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Efficiency analysis in banking firms: An international comparison

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Abstract

The intensive process of financial European integration, together with the profound transformation and deregulation that has taken place in the Spanish banking system, justifies the evaluation of its efficiency in comparison with that of other banking systems. In this context, the aim of this study is to analyze the productivity, efficiency and differences in technology of several banking systems. Using a non-parametric approach together with the Malmquist index, we compare the efficiency, productivity and differences in technology of different European and US banking systems for the year 1992. © 1997 Elsevier Science B.V.

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1. Introduction

Efficiency analysis of financial institutions has received increasing attention from specialists in recent years. The intensive process of European financial integration, together with the profound transformation that has taken place in the Spanish banking system (SBS) justifies the evaluation of its efficiency in comparison with that of other banking systems. After a period of intensive and continuous liberalization, the SBS has become a much more competitive market. At least three causes can be identified behind this process. First, the disappearance of a number of regulatory limitations like entry barriers, interest rate controls by the Bank of Spain, compulsory investment coefficients to underprice the cost of financing the public deficit, limits on branch expansion, high reserve requirement coefficients, etc. Second, the emergence of new financial intermediaries carrying out functions similar to those traditionally associated with banks. Thirdly, a disintermediation process giving markets a growing role in allocating financial funds.

The existing literature on SBS efficiency has centered traditionally on the analysis of scale and scope economies under the implicit assumption that all firms are efficient. On the contrary, very few studies have focused on efficiency analysis, in spite of the fact that the greatest potential gains on costs are obtained by eliminating existing inefficiencies rather than trying to reach the adequate size and scope of financial intermediaries (Doménech, 1992; Grifell et al., 1992; Grifell and Lovell, 1993; Pérez and Pastor, 1994). Furthermore, there exist very few studies where SBS efficiency is compared with the efficiency of other banking systems (Pastor et al., 1994, 1995).

The aim of this study is to analyze productivity, efficiency and differences in technology in the SBS,

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using a non-parametric approach, carrying out a comparison with other countries for the year 1992. This paper introduces some innovative elements into the studies done on Spain. The most relevant is the decomposition of the differences in productivity of different banking systems into differences in levels of efficiency (catching-up) and distances between the frontiers themselves. (A similar concept was introduced by Nishimizu and Page (1982) using a different approach. Färe et al. (1992) and Berg et al. (1992a) use the same approach as in this paper but it is applied to the analysis of productivity changes and not to differences on productivity. An excellent survey on these studies can be found in Groskopf (1993).)

2. Efficiency measures based on the production frontier

Traditionally, computed efficiency indicators are based on the alternative use of production, cost or profit frontiers. The frontier can be defined in each case, for a set of observations, assuming that it is not possible to find any observation above the frontier (in the case of the production and profit frontiers) or below it (in the case of the cost frontier).

More specifically, the definition of the production frontier is associated with the maximum attainable level of output, given a level of inputs, or the minimum level of inputs required to produce a given output. The profit frontier is associated with the maximum level of profits that can be obtained given a set of output and input prices. Since our purpose is the analysis of both the technical efficiency and the differences in productivity, and not that of the allocative efficiency, a production frontier will be used. (The use of the cost and profit frontiers makes possible the study of the firm efficiency in both its technical and allocative components. For the cost frontier, the knowledge of input prices is necessary; whereas, in the case of the profit frontier, input and output prices are needed. In some cases, this higher requirement of information becomes an additional inconvenience.)

The common characteristic of these three frontiers is *optimality*. They are derived from a maximum or minimum condition under given conditions on technology and prices describing a *frontier or a boundary*. Efficiency level estimations are based on the distance from each observation to such a frontier. There are different techniques employed in estimating the frontier. These are based on parametric methods (when some hypotheses are introduced on the frontier functional form, based on their properties) and in non-parametric methods (when observational criteria based on programming techniques are used to construct the frontier). The models can also be classified by the way they deal with the error term. If they do not recognize the presence of an error term, so that all firms lie below the frontier, the model is called deterministic. Alternatively, the presence of an error term gives rise to the stochastic models. Additionally, models are recognized as mathematical if (linear or quadratic) programming is used or, alternatively, as econometric models.

In this study we estimate the productive change through the use of Malmquist indexes. These indexes use the notion of *distance function*, so that a previous estimation of the corresponding frontier is required. Such an estimation is carried out by using *data envelopment analysis (DEA)*, a non-parametric deterministic frontier method based on mathematical linear programming.

3. Methodology

Using a linear programming technique — DEA — we are able to compute a *production frontier* as the superior envelope of the data. DEA calculates an indicator of efficiency for each firm, measured as the distance that separates it from the frontier. On the other hand, relative productivity is analyzed using the Malmquist index, which allows us to compute the differences in productivity between two firms belonging to different banking systems.

