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European banking after EMU



European Investment Bank

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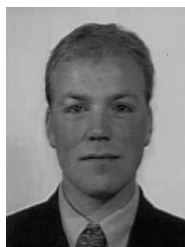
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Who are Europe's efficient bankers?



Rien Wagenvoort



Paul Schure

1. Introduction

On the first of January 1993, the Second Banking Directive (1989) of the European Union and a number of the other EU Directives (1) related to the financial service industry were implemented. This heralded a new episode of deregulation, standardised minimum capital requirements and changes in supervision rules and deposit-guarantee schemes. The *single passport* and *mutual recognition* have cleared the road for cross-border banking, while the introduction of the single currency on the first of January 1999 took away one of the last obstacles for a competitive and integrated banking market. The general belief among bankers and academics is that competition has significantly increased in this changing European banking environment. Indeed, the numerous cases of recent mergers and acquisitions in the financial world would indicate that bankers and insurers are trying to reshape their businesses into more profitable and lean (cost efficient) institutions in order to face national and global competitive pressures. Traditional income streams such as interest margins have dried up, whereas new sources of revenues such as brokerage services, investment banking products, risk management and portfolio management have become more and more important. Besides major changes in the regulatory environment, the banking industry will be further modernised by the implementation of new computer technologies.

Given the broad picture sketched above, one may ask whether the performance of European credit institutions over the five years following the implementation of the Second Banking Directive has improved. In this paper we evaluate the performance of banks in this period by looking at cost efficiency, i.e. whether banks minimise the cost incurred per unit of assets. In particular, we analyse how production costs depend on scale economies, managerial efficiency, technological progress and the legal status of the institutions. For this purpose, we estimate a cost frontier of the minimum costs to produce a certain mix and level of outputs given the prices of inputs.

Our results reveal that costs are unnecessarily high in more than 80% of the cases, i.e. more than 1600 credit institutions out of 1974 banks are not located on the cost frontier. The most important reason for inefficiencies in European banking is managerial inability to control costs, so-called X-inefficiency. The average level of X-inefficiency, computed for the European banking sector as a whole by taking into account the relative size of both its inefficient and efficient institutions, still exceeded 16% in 1997 (2). Although in some countries such as the UK and the Netherlands, cost

This paper is a condensed version of a paper entitled "Economies of Scale and Efficiency in European Banking: New Evidence", Economic and Financial Reports, 99/01, EIB. See inside back cover for details on ordering economic publications. Rien Wagenvoort is an economist at the Chief Economist's Department. Paul Schure is at the European University Institute, Florence, and visited the EIB during this research.

1) Namely, the Money Laundering Directive, the Own Funds Directive, the Solvency Ratio Directive, the Consolidated Supervision Directive, and the directive on Deposit-Guarantee Schemes. The Large Exposures Directive, the Capital Adequacy Directive and the Investment Services Directive came into force in 1994, 1995 and 1996 respectively. See, among others, Molyneux et al., (1996).

2) The weighted average of the X-inefficiency measure is equal to 20% in 1997 if only the X-inefficient banks are taken into consideration.

reductions were rapidly achieved, bankers in Austria, France, Germany and Luxembourg did not improve their performance. As size economies are exhausted at a balance sheet total of 600 million euro, we do not find major gains from economies of scale for the overall European banking industry. These empirical findings are in accordance with earlier studies (3) on US financial institutions but contradict recent results on the scale efficiency of both American and European financial institutions (4).

The paper is organised as follows: We start with introducing various cost efficiency measures and we will argue why other performance indicators such as financial ratios are less informative about production efficiency. In section 3 we enlarge upon the cost frontier methodology by explaining the adopted *intermediation* approach. Section 4 contains a brief description of the banking sector while our results regarding the cost efficiency of European banks are discussed in Section 5. Finally, section 6 concludes.

2. The cost frontier methodology

Our aim is to find those banks which provide the highest level of financial services given their resources.

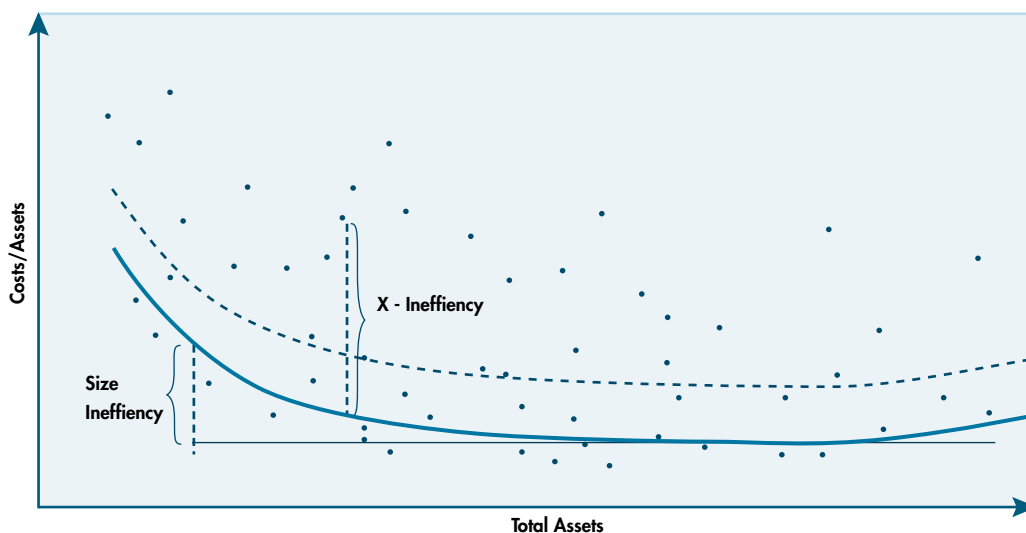
We look at banks from a production point of view. Our aim is to distinguish among a pool of credit institutions those banks, which provide the highest level of financial services (outputs) given their available resources (inputs). Therefore, we need to assess which banks in our sample have the best production technology and which ones fully exploit their production capacity. From the duality theorem in microeconomics it follows that the technology of a firm can be described by the parameters of a cost function. An example of such a so-called cost frontier is shown in Figure 1 by the solid line. At the point where the line is flat the costs per unit of assets are minimised and thus production is optimised.

When assessing efficiency one can be interested in *X-efficiency* -i.e. whether banks use their available inputs efficiently, *scale efficiency* -i.e. whether banks produce the right amount of outputs, and *scope efficiency* - i.e. whether banks choose an optimal combination of outputs. Two of these different concepts are illustrated in Figure 1. We note first that relatively small deviations from the cost frontier, indicated by the dots closely above and below the solid line, may arise due to random effects beyond the control of the banks' management (bad and good luck). Large deviations above, however, indicate managerial incompetence to control costs. Our data suggest that this X-inefficiency may be caused by wasting of resources (e.g. a bank uses old-fashioned technology, has too many offices and too many people on the pay-roll etc.) but may also stem from unprofitable purchase of these resources. Firms which are located close to the cost frontier, i.e. X-efficient companies, are still not optimally performing from a production point of view if a reduction in the costs per unit of assets can be achieved by either increasing or decreasing the volume of production. The downward sloping part of the cost frontier at the left indicates increasing returns to scale. On the contrary, the rising part to the right reflects decreasing size economies. The vertical distance between the minimum of the cost function (where the average costs are minimised) and an arbitrary location of a bank on the cost frontier reveals to which extent the average costs of this particular bank can be reduced by changing its size. In other words, it provides a measure of its scale inefficiency.

3) See, for instance, Berger and Humphrey (1987), McAllister and McManus (1993) and the review article of Berger and Humphrey (1997).

