structure variable behaves similarly for both cases. In these tests, market share proxies both for market power – as does the market structure variable – and for efficiency. The market structure variable is an aggregate measure that only changes over time. The market share variable, however, differs from bank to bank as well as over time. In an attempt to overcome this problem Berger and Hannan (1993) and Altunbas et al. (2001) use both market share and efficiency as explanatory variables for bank profit. In these studies, however, a multicollinearity problem exists if the Efficiency hypothesis holds.

Another solution is to include the market share that is *not* explained by efficiency, using firm-specific efficiency measures.³⁵ To do so, $MS_{i,t}$ is regressed on an efficiency measure. Cost X-efficiency [CE] measures how close a bank's costs, conditional upon its output, input prices and equity level, are to the costs a fully efficient bank incurs under the same conditions

³⁴ See also Bos (2004), on which this section is based.

³⁵ This modification is explained for the Cournot model and therefore in loglinear form. However, it can just as well be applied (without taking logarithms) to the traditional SCP model.

(e.g. size). As such, it is considered here to be the best efficiency measure to use in this two step approach:³⁶

$$MS_i = f(CE_i)\omega \quad (22)$$

where ω is the error term. Now, we can estimate equation 17, but replace MS_i by $MS(CE)_i$ – the residuals of the above equation. This efficiency measure $MS(CE)_i$ is by definition orthogonal on CE_i . If we now ignore λ_i and again keep η_D constant, the Cournot equation reads:³⁷

$$\Pi_i^* = f\left(MS(CE)_i CE_i \right) p_i^* Y_i \phi \quad (23)$$

where ϕ is the error term. This way, we can test both the SCP hypothesis and the Efficiency hypothesis without any identification problems. Of course, both hypotheses are not mutually exclusive. We can compare them by comparing the results of estimating equation 17 with those of estimating equation 23. If the market power hypothesis holds, $\frac{\partial \Pi_i^*(Y_i, w_i, Z_i)}{\partial MS_i}$ is significant and positive under both specifications. On the other hand, if $\frac{\partial \Pi_i^*(Y_i, w_i, Z_i)}{\partial CE_i}$ is positive and significant when estimating equation 23, this is evidence in favor of the Efficiency hypothesis.

As a final remark, note that our improvement of the Efficiency hypothesis comes at a cost: in equation 23, ϕ is a function of ε and ω . Since we use a proxy instead of MS_i in this two-step estimation, our standard errors may suffer from the generated regressor problem, and the accuracy of our estimates as well as the significance of our parameters may be over-estimated.

3.4. Synthesis

In section 3.1, we have established that banks maximize profits according to equation 1. Subsequently we looked at different models in the literature that have tried to explain bank profits, either through market power or through efficiency, and saw how they fitted into this basic framework. In table 1 we summarize the results from our tour of profit models.³⁸

³⁶ Profit X-efficiency would not really solve this problem, since – to the extent that a bank with market power can maximize profits without minimizing costs – it basically captures the same effect as MS .

³⁷ The same can of course be done with equation 17.

³⁸ The null hypothesis is based on the premise that profits increase: i.e. market power exists or efficiency goes up.

Table 1. Synthesis of Models

Model	Hypotheses	Key assumptions	Key variable(s)
[1] Iwata	$\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial \lambda_i} > 0$	η_D is constant, MS_i is ignored	λ_i
[2] Bresnahan	$\frac{\partial \Pi^*(Y, w)}{\partial \lambda} > 0$	η_D is constant, MS_i is ignored, $\lambda_i = \lambda, \forall i$	λ
[3] Panzar-Rosse	$\left(\left(\frac{\partial p^* Y}{\partial w_k} \right) \left(\frac{w_k}{p^* Y} \right) \right) > 0$	$\eta_D > -1$, MS_i and λ_i are ignored	$H(p, Y, w)$
[4] SCP	$\frac{\partial \Pi^*(Y, w)}{\partial (HHI)} > 0$	η_D is constant, λ is an implicit function of HHI	HHI
[5] Cournot	$\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)} > 0$	η_D is constant, λ_i is an implicit function of MS_i	MS_i
[6] Profit X-eff.	$\left(1 - \frac{\Pi_i^*(Y_i, w_i) * \exp(v_i)}{\Pi_i^*(Y_i, w_i)} \right) > 0$	η_D is constant, λ_i and MS_i are implicit functions of p	$\varepsilon_i = v_i - v_i$
[7] Scale economies	$\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial Y_{i,k}} > 0$	η_D, λ and MS_i are ignored	Y_i
[8] Scope economies	$\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial Y_{i,k} \partial Y_{i,l}} > 0$ for $k \neq l$	η_D, λ and MS_i are ignored	$Y_{i,k}, Y_{i,l}$
[9] Efficiency hypothesis	$\frac{\partial \Pi_i^*(Y_i, w_i, Z_i)}{\partial CE_i} > 0$	η_D is constant, λ_i and MS_i are implicit functions of $p, \phi = \varepsilon + (\beta_1 * \omega)$	$(MS(CE))_i$

To be sure, we have made an attempt at rewriting two classes of models so that they can be compared to our baseline model introduced in section 3.1. Our own main assumption in doing so is that all models discussed here share the same features that our baseline model has. Our basic framework is a profit maximization model, and we abstract from product differentiation. There is the possibility of price competition and market power in outputs. However, input markets are perfectly competitive and all banks act as price takers in these markets.

In addition, we have tried to stay away from defining any functional forms or empirical specifications. We return to this issue in section 5, where we discuss empirical evidence. For now it is important to keep in mind that:

Proposition 1 The models described here are not nested.

In fact, models [2] and [4] are aggregate models, whereas models [1], [3] and [5]–[9] (can) provide bank-specific estimates of market power respectively

efficiency. In practice, however, models [4] and [9] are also estimated on an aggregate level, with a single coefficient for all banks in a market. In fact, all models focus on one or two variables. This is why, in empirical applications we seldom find the complete specification as it was derived here. More in general, these models may – in the way they are presented here – suffer from identification problems, as they can perhaps also be derived using somewhat different assumptions and a different underlying basic model.

Proposition 2 The price elasticity of demand η_D is assumed to be constant.

The first reason for this particular feature of the models presented here is of course the fact that they all build on pure price competition. There is no product differentiation, and all banks in a market are assumed to face the same market demand.

The second reason is the fact that almost all models included here share an inherent cross-sectional nature. A prime example is model [5] (the Cournot model) which builds on the model that Cowling (1976) and Cowling and Waterson (1976) used for inter-industry comparisons. An exception is perhaps model [2] (the Bresnahan model) as that usually is applied to one country.

Proposition 3 Although price competition is assumed, output prices are absent from almost all models.

Output prices are notoriously difficult to measure in banking. As a result, almost all models presented here have found ways to argue around explicitly using prices. One obvious exception is the Bresnahan model (model [2]), which does include prices, but only for one output (loans or deposits). Also, the Panzar-Rosse framework (model [3]) includes revenues. This limitation has one very important drawback, that holds particularly for the market power models ([1], [4] and [5]): it severely restricts interpretations of tests of the null hypotheses with respect to the existence of market power to limiting cases. Only perfect competition and a perfectly collusive oligopoly result in values for the null hypothesis that are easy to interpret.³⁹ Any oligopolistic behavior that is less than perfectly collusive will at most result in the impossibility to reject the hypothesis that there is market power, without any *measurement* of market power.

The intuition is clear: uniform price setting only occurs in both extreme cases. In between, we need – in the absence of good output prices – a known

³⁹ The same holds for a monopoly (cf. the appendix).

relationship between the key variable in the model and the output price vector p in order to be able to interpret the market power tests more accurately. As an example, consider model [5], where interpretation of $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)}$ is straightforward only in two extreme cases: the Cournot oligopoly prediction is $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)} = 1$, since $\lambda_i = 0$ and impact of MS_i is exactly proportional. And in case of perfect competition an increase in market share has no impact on performance and since $\lambda_i = -1$, this means that $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)} = 0$. However, if any type of collusive behavior exists, $\lambda_i > 0$ and the impact of market share is more than proportional, the prediction is that $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)} > 1$. We can then only rank predictions for $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)}$ for one market over time. But we cannot (i) compare scores across markets, or (ii) compare the magnitudes of different predictions of $\frac{\partial \Pi_i^*(Y_i, w_i)}{\partial (MS_i)}$.

4. Trends

This section surveys general trends in the banking industry, particularly those relating to competition and profitability, keeping in mind the assumptions underlying the various approaches for measuring competition and efficiency. This assessment of current banking market conditions enables us to evaluate which approaches have become obsolete and which are most appropriate today.

In observing trends, we distinguish original causes, subsequent changes in banking behavior and in the structure of financial markets, and final consequences, aware all the while, that this classification may be somewhat arbitrary.⁴⁰

Table 2. Classification of trends in original causes and consequence

Causes
<ul style="list-style-type: none"> • IT developments (change in production technology and distribution channels, quick exchange of information, new products) • Changes in (legal) environment of banks and other financial institutions (liberalization/deregulation, economic and financial integration within the EU, introduction of the euro, new regulatory, tax and accounting regimes)
Subsequent changes in banking behavior and the structure of financial markets
<ul style="list-style-type: none"> • Internationalization • Disintermediation (lower market shares for savings and lending, increase of other types of banking activities) • More (foreign) competition • Blurring of borders (both geographically and between sectors) • Concentration (mergers and acquisitions) • Higher contestability
Final consequences
<ul style="list-style-type: none"> • Lower profit margins • Higher efficiency • Cost reductions

⁴⁰ For all trends described here, empirical evidence in the form of figures over the last decade is provided by Bikker and Wesseling (2003). See also Danthine et al. (1999) and European Central Bank (2002).

4.1. Causes

4.1.1. Developments in information and financial technologies

Advances in information technologies, in particular regarding the personal computer, software, databases and communication, have transformed banking practices and products. Information technology has contributed to the internationalization of the money and capital markets, to the development of new risk management techniques and to the arrival of a spate of new complex financial products. Furthermore, the Internet has created a world of new challenges and threats in banking services and sales potential. Transaction costs are substantially lower using new distribution channels such as the Internet, encouraging banks to develop these channels further. Many banks are cautious about these developments and are opting for a multi-channel distribution strategy, combining the traditional ‘bricks-and-mortar’ branch network with remote distribution channels, such as telephone banking and internet banking. The Internet has made established markets more vulnerable to new entrants.

4.1.2. Liberalization and harmonization

Liberalization and harmonization in the European Union (EU), culminating in the Second Banking Co-ordination Directive as part of the single European market project in 1992⁴¹ and the establishment of Economic and Monetary Union (EMU) in 1999, have dramatically changed the financial environment in Europe over the past decade and are expected to bring further changes in the near future.⁴² Likewise, the Riegle-Neal Act of 1994 and the gradual repeal of the 1933 Glass-Steagall Act have drastically transformed the banking landscape in the US. The creation of large and transparent euro capital markets further enhanced competition in the European banking industry and stimulated disintermediation and securitization. The

⁴¹ This directive boosted the deregulation and liberalization of international capital flows. Other policy initiatives were lifting of restrictions on interest payments on deposits and the development of a harmonized framework for supervision of the European banks. In the beginning of 1993, all formal restrictions regarding the provision of financial services across the European Union were removed. Banks which are licensed anywhere in the Union are given a ‘single banking licence’, which allows them to service the entire European market, either by setting up branches in other countries or by offering products across national borders.

⁴² European Commission (1997) gives a detailed evaluation of the impact of the single market programme on the performance and strategic reaction of the banking sector in European countries. See also Molyneux and Gardner (1997), Vander Vennet (1997), Danthine et al. (1999) and Bos (2002). For a detailed description of the economic integration in the EU, see Vanthoor (2002).

comparative advantages of domestic banks on national markets for bonds and equity in the field of underwriting and trading activities have diminished since the euro has replaced national currencies. For similar reasons, fund management is no longer the preserve of local financial institutions. These contributions to international integration, together with national deregulation and entry of new types of competitors, have boosted competition between banks in the countries involved and will continue to do so in the years to come. These developments contribute to further consolidation and rationalization in the European banking sectors.⁴³ Moreover, EMU will also further increase the pressure for ongoing harmonization of regulation across EU countries, cutting down remaining obstacles to cross-border competition. The Financial Service Action Plan of the EU (to be implemented in 2005) seeks to finalize the integration of the EU financial markets. The new 2004 Basel Accord on capital requirements forms a new regulatory regime for banks to enter into force by end 2006, and is another new development which may affect competition, consolidation and efficiency in the banking industry, though such effects are extremely difficult to predict.