The indexes that have been used most frequently in the literature to analyze productive change are those of Fisher (1922), Törnqvist (1936) and Malmquist (1953). The benefits in using indexes like those of Fisher and Törnqvist lie in that they do not require the estimation of the technology; in fact, only quantities of outputs and inputs, as well as prices, are needed.

On the other hand, the main drawback presented by the Malmquist index is that it requires the estimation of the production frontier. (However, Caves et al. (1982) show that under general given conditions, the geometric average of the two Malmquist productivity indexes is equal to the quotient between the Törnqvist indexes of outputs and inputs, which require data on outputs, inputs and prices, but not on technology.) Nevertheless, this method has three interesting features. First, contrary to the other two methods, it does not require a cost minimizing or profit maximization condition. Second, it does not require any data on prices. This is convenient for those cases in which there are data problems and/or the presence of market power makes their use inadvisable. Lastly, it allows the decomposition of productive change into technical efficiency (catching-up) and technical change (frontier shifts), the main objective of our study (see Grifell and Lovell, 1993).

Moorsteen (1961) was the first author to use Malmquist's idea, initially conceived in the consumer context, to compare the input of one firm in two different moments of time, and to compute the maximum factor by which the inputs of one period might be reduced in such a way that it could still produce the observed level of output corresponding to the other period.

On the other hand, Caves et al. (1982) adapted the problem of a firm observed in two different periods of time to that of two firms observed simultaneously, establishing the relationship between the Malmquist and Törnqvist indexes. They developed the Malmquist productivity index with two approaches. The first approach defines the differences in productivity as the differences in the maximum reachable output given some input levels. It is called the *output based Malmquist productivity index.* Alternatively, the *input based Malmquist productivity index* measures the differences in productivity as differences in the minimum level of inputs that make possible the production of some given output levels. Caves et al. (1982) show that both indexes give identical results only when returns to scale are constant.

This study makes use of the input based Malmquist productivity index because it provides the best intuition for potential savings by cutting out the excessive use of inputs (Berg et al. (1992a) also use this approach; Grifell and Lovell (1993) use the output-based index).

Caves et al. (1982) used the concept of distance function, although without establishing a connection with the efficiency measures of the Farrell type (see Farrell, 1957). In particular, they assumed that firms were efficient, that is, that they always operated on the frontier. It was Berg et al. (1992a) who related the two concepts and allowed for the presence of existing inefficient observations. For that particular reason, the concept of *technological frontier* is substituted by *technology*, so that in order to carry out reasonable comparisons between firms, they must be adjusted first to the corresponding frontier.

3.1. Technology characterization

Let us assume that the transformation function that describes the technology of banks is:

$$F_i(y^i, x^i) = 0 \quad i = 1, \dots, S \tag{1}$$

where $y^i = (y_1^i, \dots, y_N^i) \in \mathbb{R}_N^+$ is the output vector, $x^i = (x_1^i, \dots, x_M^i) \in \mathbb{R}_M^+$ denotes the input vector corresponding to country i, and S is the number of banking systems considered.

Technology can be represented in a more convenient way through the '*input distance function*' used by Caves et al. (1982):

$$D^i(y^j, x^j) = \operatorname*{Max}_{\mu_{ij}} \left[\mu_{ij}: F_i\left(y^j, x^j/\mu_{ij}\right) = 0 \right] \quad i, j = 1, \dots, S \tag{2}$$

Where the scalar μ_{ij} is the maximum reduction of the input vector of the firm of country j (x^j), the resulting deflated input vector (x^j/μ_{ij}) and the output vector (y^j) are on the frontier of the banking system of country i.

If $i = j$ we are comparing each firm with all firms in the same banking system, so that the input distance function is $D^i(y^i, x^i) \geq 1$. This distance is equal to one when the evaluated firm is efficient and, therefore, on the frontier.

On the contrary, if $i \neq j$ the distance function can take values less than one, since observation j belongs to a different banking system than the one of reference (i).

3.2. The Malmquist index

The Malmquist index of productivity based on inputs (henceforth will be referred to simply as the

Malmquist index), taking the technology of the banking system of country i as reference to compare two banks belonging to countries 1 and 2 is defined as:

$$M_i(y^2, x^2, y^1, x^1) = \frac{D^i(y^1, x^1)}{D^i(y^2, x^2)} \tag{3}$$

$M_i > 1$ indicates a higher productivity of the firm in country 2 than that in country 1, since the reduction of the input vector of the firm in country 1 necessary to reach the frontier of country i is higher than that corresponding to the firm belonging to country 2. On the other hand, $M_i < 1$ implies that the productivity of the bank in country 2 is inferior to that of the bank in country 1.