4) See Hughes and Mester (1998) on the US and Altunbas and Molyneux (1996) for Europe.

Figure 1. Various efficiency measures which can be derived from the cost frontier



Note: There are different curves for different types of banks, or the frontier can move due to technical change and the like over time.

Note that the efficiency measures introduced so far are defined with respect to a benchmark group of relatively efficient financial institutions. Evidently, these X-efficient banks themselves may lower their average costs over time, at any output level, when structural changes in the banking environment occur. As mentioned, there are numerous examples in recent European banking history of such changes (deregulation, the introduction of the single currency, technological innovation, etc.). In Figure 1, these phenomena are represented by a downward shift in the cost frontier (compare the solid and the dashed lines). On the other hand, there are also other reasons that can be brought up to explain shifts in the frontier. When comparing the cost functions of different types of financial institutions it may be that average costs differ for a particular level of total assets. Banks of different types may operate at different costs per unit of assets, due, for instance, to their legal status, their ownership structure, their capital requirements etc., but also because they deliver financial products of different nature and quality. Related to this argument is the fact that a bank may reduce its costs, given its amount of total assets, by choosing an optimal mix of outputs.

Our specific model, presented in Box 1, is not suitable to measure these economies of scope since a restricted set of technological possibilities has to be chosen. Therefore, we refrain from predicting what will be the economic gains of *universal banking*. In recent efficiency studies, however, only small increasing economies of scope were detected (5). Although this result may possibly have arisen due to the application of inappropriate models and methods rather than the absence of economic returns from diversifying the output portfolio, it remains a puzzle for researchers in the field. This paper addresses especially X-efficiency, scale efficiency, technological innovation and dispersion of costs among different types of financial institutions.

5) See Berger, Hunter and Timme (1993), Berger and Humphrey (1997), Berger and Mester (1997), and Berger, Demsetz and Strahan (1998) for comprehensive surveys of empirical findings regarding the existence of scale and scope economies and X-efficiency of financial institutions.

Cost minimisation does not necessarily lead to profit and revenue maximisation in economies that can be characterised by oligopolistic markets, asymmetric information and risk-averse individuals. In response to this argument, some recent articles (6) consider, besides the traditional cost function, also the profit and revenue frontiers and derive from these functions X-efficiency measures. Although these studies give useful insights in the differences in profitability of banks, a serious problem with these approaches is that market power may obscure the efficiency (in terms of productivity) results (7). The same critique applies to other simple performance measures such as balance sheet ratios (8). Moreover, these ratios may also depend on the tax regime, loan loss provision schemes, historic accounting and the like. In this study we only focus on cost minimisation, and leave profit or revenue maximisation aside.

3. Defining the inputs and outputs of a credit institution

Bank total costs are defined as the sum of interest expenses, total operating expenses and commission expenses as reported in the annual income statement. Total operating expenses include labour costs, depreciation of fixed assets, marketing costs, while commission expenses include fees paid to other financial institutions.

It is rather straightforward to define the total costs of a bank. Distinguishing between outputs and inputs is far more complicated.

Although it is rather straightforward to define the total costs of a bank, distinguishing between its outputs and inputs is far more complicated. We view a bank as a *producer of services* such as screening projects, monitoring borrowers, enforcing contracts, portfolio selection, hedging risks, providing brokerage services, keeping deposits and other claims liquid, providing repayment insurance, etc. By defining services as the banks' output implies that we adopt what Berger and Humphrey (1992) call the *value-added approach* in defining a bank's production or what is traditionally called the *intermediation approach* (9). All services which are needed to generate the value-added are defined as inputs.

The cost frontier relates total costs to output and the prices of inputs. In this study, three input prices, for each country and each year, have been defined: the price of loanable funds, the price of labour and the price of buildings (10). The *price of funds* is obtained by taking a weighted average of the average 3-month interbank rate and the deposit rate (11). The *price of labour* represents the average wage rate in the banking sector in each country (12). The *price of buildings* is created by taking an appropriate price index for newly delivered buildings and correcting it for the relative price levels in each country. A detailed description of the data sources and the computation of the price indices are given in Schure and Wagenvoort (1999).

6) See, among others, Berger and Mester (1997), and Rogers (1998).

7) An interesting related topic is whether high market concentration or high market shares is a result of better performance or whether it reflects monopoly power. This question is especially relevant for public policy considerations such as anti-trust actions. In this study we do not test this so-called structure-conduct-performance relationship (see, among many others, Berger (1995), Goldberg and Rai (1996) and Maudos (1998)).

8) Examples of such financial indicators, often reported in annual accounting reports, are: the return on equity, the cash flow ratio, the cost to income ratio, the dividend payout, etc..

9) See Sealey and Lindley (1977).

10) The reader could correctly point out that banks purchase more than these three inputs. Our assumption here is not so much that the bank faces only three prices, but that a linear combination of these can sufficiently well approximate the prices that the bank might face.

11) This data is obtained from Datastream International and IFS, respectively. The weights are determined by the amount of deposit funding as part of total funding (total assets) of each bank.

12) The data needed to construct an index for the price of labour is taken from Bankscope (Bureau van Dijk, Brussels) and the OECD.

We view a bank as a producer of services - the Value-Added approach. However, measuring the services produced by a bank is a problem in itself.

Our data set allows for a more general definition of X-efficiency than obtained in the usual studies of this type. In traditional cost studies, X-inefficiencies may appear due to wasting of resources. However, differences in performance cannot be caused by inefficient acquisition of the inputs, since every bank is assigned a different input price vector, usually based on the actual cost incurred. For example, the price of labour is defined as the bank's expenses on labour divided by its number of employees. Choosing input prices in this way means that they will differ for each bank in the sample. It is thus implicitly assumed that banks pay the "right" amount for their inputs which may differ in quality. By contrast, in our study we adopt the idea that differences in efficiency stem from both the wasting of resources and because managers acquire these resources inefficiently. In particular, input prices are, as far as possible, constructed from general price indices (for buildings, financial services, wages etc.) instead of the actual expenses of a bank. In our case, input prices are equal for different banks in the same country and the same year.

McAllister and McManus (1993) argue that the traditional way of choosing input prices may bring about the economies of scale puzzle (13) since larger firms have better risk diversification opportunities and thus lower cost of funding than small firms. These so-called *financial* scale economies will also be revealed by our approach. If larger banks pay less than our constructed average price of funds, and thus have lower interest costs, then these banks will have lower average costs than small banks and this will eventually show up in our measure of economies of scale. In most recent cost studies this effect would remain undiscovered.

Measuring the service production of a bank is a problem in itself. How are, for example, the services offered to account holders quantified? Ideally one would like to have data on the number of transactions processed, the number of account statements sent to customers and the like. Unfortunately these data are not available. And for other outputs, such as the 'amount' of contract enforcement and the 'amount' of risk hedged, the problems get even worse. In the value-added approach these problems are by-passed by assuming that the amount of services produced are proportional to various variables on the balance sheet and the profit and loss account. Variables which imply service production are then used as proxies for the amount of services produced and plugged into the statistical model. As an example, loans are considered to be an output because when offering loans, services are supplied, such as screening the projects, monitoring borrowers, enforcing contracts, and diversifying risks. Another output could be deposits, as deposits imply services such as processing of transactions, production of account statements, etc. It is less clear that other assets such as government bonds, treasury bills, cash balances and the like are "production" as normally purchasing government bonds does not, for instance, imply much screening effort or contract enforcement. Some of these assets provide liquidity and thus, besides having some output characteristics, are an input in the form of loanable funds, though this is not considered here.