4.2. Trends

4.2.1. Internationalization

The steady development towards integrated European financial markets has made the banking sector more international. Banks are increasingly involved in offering financial services to foreign businesses and individuals. Although internationalization has been a long-term trend, it has been fostered by the introduction of the euro, for example the merging of the infrastructures for large-value payments and interbank markets, as well as the increasing integration of capital markets. The most visible response has been consolidation either through mergers and acquisitions or through cross-shareholdings. Other ways to internationalize are the development of foreign banking through direct provision of financial services and through foreign branches. Persistent significant differences in national legal and regulatory environments continue to hinder cross-border mergers. Cultural factors and differences in the framework for corporate governance also tend to discourage cross-border consolidation.

⁴³ European Commission (1997) discusses the increase of competition. Improved efficiency has been observed by Groeneveld (1999), Altunbas et al. (2001), Maudos et al. (1999, 2001, 2002). This is also confirmed in later sections.

4.2.2. Disintermediation

Non-financial sectors in the euro area increasingly direct their savings and surplus funds away from banks towards new forms of financial intermediation, such as investment funds, insurance corporations and pension funds, as well as towards the capital markets, to invest in shares or debt instruments (as is quite common in the US). Non-financial enterprises increasingly access the capital markets for their financing and, although still on a limited scale, increasingly use debt securities. Underlying causes are the development of capital markets and increased possibilities for asset diversification (thanks to liberalization and new information technologies), the introduction of the euro, changes in tax regulations and an increased demand among investors for high-yield, though riskier, instruments. While the importance of traditional banking activities (collecting deposits and extending loans on a retail basis) has diminished in relative terms, banks still remain the predominant players in the euro area financial system. Because the euro area economy is dominated by small and medium-sized enterprises (ECB, 2002), traditional bank loans, trade credits and non-listed shares, as well as other equity, tend to be the primary sources of financing rather than market-based financing, such as publicly listed shares and corporate debt issuance. Moreover, despite a gradual shift towards more transaction or deal-based banking, the relationship between banks and their corporate customers continues to be very important in all EU countries. Disintermediation is a relative phenomenon as bank loans, expressed as a percentage of gross domestic product (GDP), are still increasing substantially in most countries and regions and also in the EU as a whole.

As a consequence of disintermediation, banks have shifted their activities from traditional bank lending towards investment banking style activities such as enhancing financial market intermediation by creating and selling new capital market products or advising clients on the pricing and structuring of a merger or acquisition. This is in turn reflected by a shift in bank revenue flows away from interest income alone towards non-interest income such as fees, commissions and trading profits.

4.2.3. Concentration

Intensified competition on the financial markets, on which banks operate, has further encouraged consolidation, for example through mergers and acquisitions. A clear majority of M&A transactions has occurred between banks, but financial conglomerates involving banks, insurance companies and

securities firms have also been created. Domestic mergers continue to dominate international mergers. The relatively modest volume of international mergers could indicate that domestic banking mergers are apparently more advantageous than international mergers. Individual European economies are rather heterogeneous, implying that purely domestic banking mergers offer ample opportunities for asset risk diversification. Domestic mergers will therefore be preferred to international mergers, with their concomitant cultural and language problems, differences in national regulations on, for instance, deposit insurance systems, taxation differences and country-specific restrictions on banking activities. This will discourage cross-border consolidation.

Concentration indices show increased concentration in almost all EU countries, confirming the ongoing process of further consolidation in Europe, in particular in the larger countries where consolidation was lagging behind. While the level of concentration for the EU as a whole, though rising, is still substantially lower than in the US, reflecting the limited level of cross-border consolidation in Europe, the pace at which concentration is progressing is also higher in the US than in Europe.

4.2.4. Contestability

Banking contestability is a major condition for sound competition, particularly where the number of banks is declining due to consolidation. Various developments have contributed to an increase in contestability. The EU's single passport policy allows banks with a banking permit in one EU country to operate in all EU countries. Low-cost distribution channels such as the Internet enable banks to expand their activities across countries at limited expense. Not only have geographical borders become blurred, the borders between sectors tend to fade away. Other financial institutions, such as insurance firms, pension funds and investment funds, have moved into the mortgage and general lending markets, and various financial institutions can manage private sector savings and investments. On the other hand, new foreign entries may in price be deterred by differences in legal, tax and regulatory regimes and in language, preferences and so on. Moreover, the Internet may prove not to be the right medium for many banking activities where face to face contact is important and for the many clients who rely on more traditional distribution channels. Finally, neither foreign banks nor the Internet have solved the problem of information asymmetry in lending to small and medium-sized enterprises.

4.3. Consequences

The Internet and EU liberalization and harmonization have contributed enormously to enhancing competition among banks, particularly competition across borders. Increased competition has also forced banks to improve their efficiency, in order to avoid being pushed out of the market. On the other hand, increased concentration and the enlarged market shares of major banks may have impaired competition somewhat. As competition cannot be measured directly (in the absence of clear prices of banking output), we have to observe this trend of increased competition and efficiency indirectly. We discuss a few proxies of competition and efficiency here, while the measurement of competition and efficiency and empirical results are treated elsewhere.

The net interest rate margin is an interesting measure of bank profitability, which allows comparison over time and across countries. It also reflects competitive conditions or efficiency on the banking markets, assuming that competition enforces efficiency and presses the margin down. Margins in most countries fell during the last decade, indicating growing competition, although the gradual decline in interest rates may also have contributed to lower margins.

Operating expenses expressed as a percentage of gross income is also often used as a proxy of competitive conditions, although its interpretation is somewhat ambiguous (as will be explained in section 5). This ratio tends to fall over time, indicating lower costs compared to income. Given the falling interest rate margins, this is remarkable, and points to cost reduction. Indeed, the staff-costs ratio also declines over time, reflecting rationalization of bank production. Evidently, what we observe here are the efficiency effects of increased competitive pressure. Increased attention to share holder value may have contributed to this trend too.

On average across Europe, returns on assets and returns on equity – as measures of profitability – remained roughly constant during the last decade. This is remarkable, given the observed decline in net interest rate margins, and reflects cost reduction and the increasing non-interest income from non-traditional banking activities, such as asset management, the management of stock and bond issues and trading. Returns diverged strongly across countries, reflecting varying levels of profitability and of economic and institutional conditions.

4.4. Synthesis

We have seen that the banking landscape has changed considerably in the last decade. First, significant changes have occurred on the demand side. It has become easier for customers to shop across borders, just like it has been easier for banks to compete across borders. In addition, competition from non-bank financial firms (insurance companies, brokerage firms, etc.) continues to have an impact on demand, both observed and potential. As a result, the assumption that the price elasticity of demand faced by all firms is the same and constant over time seems more and more questionable. All models included here have problems adjusting to this new reality.

Second, banks themselves have reacted to changes in regulation and (production) technology. They have branched out into new products and become less and less like the traditional intermediaries we model them after. What we do not know is how this process has affected bank *behavior*. Reaction curves may have shifted considerably, both on a market level (λ) and for individual banks (λ_i). In what direction is uncertain and probably depends on the individual bank. While competition may have increased on an international level, some banks may occupy dominant positions within national borders that allow them to react differently from their smaller competitors. Some of the models we reviewed are theoretically able to cope with these changes. However, as we will see in section 5, empirical applications of these models have traditionally assumed that all banks react similarly to each other.

Table 3. Effects of trends on approaches

Trend	Variable(s) affected	Models most affected	Explanation
[a] Internationalization	$\eta_D \uparrow, \lambda, \lambda$	[1],[2],[4],[5] and [6]	All market power models affected. Bos and Kolari (2005) show that profit X-eff [6] goes up with internationalization.
[b] Disintermediation	Y	[2], [7], [8]	Model [2] focusses exclusively on the loans/deposits market and thus becomes less relevant. Scale and scope economies have altered.
[c] Foreign competition	$MS_i \downarrow, HHI \downarrow, \lambda \uparrow$	[4], [5]	Models [4] and [5] both assume an implicit, stable relationship between λ and MS_i (resp. HHI)
[d] Contestability	$\lambda \uparrow, \lambda_i \uparrow$	all	Estimates of market power are affected, but contestability itself is not identified, since prices are not available.
[e] Concentration	$MS_i, HHI \uparrow, \lambda, \lambda_i$	[2][4]	Unlike their “rival” models [1] and [5], models [2] and [4] assume that all banks in a market react similarly on increase in concentration.

[1] = Iwata; [2] = Bresnahan; [3] = Panzar-Rosse; [4] = SCP; [5] = Cournot; [6] = Profit X-eff.; [7] = Scale economies; [8] = Scope economies; [9] = Eff. hypothesis

Third, the markets banks operate in have themselves also changed. Concentration has gone up in all countries and markets. This holds particularly for retail markets, which are still predominantly national. This has mostly plagued reduced form market structure models, such as the Cournot model and the SCP model. In principle, we expect a decrease in competition as a result of this increase in concentration. Other trends, however, have opposite effects. For example, foreign banks have started to join the ranks of banks’ traditional competitors. As a result, it is uncertain what the effect of the increase in concentration has been on *individual* banks.

With respect to the individual trends we have identified here, we find that disintermediation undermines the Panzar-Rosse approach as the Panzar-Rosse model is based entirely on banks’ traditional role as financial intermediary (attracting deposits and other funds and transforming them into loans and investments in securities). Other income from bank services and

trading can be incorporated into the P-R model in various ways, so that the model continues to be useful, but less so because the model structure reflects reality less accurately. Iwata and Bresnahan do not have this drawback for disintermediation.

Internationalization, foreign competition, contestability and concentration do not generate problems for the Iwata, Bresnahan and Panzar-Rosse approaches. The mark-up set on cost-based prices (conjectural variation, estimated by λ) and the interest rate revenue elasticities of input prices (constituting H) are direct measures of competition. Observations of new (or potential) entries, foreign competitors or competitors from other sectors are not needed, as their effects on competition are already reflected in the estimated measures. Of all the models that study a specific market, the reduced-form market structure models – the SCP model in particular – are most strongly affected by these trends, as the market structure measure has become less and less easy to define.

Most approaches measure the competitive position (or efficiency) of a bank as a whole, ignoring the fact that banks produce various products and operate on various markets. Competitive positions may differ per product or market. An exception is the Bresnahan model which considers the competitive position of one product (e.g. loans, deposits) and hence measures competition on a single submarket. Approaches based on observations of individual banks (Iwata, Panzar-Rosse, X-efficiency) can circumvent this problem somewhat, as they distinguish various bank-size classes, operating on different markets, e.g. small banks on local or retail markets and large banks on international or wholesale markets (Bikker and Haaf, 2002).

Gradual effects on competition of these (and other) trends over time can be incorporated by using time (or trend) dependent coefficients (Bikker and Haaf, 2002). An alternative would be to split the sample into periods or separate years. This works out well for the Panzar-Rosse and Iwata models, where many observations provide enough information to estimate time dependent coefficients, but not for the Bresnahan approach, where observations are scarce owing to its aggregated level. The Bresnahan approach is based on time series of country-specific data. Due in particular to structural changes in banking markets over time, and also to reduced reliability of the required data (among them, interest rates for credit loans and deposits), the estimation of λ appears to be fairly ponderous. Empirical estimations are rare and results are generally far from robust. The Iwata model could provide a solution, but it is applied only once because of problems with the required data, especially

given the lack of micro-data for the structure of cost and production for homogeneous products offered by a large number of players in the European banking markets.

The major problem presented by the efficiency models discussed here is the fact that their outcomes are very difficult to validate. We have no sound theory that tells us what is the correct distribution of the efficiency term, and we know very little about the economic validity of our efficiency scores. In particular, and related to increasing internationalization, contestability and foreign competition, it is hazardous to transpose best-practice in one country/market to another country/market.

To conclude, it would seem that these trends have similar consequences for most banks. Increases in competition result in lower profit margins, higher cost efficiency and lower profit efficiency. In absolute levels, we also expect cost reductions. The dynamics of the consolidation process, however, may have increased the volatility of earnings.

5. Empirical Evidence

This section presents the empirical applications of two of the models reviewed in section 3 (the Panzar-Rosse model of market power and the X-efficiency model of managerial ability) in light of the trends described in section 4. Moreover, it surveys a number of well-known simple proxies of competition and efficiency, both across countries and over time, and compares them with the model-based estimates.