One of the main virtues of the Malmquist index is that it can be decomposed into two parts: the catching-up effect and the distance between the frontiers considered (see Nishimizu and Page, 1982; Berg et al., 1992a,b; Grifell and Lovell, 1993).

$$M_i(y^2, x^2, y^1, x^1) = \frac{D^i(y^1, x^1)}{D^i(y^2, x^2)} = \frac{D^1(y^1, x^1)}{D^2(y^2, x^2)} \cdot \frac{D^i(y^1, x^1)/D^1(y^1, x^1)}{D^i(y^2, x^2)/D^2(y^2, x^2)} \tag{4}$$

The first quotient represents the relative efficiency of the firms in countries 1 and 2, while the second term shows the relative distance of the frontiers of countries 1 and 2 with respect to country i.

If the efficiency of the banking systems in country 1 and 2 is equal, the first term will be equal to 1 and the productivity difference represented by M_i will be explained only by the distance between their respective frontiers. On the contrary, if the second term is 1 (both frontiers are exactly the same), the productivity differences in the banking systems 1 and 2 estimated by M_i will be explained only by the differences in their actual levels of efficiency (catching-up).

In all other cases, the differences in productivity reflected by M_i will be a combination of differences in efficiency with differences in the frontiers.

Färe and Lovell (1978) formalized the existing relationship between the distance function based on inputs and the Farrell measures of input savings $E_{ii}(y^i, x^i)$, and they showed that the distance function is equal to the inverse of the Farrell measure of input savings:

$$D^i(y^i, x^i) = \left[E_{ii}(y^i, x^i)\right]^{-1} \tag{5}$$

To illustrate all the concepts mentioned above, let us assume the most simple case of production of only one output with only one input (see Fig. 1). Consider two combinations representing two banks belonging to two countries 1 and 2 (y^1, x^1) and (y^2, x^2). Farrell efficiency measure (the inverse of the distance function) is computed by comparing each observation with the corresponding frontier. In this way we obtain the following ratios, where the subindex indicates the frontier of reference: $E_{11} = x_1^1/x^1$, $E_{22} = x_2^2/x^2$, $E_{12} = x_1^2/x^2$, $E_{21} = x_2^1/x^1$.

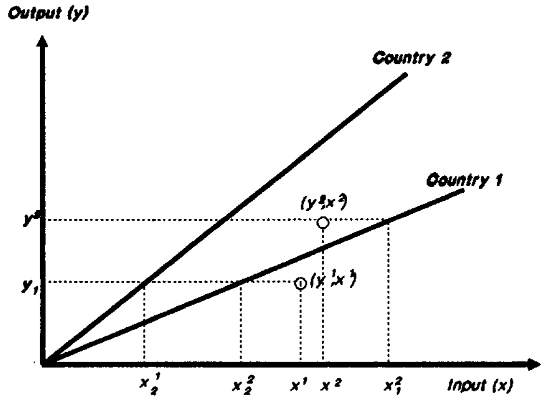

Fig. 1. Malmquist index decomposition. Two countries 1 and 2 (y^1, x^1) and (y^2, x^2). The Farrell efficiency measure is computed by comparing each observation with the corresponding frontier. In this way we obtain the following ratios: $E_{11} = x_1^1/x^1$, $E_{22} = x_2^2/x^2$, $E_{12} = x_1^2/x^2$, $E_{21} = x_2^1/x^1$. The Malmquist index can be expressed as: $M_1 = E_{12}/E_{11} = (x_1^2/x^2)/(x_1^1/x^1) = (y^2/x^2)/(y^1/x^1)$. In this case is a simple ratio between productivity indexes of the two firms in countries 1 and 2. The decomposition of the Malmquist index can be expressed as $M_1 = E_{12}/E_{11} = (E_{22}/E_{11}) \cdot (E_{12}/E_{22})$, the first term being the catching-up effect (MC), and the second one the distance between frontiers (DF). The situation reflected indicates that the bank in country 2 is less efficient than the bank in country 1 (MC < 1), and the frontier of the banking system of country 2 is above the frontier of country 1 (DF > *1*). The global result is a productivity index less than one, meaning higher productivity for country 2 ($M_1 < 1$).

Given that under constant returns to scale $x_1^2/x_1^1 = y^2/y^1$ the Malmquist index, taking as reference country 1 ($i = 1$), can be described as:

$$M_1(y^2, x^2, y^1, x^1) = \frac{D^1(y^1, x^1)}{D^1(y^2, x^2)} = \frac{E_{12}}{E_{11}} = \frac{x_1^2/x^2}{x_1^1/x^1} = \frac{y^2/x^2}{y^1/x^1} \qquad (6)$$

The Malmquist index can be reduced in this case as a simple ratio between productivity indexes of the two firms in countries 1 and 2.