We have defined five output variables using Bankscope data (Bureau van Dijk, Brussels): customer deposits, loans, equity investments, off-balance sheet items, and other services. *Customer deposits* comprise demand, savings and time deposits. The variable *loans* consist of the total EUR value of

13) Empirical studies on US banks in the 1980s and early 1990s do not find large scale economies.

lending to borrowers to whom substantial financial services are supplied (14). *Equity investments* are obtained by adding up the book value of participations and shares in companies with related business and shares in other non-financial affiliates (15). Here we have to remark that in many cases this latter output can be substantially under-valued since its book value, as taken from Bankscope, is usually determined on the basis of historic costs instead of its market value. However, this does not necessarily pose as a problem in measuring financial services as long as banks use similar accounting techniques. Evidently, there is a potential danger of mis-measurement of the level of the output variable equity investments for our bank set. *Off-balance sheet items* contain contingent liabilities arising from guarantees, irrevocable letters of credit, irrevocable facilities, discounted bills, etc. Derivatives are not included in this item. Like loans, off-balance sheet items force the bank to screen and monitor projects and hence provide services. Finally, the variable *other services* is equal to commission revenue. Contrary to all other output variables, which are stock variables on and off the balance sheet, other services is a flow variable taken from the profit and loss account.

In a panel data framework, i.e. with data on cross-sections spanning several years, the values of the output variables may not imply an equal proportion of service production in different years. That is, if inflation has been substantial, then a deflator must be employed to keep outputs in different years comparable. With this end in view, in the special case of the output variable *other services*, we divide through a price index for banking services. Obviously, changes in prices of the other output variables can be relevant too. Unfortunately no adequate data on these prices are available. We minimise this problem by *scaling* all the output variables, including the deflated commission revenue, and total costs by total assets (16). A more fundamental problem with bank efficiency studies is that amounts of output variables of different banks may not be comparable either (17). Take the example of customer loans on the balance sheet. Customer loans are heterogeneous and different banks may supply different types of loans requiring different amount of effort. Hence, it may be that, without being inefficient, one bank incurs higher costs per unit of loans. As a result, this bank will incorrectly be judged as being inefficient. In our study this problem is potentially severe. Namely, as our focus is on the European Union we will have to assume that within this area output proxies can be compared. Although the implementation of the Second Banking Directive on 1 January 1993 implied a considerable harmonisation of the EU banking laws, it is clear that there are still large structural differences between EU member states. We must bear this in mind when interpreting the results in section 5.

14) Loans are created by taking the 'total loans', which includes mortgages, from the Bankscope database, and subtracting 'loans to municipalities / government' and 'loans to group companies / associates'. The latter two variables are subtracted as we suspect that relatively few actions need be undertaken when offering loans to these groups of borrowers and thus these assets do not significantly incur additional costs. We share the opinion that mortgages may also imply a different amount of services per unit than other loans and therefore should be treated as an separate output variable. However, unfortunately for most countries Bankscope data does not separate mortgages from loans.

15) Using Bankscope terminology, we add up 'equity investments' and 'other investments'.

16) There is also an econometric argument for it since scaling reduces the problem that the model errors are not orthogonal to the regressors in a cost model specification and on that score the fundamental orthogonality condition is not fulfilled.

17) Mester (1996) attempts to address this problem by including the average volume of non-performing loans as a measure for the quality of the loan portfolio.

4. The structure of the European banking sector

The focus of our study is on *credit institutions*, as defined in the two EU Directives as "an undertaking whose business is to receive deposits or other repayable funds from the public and to grant credits for its own account" (First banking Directive, 1977) (18).

The structure of the banking sector of the EU-15 countries varies considerably.

Table 1 reports the country of origin and the type of 1974 banks which were left over after cleaning of our data (19). In the table we have grouped the banks into four categories: Commercial Banks (Commercial), Savings Banks and Co-operative Banks (Savings), Real Estate/Mortgage Banks (Mortgage), and Medium & Long Term Credit Banks and Non Banking Credit Institutions (Long-term and Non-bank). We will follow this classification throughout the rest of the paper. From this table, which fairly well covers the overall European banking industry, and Figure 2 it can be seen that the structure of the banking sectors of the EU-15 countries varies considerably. In particular, Austria, Germany, Italy and Spain have relatively many savings banks (more than 40% of the total). On the other hand, in Ireland, Greece, Luxembourg, The Netherlands, Sweden and the UK, less than 10% of the credit institutions of our sample are savings banks. Although these numbers slightly change when including all banks which reside in Europe, the broad picture holds true for the whole

Table 1. Number of credit institutions in the EU-15 analysed in this study

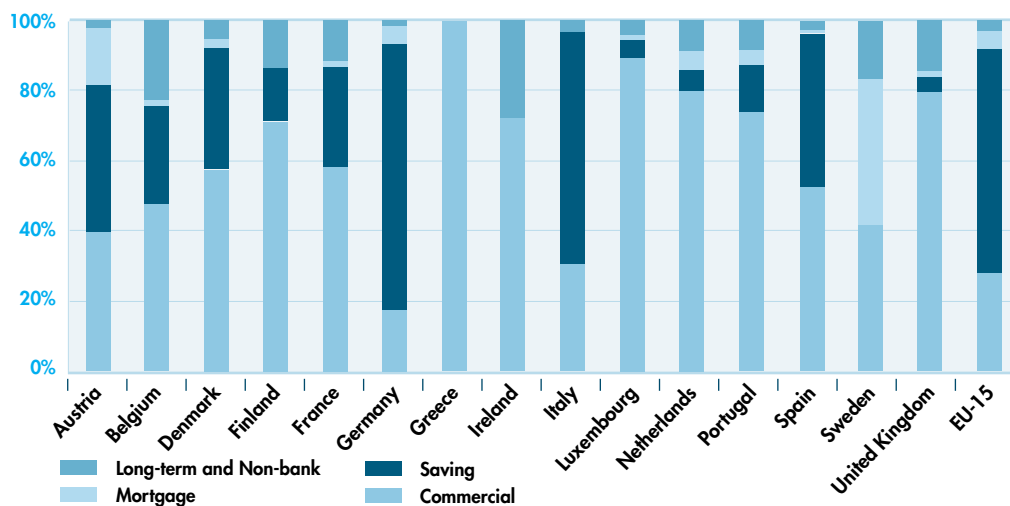
Country (Population in millions in 1995)	Commercial	Savings	Mortgage	Long-term and Non-bank	Total
Austria (8.05)	20	21	8	1	50
Belgium (10.14)	33	19	1	16	69
Denmark (5.23)	47	28	2	5	82
Finland (5.11)	5	1	0	1	7
France (58.15)	171	86	3	35	295
Germany (81.64)	156	673	49	8	886
Greece (10.46)	17	0	0	0	17
Ireland (3.58)	5	0	0	2	7
Italy (57.29)	57	129	0	8	194
Luxembourg (0.4)	86	5	1	5	97
Netherlands (15.45)	28	2	2	3	35
Portugal (9.9)	18	3	1	2	24
Spain (39.21)	66	55	1	3	125
Sweden (8.83)	5	0	5	2	12
United Kingdom (58.26)	59	3	1	11	74
EU-15 (371.7)	773	1025	74	102	1974

Sources: IFS and BankScope.

18) To translate this in practical BankScope terms, we selected "Commercial Banks", "Savings Banks", "Cooperative Banks", "Real Estate/Mortgage Banks", "Medium & Long Term Credit Banks", and "Non Banking Credit Institutions".