5.1. Bank's Market Power: the Panzar-Rosse Model

The Panzar-Rosse model provides a method for measuring market power, in which a bank's interest income depends in part on input prices (Bikker and Groeneveld, 2000; Bikker and Haaf, 2002). This dependency is described by the H parameter, representing the sum of all input price elasticities, which permits various types of market structure to be distinguished. The first of these is perfect competition ($H = 0$), a market type in which interest income moves up and down in proportion to input prices. Perfect competition will prevent excessive profits, so that banks must on-charge any rise in input prices in order to prevent losses, while they must match any fall in input prices by a decrease in output prices, because competitors will do likewise. The second market type is monopoly or perfect collusion, in which the bank or the cartel chooses prices that yield maximum profits. Under perfect collusion, the relation between output and input processes is absent or negative (so that $H \leq 0$): any input price rise will eat into the monopoly's profits and vice versa. The third market type, monopolist competition, is found especially frequently in the financial sector. Competition may be eased to some extent as products and services differ from those of other banks, at least in (minor) details. Under monopolist competition, or oligopoly, there is some correlation between input and output prices, but it is less than proportional ($0 < H < 1$). Thus H , in this model, is a measure of competition.

Table 4 presents estimates of H for a number of European and non-European countries based on three input prices: funding rate, personnel expenses and other expenses.⁴⁴ It also shows the average of H for 23 OECD countries. The

⁴⁴ Empirical results in this article are based on balance sheet data and profit and loss accounts taken from Bankscope (Fitch-IBCA), unless otherwise indicated. Wherever possible, figures have been adjusted for national differences in accounting rules and possible (input) errors. Our own calculations show that more recent estimates yield very similar results. Apparently, changes over time are limited.

first column provides estimates for all banks. Notably, of the 23 national banking markets taken as a whole, none is a pure monopoly or cartel, nor is any one of them characterized by perfect competition. Apparently, all national banking markets considered are characterized by either oligopoly or monopolist competition. This result tallies with those of the SCP analysis, which in most cases also point to a degree of market power (Bos, 2004). Competition turns out to be more pronounced in Europe (0.73) than elsewhere (0.64). Notably, Germany and the Anglo-Saxon countries appear to be lagging behind in this respect. Germany and the US have banking markets that are less consolidated, with large numbers of small banks targeting local markets where they meet limited competition. This is reflected by low average competition estimates: 0.63 and 0.56, respectively.

Table 4. Estimates of H for different bank sizes

	All banks	Small	Medium	Large
Austria	0.87	0.93	0.89	0.91
Belgium	0.89	0.95	0.88	0.88
Denmark	0.36	0.34	0.75	1.16
Finland	0.78	0.67	0.76	0.70
France	0.70	0.59	0.79	0.89
Germany	0.63	0.59	0.70	1.03
Greece	0.76	0.41	0.66	0.94
Ireland	0.65	0.99	0.63	0.93
Italy	0.82	0.75	0.86	0.81
Luxembourg	0.93	0.94	0.95	0.91
Netherlands	0.75	0.74	0.87	0.95
Norway	0.77	0.80	0.75	0.71
Portugal	0.83	0.84	0.84	0.91
Spain	0.62	0.64	0.59	0.66
Sweden	0.80	0.84	0.76	0.95
Switzerland	0.58	0.54	0.92	1.01
United Kingdom	0.64	0.41	0.85	1.20
Australia	0.57	<i>-0.14</i>	0.70	0.68
Canada	0.62	0.74	0.63	0.60
Japan	0.54	0.43	0.11	0.61
New Zealand	0.86	—	1.13	0.86
South Korea	0.68	—	0.72	0.77
US	0.56	0.62	0.54	0.72
Averages	0.70	0.65	0.75	0.86
Minimum	0.36	-0.14	0.11	0.60
Maximum	0.93	0.99	1.13	1.20
Average European	0.73	0.70	0.79	0.91
Avg. non-European	0.64	0.41	0.64	0.71

Source: Bikker and Haaf (2002). Explanation: italics indicate monopoly or perfect cartel, boldface indicates perfect competition. Data relates to 1997.

The banking market breaks down into several partial markets, distinguished by customer (private consumers; small and medium-sized businesses; large, international concerns), by product (savings; mortgage loans; business credit; capital market services), and by service area (local; national; international). Table 1 takes a first step towards segmentation of the banking market by size, distinguishing small banks, operating mostly locally and targeting the retail market; large banks operating internationally and mostly targeting large companies; and medium-sized banks taking up an intermediate position (columns 2–4). Obviously, this distinction provides only an approximative understanding of competitive conditions in the submarkets.

As expected, small banks generally face milder than average competition: apparently, the retail segment of local markets is competed for less energetically (with H values averaging 0.65). In only seven countries is perfect competition probable (boldface in table 4). Only for Australia, do the results for small banks point to monopoly or perfect cartel (italics in table 4). Large banks operate in a markedly more competitive environment, in which counterparties are more powerful and foreign banks participate as well (with H values averaging 0.86). In this sector, the results for many more countries point to perfect competition. Values of H greater than 1 – as found for large banks in Denmark and the UK – are an indication that banks co-operate and apply strategic pricing methods, taking into account the manner in which they expect competitors to respond to their prices. Medium-sized banks again take up an intermediate position.

5.2. *Efficiency and market power*

In an attempt to acquire a firmer grip on measuring banks' performance, researchers have increasingly sought to analyse, in addition to banks' *actual* performance (profit), their *potential* performance. Standard microeconomic theory states that in a market characterised by perfect competition, no bank will be able to make excessive profits. On a more general level, a bank – in the absence of other causes of market power – can only achieve above average profit efficiency if its cost efficiency is above average as well. An important underlying idea here is that under conditions of perfect competition (ideal for consumers) banks will be forced to minimize their cost levels as much as they can so as not to be pushed out of the market. Where there is market power, banks may succeed in making higher profits without having to cut down on costs. In such conditions, excess profits are realised through price increases. The extent to which profits may be raised this way depends

on competitors' response, but also on the response of the consumer. Hence the performance of banks in a certain market segment is explained partly by internal factors such as proper management, but partly also by market conditions. Because internal and external factors influence each other, it is difficult to distinguish managerial competence from market conditions.

A bank with a degree of market power ceases to be a price taker and may increase its profits by raising its prices (higher profit efficiency) without having to lower its costs (unchanged cost efficiency). Such market power may have been created by the existence of a monopoly, through co-operation (oligopoly), by economies of scale, allowing large banks to produce more than smaller banks under similar cost conditions, or as a result of product diversification.

A banking market may therefore be characterized by measuring the performances of the banks in that market. Performance, here meaning the *relative* ability of a bank to minimize costs or maximize profits, is measured by comparing the costs or profits of a bank to those of the best performing bank of the same size (eliminating scale effects), taking into account any differences in input prices and product range. These differences in performance are expressed in terms of 'X-efficiency' and may be attributed to the quality of banks' management.

For the estimation of the cost and profit frontier functions, a translog functional form is commonly used. This form allows for the necessary flexibility when estimating frontier models. Berger and Mester (1997) have compared the translog to the Fourier Flexible Form (FFF). Despite the latter's added flexibility, the difference in results between these methods appears to be negligible (see also Swank (1996)). Moreover, previously cited bank efficiency studies have shown that the translog cost and profit functions are locally stable in large bank applications.

Usually, profit is taken before tax (PBT), Y stands for outputs, and W stands for input prices.⁴⁵ Also, the control variable equity (Z) reflects differences in

⁴⁵ With respect to notation, we use lower case symbols in italics to denote logarithms. Upper case symbols represent actual values of the variables. Note that although the translog (and comparable functional forms) has many advantages, for profit functions it has a considerable drawback: it cannot handle banks with negative profit very well. In the literature, either these observations are deleted, or – before taking logs – the minimum profit (i.e. the maximum loss in the sample) plus one is added to each bank's profits. Whereas the former solution results in sample bias, the latter results in a nonneutral transformation. In Bos et al. (2004), alternative

risk-taking behavior. In the typical specification below, the optimal profit level for bank k in period t is now a function of the number of outputs, input prices, and the control variable Z . In a three-input, three-output translog setting, u and v are the inefficiency and random error terms, respectively, and $a_j, a_{jk}, b_j, b_{jk}, c_j, d_j, d_{jk}, e_j, f_j, g_j,$ and h_j are parameters:

$$\begin{aligned}
 pbt_i(y, w, z) = & a_0 + \sum_{j=1}^3 a_j w_j + \frac{1}{2} \sum_{j=1}^3 \sum_{k=1}^3 a_{jk} w_{ij} w_{ik} + \sum_{j=1}^3 b_j y_{ij} \\
 & + \frac{1}{2} \sum_{j=1}^3 \sum_{k=1}^3 b_{jk} y_{ij} y_{ik} + c_0 z_i + \frac{1}{2} c_1 z_i^2 + \sum_{j=1}^3 \sum_{k=1}^3 d_{jk} w_{ij} y_{ik} + \sum_{j=1}^3 e_j w_{ij} z_i \\
 & + \sum_{j=1}^3 f_j y_{ij} z_i + g_0 T + \frac{1}{2} g_1 T^2 + \sum_{j=1}^3 d_j w_{ij} T + \sum_{j=1}^3 h_j y_{ij} T + c_2 z_i T + v_i - u_i
 \end{aligned} \quad (24)$$

Duality requires the imposition of symmetry and linear homogeneity in input prices to estimate our cost and profit models (see Beattie and Taylor (1985) and Lang and Welzel (1999)):

$$a_{jk} = a_{kj} \forall_{j,k}, \quad b_{jk} = b_{kj} \forall_{j,k}, \quad \sum_{j=1}^3 a_j = 1, \quad \sum_{j=1}^3 a_{jk} = 0 \forall_j, \quad \sum_{j=1}^3 b_{jk} = 0 \forall_j, \quad \sum_{j=1}^3 d_{jk} = 0 \forall_j, \quad \sum_{j=1}^3 e_j = 0, \quad \sum_{j=1}^3 d_j = 0$$

Linear homogeneity in input prices should be imposed by normalizing the dependent variable and all input price variables (W) before taking logarithms (see Coelli, Prasado Rao, and Battese (1998)).⁴⁶

Bikker (2002) performed such a measurement exercise for banks in European countries, determining their cost efficiencies.⁴⁷ This study compared European banks to their best-practice banks – an exercise of crucial importance for cross-border comparisons. Many studies in this area have been single-country studies, comparing banks to their own national champion

transformation with less problems is suggested. Losses are modelled as a netput, and a negative profit variable is constructed. For banks that exhibit positive profits, this variable has a value of one. However, for banks exhibiting negative profits, the left-hand-side is substituted with this value of one and the absolute value of these negative profits is included in the negative profit variable on the right-hand side. Three different checks supported this approach: (i) banks with positive profits were on average more efficient; (ii) the coefficient for our negative profit variable was negative; (iii) there were extremely high correlations of the levels and ranks of efficiency of the banks with positive profits for the specifications with and without the negative profit variable.

⁴⁶ Each of these variables is included as a ratio to one of the input price variables, and the coefficient for each input price is inferred ex post from the imposed restriction. This procedure only ensures homogeneity of degree one in factor prices. Imposing constant returns to scale would require normalization of the output variables as well.

⁴⁷ Relatively little research has been done in the field of international comparisons. Exceptions are Pastor et al. (1997), Altunbas et al. (2001), Bikker (2001) and Maudos et al. (1999, 2001 and 2002).

performers only. As these national champions lag farther and farther behind the European champions, however, the local (lagging) banking sector will continue to compare itself favourably with ever less justification. The present multi-country study lacks this problem.

Table 5 presents *efficiency* estimates for the EU countries plus Switzerland.⁴⁸ On average, cost efficiency turns out to be rather low at 70%, at least compared to studies on US banks, indicating an 80% average efficiency. Lower results were found by many other studies for European countries, although some of the different model specifications used in other studies have produced higher efficiency percentages. The results suggest that on average, banks in Europe are lagging far behind their best performing peers. Differences between countries also appear to be rather large. Banks in Germany, Luxembourg and Switzerland, with efficiencies averaging 70%, lead the European pack, while banks in Spain, Belgium and Greece trail behind with average efficiencies below 55%. Higher efficiency estimates for banks in Luxembourg and Switzerland are somewhat misleading, as they do not necessarily reflect better managerial performance but are produced by special circumstances including bank secrecy, zero tax rates for foreigners and stable local currencies, which make it easier to attract (foreign) investment at low cost.