For this simple example, the decomposition of the Malmquist index into the catching-up effect (MC) and the distance between frontiers (DF) can be expressed as:

$$M_1(y^2, x^2, y^1, x^1) = \frac{E_{12}}{E_{11}} = \frac{E_{22}}{E_{11}} \cdot \frac{E_{12}}{E_{22}} = \mathrm{MC}(y^2, x^2, y^1, x^1) \cdot \mathrm{DF}(y^2, x^2, y^1, x^1) \qquad (7)$$

where the catching-up or difference in efficiency levels of countries 1 and 2 would be (note that according to the situation reflected in Fig. 1 this expression would be less than one, indicating that the bank in country 2 is less efficient than the bank in country 1, comparing both to their own banking systems):

$$\mathrm{MC}(y^2, x^2, y^1, x^1) = \frac{E_{22}}{E_{11}} = \frac{x_2^2/x_2}{x_1^1/x_1} \qquad (8)$$

and the distance between the frontiers of the two countries could be expressed as (in Fig. 1 this distance is greater than one, an indication that the frontier of the banking system of country 2 is above the frontier of country 1. The global result is a productivity index less than one, meaning higher productivity for country 2):

$$\mathrm{DF}(y^2, x^2, y^1, x^1) = \frac{E_{12}}{E_{22}} = \frac{x_1^2/x^2}{x_2^2/x^2} = \frac{x_1^2}{x_2^2} \qquad (9)$$

In Fig. 2 we observe the difference between the assumption of constant returns to scale (frontier OF) and variable returns to scale (frontier ABCDE). Farrell measure based on inputs is obtained as the horizontal distance that separates each firm from the corresponding frontier for each year. The *global technical efficiency* measure of input savings for firm h can be expressed as:

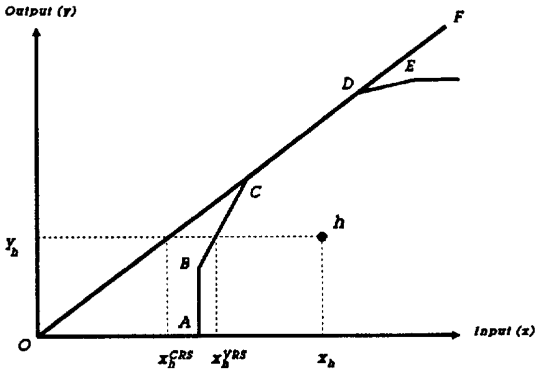

Fig. 2. Measurement of technical efficiency under constant and variable returns to scale. The frontier under the assumption of constant returns to scale (OF) and under the assumption of variable returns to scale (ABCDE). Farrell measure based on inputs is obtained as the horizontal distance that separates each firm from the corresponding frontier for each year. The *global technical efficiency* is $E_h = x_h^{CRS}/x_h = (x_h^{VRS}/x_h) \cdot (x_h^{CRS}/x_h^{VRS})$, the first term being the *pure technical efficiency* (ETP) and the second one the *scale efficiency* (ES).

$$E^h = \frac{x_h^{CRS}}{x_h} \qquad (10)$$

However, it is possible to consider that one part of this global technical inefficiency may be due to the fact that firms operate at a suboptimal scale (scale inefficiency), the rest being pure technical inefficiency. The procedure to decompose the global technical efficiency (E) into *scale efficiency* (ES) and *pure technical efficiency* (ETP) is based on comparisons of Farrell measures obtained under constant, non-increasing and variable returns to scale. If all three measures coincide, the firms are operating at an optimal scale, and otherwise, on a suboptimal scale.

The Farrell measure can then be expressed as the product of the pure technical efficiency and the scale efficiency:

$$E^h = \frac{x_h^{CRS}}{x_h} = \frac{x_h^{VRS}}{x_h} \cdot \frac{x_h^{CRS}}{x_h^{VRS}} = \mathrm{ETP}^h \cdot \mathrm{ES}^h \qquad (11)$$

where the pure technical efficiency, assuming variable returns to scale, is:

$$\mathrm{ETP}^{\mathrm{h}} = \frac{x_h^{\mathrm{VRS}}}{x_h} \tag{12}$$

the scale efficiency being

$$\mathrm{ES}^{\mathrm{h}} = \frac{x_h^{\mathrm{CRS}}}{x_h^{\mathrm{VRS}}} \tag{13}$$

4. Computation of distance functions using DEA approach

For the computation of the distance function we rely on the Farrell measures obtained by using *data envelopment analysis* (DEA). This technique elaborates a frontier of reference through methods of linear programming. The frontier is composed of efficient banks and linear combinations of them. Efficiency measures are based on the distance that separates each firm from this frontier. This distance is measured through the potential input savings or through the potential increase in outputs. We selected the first measure for the reasons given above.