19) See Schure and Wagenvoort (1999) for a detailed description of the bank selection criteria.

Figure 2. Percentages of banks of different legal status in the European Union



Source: Bankscope.

European banking sector. For instance, while not in our data set, there are a few savings banks in Sweden and Greece.

Another striking fact from Table 1 is that Austria, Belgium, Denmark, France, Germany and, last but not least, Luxembourg have relatively many banks. In these countries there are more than 5 banks per 1 million of inhabitants whereas the median in Europe is only about 3.2 banks per 1 million people.

For the overall European banking industry, average costs fell by one-quarter from 1993 to 1997, but to interpret this we have to take into consideration changes to input prices and the mix of outputs.

Figure 3 shows that across Europe there are also considerable differences in the cost levels. Average costs, i.e. the ratio of costs over total assets, range for most countries between 4% and 8%. Besides the striking outlier of Greece, average costs are also relatively high in France, Italy, Luxembourg and Portugal when compared with the EU-15 average (of 6.6% in 1997) (20). In all European countries, however, costs per unit of assets substantially decreased. Figure 4 shows that for the overall European banking industry, average costs fell about 25% during the period 1993-1997.

It would be premature to conclude from Figure 3 and Figure 4 that Greek banks are more inefficient than other European banks or that the performance of European banks has improved over time. For testing these kinds of hypotheses we have to take into consideration changes in the input prices and changes in the level and mix of the outputs. For example, it is notable that the interbank fund rate in 1997, on average, is only 47% of the prevailing rate in 1993. Indeed, our cost frontier regression (presented in the next section) gives a fund price elasticity of about 40% with respect to average costs. This means that average costs of X-efficient banks decreased with roughly 20% just because the fund rate fell from 8.4% to 4.5%. Figure 4 shows this relationship between average costs and the fund rate for the European Union. Evidently, given the sharp fall in the price of funds in Europe

20) The EU-15 averages in figures 1 to 4 are constructed by applying country weights on the basis of the share of each country in total European assets.

one may expect substantially lower average costs for banks in general. Whether banks have actually improved in efficiency terms can only be detected by careful interpretation of the cost frontier regression results.

Figure 3. Costs over total assets in the European Union, full sample

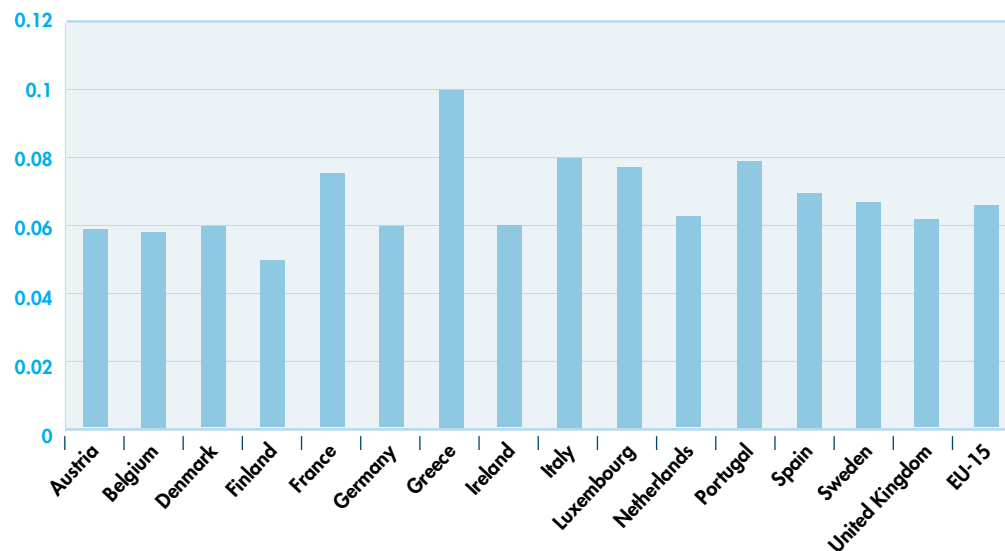
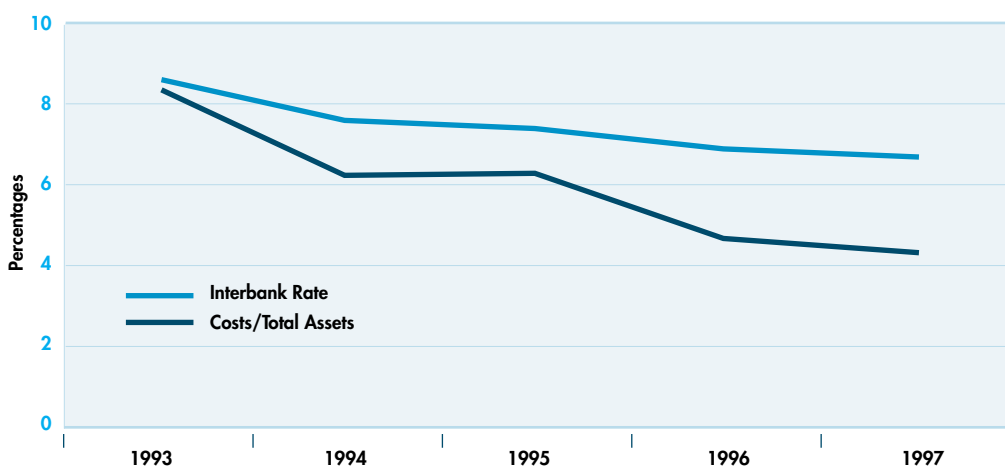


Figure 4. Costs over total assets and the interbank rate in the EU-15



Substantial differences across the banking industry are also revealed by looking at the banks' output structure in the respective European countries. Figure 5 shows the decomposition of the earning assets. On average, equity investments are less than 2% of total assets whereas 50% of the balance total consists of loans and mortgages. Luxembourg and Greece have relatively many "other assets". As mentioned before, these assets, such as treasury and other bills, are not included as outputs in our cost model since they do not significantly incur additional costs. In the special case of Luxembourg, however, this assumption could be too restrictive.

Box 1. The functional form of the cost frontier

We have chosen the following augmented Cobb-Douglas cost function to describe the banks' technology (See Schure and Wagenvoort (1999) for a detailed explanation of the model):

$$(2) \quad \frac{TC_{it}}{TA_{it}} = \gamma_0 \left(\frac{y_{it,1}}{TA_{it}} \right)^{\beta_1} \dots \left(\frac{y_{it,5}}{TA_{it}} \right)^{\beta_5} p_{t1}^{\alpha_1} p_{t2}^{\alpha_2} p_{t3}^{\alpha_3} \sigma_1^{s_{1,it}} \dots \sigma_7^{s_{7,it}} \delta_1^{t_1} \dots \delta_4^{t_4} \gamma_1^{d_{1i}} \gamma_2^{d_{2i}} \gamma_3^{d_{3i}} + \varepsilon_{it}$$

where TC_{it} , TA_{it} and $y_{it,k}$ are the total costs, total assets, and output k of bank i in period t respectively. There are 5 outputs and 3 inputs. p_j is equal to the price of input j . We split our sample of European banks into 8 non-overlapping size groups^a and thus include 7 size dummies $s_{1,it}, \dots, s_{7,it}$. For example, the size dummy (s_1) for the group of smallest banks is defined according to $s_{1,it} = 1$ if $TA_{it} \leq 100$ ECU million, $s_{1,it} = 0$ otherwise. t_1, \dots, t_4 are four time dummies. d_{1i}, \dots, d_{3i} are the values of the type dummies to distinguish commercial banks, mortgage banks and long-term and non-bank credit institutions respectively from savings banks and ε_{it} is the random disturbance term. Let $w = (\gamma_0, \beta_1, \dots, \beta_5, \alpha_1, \alpha_2, \alpha_3, \sigma_1, \dots, \sigma_7, \delta_1, \dots, \delta_4, \gamma_1, \gamma_2, \gamma_3)$ be the vector of parameters to be estimated. Under the null hypothesis of no economies of scale, no technological progress or other structural changes and equal cost structures across different types of institutions the parameters $(\sigma_1, \dots, \sigma_7, \delta_1, \dots, \delta_4, \gamma_1, \dots, \gamma_3)$ are all equal to one.