The efficiency ranking of national markets does not always correspond to expectations. Germany, with its low level of banking market consolidation and high level of government interference, is often regarded as a less efficient banking market. Similar reasons, in combination with economic developments that lag behind in certain respects, have led to lower a priori estimates of efficiency with regard to France and Southern European countries, as well. In this respect, the ranking of Belgium in table 5 is lower than expected, while those of Italy and Portugal are higher than expected. The UK, too, turns out to be less competitive than some observers think. On further analysis, however, rankings turn out differently as more factors are taken into consideration, especially if the distribution of a country's banks across each banking category is taken into account. Then it becomes clear that on account of their simplified structures, savings and co-operative banks tend to be relatively inefficient. The effects of differences in managerial competence on cost differences turn out to be less strong. On the other hand, universal banks tend to be less efficient as a result of their more complex structures and concomitant management problems.

⁴⁸ Austria was left out for lack of sufficient data.

Table 5. Estimates of X-efficiency using the SCF model (1990–1997)

Countries	Obs.	Efficiency	Ranking #1	Ranking #2
Belgium	44	0.48	14	13
Denmark	57	0.54	13	12
Finland*	13	0.68	5	9
France	964	0.55	12	10
Germany	2 983	0.76	1	5
Greece	40	0.40	15	15
Ireland*	20	0.70	4	4
Italy	1 221	0.60	10	11
Luxembourg	177	0.72	2	1
Netherlands	164	0.62	8	3
Portugal	67	0.65	6	8
Spain	105	0.58	11	14
Sweden*	17	0.62	9	7
Switzerland	299	0.71	3	2
UK	187	0.65	6	6
Average		0.70		
R ²		0.97		

Asterisks refer to countries with a (too) limited number of observations. Ranking #1 is unweighted ranking. Ranking #2 is based on weighted average of category related rankings, see Bikker (2002).

The last column of table 5 presents averages of country rankings based on efficiency estimates per banking category, with e.g. savings banks being compared only to best-practice savings banks etc. This leads to a dramatic shift in position for Germany, where more than 90 per cent of the banks are of the co-operative and savings bank type: plain banking institutions, whose inefficiency is limited. This strong concentration of relatively efficient cooperative and savings banks in Germany results in a high average level of efficiency. However, within these categories – and among the other categories – German banks are not the most efficient ones. After adjustment for this category effect, German efficiency turns out to be just slightly above average (5th instead of 1st, see the last column of table 5). A similar bias appears to have crept in in the case of Italy and Spain where, respectively, 73 per cent and 64 per cent of banks are co-operative and savings banks. For the Dutch banks, 78 per cent of which are commercial banks, we see a landslide ranking shift in the opposite direction. Commercial banks have, on average, high inefficiencies but in relative terms the Dutch commercial banks are among the most efficient. After adjustment, Dutch banks rank 3rd instead of 8th.⁴⁹

⁴⁹ A caveat in interpreting these results is our implicit assumption that different types of banks operate in the same environment, have the same production sets and share a similar production technology (i.e. a single frontier)

5.3. Efficiency of large banks compared internationally

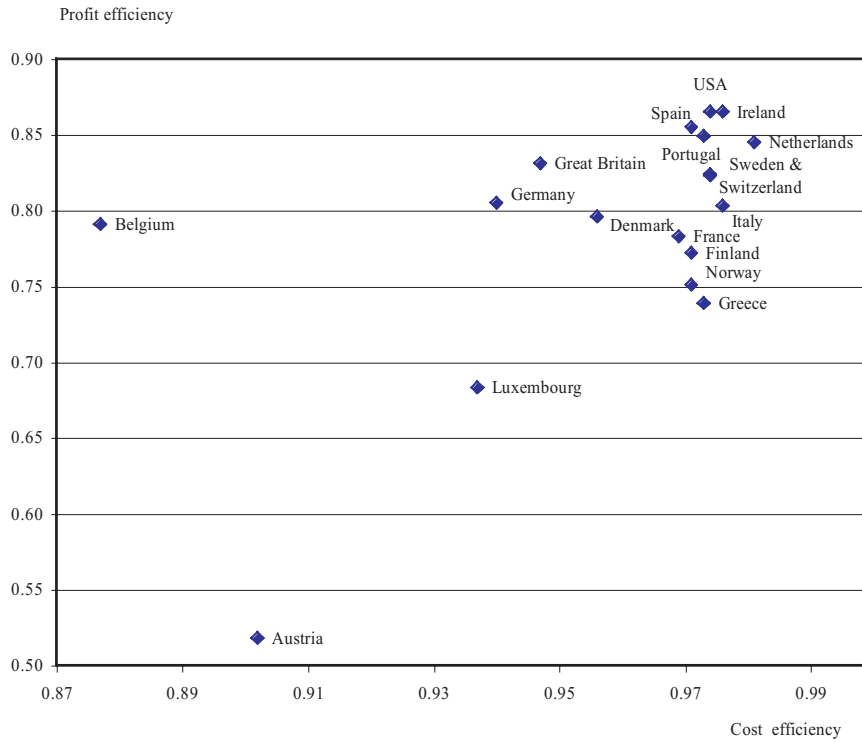
The interest of researchers has concentrated mostly on the largest banks, both because they are economic heavyweights and because international competition makes them easier to compare with one another. The present section therefore shifts its attention to an international comparison of large banks in Europe and the US. Also, profit efficiency is considered in addition to cost efficiency. A result often found is that differences in cost efficiency (measured in percentages) tend to be significantly smaller than differences in profit efficiency (Berger et al., 1993; Berger and Humphrey, 1997). Note, however, that a relatively small reduction in costs may take away a large share of profit inefficiency. The difference between cost and profit efficiency may also be explained in part by the fact that profit efficiency is determined to a much larger extent than cost efficiency by conditions of the market in which a bank operates, because the pricing levels a bank can afford to use have an immediate effect on profit maximisation. Also, profit is more volatile than costs, so that percentage differences between profit and profit efficiencies of banks are larger than in the case of costs. In sum, examining profit efficiency can result in additional evidence on the nature of the competition in a banking market.

Figure 1 shows average efficiencies of large banks with world-wide operations, by country and weighted for banks' total assets.⁵⁰ The absolute champions turn out to be banks in Ireland, the Netherlands and the USA, in terms of both cost and profit efficiency. The surprisingly low marks scored by Luxembourg and Austria may be less reliable, because the number of large banks in these countries is small. Profit efficiency, varying between 0.52 and 0.87, is much more widely spread than cost efficiency (0.88–0.98).⁵¹ The difference in spread is caused in large part by national differences in market conditions. To the extent that profit efficiency is determined by local market conditions, such as the existence of market power or institutional conditions, the same efficiency is unlikely to be 'exported' entirely when banks spread their wings across national borders. For this reason, a Dutch or Irish bank starting operations in Germany, Belgium or Austria (as through a takeover) will probably find it more difficult to attain the same profit levels abroad that it has been used to at home.

⁵⁰ Data on independent institutions over the 1995–99 period. Source of data on European banks: BankScope. Source of data on US banks: Federal Reserve Call Reports.

⁵¹ Cost efficiency is much higher here than it is in the estimates of section 5.2. This is because only large, international banks are considered, as appears also from the calculations underlying figure 1 in the next section. Also, a different model specification is used here.

Figure 1: Profit and cost efficiency of large banks (Bos and Kolari (2005))



A comparison of large banks' rankings in figure 1 with the rankings of all (or average) banks in table 5 confirms the relative efficiency of Dutch, Irish, Swiss and Swedish banks, while French, Danish and Belgian banks again come out as being less efficient. Notably, large banks in Italy, Spain and Greece, in their ability to keep pace with the most efficient large banks in Europe, stand out favourably among the other banks in those countries.

Of course, banks may be relatively X-efficient, but operate at a suboptimal size or with a suboptimal output-mix. Although Berger and Humphrey (1991) report that scale and scope economies are less important than X-efficiency, it may be worthwhile to investigate how the large European and US banks described above compare. As explained in section 3.3.2, output-specific economies of scale are calculated by taking the derivative of the profit (or cost) model with respect to a firm's output. Bos and Kolari (2005) also calculate scope economies for their sample of large European and US banks. On the cost side, overall scale economies for European and US banks are 1.127 and 1.042 respectively. Thus, for European banks, an increase of 1 USD

in total output results in an increase in total costs of almost 1.13 USD. These differences are significant, even though they only include large banks (over 1 bn USD). On the profit side, scale economies are 1.151 for European banks and 1.099 for US banks, again significantly different. Scope economies differ even more. Using the measure described in section 3.3.2, cost scope economies are -0.340 and -1.024 respectively for European and US banks. So, specialized banks face lower costs, both in Europe and the US (although scope economies for European banks are not significantly different from zero). On the profit side, the same picture emerges with scope economies of 0.367 and 0.950 respectively for European and US banks. Our conclusion is that in terms of scale and scope economies, although economically less important than X-efficiency, considerable differences continue to exist between banks in different markets, even if we only consider a relatively homogenous sample of large commercial banks.

5.4. National differences in market conditions

As noted above, it is useful, in comparing banks' efficiency internationally, to establish to what extent market conditions and regulatory environments differ from country to country. Together, these variables determine, for a given country, the maximum possible efficiency levels for banks of a given size, known technically as the efficiency frontier. Efficiency frontiers estimated for individual countries, on the basis of the best-performing banks, permit efficiency levels to be compared *within* each country but not, of course, *between* countries, because efficiency is measured as the distance vis-à-vis the best-performing banks, whose performances vary from country to country. However, a joint efficiency frontier estimated for a group of banks in several countries *does* permit international comparison of efficiency levels, although efficiency levels of individual banks' may be distorted through disregard of national or market-specific factors. As a result, banks in some countries may appear extremely inefficient, because they are compared to unrealistic optimum levels. To resolve this problem, one may employ an estimation technique by which a so-called meta frontier is construed on the basis of country-specific efficiency frontiers, i.e. the best-performing banks (see Bos and Schmiedel, 2003). The meta frontier technique takes account of country-specific characteristics, yet yields commensurable efficiency scores.⁵²

⁵² With a pooled frontier, banks in all countries are assumed to face a frontier with the same shape. The shapes of country-specific frontiers can differ, but efficiency scores cannot be

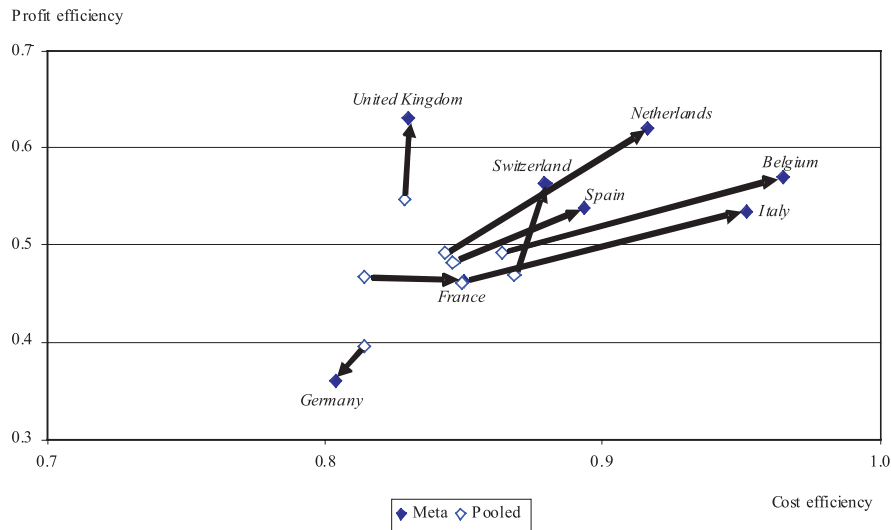
Figure 2: From a pooled frontier to a meta frontier

Figure 2, taken from Bos and Schmiedel (2003), also compares banks in several countries.⁵³ In contrast to figure 1, which only looks at large banks (including US banks), this figure represents all banks, illustrating how relative cost and profit efficiencies change if a meta frontier is estimated instead of the one-size-fits-all pooled model used in figure 1. The most notable change is the increase, for almost every country, of average cost and profit efficiencies, owing to the apparent divergence of national efficiency frontiers. The odd one out amid this pattern of increasing efficiencies is Germany, where both cost and profit efficiencies decline. This is all the more notable because both types of efficiency, but especially profit efficiency were already low to begin with. Indeed, the analysis shows that even the most efficient German banks are relatively inefficient compared to other European banks. These low efficiency levels also play a part, of course, in the recently rekindled debate on the efficiency of the German banking system. Another remarkable result is the particularly strong increase in both cost and profit efficiencies of banks in Belgium, Italy and the Netherlands. This result

compared between banks operating under different frontiers. With a meta-frontier, linear-programming is used to create an envelope (or umbrella) around country-specific frontiers. This way, the shape of these country-specific frontiers can differ, but – depending on how closely the meta-frontier envelops these frontiers – efficiency estimates from these country-specific frontiers can be compared.