In this study we compute the frontiers of reference imposing constant returns to scale. However, DEA easily allows for variable returns by introducing an additional restriction on the sum of the weights of each firm as will be seen below. Nevertheless, since Malmquist indexes estimate the productive change that has occurred over a period of time by comparing firms at one moment of time with frontiers at other moments of time, the assumption of constant returns to scale (CRS) is sufficient to assure a solution to the problem. (The introduction of the assumption of variable returns to scale has caused problems only when comparing a firm belonging to a banking system which is not the reference banking system. In this case optimization (Eq. (14)) may not have a solution. We found problems only for some large banks. There are two possible solutions, either to use FDH approach (see Tulkens, 1993), or to assume constant returns to scale. In this study we adopt the second alternative.)

In general, the problem faced by a firm belonging to country j, with respect to the frontier of reference composed by H firms in country i that produce N outputs using M inputs, may be stated as:

$$\begin{aligned}
&\min_{\mu} E_{ij}^h && h = 1,\dots, H, \forall i;\\
& && i, j = 1,\dots, S\\
&\text{s.t.}\\
&\sum_{h=1}^{H} \mu_h \cdot y_{nh}^i \geq y_{nh}^j && n = 1,\dots, N \text{ outputs}\\
&\sum_{h=1}^{H} \mu_h \cdot x_{mh}^i \leq E_{ij}^h \cdot x_m^j && m = 1,\dots, M \text{ inputs}\\
&\mu_h \geq 0
\end{aligned} \tag{14}$$

Solving the problem for each of the H firms, we achieve the corresponding estimates of Farrell measures E_{ij}, whose inverse is equal to the distance function. The introduction of the additional restriction $\sum \mu_h = 1$ allows us to generalize the problem to the case of variable returns to scale (VRS).

Obviously, if $i = j$ we are comparing a firm with its own banking system, so that $E_{ii} < 1$ indicates that it is possible to reduce the use of inputs in a $(1 - E_{ii})$% and produce the same outputs through efficiency improvements that have been proven attainable by other firms.

On the contrary, if $i \neq j$ we are comparing a firm of banking system j with the frontier of reference of country i, so that either $E_{ij} > 1$ or $E_{ij} < 1$ may occur. The first inequality means that the firm in country j is more efficient than any firm of country i (even those on the frontier). In this case, the firm in country j would find itself in a situation above the frontier of country i. The opposite case, $E_{ij} < 1$, would mean that observation j is below the frontier of reference of country i.

5. Data

The data used are those of the IBCA panel (see IBCA Ltd.). The deterministic nature of the technique used implies that we do not consider the possibility that a random term may bias the results when the observations of some of the firms — by their own nature, by specialization or by random causes — could otherwise be considered atypical.

The need to establish domestic and international comparisons imposed certain restrictions in obtaining a domestic and internationally homogeneous sample of banks in terms of specialization.

Obviously, if what we want is the measurement of bank efficiency through the distance that separates them from the production function, we should consider only those firms that share the same technology to produce the same output vector (specialization). This consideration requires the choice of some level of specialization. We have included commercial banks and rejected savings, public, industrial, development, regional and UK building societies, as well as merchant banks.

The data refer to non-consolidated bank income and balance sheet accounts corresponding to 1992. Finally the sample is formed by a study of the following banks: 168 in the US, 45 in Austria, 59 in Spain, 22 in Germany, 18 in UK, 31 in Italy, 17 in Belgium and 67 in France. (Variables are in US dollars using prevailing exchange rates. We exclude some banks with no information on the income account. Nevertheless, the selected sample represents more than 90% of commercial banks total assets and includes almost all commercial banks specialized in retail banking.)

6. Selected variables: Inputs and outputs

The choice of output and input variables is the first difficult question that must be addressed by any study on banking. Such a choice will be influenced by the selected concept of banking firm, by the particular question under consideration and, also, by the availability of reliable information.

The main discrepancies between authors refer to the role of deposits and, more specifically, whether they should be treated as inputs or outputs. The answer to this question has been multiple. Some studies treat them as inputs (Mester, 1989; Elyasiani and Mehdian, 1990a,b, 1992), as outputs (Berger and Humphrey, 1993; Berg et al., 1992a; Ferrier and Lovell, 1990; Rangan et al., 1988), or simultaneously as inputs and outputs (Humphrey, 1992; Aly et al., 1990).