In order to disentangle the effects of input prices on the average costs from other time-related effects such as structural changes caused by innovation in technology and deregulation we start with the following three auxiliary regressions:^b

$$(2) \quad \ln p_{tj} = \eta_{0j} + t_1 \eta_{1j} + t_2 \eta_{2j} + t_3 \eta_{3j} + t_4 \eta_{4j} + dp_{tj}, \quad j = 1, \dots, 3$$

Here $\eta_{0j}, \eta_{1j}, \eta_{2j}, \eta_{3j}, \eta_{4j}$ are the unknown parameters of the constant and time dummies and $dp_{tj}, t = 1, \dots, T$ are the errors. These errors can be interpreted as the deviation of the prices from their time pattern in Europe. By construction, the estimated deviations in the prices, after taking into account time effects, are orthogonal to the time dummies. Therefore, price effects on total costs can be separated from other effects such as technological progress and the like by substituting equation (2) in model (1).

Taking logs of both sides of equation (1) and using the equations in (2) gives:^c

$$(3) \quad \ln \left(\frac{TC_{it}}{TA_{it}} \right) = c + \beta_1 \ln \left(\frac{y_{it,1}}{TA_{it}} \right) + \dots + \beta_5 \ln \left(\frac{y_{it,5}}{TA_{it}} \right) + \alpha_1 dp_{t1}^* + \dots + \alpha_3 dp_{t3}^* \\ + s_{1,it} \kappa_1 + \dots + s_{7,it} \kappa_7 + t_1 \lambda_1 + \dots + t_4 \lambda_4 + d_1 \pi_1 + d_2 \pi_2 + d_3 \pi_3 + \eta_{it}$$

where

^a Group 1: total assets ≤ 100 million ECU, Group 2: 100 million ECU < total assets ≤ 300 million ECU, Group 3: 300 million ECU < total assets ≤ 600 million ECU, Group 4: 600 million ECU < total assets ≤ 1 billion ECU, Group 5: 1 billion ECU < total assets ≤ 5 billion ECU, Group 6: 5 billion ECU < total assets ≤ 10 billion ECU, Group 7: 10 billion ECU < total assets ≤ 50 billion ECU, Group 8: 50 billion ECU < total assets.

^b At first glance the following regression looks strange as the notation suggests that we have five observations and as many unknown parameters. However, for each country we have different price observations, so that the equation detects a general (EU-15) time pattern in each price. Subscripts indicating the relevant price in each country are omitted for notational clarity.

^c The number 1 is added to TC_{it} and $y_{it,j}, j=1, \dots, 5$ in order to have a well-defined logarithmic function.

$$(4) \quad c = \ln(\gamma_0) + \eta_{01}^* \alpha_1 + \eta_{02}^* \alpha_2 + \eta_{03}^* \alpha_3$$

$$(5) \quad \kappa_k = \ln(\sigma_k), \quad k = 1, \dots, (K-1) = 7$$

$$(6) \quad \lambda_1 = \ln(\delta_1) + \eta_{11}^* \alpha_1 + \eta_{12}^* \alpha_2 + \eta_{13}^* \alpha_3$$

$$(7) \quad \lambda_2 = \ln(\delta_2) + \eta_{21}^* \alpha_1 + \eta_{22}^* \alpha_2 + \eta_{23}^* \alpha_3$$

$$(8) \quad \lambda_3 = \ln(\delta_3) + \eta_{31}^* \alpha_1 + \eta_{32}^* \alpha_2 + \eta_{33}^* \alpha_3$$

$$(9) \quad \lambda_4 = \ln(\delta_4) + \eta_{41}^* \alpha_1 + \eta_{42}^* \alpha_2 + \eta_{43}^* \alpha_3$$

$$(10) \quad \pi_l = \ln(\gamma_l), \quad l = 1, \dots, 3$$

$$(11) \quad \eta_{li} \text{ is the new error term.}$$

Variables with superscript * indicate their estimated values.

For each cost function the sum of the input price elasticities, or α_j in the model, equals unity. We therefore estimate model (3) under the restriction:

$$(12) \quad \sum_{j=1}^3 \alpha_j = 1.$$

The parameters of interest given by vector w can be reconstructed using relationships (4)-(10) once the parameter estimates of the regression models (2) and (3) are obtained. Computing the variances of the parameters of interest sometimes causes more difficulties. See Schure and Wagenvoort (1999) for the adopted method of approximation.

Define TC_{ii}^{min} to be the estimated cost level of bank i in year t if it were on the efficient frontier:

$$(13) \quad TC_{ii}^{min} = \ln \left(\frac{TC_{ii}}{TA_{ii}} \right)^* TA_{ii}.$$

A measure for X-efficiency would be given by the fraction TC_{ii}^{min} / TC_{ii} . X-inefficiency represents the distance of a particular firm to the efficient frontier, or

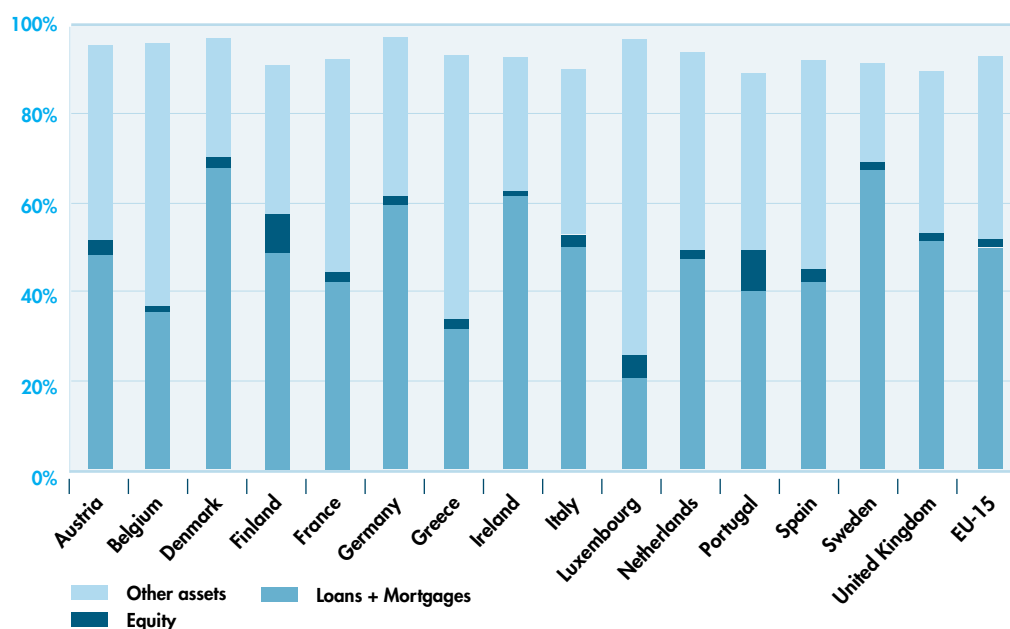
$$(14) \quad X - ineff_{ii} = \left| 1 - \frac{TC_{ii}^{min}}{TC_{ii}} \right|.$$

As was explained in section 2, efficiency may also differ because some banks do not operate at a right size. Let us define $\sigma^{min} = \min\{1, \sigma^1, \dots, \sigma^7\}$, i.e. σ^{min} represents the value of the size dummy of banks in the size class with minimum costs. Then a useful measure of size-inefficiency is defined as:

$$(15) \quad S - ineff_{ii} = \left| 1 - \frac{\sigma^{min}}{\sigma_1^{s_1, ti} \dots \sigma_7^{s_7, ti}} \right|.$$

We note that formula (15) is only applied to those banks which are member of a size class with significantly higher costs than the optimal size group of banks. If, on the contrary, the respective size dummy is not significantly different from the optimal scale dummy, then $S - ineff_{ii} = 0$.