⁵³ Asset-weighted averages for 1993–2000.

demonstrates that the national efficiency frontiers for banks in these countries are still considerably higher than for banks in other European countries. By consequence, the efficiency of banks in these countries is probably underestimated (more strongly than elsewhere) when compared to a pooled frontier instead of a meta frontier.

The shifts observed in figure 2 also explain the almost complete absence of cross-border bank mergers and takeovers within the EU. Apparently, successes realised domestically are difficult to repeat abroad. Another notable point is that successful cost management does not lead automatically to greater profit efficiency and, by consequence, to higher profits. Belgian banks, for instance, although they have the highest average cost efficiency, are relatively less efficient in turning this into profits than e.g. their Dutch or British competitors. It is unclear what causes these differences. Perhaps average managerial capabilities differ significantly from country to country; another possibility is that further integration is impeded by national differences in market and regulatory conditions.

5.5. Competition and efficiency in 2003

Table 6 provides figures for EU countries of a number of well-known and often used simple measures or proxies of competition and efficiency for 2003, namely return on equity (ROE), return on assets (ROA), the ratio of operating (non-interest-rate) expenses to gross income (or cost-income ratio), the interest rate margin ratio,⁵⁴ and an index of concentration, based on total assets.⁵⁵ Note that competition and efficiency are often seen as near synonyms, in the sense that strong competition leads to efficiency. These measures are also linked to profitability in the sense that high competition tends to reduce profitability, whereas high efficiency may improve profitability. For the sake of comparison, table 6 also gives a number of model-based estimates of competition and efficiency, based on data over, roughly, the last decade. These estimates are Panzar and Rosse's *H*-value of competition (Bikker and Haaf, 2002), a few measures based on cost

⁵⁴ Source: for 1993–2001, OECD (2000, 2002), Bank Profitability; Financial Statements of Banks, OECD, Paris. Figures for 2002 and 2003 are based on own calculations using Fitch/IBCA figures.

⁵⁵ Source for the EU: own calculations based on 'ECB working group on developments in banking, Review of structural developments in the EU banking sector year 2003', and earlier reports. Figures for the US and Japan are based on own calculations using Fitch/IBCA figures. Concentration measures based on deposits or lending behave similarly.

Table 6. Measures of competition and profitability in 2003

	ROE	ROA	C/I	IRM	CR5	Panzar-Rosse	X-Efficiency	X-rank	BR deposits	BR lending	Average rank
AT	9.67	(9) 0.48	(9) 67.72	(2) 1.07	(7) 44	(5) 0.87	(3)				5.8 (3)
BE	8.11	(7) 0.31	(4) 59.84	(7) 0.57	(2) 83	(14) 0.89	(2) 0.48	(13)		0.000064 (5)	7.6 (9)
DE	-1.63	(1) -0.06	(1) 67.94	(1) 0.76	(4) 22	(1) 0.63	(13) 0.76	(1)	4	0.000627 (7)	0 (1) 3.3 (1)
DK	17.14	(14) 1.03	(14) 45.62	(15) 1.66	(11) 67	(11) 0.36	(15) 0.54	(12)	11		12.9 (15)
ES	8.19	(8) 0.71	(12) 51.21	(13) 2.02	(14) 44	(5) 0.62	(14) 0.58	(10)	13	0.000504 (6)	0 (1) 11.1 (13)
FI	39.15	(15) 2.38	(15) 46.61	(14) 1.91	(12) 81	(13) 0.78	(7) 0.68	(4)	8		11.0 (12)
FR	6.19	(5) 0.35	(5) 61.00	(5) 0.71	(3) 47	(8) 0.70	(10) 0.55	(11)	9	0.000106 (4)	0.000002 (4) 7.0 (6)
GR	12.43	(13) 0.81	(13) 57.97	(8) 2.79	(15) 67	(11) 0.76	(8) 0.40	(14)	14		12.0 (14)
IE	9.84	(10) 0.45	(8) 53.18	(11) 0.81	(5) 44	(5) 0.65	(11) 0.70	(3)	3		7.0 (6)
IT	4.18	(4) 0.31	(3) 55.04	(10) 1.92	(13) 28	(2) 0.82	(5) 0.60	(9)	10	0.000314 (5)	0.000147 (6) 7.0 (6)
LU	7.84	(6) 0.23	(2) 52.94	(12) 0.40	(1) 32	(3) 0.93	(1) 0.72	(2)	1		3.5 (2)
NL	11.12	(12) 0.42	(7) 65.25	(4) 1.49	(10) 84	(15) 0.75	(9) 0.62	(7)	2	0.000023 (3)	0 (1) 8.3 (11)
PT	2.90	(3) 0.37	(6) 59.85	(6) 0.99	(6) 63	(10) 0.83	(4) 0.65	(5)	7	-0.00014 (1)	0.001128 (8) 5.9 (4)
SE	2.21	(2) 0.64	(11) 66.13	(3) 1.18	(8) 54	(9) 0.80	(6) 0.62	(7)	6	0.009889 (8)	0.000492 (7) 6.5 (5)
UK	11.11	(11) 0.54	(10) 56.73	(9) 1.30	(9) 33	(4) 0.64	(12) 0.65	(6)	5	0.000001 (2)	0.020572 (9) 8.1 (10)
EU	5.98	0.36	59.95	1.20	41	0.70	0.62				
JP	-4.46	-0.14	96.43	0.67	49	0.54					
US	10.05	0.93	59.41	2.55	23	0.56					

The first five variables comprise of 2003 figures, the next columns comprise figures for longer periods (see below). Each measure is followed by its ranking (in parentheses). ROE = return on equity; ROA = return on assets; C/I is cost-income ratio; IRM = interest rate margin; CR5 = the market share of the largest five banks in terms of total assets; Panzar-Rosse is estimated over the period 1990–1998; X-efficiency over 1990–1997; X-rank is weighted average efficiency rank (cf. Bikker (2002) for 1990–1997; BR = Bresnahan (1980–1998); Average rank = average ranking across all measures except Bresnahan. “EU” is weighted average over EU countries.

Table 7. Measures of competition and profitability for 1994–2003

ROE	ROA	C/I	IRM	CR5	Panzar-Rosse	X-efficiency	X-rank	BR deposits	BR Lending	Average rank
AT	8.60 (6)	0.41 (6)	68.04 (4)	1.42 (4)	41.81 (6)	0.87 (3)				4.8 (3)
BE	10.98 (7)	0.33 (3)	64.56 (7)	1.06 (3)	68.28 (12)	0.89 (2)	12		0.000064 (5)	7.4 (9)
DE	4.80 (1)	0.19 (1)	65.21 (6)	1.55 (5)	18.93 (1)	0.63 (13)	4	0.000627 (7)	0 (1)	4.0 (1)
DK	12.46 (10)	0.81 (12)	57.52 (13)	2.33 (12)	68.33 (13)	0.36 (15)	11			12.3 (14)
ES	8.27 (5)	0.71 (9)	59.35 (10)	2.45 (14)	39.23 (5)	0.62 (14)	13	0.000504 (6)	0 (1)	10.0 (13)
FI	15.19 (13)	0.82 (13)	76.42 (1)	1.81 (8)	80.86 (15)	0.78 (7)	8			8.6 (10)
FR	5.85 (3)	0.28 (2)	66.30 (5)	0.94 (2)	43.73 (8)	0.70 (10)	9	0.000106 (4)	0.000002 (4)	6.3 (4)
GR	16.98 (14)	0.99 (15)	59.20 (11)	2.35 (13)	63.24 (11)	0.76 (8)	14			12.5 (14)
IE	14.74 (12)	0.91 (14)	54.41 (14)	1.86 (9)	42.58 (7)	0.65 (11)	3			9.1 (12)
IT	5.39 (2)	0.38 (5)	61.61 (8)	2.50 (15)	28.85 (4)	0.82 (5)	10	0.000314 (5)	0.000147 (6)	7.3 (7)
LU	14.52 (11)	0.37 (4)	46.00 (15)	0.62 (1)	26.11 (2)	0.93 (1)	1			4.6 (2)
NL	11.80 (9)	0.49 (7)	68.36 (3)	1.69 (6)	80.52 (14)	0.75 (9)	2	0.000023 (3)	0 (1)	7.1 (6)
PT	6.17 (4)	0.63 (8)	59.75 (9)	2.00 (11)	59.15 (10)	0.83 (4)	7	-0.00014 (1)	0.001128 (8)	7.3 (7)
SE	11.09 (8)	0.80 (11)	70.49 (2)	1.71 (7)	56.40 (9)	0.80 (6)	6	0.009889 (8)	0.000492 (7)	7.0 (5)
UK	17.54 (15)	0.76 (10)	58.82 (10)	1.98 (10)	27.30 (3)	0.64 (12)	5	0.000001 (2)	0.020572 (9)	9.0 (11)
EU	8.84	0.46	62.88	1.74	37.91	0.70				0.62
JP	-10.25	-0.35	83.22	1.29	34.19	0.54				
US	12.89	1.09	61.38	3.31	20.29	0.56				

All numbers for the first five variables refer to averages for the 1994–2003 period. Each measure is followed by its ranking (in parentheses). ROE = return on equity; ROA = return on assets; C/I is cost-income ratio; IRM = interest rate margin; CR5 = the market share of the largest five banks in terms of total assets; Panzar-Rosse is estimated over the period 1990–1998; X-efficiency over 1990–1997; X-rank is weighted average efficiency rank (cf. Bikker (2002)) for 1990–1997; BR = Bresnahan (1980–1998); Average rank = average ranking across all measures except Bresnahan. “EU” is weighted average over EU countries.

Table 8. Correlation between measures of competition and profitability

2003 ^a										
ROE	ROA	C/I	IRM	CR5	P-R	X-rank	X-Eff	BR deposits	BR lending	Average rank
1.00	0.94	***	***	0.53	***	0.15	*	-0.06	0.45	***
ROA	1.00	-0.59	***	0.52	***	0.27	**	-0.09	0.24	**
C/I		1.00	-0.34	***	0.38	*	*	0.07	-0.24	***
IRM			1.00	0.25	-0.25	*	***	-0.50	0.05	0.78
CR5				1.00	0.05	0.29	***	-0.49	-0.29	* 0.55
P-R					1.00	-0.18	0.04	0.31	-0.36	*** -0.51
X-eff rank						1.00	-0.81	-0.09	0.19	*** 0.68
X-eff							1.00	-0.03	-0.16	*** -0.64
BR deposits								1.00	1.00	*** -0.12
BR lending									1.00	*** 0.15
Average rank										1.00
1994-2003 ^b										
ROE	ROA	C/I	IRM	CR5	P-R	X-rank	X-Eff	BR deposits	BR lending	Average rank
1.00	0.67	***	0.04	0.29	-0.07	-0.11	-0.13	0.17	0.76	* 0.51
ROA	1.00	-0.06	0.60	***	0.40	*	-0.24	0.45	0.44	*** 0.81
C/I		1.00	0.03	0.47	***	0.16	-0.07	0.61	-0.46	*** -0.15
IRM			1.00	0.12	-0.49	***	-0.25	-0.10	0.16	* 0.70
CR5				1.00	-0.02	0.27	-0.44	0.20	-0.35	** 0.44
P-R					1.00	-0.18	0.04	0.31	-0.36	*** -0.55
X-eff. rank						1.00	-0.81	-0.09	-0.26	*** 0.62
X-eff.							1.00	-0.03	0.19	*** -0.63
BR deposits								1.00	-0.16	*** -0.07
BR lending									1.00	*** 0.40
Average rank										1.00

^a Based on numbers from table 6; ^b Based on numbers from table 7. For all abbreviations, cf. table 6. *, **/*** = 10/5/1% significance level, respectively. Shading indicates that negative correlations are expected, given the interpretation (or definition) of the measures.