Recently, new studies have tried to solve the problem of identifying the role of deposits in very different ways. Thus, Berger et al. (1993) avoid the problem of identification by analyzing firm efficiency through the profit function. Fixler and Zieschang (1993) use a method that allows them to establish whether a financial product is an input or an output according to its net contribution to firm income. If the return on a financial product is greater than its opportunity cost, the financial instrument is considered an output, otherwise it is considered an input. Unfortunately these methodologies, if applied to the Spanish banking system, require unavailable statistical information.

This study considers the bank as a firm that produces a flow of services out of the consumption of inputs. This flow of services, associated both to items of the asset as well as of the liability side, would be the *ideal* measure of output. Some authors measure this flow of services by the number of checks drawn, or by the number of cash withdrawals, or by the number of loan operations, etc. Unfortunately, we do not have available data for these variables. Furthermore, this approach would be acceptable only if the ratio between the number of operations in relation to the number of accounts was similar for all firms and over a period of time (however, over the last years there has been an increase in the general use of banking services, checks drawn, credit cards, cash cards, etc.). Additionally, it is not satisfactory to give the same treatment to accounts of different size. (Grifell and Lovell (1993) in a study referring to Spanish savings banks, use the number of accounts as a measure of output, without considering their size. Grifell et al. (1992) avoid this problem by using information on the average size of the accounts. In our study, changes in the way information is reported do not allow us to compute the average size of accounts.)

For all reasons mentioned above, this study uses the *added value approach* (see Berger and Humphrey, 1993; Berger et al., 1987), according to which all items on both sides of the balance sheet may be identified as inputs or outputs. Unfortunately we do not have available accounting information to be able to compute the added value of the main items on the balance sheet, so we have to rely on other studies that use such information. Berger and Humphrey (1993), using information from the *Functional Cost Analysis* (FCA), find that the items that generate more added value are (demand, savings and time) deposits and loans, so that these are considered outputs.

The choice of deposit and loan nominal volumes as measurements of banking output is made under the assumption that these are proportional to the number of transactions and the flow of services to customers on both sides of the balance sheet. This approach, however, raises the problem of not capturing the function of deposits as instruments for raising loanable funds. Humphrey (1992) specifies the deposits as inputs and outputs simultaneously to capture the double side of deposits, including the variable financial costs in the estimation of the translog function. However, this procedure, although acceptable in a translog specification, is not appropriate in a DEA approach.

The introduction of the number of branches as an additional output variable would be convenient if we wanted to capture the flow of services produced by a bank. The consideration of the number of branches can also correct any biases that might arise if some banks captured deposits offering high interest rates instead of providing services through a dense branch network. Not including the quality of the services provided by banks in terms of proximity to their customers would underestimate the estimates of efficiency of banking systems with a well developed network. In this paper, the number of branches has not been considered because of lack of information (Berger and Humphrey, 1991; Berg et al., 1992a,b, 1993; Pastor, 1995) have used branches as an additional output).

Similarly, lack of data on the number of employees for the whole sample has made us approximate the quantity of the labor input by personnel expenses (Berg et al. (1992b) also use this approach). In this way, prices and quantities are mixed together. At a domestic level, assuming there is no market power in the labor market, the measurement of labor in nominal terms would be even more convenient when we are estimating efficiency, since we would be correcting labor by productivity as reflected in wages. In this way, differences in efficiency would be attributable to firm management. If wage differentials are not due to different labor quality but to market imperfections, then our measurement of labor will overestimate the efficiency of the firms that hire labor at lower wages.

International comparisons, however, are subjected to the problem of measuring labor by personnel comparisons. Labor market segmentation does not allow the interpretation of wage differentials as quality heterogeneity. Consequently, there will exist a bias in the distance function, undervaluing the position of the frontier and, therefore, the productivity of those banking systems with higher wages.

In sum, we may find differences in productivities that are not due to different positions of the frontiers and/or different levels of efficiency. They may contain elements like accounting errors in measuring variables, wage differentials, different regulation, distinct densities of demand, etc. Some, but not all, of these elements may be corrected and we should keep this in mind when we interpret the measurements of the distance to the frontier.