Figure 5. Decomposition of earning assets (output over total assets), 1997



Note: The fixed capital stock, which contains for example buildings, is not explicitly shown in this graph. This explains why the columns do not add up to 100%.

5. Cost efficiency of European banking

A brief exposition of the cost frontier model is given in Box 1. The adopted estimation procedure, i.e., the Recursive Thick Frontier Approach (RTFA), is briefly explained in Box 2. Here we will discuss the results regarding the various cost efficiency measures introduced in section 2. Schure and Wagenvoort (1999) give more details of the estimated input price and output elasticities, and the full regression results.

Our cost frontier reveals that there are large inefficiencies in the European banking sector. Only 16% of the credit institutions, i.e. 321 banks, are located on the cost frontier throughout the whole sample period. The model fits the data quite well. Choosing the popular translog specification instead of the adopted augmented Cobb-Douglas function does not lead to improvement in explanatory power. Managerially efficient banks incur between 10% higher costs and 14% lower costs than the predicted optimal costs at the 95% confidence interval (21). The "thickness" of the cost frontier, that is the band around the cost function wherein the average cost of X-efficient firms fluctuate, is relatively small in comparison with the dispersion of the inefficient banks. These latter banks are highly inefficient with an average X-efficiency of 77%. In this case, the corresponding 95% confidence interval spans from 57% to 97%. The overlapping part of these two 95% confidence intervals indicate a "twilight zone" where banks are close to optimal performance but not fully cost efficient. The conclusion that can be drawn from these findings is that many banks are managerial inefficient and sometimes X-inefficiencies are extremely high. There is thus plenty of scope for improving the European banking industry.

Many banks are managerially inefficient, and sometimes these X-inefficiencies are extremely high.

21) Our estimation method, RTFA, guarantees that X-efficient banks are not systematically located above or below the frontier.

Box 2. The estimation technique

We employ the Recursive Thick Frontier Approach (RTFA), developed in Wagenvoort and Schure (1999), to estimate the model (3) described in Box 1. The traditional econometric techniques for frontier models, namely the Stochastic Frontier Approach (SFA), the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA) (see Aigner, Lovell and Schmidt (1977), Berger and Humphrey (1992) and Berger (1993) respectively) have in common that they depend on a priori assumptions that are, whether feasible or not, difficult to test. Our approach is based on the assertion that if deviations from the frontier of X-efficient companies are completely random then one must observe for this group of banks that the probability of being located either above or below the frontier is equal to a half. This hypothesis can be tested for panel data sets but requires sorting of the full sample into a group of X-inefficient banks and a group of X-efficient banks. The cost frontier is estimated using only the observations of the latter category.

Let us define the following random variable

$$(1) \quad Z = \sum_{i=1}^n indic_i$$

where $indic_i = 1$ if the event " $T - 1$ or T of the residuals r_{it} are positive" occurs or the event " $T - 1$ or T of the residuals r_{it} are negative" occurs, $indic_i = 0$ otherwise. T is equal to the number of time periods whereas n indicates the number of banks in the sample. r_{it} are the regression residuals associated with the model. The random variable Z has a binomial distribution with probability p that the indicator function $indic_i$ returns 1. For example, in our case the panel data set consists of 5 periods ($T = 5$) and thus $p = 12 \cdot 0.5^5 = 0.375$. For large samples (in n) and probability p not too small the binomial distribution approximates to the normal distribution. Therefore, we suggest to compute the following "binomial test" statistic

$$(2) \quad \lambda_B = \frac{(Z - np)^2}{np(1-p)}$$

λ_B is asymptotically chi-squared distributed with one degree of freedom.

The RTFA starts with a regression using all observations as if all banks were X-efficient. Then we compute λ_B and evaluate whether it exceeds the 99th percentile of the chi-squared distribution. If the binomial test statistic rejects that all banks included in the regression are equally X-efficient then we reduce our set of X-efficient banks by eliminating $h \cdot \delta\%$ (for instance, in our case $\delta = 1$) of the banks which incur relatively the highest cost, where h indicates the number of steps in the iterative procedure. For the remaining group of firms, which are relatively closer positioned to the regression line, a new cost frontier and corresponding binomial test statistic are computed. The algorithm stops when the largest possible group of X-efficient banks is detected.

We employ the one-sided trimmed least squares estimator in order to obtain parameter estimates of model (3) for the group of X-efficient banks which are less vulnerable to severe outlying observations below the cost frontier (extremely efficient banks) than classical OLS estimates. Wagenvoort and Schure (1999) provides more details.

Since our full sample of firms contains relatively many German saving banks it could happen that the cost frontier is solely determined by these institutions. Our regression results for the full sample of firms reveal that this problem does not occur. For the separate regression including only saving banks, however, German saving and cooperative institutions put their stamp on the shape of the cost frontier. We therefore repeated the regression for a smaller sample of saving banks which included, besides all the saving banks in the other EU countries, only 150 German saving banks. The latter ones were randomly chosen among 673 German saving institutions. Needless to say, when computing size and X-inefficiencies all German saving banks were taken into account.

Before turning to country differences in X-inefficiency, in the remainder of this section we first discuss the other potential sources of cost inefficiencies. Table 2a and Table 2b summarise some of the key statistics.

5.1 Cost differences between different types of credit institutions

Other types of banks operate at significantly lower costs than savings banks.

The full sample regression results reveal that mortgage banks and long-term and non-bank credit institutions operate at significantly lower costs than savings banks. In both cases the ratio of costs to total assets is about 20% lower than for savings banks. Structural differences between different credit institutions may underlie this result. For example, the nature of the outputs or the institutional environment of mortgage banks and long-term and non-bank credit institutions may fundamentally differ from savings banks. For this reason the cost differences mentioned above need not reflect differences in the competence of management.

Our analysis also suggests that on average managerial efficient commercial banks operate at 4% lower costs than savings banks. Again this can be due to differences in structure or X-efficiency. For example, a difference in X-efficiency could occur since managers of savings banks have more discretion over the use of the bank's cash flow.

From a cost reduction point of view, one may therefore expect that competitive forces will eventually trigger restructuring of the European banking sector in the form of de-mutualisation of savings banks. On the other hand, mortgage banks are considerably different from commercial banks in respect to the financial services they offer. It is, thus, very likely that certain types of niche players may flourish while at the same time the bulk of the European financial institutions go in the direction of commercial banking.

5.2 Technological progress

Has the cost frontier shifted over time in the sample period? For the full sample there is no evidence that the optimal cost level of a typical efficient bank changes over time in the period from 1993 to 1997. We find the same result for the regression including only the commercial banks. By contrast, we see that the costs of efficient savings bank decreases over time (i.e. when using only data on savings banks). In particular, for X-efficient banks we find a steady reduction in the costs over total assets of about 2% each year. Therefore, from 1993 to 1997 efficient savings banks reduced their costs by 9%.