Table 9. Changes in measures of competition and profitability over time

	ROE		ROA		C/I		IRM		CR5		Panzar-Rosse				
	2001-03	1993-95	2001-03	1993-95	2001-03	1993-95	2001-03	1993-95	2002	1995	1997	1991			
	Δ		Δ		Δ		Δ		Δ		Δ				
AT	9.93	7.01	2.92	0.48	0.34	0.14	67.84	67.90	-0.06	1.21	1.76	-0.55	45.00	35.74	9.26
BE	10.47	9.41	1.06	0.38	0.23	0.15	62.24	68.34	-6.11	0.85	1.24	-0.39	81.00	51.27	29.73
DE	1.26	6.24	-4.98	0.05	0.26	-0.21	68.52	62.80	5.72	1.11	2.03	-0.92	20.67	16.99	3.68
DK	14.13	10.03	4.11	0.89	0.72	0.17	50.40	61.13	-10.73	1.81	3.27	-1.46	67.67	70.00	-2.33
ES	8.14	7.19	0.95	0.71	0.64	0.08	54.10	61.70	-7.60	2.25	2.81	-0.56	44.33	33.49	10.85
FI	40.70	-8.72	49.42	2.15	-0.43	2.58	45.43	113.56	-68.13	1.88	1.72	0.16	80.00	69.83	10.17
FR	7.90	0.79	7.12	0.45	0.03	0.43	62.04	68.94	-6.90	0.87	1.15	-0.28	46.33	41.82	4.51
GR	10.00	16.33	-6.33	0.77	0.78	-0.01	60.89	63.99	-3.10	2.68	1.81	0.87	67.00	59.04	7.96
IE	12.07	14.99	-2.92	0.68	1.06	-0.37	53.60	58.44	-4.84	1.27	2.75	-1.48	44.33	44.73	-0.39
IT	6.40	1.98	4.42	0.45	0.14	0.31	55.63	67.60	-11.97	2.37	2.82	-0.44	29.33	34.22	-4.89
LU	12.06	14.45	-2.39	0.34	0.36	-0.02	49.24	46.00	3.23	0.57	0.71	-0.14	30.00	22.20	7.81
NL	10.70	11.80	-1.10	0.41	0.53	-0.13	67.85	67.21	0.64	1.49	1.88	-0.39	83.33	75.74	7.60
PT	4.59	6.22	-1.63	0.55	0.56	-0.01	57.79	63.67	-5.88	1.54	2.40	-0.87	61.00	74.67	-13.67
SE	2.47	17.80	-15.33	0.73	1.01	-0.27	67.80	71.64	-3.84	1.22	2.56	-1.33	55.00	57.82	-2.82
UK	12.46	19.43	-6.97	0.63	0.76	-0.13	56.95	63.29	-6.34	1.58	2.27	-0.69	30.67	23.99	6.68
EU ^a	7.54	6.07	1.46	0.44	0.39	0.06	60.89	65.04	-4.14	1.47	2.08	-0.61	40.59	36.25	4.33
EU ^b	7.32	5.96	1.36	0.42	0.30	0.12	61.03	65.18	-4.15	1.47	2.02	-0.55	39.65	34.70	4.96
JP	-17.91	-2.80	-15.11	-0.61	-0.10	-0.51	105.04	72.91	32.13	1.11	1.39	-0.28	33.65	43.48	-9.83
US	11.48	13.38	-1.90	1.01	1.08	-0.06	58.56	63.97	-5.41	2.92	3.56	-0.64	22.45	18.16	4.28
															0.61
															0.03
															0.52
															0.39
															0.58
															0.04
															0.60
															0.32
															0.04
															0.62
															0.55
															0.07

For all abbreviations, cf. table 6; ^a Weighted average; ^b Weighted average excluding Scandinavia.

X-efficiency (Bikker, 2002) and Bresnahan's λ of conjectural variation for, respectively, loan and deposit markets (Bikker, 2003). The variable "efficiency ranking" (a weighted average of rankings of efficiency) takes the distribution of a country's banks across bank categories into account, which is much more precise when efficiency differs substantially across bank types (see section 5.2 or Bikker, 2002).

The interpretations of most measures are quite obvious. Strong competition (and high efficiency) reduces ROE, ROA and the interest rate margin ratio and competition is expected to be stronger, the lower the concentration is. While Panzar and Rosse's H -value is a measure of competition, Bresnahan's λ reflects market power. As strong competition forces high efficiency, the measures correlate with efficiency in a similar manner as with competition. ROE, ROA and the interest rate margin ratio are also proxies for profitability. The meaning of the cost-income ratio, however, is not wholly unambiguous. A high ratio is usually assumed to indicate high efficiency, (forced by) strong competition and (as a result) a low profit rate (focussing on low profits). This interpretation supposes that bank service tariffs, such as lending rates,⁵⁶ commissions and fees, are dictated by competition and hence that, given the output level, revenues are a residual item. An alternative view focuses on costs instead of profits and assumes that competition causes relatively low costs (reflecting high efficiency), whereas profits may be seen as accidental or determined by external factors. This would, for instance, be the case if bank service tariffs were determined by a mark-up on costs.⁵⁷ Our empirical analyses reveal that the first interpretation – and the most common one – appears to be most plausible, at least for 2003. Note that all (simple) measures are rough approximations at best. ROE, ROA and the interest rate margin ratio, for instance may be distorted by the composition of assets and liabilities, differences in the yield curve between the countries considered, the relative size of equity capital and book-keeping operations, which lengthen or shorten the balance sheet.

Table 6 also presents rankings for each measure, where low values indicate high competition and efficiency. It is clear that rankings and patterns in the figures are often rather similar across the five simple proxies, but that large deviations also occur. For some countries it is clear that the results reflect

⁵⁶ And hence interest margins when funding costs are given.

⁵⁷ Note that a ratio would be meaningless if the profit margin were proportional to costs (as in the case of a mark-up in terms of a percentage of costs) because the ratio would be constant. The first view assumes that profits are – strongly – negatively correlated with costs, whereas the second assumes that profits are uncorrelated or less than proportionally related to costs.

their particular position, see, for instance, Luxembourg where many banks are subsidiaries of foreign banks, taking advantage of bank secrecy and tax benefits. Table 8 gives correlations between the measures. Boxes indicate where negative correlations are expected, given the interpretation (or definition) of the measures. Generally high and significant correlations between these proxies confirm that the respective figures are rather similar. Whereas the efficiency measures correlate significantly with some of the proxies, including ROA and the interest rate margin, the P-R measure does not correlate significantly with any of them. Bresnahan figures for deposit and loan markets are available for a limited number of countries only, due to data constraints. Nevertheless, they correlate significantly with many of the other measures.⁵⁸

The last column of table 6 gives an average of the various rankings and, in a very simple manner, reflects the respective information contained in the earlier measures. Surprisingly, this overall measure correlates significantly with all the measures (except Bresnahan's). The variable net interest rates comes closest to this overall average measure. Banks in France, Germany and, in particular, Southern European countries, such as Greece, Italy, Portugal and Spain, are sometimes seen as less efficient (and the banking markets in these countries as less competitive).⁵⁹ The rankings we find here do not at all coincide with such 'accepted wisdom'.

5.6. Changes in competition and efficiency over time

Table 7 provides similar figures as table 6, but with simple proxies based on averages over the last 10 years, which makes them more comparable with the model-based measures which are also based on, say, the last decade. The results in this table differ significantly from those in the preceding one. The correlations between the simple proxies are much weaker and less often significant (see the lower part of table 8). The net interest margin is significantly correlated with ROA only, and concentration is uncorrelated

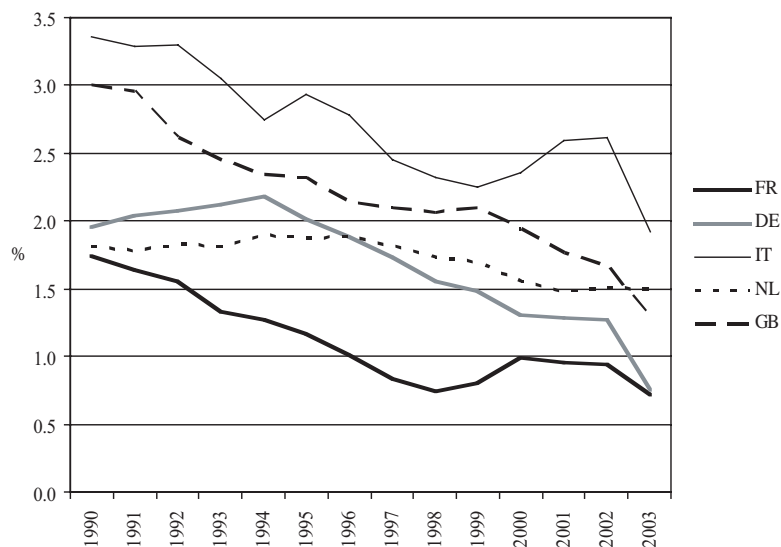
⁵⁸ The cross correlations with Bresnahan's measures may be less reliable due to the limited number (of countries) of the respective series.

⁵⁹ Arguments for the alleged diverging level of efficiency are more severe regulation by the supervisory authorities, interference by local government in the German Länder, which reduces competition, financial conservatism, a low level of consolidation and an extended network of branches (Germany), strong direct interference by the government (France and Italy) and lagging economic development (Greece, Spain, Portugal). Banks in the UK are often seen as more advanced and exposed to stronger competition.

with any of the other measures. The P-R measure is only correlated significantly with the net interest rate margin. The net interest rate margin also remains the proxy which is most similar to the efficiency ranking. The cost-income ratio is not correlated with most of the other measures neither with the ‘average ranking’. This suggests that this ratio is a rather unreliable indicator of competition and inefficiency, possibly as a consequence of its ambiguous interpretation. The ROA is the best proxy, in that it has the strongest correlation with the ‘average ranking’. The country rankings do not differ much from table 6, apart from the Netherlands (from 11 to 6) and Ireland (from 6 to 12). The main conclusion is that, apparently, the 10 year averages of the simple proxies and the model-based measures are too one-dimensional. They only offer a partial explanation for the degree of competition and efficiency. The data itself do not shed much light on the question which measure outperforms the others.

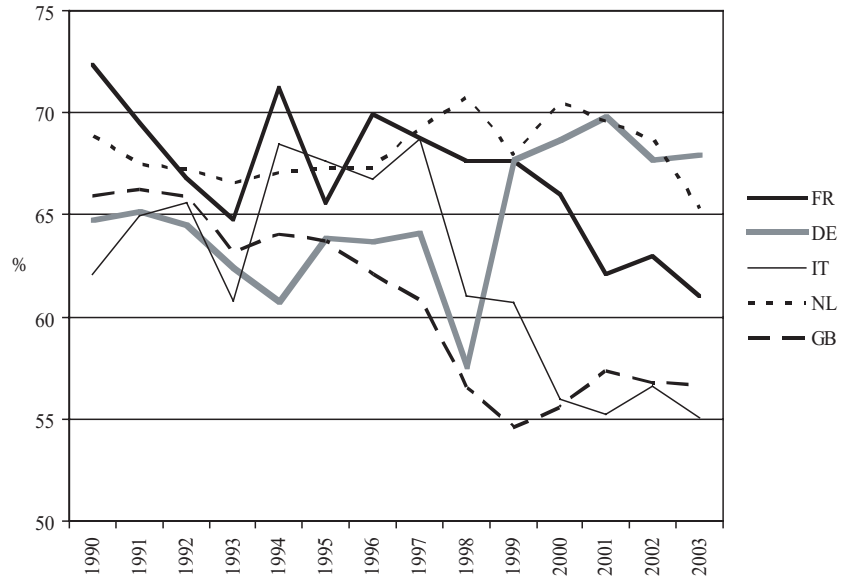
A commonly held view holds that deregulation, liberalization and technological innovation during the last decade have strengthened national and international competition. For the EU, this process was reinforced by progressive financial and monetary integration. The resulting increased competition forces banks to become ever more efficient. The question arises whether these changes are expressed in competition and efficiency estimates.

Figure 3: IRM of 5 large EU countries (in %)



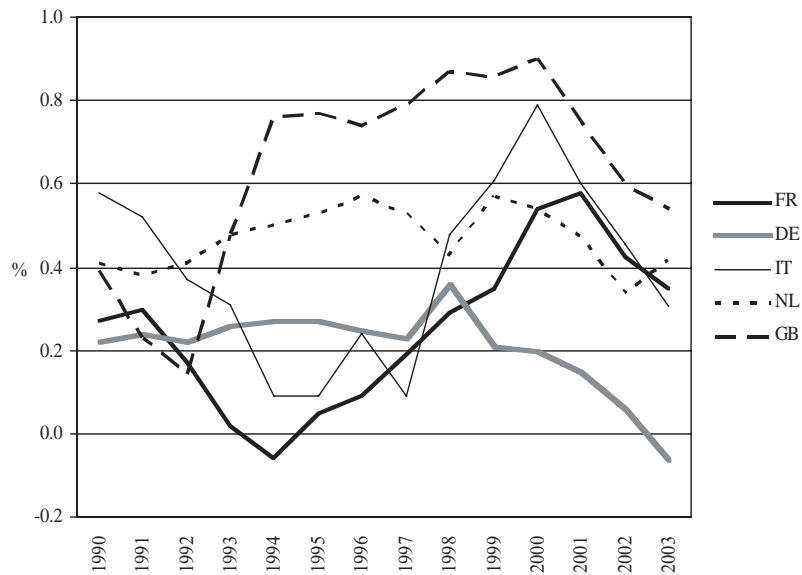
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA.