Table 1
Efficiency scores

	Median bank			Average			Weighted average		
	CRS	VRS	SE	CRS	VRS	SE	CRS	VRS	SE
United States	0.541	0.602	0.898	0.635	0.704	0.901	0.624	0.811	0.769
Spain	0.764	0.776	0.984	0.716	0.790	0.905	0.822	0.894	0.918
Germany	0.504	0.816	0.617	0.593	0.720	0.824	0.650	0.936	0.694
Italy	0.662	0.684	0.967	0.711	0.825	0.861	0.773	0.926	0.832
Austria	0.507	0.507	0.998	0.541	0.699	0.773	0.608	0.929	0.654
United Kingdom	0.265	0.267	0.992	0.494	0.536	0.921	0.537	0.548	0.980
France	0.856	0.856	0.999	0.672	0.673	0.999	0.950	0.951	0.999
Belgium	0.631	0.649	0.972	0.673	0.769	0.874	0.806	0.924	0.872

The numerous accounting criteria used in the seven countries considered limit the choice of input and output variables. To eliminate this bias we have chosen broad definitions of variables as presented by IBCA. Taking into account the factors mentioned above the output vector is formed by: y_1 = loans, y_2 = other productive assets (it includes all existing deposits with banks, short-term investments, other investments, and equity investments), y_3 = deposits (deposits include customer and short-term funding = demand + savings + time + interbank + other). The input vector is formed by two variables: x_1 = non-interest expenses, other than personal expenses, x_2 = personal expenses (as Berg et al. (1993), to convert values in local currencies into a common currency we use the official exchange rate).

7. Technical efficiency: Domestic results

The technical efficiency results for the median bank, the simple average of banks and the weighted (by assets) average of banks under variable and constant returns to scale are presented in Table 1, where we have considered a separate frontier for each country. These indexes inform about the relative internal efficiency (dispersion) of every banking system. Our comments will refer only to the weighted mean of banks. Relatively similar comments are applicable to the median bank in which the whole banking system is treated as an aggregate unique bank. Results change more significantly if we use the simple average of banks treating all banks belonging to a system equally.

As shown in the table for constant returns to scale, France has the banking system with the highest efficiency level (0.950), followed by Spain (0.822), Belgium (0.806), Italy (0.773), Germany (0.650), US (0.624), Austria (0.608) and UK (0.537). The second column shows the efficiency scores assuming variable returns to scale. The efficiency levels of some of the banking systems change substantially from CRS to VRS, an indication of the existence of scale inefficiencies. This is the case of Austria, Germany, the US and Italy. The banking systems from Belgium, Spain, the UK and France have smaller scale inefficiencies (SE). The values of the weighted average are, with the exception of the US, greater than the simple average. This indicates that the large banks are more efficient than the small ones.

8. Productivity, catching-up distance to the frontier: International results

In the application of the Malmquist index to analyze the international differences in productivity we have taken the Spanish banking system as the technology of reference. As shown in Eq. (3) we compare the factors by which inputs in banking systems belonging to two countries can be reduced and still produce at the same level as the Spanish banking system. This allows us to establish cross country relative productivity ratios as shown in Table 2. The results for the median bank, the average bank, and the weighted average of banks appear in the table. (Weights on banks are their size as measured by assets. Only results under CRS are reported since the assumption of VRS does not allow us to obtain a solution to problem Eq. (14).) Our comments will refer only to the section that uses the weighted average of banks.

The fourth column on section C of Table 2 contains the results of comparing the productivity of the Spanish banking system with that of the other countries. The value of the index equal to 0.68, corresponding to the USA, means that the US system is more productive than the Spanish, requiring only 68% of the inputs required by Spanish banks. The relative values of productivity show the Austrian as the most productive sector (0.27), followed by those of Italy (0.35), Germany (0.38), Belgium (0.42), USA (0.68), UK (0.69), France (0.70) and Spain (1.0). It is interesting to note the poor performance of the Spanish banking sector in terms of relative productivity. The Austrian banking sector, as an average, only requires almost one fourth of the inputs used by the Spanish banks. Similarly, any other banking system can be compared with the rest of the banking sectors by reading horizontally the column containing the Malmquist index M. Values above unity mean higher productivity of the banking sector heading the column, and values under unity mean lower productivity.