With our limited study we are not in the position to judge what are the driving forces behind the drop in costs for savings banks, and why this effect did not occur for commercial banks. One can think however of several explanations. As was mentioned above, saving banks are on average less efficient than commercial banks. The reduction in the cost per unit of assets of the group of managerial efficient savings banks, could simply reflect that these banks have reduced their distance to the even more efficient commercial banks. The possible reasons for observing such a rise in X-efficiency are numerous. For instance, small saving banks may reduce costs by centrally organising the acquisition of funds on the money markets or the portfolio management of securities. Within this view, German "Sparkassen" provide an illustrative example. Cost reductions can possibly also be ascribed to the implementation of new (computer) technology that facilitates data processing, data communication with other institutions, credit risk evaluation and decision-making.

There is no evidence that the optimal cost level of efficient banks changes over the time period from 1993 to 1997.

It is not unlikely that savings banks were slower in adopting the latest technology in comparison with commercial banks since the latter group of banks are usually more market orientated. Commercial banks may have started earlier with exploiting new technology in comparison with saving banks, but the returns have faded away or were offset by other structural changes. That does not mean that technological innovation such as Internet banking will have no impact on commercial banks in the future. However, for our sample period, technological progress was statistically irrelevant for commercial banks.

Table 2. A summary of the regression results

2a. Attainable cost reductions and their sources in European banking

Factor	Full Sample	Commercial Banks	Savings Banks	
Number of banks	1974	773	1025	
	X-inefficiency	X-inefficiency	Inefficiency	
			X	Size
1997	16%	13%	9%	5.6%
1996	20%	18%	6%	5.7%
1995	19%	14%	7%	5.4%
1994	19%	14%	7%	5.4%
1993	20%	13%	7%	5.3%
Cost improvement in 1993 - 1997 (e.g. due to technological progress)	Not Significant	Not Significant	9%	

Note: The results in column 2 to column 4 are obtained by executing three separate regressions, including all banks, commercial banks and savings banks respectively.

2b. Differences in average cost among various types of European banks

	Savings versus Commercial banks	Savings versus Mortgage banks	Savings versus Long-term and Non-bank credit institutions
Costs difference per unit of assets	4%	19%	20%

Note: These results are based on the full sample regression.

5.3 Size inefficiencies

From the parameter estimates of the size dummies for the full sample we find initially increasing returns to scale and afterwards constant returns to scale. It seems that only very small banks face higher costs than the reference class of banks. In particular, banks with less assets than EUR 100 million have approximately 7.5% higher costs per asset and banks with assets between EUR 100 million and EUR 300 million have approximately 6% higher costs per asset.

Turning to the separate regression for saving banks we clearly find a U-shaped average cost curve. This indicates that small savings banks face increasing returns to scale while very large banks have decreasing returns. Savings banks with less assets than EUR 100 million have approximately 16%

higher costs per asset than the savings banks falling in the reference class. Also the next two smaller size groups have significantly higher costs per asset of roughly 3 and 5%, respectively. After that there are constant average costs until we arrived at the ten very large savings banks with total assets exceeding EUR 50 billion. These banks have roughly 10% higher costs over assets than the medium-sized reference class. Hence, small and very large savings banks can improve efficiency by choosing their total assets between EUR 600 million and EUR 50 billion.

For the group of commercial banks the size picture is much less transparent, as costs seem to jump up and down with increasing size class. In our view these rather strange results are due to the fact that commercial banks form a very diverse group of banks. Some small investment banks that offer a range of products which is substantially different from the average product mix, could belong to this group. This could also be taken as evidence that there is scope for niche players to play an important role in the banking industry.

Using the results above we can determine to which extent the banking sector may improve its performance by exploiting the increasing returns of scale. The European banking sector as a whole hardly would improve efficiency by choosing the right scale of operations. This is because small banks, although there are more than 800 credit institutions in Europe which are smaller than EUR 600 million measured in balance total, account for a small fraction of the European banking sector's assets. By contrast Table 2a shows that savings banks do have scope for improvement. By choosing the right scale, savings banks can reduce costs per asset by approximately 6%. This empirical finding is driven by France and Germany where cost reductions of approximately 8% and 6% are attainable (22). Indeed, most of the European savings banks are based in these two countries and many of them are either small or very large.

We find increasing returns to scale, but only for very small banks.

Other studies using European data (see, for instance, Altunbas and Molyneux, 1996) tend to find positive economies of scale also for larger size classes (in some cases up to a level of total assets of EUR 10 billion). Our results are more in line with previous US evidence. Hence, in our view, it remains unclear whether there are greater economies of scale in Europe than in the US.

A final remark has to be made for savings banks in countries such as Germany where there is a very high degree of co-operation between the, from a legal point of view, independent mutual organisations. One could argue that all the small savings banks in Germany constitute one large saving institution. Given such an interpretation, measuring scale economies for this group of banks makes no sense. Our results would then indicate that relatively small savings banks and the ten mega savings banks are much more X-inefficient than the others.

5.4 X-efficiency

Since inefficiency stemming from the sources discussed above is modest, it is clear that the largest cost reductions in the European banking industry can be achieved by improving management skills, i.e. by improving X-efficiency. In Table 2a we find that for the full sample of banks the average X-inefficiency in the sector is of the order 15-20% throughout the sample period. This figure is similar to what has been found for the US. Average X-inefficiencies within the European Union considerably

22) Lang and Welzel (1996) also find moderate size economies for all size classes of German cooperatives using 1989-1992 data.

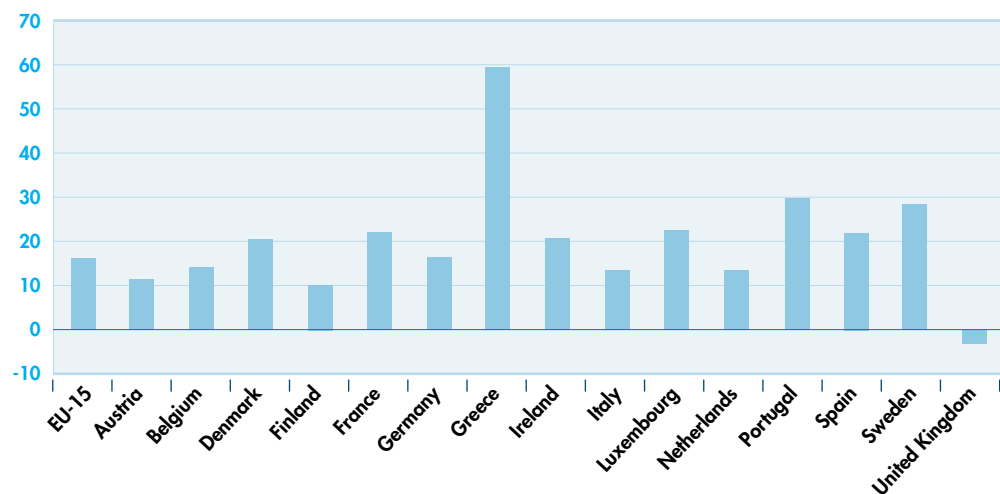
fell from about 20% in 1996 to 16% in 1997. There remains, however, plenty of scope for improving the banking sector.