Figure 4: C/I of 5 large EU countries (in %)



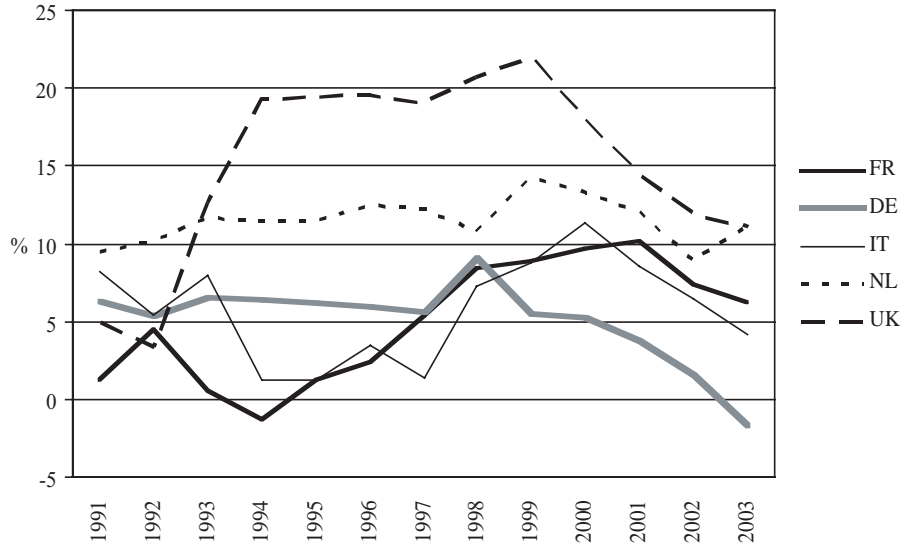
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA.

Figure 5: ROA of 5 large EU countries (in %)



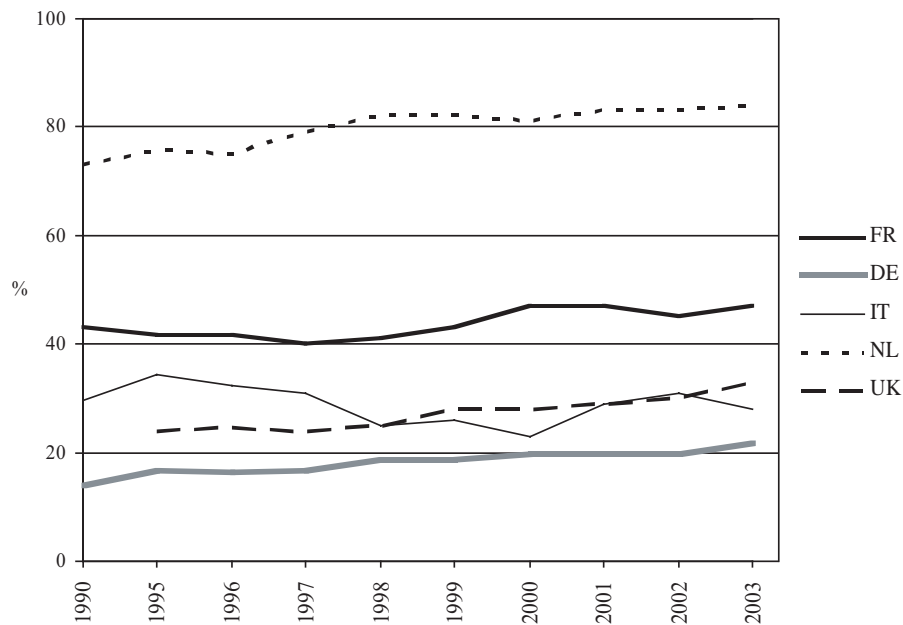
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA.

Figure 6: ROE of 5 large EU countries (in %)



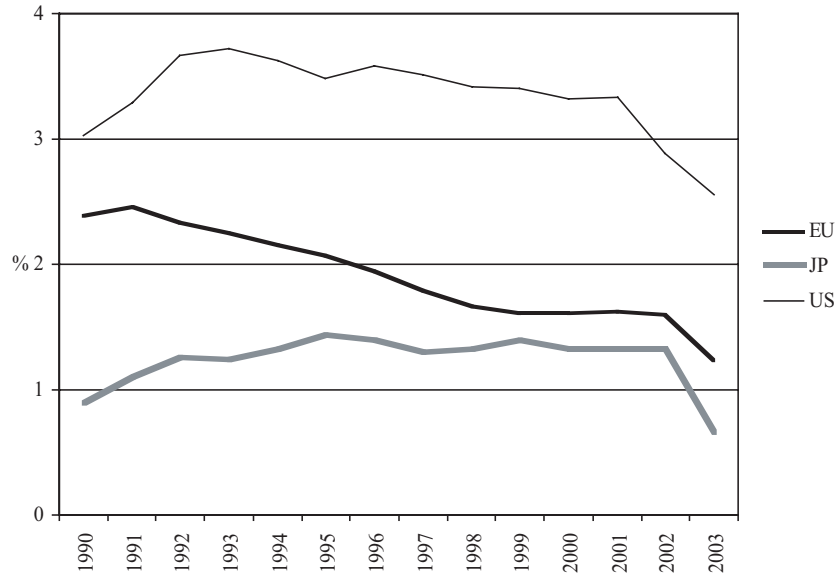
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA.

Figure 7: CR5 of 5 large EU countries (in %)



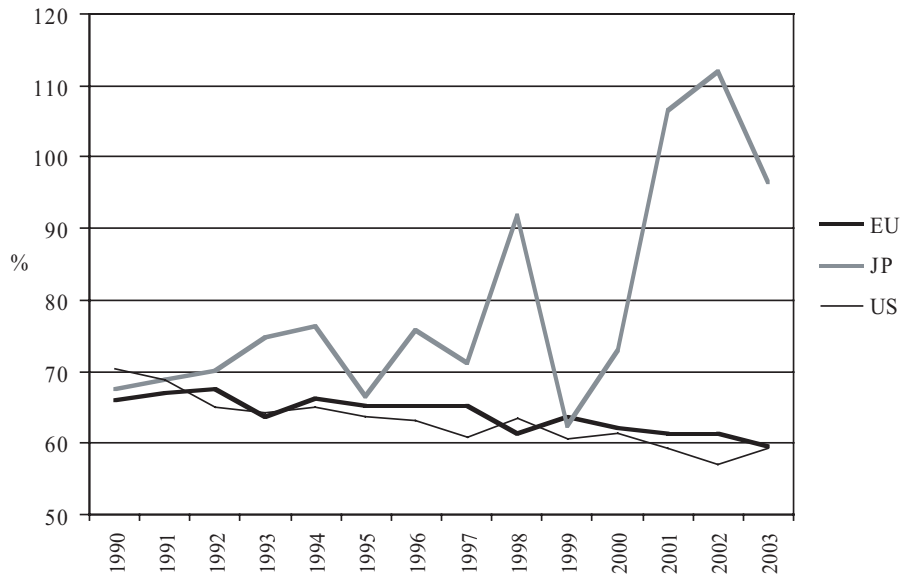
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA.

Figure 8: IRM of the EU, the US and Japan (in %)



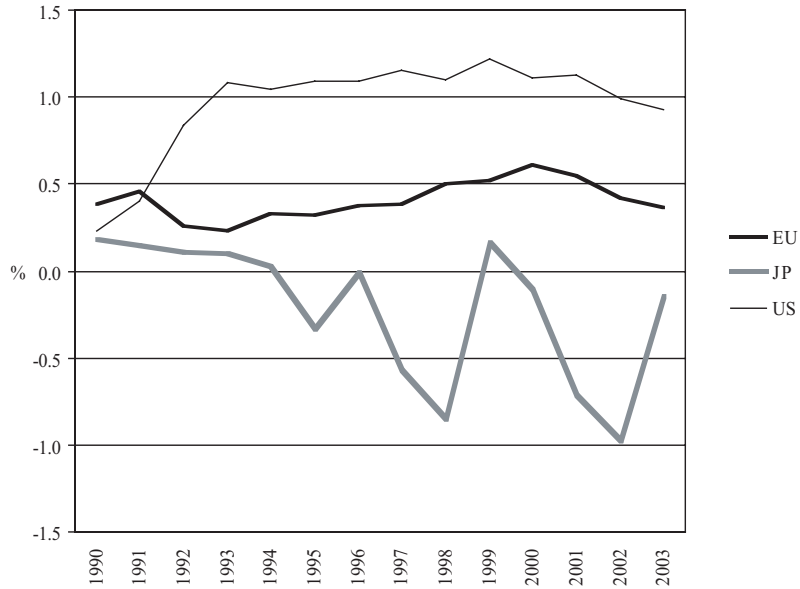
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA. EU is the equity-weighted average over EU countries.

Figure 9: C/I of the EU, the US and Japan (in %)



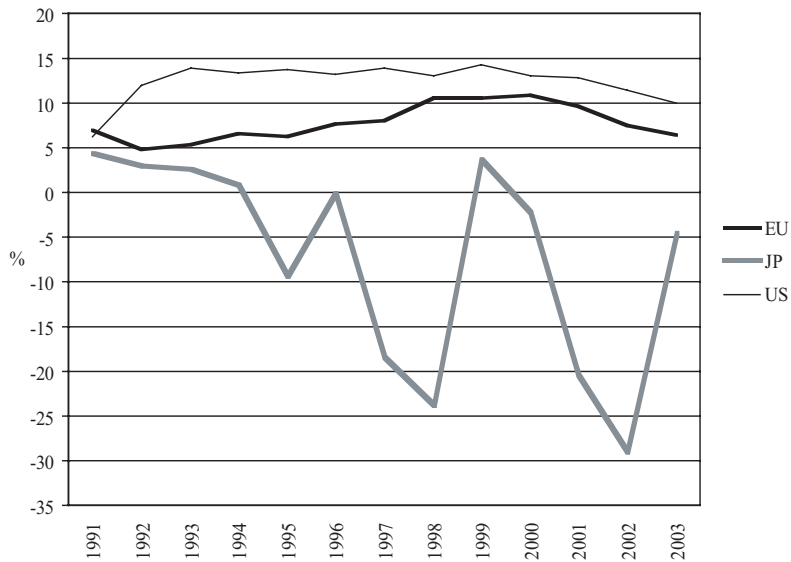
Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA. EU is the equity-weighted average over EU countries.

Figure 10: ROA of the EU, the US and Japan (in %)



Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA. EU is the equity-weighted average over EU countries.

Figure 11: ROE of the EU, the US and Japan (in %)



Sources: for 1990–2001: OECD; for 2002–2003: own calculations based on Fitch-IBCA. EU is the equity-weighted average over EU countries.

Table 9 provides changes over time for the simple proxies and for Panzar-Rosse's H value. Moreover, figures 3–7 present these simple proxies for the period 1994–2003 for the four largest countries plus the Netherlands and figures 8–11 present the first four proxies for the EU, the US and Japan. In the early 1990s, ROE, ROA and the net interest rate margin in the Scandinavian countries were affected particularly severely by the banking crises. Since this would distort any comparison over time, we ignore these countries. We then observe that ROE and the net interest rate margin tend to decrease over time in most countries and also 'on average', which may reflect intensified competition although this downward trend could also be due in part to the fall in interest rates over time. The cost-income ratio also fell somewhat over the years, reflecting cost reduction (in order to improve shareholder value) but also – relatively – higher profits. Strong differences across countries exist (cf. figure 4). ROA increased over time, reflecting – given decreased interest rate margins – higher profits on non-traditional banking services. The concentration figures reflect the gradually increased concentration for many countries. The 1997, H indices (see the discussion around table 10) are compared to H indices for 1991. Given the dramatic changes in the banking market over the past decade, one would expect to see competition levels increase significantly. Yet in fact while the level of competition did increase in many countries and in various sub-sectors, the differences as expressed by the H statistic, though significant, remain limited in size. Possibly, this is because banks manage to mitigate increasing competitive pressures to some extent, by oligopolistic behavior or by product differentiation (for which the present framework is not very well suited).