Table 3. Weighted average of the estimated X-inefficiencies in the European Union, percent

Country	1997	1996	1995	1994	1993
EU-15 (1974)	16	20	19	19	20
Austria (50)	11	16	18	14	7
Belgium (69)	13	23	18	16	20
Denmark (82)	20	25	27	37	32
Finland (7)	10	17	11	28	32
France (295)	22	21	21	22	22
Germany (886)	16	19	14	14	10
Greece (17)	59	63	64	67	67
Ireland (7)	21	35	33	35	31
Italy (194)	14	18	26	22	24
Luxembourg (97)	22	20	19	11	20
Netherlands (35)	13	24	21	21	28
Portugal (24)	30	33	36	36	41
Spain (125)	22	24	25	23	29
Sweden (12)	28	30	23	35	39
United Kingdom (74)	-4	8	10	13	20

Note: The weight of each bank is obtained from its total asset amount. The number of banks in each country is given in parentheses.

Figure 6. X-inefficiency of European banks in 1997, percentages



In Table 3 we have computed country averages of X-inefficiency in each year. In constructing these averages we weight the X-inefficiencies of a particular bank by its share of total bank assets in the respective country (23). In the same way we also created averages for the European Union. Who are Europe's efficient bankers? There are some striking differences in X-efficiency in Europe that are worth mentioning. These are also illustrated in Figure 6. In the UK, bankers were able to reduce their managerial inefficiency from approximately 20% in 1993 to full X-efficiency in 1997. On the other hand Greek banks appear to be the most inefficiently managed in Europe. Although Greek bankers improved, average X-inefficiency still exceeded 59% in 1997. Like the UK, the Netherlands and Finland show considerable gain in X-efficiency in the sample period. Conversely, Austria, France, Germany and Luxembourg did not improve over time or even worsened. The other differences we observe are less pronounced and sometimes do not match with the prior views that one may have. For example, Sweden is found to have a relatively inefficient banking sector with X-inefficiency ranging between 39% (1993) and 28% (1997). In Italy on the other hand, which many think is still at an early stage in restructuring, the banking sector is found to be relatively efficient (X-inefficiency fell from 24% in 1993 to 14% in 1997).

The UK, Netherlands and Finland show considerable gains in efficiency. Many countries, such as Austria, France, and Germany, do not improve or even worsen. Greek banks are the most inefficient.

Splitting up the sample into commercial banks and savings banks reveals some additional interesting results. Looking at the EU averages in Table 2a it is clear that commercial banks have higher average X-inefficiencies (around 13%) than savings banks (around 7%), when each type is compared to its respective cost frontier. We also investigated whether there are differences in X-efficiency between small and large banks. Here we defined a bank to be 'large' when its 1997 total assets amount exceeded EUR 10 billion. The other banks were defined as 'small'. In our data set there are 200 big banks and 1774 small ones. Table 4 shows that, on average, large banks have around 6% lower X-inefficiency than small banks. To us this result seems somewhat counterintuitive, as we would expect that smaller banks are easier to manage. Possibly large banks operate in a more competitive environment which forces them to be more efficient. Another reason can be that managers of large commercial banks are better monitored by shareholders. It is interesting to note that both small and large banks reduced their X-inefficiency over time.

Table 4. Weighted average of X-inefficiency of small and large banks, percent

Year	Large	Small
1997	14	20
1996	18	25
1995	18	24
1994	18	24
1993	19	24

Note: A bank is defined to be 'large' when its total assets in 1997 exceeded EUR 10 billion. The remainder is 'small'. In our sample there are 200 big banks and 1774 relatively small ones.

23) In order to reduce the influence of severe outlying observations we ignore those banks with X-inefficiencies that are extremely large or small. This can be revealed by means of a (two-sided) trimmed least squares regression of X-inefficiency on a constant and country dummies. We evaluate whether the absolute value of robust standardized residuals from this regression exceed the cut-off value 5.

Our findings on scale economies cannot explain the recent wave of national and cross-border bank mergers both in Europe and the US. First, our study focused on the bulk of European credit institutions (most of them have total assets less than EUR 5 billion euro) and is less well designed for analysing the cost structure of giants, the so-called mega banks. Also, our model cannot fully detect economies of scope (24).

Large banks have lower X-inefficiency than small banks - a somewhat counterintuitive result since we would expect that smaller institutions are easier to manage.

Here we consider only one particular merger case to illustrate our results (25). In 1994 Lloyds Bank and TSB Bank joined hands by establishing Lloyds TSB Group, one of the largest credit institutions in the United Kingdom, employing 82 850 people to manage assets of EUR 92 billion in 1997. Both banks however still exist as separate legal entities. In view of our study, this particular example is of special interest since it involves a merger between two banks with substantial differences in X-efficiency and a difference in type since Lloyds is a commercial bank while TSB was a saving bank. Neither of these banks was in the set of X-efficient banks that determined our cost frontier. In 1993, Lloyds was operating at an X-inefficiency level of 19% which means that it was very close to the average X-inefficiency of UK credit institutions at that time (see Table 3). TSB was much worse as is shown in Table 5. In comparison with a managerial efficient bank of equal size, TSB incurred 37% higher costs per unit of assets in 1993. Although TSB is still, at the end of 1997, drastically under-performing with respect to Lloyds, the merger of the two institutions did work out well for both of them. By 1997 Lloyds bank had reached best practice while TSB reduced costs by 13%. The remarkable gap in cost efficiency between Lloyds and TSB means that overall group profitability has scope to much increase if TSB can also be brought to best practice. From an economy of size point of view, both banks before 1994 were already well beyond the point at which we found increasing returns to scale.

Table 5. X-inefficiency of Lloyds and TSB, percent

Year	Lloyds Bank PLC	TSB Bank PLC
1997	0	24
1996	11	32
1995	8	31
1994	18	25
1993	19	37

6. Conclusion

The number of studies that evaluate the performance of European banks sink into insignificance beside the voluminous literature on US financial institutions. This paper partially fills this gap by investigating the cost efficiency of almost 2000 credit institutions across 15 European countries.

As size economies are exhausted at a balance sheet total of EUR 600 million, we do not find major economic gains from economies of scale for the overall European banking industry. In contrast with the consequences of size and type, large cost reductions are possible when managers organise

24) Hughes and Mester (1998) argue that large banks take more risk due to the financial scale economies mentioned in section 3. As a consequence, the quality of the output mix of larger banks is of a different nature than the quality of the financial products of small credit institutions. Therefore, large banks may incur higher costs per unit of output and thus measures of output quality must be included in the cost model when assessing efficiency.

25) Vander Venet (1996) analyzes the effects of 492 takeovers in European banking over the period 1988-1993.

One can only guess about the rapidity with which restructuring will take place. However, there is plenty of scope to reduce costs throughout Europe.

their business in a more efficient manner. Our results show that more than 80% of the European banks are not located at their cost frontier and that these banks can reduce the cost per unit of assets with more than 16% on average. The slimming course of the European banking sector has already led to substantial cost cutting across Europe, and X-inefficiency decreased on average say about 4% over our sample period. A remarkable result is that bankers in the UK were able to reduce X-inefficiencies from over 20% to essentially zero in this fairly short time span. Although some countries showed rapid improvement in bank performance, in other countries such as Austria, France, Germany, and Luxembourg, bankers have yet to step on the scales. Therefore, considerable differences in cost efficiency still exist across Europe.

This empirical evidence was obtained by estimating an augmented Cobb-Douglas model, which allows us to disentangle the effects of input prices on average costs from other time-related effects such as technological progress. Furthermore, an innovative regression technique was also used.

Although the European banking industry is at the beginning of a new era with the introduction of the euro, one can only guess about the rapidity at which the necessary restructuring will take place. However, there is plenty of scope to reduce costs and enhance efficiency throughout Europe.

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