Table 10. Changes in efficiency over time

	No. of banks	Efficiency
1990	31	0.563
1991	52	0.543
1992	220	0.563
1993	364	0.564
1994	515	0.590
1995	1 126	0.653
1996	2 135	0.733
1997	1 907	0.739

Source: Bikker (2002)

Next, we look at annual cost efficiency changes over the 1990–1997 period. Amid growing competition awareness in banks, caused in part by rising levels of competition, one would expect to see cost efficiency increase over time. Table 10 shows that this is indeed the case, as indicated by a consistent

year-on-year rise in efficiency levels of EU banks over the 1991–1997 period. Whereas in 1990, average efficiency lagged considerably behind that of US banks, seven years on, inefficiency levels had fallen by as much as 45 per cent, significantly reducing the efficiency lag. This suggests major contributions made by deregulation and economic and financial integration within Europe to the wealth of both customers and owners of banks. As demonstrable increases in competition levels are limited, it follows that competition was not the impelling force driving efficiency improvements. Therefore, other factors must have contributed as well, as, for instance, increased concern for profitability or shareholder value.

5.7. *Synthesis*

In this section, we have reviewed empirical applications of the models derived in section 3. In light of the evidence presented here, a relatively clear picture emerges.

Although we have emphasized the many different ways we can look at competition and profitability, most performance measures reviewed here tell a fairly similar story. However, there are two major exceptions. First, the cost/income ratio is not correlated with other measures: competitive conditions have much more of an impact on the revenue side. In addition, *relative* performance as measured by cost X-efficiency does correlate with most other performance measures, and it has shown a marked decrease over time. Savings and co-operative banks are relatively efficient. These plain banks tend to perform the traditional intermediary role that is assumed in most of the models reviewed here. With increasing disintermediation, the question arises as to how to interpret this result.

Second, the Panzar-Rosse model indicates that competition has *increased* over the period reviewed here. Some other evidence, however, points in other directions: returns (ROA and ROE) have increased, and concentration has gone up. At the same time, the interest rate margin has fallen somewhat in the same period. The Panzar-Rosse model may have picked up the effects of internationalization that are less apparent in other measures.

Country comparisons show that there are still marked differences between countries. Thus, controlling for country-specific circumstances appears to still be crucial in comparative studies. This point is also made when the meta-frontier technique is applied to European countries: markets may have

become more contestable and foreign competition may have increased, but this does not mean that performance (both absolute and relative) is easily exported across national borders.

However, relative performance, as measured by X-efficiency, can shed some light on the (differences in) competitive conditions in different countries. From our comparison of cost and profit X-efficiency, we observe that there is no clear correlation between the two measures. In some countries, a high profit efficiency is accompanied by a high cost efficiency, whereas this is not the case in other countries. Thus, efficiency may be useful as an indirect measure of market power.

6. Conclusions

This paper derives nine approaches to measuring competition and efficiency from a single theoretical profit maximizing framework, assuming that these models share the same features that our baseline model has. The major conclusion is that all models focus on a single variable instead of a set of variables as theory prescribes. For this reason, all models may suffer from identification problems in the sense that they pick up market power when estimating efficiency and vice versa. Also contributing to this problem is the measurement of input and output prices in banking. These problems may explain why the various approaches result in such diverging outcomes.

The banking landscape has changed considerably over the last decade. First, demand is affected by foreign competition and competition from non-bank financial firms. This calls into question the underlying assumption that the price elasticity of demand faced by all firms is the same and constant over time. Second, banks have reacted to changes in regulation and production technology. They have branched out into new products and behave less like the traditional intermediaries we model them after. Reaction curves may have shifted considerably, both on the market level and for individual banks. Although competition has intensified internationally, some banks may occupy dominant positions within national borders that allow them to react differently than their smaller competitors. Some of the models we reviewed are theoretically unable to cope with these changes, as they have traditionally assumed that all banks react similarly to each other. Third, the markets banks operate in have also changed as e.g. concentration has gone up, which may weaken competition. But foreign competition has intensified, so that it is uncertain what, on balance, the effects on individual banks have been.

Most approaches ignore the fact that banks produce various products and operate on various markets, where competitive positions may differ per product or market. An exception is the Bresnahan model, which considers competition on one submarket (e.g. loans, deposits). Approaches based on bank observations (Iwata, Panzar-Rosse) can circumvent this problem distinguishing various bank-size classes linked to different markets, e.g. small banks on local or retail markets and large banks on international or wholesale markets (Bikker and Haaf, 2002). Where ample observations are available, gradual effects on competition of the trends over time should be incorporated by using time (or trend) dependent coefficients (Bikker and Haaf, 2002).

Structural changes in banking markets and the lack of reliability of the data (particularly interest rates for credit loans and deposits) reduce the reliability of the estimates of the Bresnahan approach.

One notable problem for the efficiency models discussed here is the fact that their outcomes are very difficult to validate. There is no sound theory providing the correct distribution of the efficiency term, and we know little about the economic validity of the efficiency scores. Particularly with increasing internationalization, contestability and foreign competition, it is hazardous to transpose best practices in one country or market to another. All in all, we expect that the observed trends have similar consequences for most banks: increases in competition result in lower profit margins, higher cost efficiency and lower profit efficiency. In absolute levels, we also expect cost reductions. The dynamics of the consolidation process, however, may have increased the volatility of earnings.

Although we have emphasized the many different ways of looking at competition and profitability, most empirical performance measures reviewed here tell a fairly similar story, with two important exceptions. First, the cost-income ratio is not correlated with other measures: competitive conditions affect revenues more strongly. In addition, relative performance as measured by cost X-efficiency does correlate with most other performance measures, and has shown a marked decrease over time. Savings and co-operative banks are relatively efficient. These plain banks tend to perform the traditional intermediary role that is assumed in most of the models reviewed here. With increasing disintermediation, the question arises as to how to interpret this result. Second, the Panzar-Rosse model indicates that competition has increased over the last decade. Other evidence, however, points in the opposite direction: returns (ROA and ROE) have increased, and concentration has gone up. At the same time, interest rate margins have fallen somewhat. The Panzar-Rosse model may have picked up the effects of internationalization that have not been picked up by other measures.

Country comparisons reveal marked differences between countries. Therefore, controlling for country-specific circumstances remains crucial in comparative studies, such as the metafrontier technique, applied to European countries. Although markets may have become more contestable and foreign competition may have intensified, performance – both absolutely and relatively – is not easily exported across borders, due to these differences in national competitive conditions. Relative performance, as measured by X-efficiency, can shed some light on these differences. The comparison of

cost and profit X-efficiency reveals that there is no clear correlation between the two measures. Hence, estimating both types of efficiency may be useful as an indirect measure of market power.

At this point, we may draw up a future research agenda. Our first recommendation concerns the use of data. Although we are aware of the difficulty of finding good (proxies for) output prices, this paper has once again emphasized the need for output prices in an analysis of bank competition and profitability. Without output prices, we are unable to calculate banks' mark-up on costs or to derive the reaction functions to their competitors. As a result we know very little about the differences *between* banks in a single market. The increase in concentration in all markets reviewed here makes this an important concern. A change in the definition of the production process of banks would also be welcome. We need to rethink the traditional intermediation approach and focus more on other types of income. Our choice of variables in all models described here is mostly determined by banks' balance sheets. An increasing part of the action in today's banking markets, however, takes place *off* the balance sheet. Including off-balance sheet items in the intermediation approach therefore is a first step towards a more balanced view of bank production.

Our second recommendation regards the theoretical foundation of the models employed to measure market power and efficiency. As we have shown, models focussing on a single variable may suffer from identification problems. In particular, we emphasize the distinction between market power and efficiency, for example using the efficiency hypothesis test in section 3.3.3 or through a comparison of cost *and* profit efficiency. In addition, the fact that we observe such strong trends in banking calls for time-dependent models. In particular, we stress the need for making both the price-elasticity of demand η_D and conjectural variation λ time-dependent.

Our third recommendation concerns the market under examination. For reduced-form market structure models such as the SCP model, we advocate their application to a wider range of specific submarkets. (Sub)markets that are not very contestable and have experienced less internationalization (e.g. deposits or mortgages) lend themselves particularly well to this type of analysis. For non-structural models such as Iwata, Panzar-Rosse and Bresnahan we suggest estimating a different H or λ for different size classes and submarkets.

74 Conclusions

As a final remark, we observe that all models introduced here are highly complementary. For example, whereas some lend themselves better to assess the impact of disintermediation, others are more suitable for analyzing the consequences of internationalization. By using several complementary models we can overcome the identification problems that arise when we limit ourselves to applying a single model to analyze bank competition and profitability.

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Appendix: The Stigler Approach

In this appendix we show that, presuming the de facto existence of collusive behavior, the extent to which banks will engage in collusive behavior is directly and positively related to their market share.⁶⁰ An increase in market share (MS_i) leads to an increase in awareness (λ_i), and thereby to collusive behavior.⁶¹

To prove this, we depart from Stigler's rule that the (pricing) behavior of firms must be inferred from the way their customers react. The assumption then is that "[T]here is no competitive price-cutting if there are no shifts of buyers among sellers" (Stigler (1964), p. 48). Thus, the higher the loyalty of customers, the less likely a bank is to behave collusively. Intuitively, the higher customer loyalty, the less a bank has to gain by cutting prices: it does not have to do so to keep its old customers nor does it expect to gain a lot of new customers. In terms of the dynamic Cournot model, the lower the conjectural variation λ_i , the more likely the bank is to engage in collusive behavior.

In line with Stigler (1964), a bank targets three groups of customers. First, it wants its share of the growth of new customers [C_n]. Second, it wants to retain as many of its old customers as possible [C_r]. Third, it wants growth through other banks' old customers [C_o]. Let N_n = number of new customers, and N_o = the total number of old buyers in the market.⁶² Also, let n_o^i = the number of old customers for bank i . The probability of repeat purchases is denoted p , and MS_i is bank i 's market share.⁶³ The expected number of customers for each group is given by:

$$E(C_n^i) = MS_i * N_n \quad (25)$$

$$E(C_r^i) = p * MS_i * N_o \quad (26)$$

$$E(C_o^i) = (1 - p) * MS_i * (N_o - n_o^i) \quad (27)$$

⁶⁰ This appendix is taken from Bos (2004).

⁶¹ On a market level, the notion that concentration "facilitates collusion between firms and increases industry-wide profits" (Tirole (1993), p. 222) is widely accepted.

⁶² Where $\sum_{i=1}^M Y_i = Y = f(N_o)$.

⁶³ Where $MS_i = Y_i / \sum_{i=1}^M Y$.

For each group the cost of cheating (i.e. not behaving collusively) is given by the variance of the expected number of customers. The higher this variance, the more likely a bank is to show collusive behavior. For each set of customers, variances are given by:⁶⁴

$$\text{var}(C_n^i) = [N_n * MS_i * (1 - MS_i)] \quad (28)$$

$$\text{var}(C_r^i) = [N_o * p * MS_i * ((1 - p)MS_i)] \quad (29)$$

$$\text{var}(C_o^i) = [(N_o - n_o^i) * ((1 - p)MS_i) * (1 - (1 - p)MS_i)] \quad (30)$$

As explained, an increase in market share (MS_i) leads to more collusive behavior if $\partial \text{var}(\cdot) / \partial MS_i > 0$. This requires:

$$\frac{\partial \text{var}(C_n^i)}{\partial MS_i} = N_n - (2 * N_n * MS_i) > 0 \quad (31)$$

$$\frac{\partial \text{var}(C_r^i)}{\partial MS_i} = pN_o - (2 * N_o * p^2 * MS_i) > 0 \quad (32)$$

$$\frac{\partial \text{var}(C_o^i)}{\partial MS_i} = ((1 - p)(N_o - n_o^i)) - (2(1 - p) * (N_o - n_o^i) * MS_i) > 0 \quad (33)$$

Equations 31 and 33 hold if $MS_i < 0.5$. Equation 29 holds if $p > 2p^2 * MS_i$. If $MS_i < 0.5$, this condition is also satisfied.

Since C_n^i , C_r^i and C_o^i are disjoint subsets of the whole customer population (i.e. there is no overlap), we can simply add up their variances, which under the above mentioned conditions are larger than zero. Summing up therefore, an increase in market share MS_i leads to an increase in awareness λ_i and hence to more collusive behavior.

⁶⁴ A bank expects a consumer to become either customer (with expectations dependent on its current market share) or not. Thus, for the binomial mean $\mu = n * p$, variance is $n * \pi(1 - \pi)$.

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