Table 2
Malmquist index decomposition international comparisons

	USA			Spain			Germany			Italy			Austria			United Kingdom			France			Belgium		
	M	MC	DF	*M*	MC	DF	*M*	MC	DF	*M*	MC	DF	*M*	MC	DF	*M*	MC	DF	*M*	MC	DF	*M*	MC	DF
Section (a): Median bank																								
USA	1.00	1.00	1.00	0.71	1.41	0.50	1.57	0.93	1.68	1.10	1.22	0.90	1.49	0.94	1.59	0.87	0.49	1.76	0.94	1.58	0.60	1.38	1.17	1.18
Spain	1.40	0.71	1.98	1.00	1.00	1.00	2.20	0.66	3.33	1.55	0.87	1.79	2.10	0.66	3.16	1.21	0.35	3.49	1.32	1.12	1.18	1.94	0.83	2.35
Germany	0.64	1.07	0.59	0.45	1.51	0.30	1.00	1.00	1.00	0.70	1.31	0.54	1.05	0.99	1.06	1.81	0.53	3.44	0.60	1.70	0.35	0.88	1.25	0.70
Italy	0.91	0.82	1.11	0.65	1.15	0.56	1.42	0.76	1.87	1.00	1.00	1.00	1.35	0.77	1.77	0.78	0.40	1.95	0.85	1.29	0.66	1.25	0.95	1.31
Austria	0.67	1.07	0.63	0.48	1.51	0.32	0.95	1.01	0.95	0.74	1.31	0.57	1.00	1.00	1.00	0.58	0.52	1.11	0.63	1.69	0.37	0.39	1.25	0.32
UK	1.16	2.03	0.57	0.82	2.87	0.29	0.55	1.90	0.29	1.28	2.49	0.51	1.73	1.91	0.90	1.00	1.00	1.00	1.09	3.22	0.34	1.60	2.38	0.67
France	1.06	0.63	1.68	0.76	0.89	0.85	1.66	0.59	2.82	1.17	0.77	1.51	1.58	0.59	2.67	0.92	0.31	2.95	1.00	1.00	1.00	1.47	0.74	1.99
Belgium	0.72	0.86	0.84	0.52	1.21	0.43	1.13	0.80	1.42	0.80	1.05	0.76	2.53	0.80	3.16	0.63	0.42	1.49	0.68	1.35	0.50	1.00	1.00	1.00
Section (b): Average																								
USA	1.00	1.00	1.00	0.45	1.13	0.40	2.06	0.93	2.21	3.78	1.12	3.38	5.80	0.85	6.80	1.27	0.78	1.63	3.36	1.06	3.17	5.35	1.06	5.05
Spain	2.21	0.89	2.49	1.00	1.00	1.00	4.56	0.83	5.50	8.37	0.99	8.43	12.82	0.76	16.97	2.80	0.69	4.06	7.44	0.94	7.92	11.83	0.94	12.60
Germany	0.49	1.07	0.45	0.22	1.21	0.18	1.00	1.00	1.00	1.84	1.20	1.53	0.36	1.10	0.32	1.63	0.83	1.95	1.63	1.13	1.44	2.59	1.13	2.29
Italy	0.26	0.89	0.30	0.12	1.01	0.12	0.54	0.83	0.65	1.00	1.00	1.00	1.53	0.76	2.01	0.33	0.70	0.48	0.89	0.95	0.94	1.41	0.95	1.49
Austria	0.17	1.17	0.15	0.08	1.32	0.06	2.81	0.91	3.09	0.65	1.31	0.50	1.00	1.00	1.00	0.22	0.91	0.24	0.58	1.24	0.47	0.07	1.24	0.06
UK	0.79	1.29	0.61	0.36	1.45	0.25	0.61	1.20	0.51	2.99	1.44	2.08	4.58	1.09	4.18	1.00	1.00	1.00	2.65	1.36	1.95	4.22	1.36	3.10
France	0.30	0.94	0.31	0.13	1.06	0.13	0.61	0.88	0.69	1.13	1.06	1.06	1.72	0.80	2.14	0.38	0.73	0.51	1.00	1.00	1.00	1.59	1.00	1.59
Belgium	0.19	0.94	0.20	0.08	1.06	0.08	0.39	0.88	0.44	0.71	1.06	0.67	13.65	0.80	16.97	0.24	0.74	0.32	0.63	1.00	0.63	1.00	1.00	1.00
Section (c): Weighted average																								
USA	1.00	1.00	1.00	0.68	1.31	0.52	1.79	1.04	1.72	1.93	1.23	1.56	2.50	0.97	2.57	0.99	0.88	1.12	0.98	1.52	0.65	1.63	1.29	1.27
Spain	1.46	0.76	1.93	1.00	1.00	1.00	2.62	0.79	3.30	2.83	0.94	3.01	3.66	0.74	4.94	1.44	0.67	2.15	1.44	1.16	1.24	2.39	0.98	2.44
Germany	0.56	0.96	0.58	0.38	1.26	0.30	1.00	1.00	1.00	1.08	1.19	0.91	0.71	1.07	0.67	1.81	0.85	2.14	0.55	1.46	0.38	0.91	1.24	0.74
Italy	0.52	0.81	0.64	0.35	1.06	0.33	0.93	0.84	1.10	1.00	1.00	1.00	1.29	0.79	1.64	0.51	0.71	0.72	0.51	1.23	0.41	0.85	1.04	0.81
Austria	0.40	1.03	0.39	0.27	1.35	0.20	1.40	0.93	1.50	0.77	1.27	0.61	1.00	1.00	1.00	0.39	0.91	0.44	0.39	1.56	0.25	0.27	1.33	0.20
UK	1.01	1.13	0.89	0.69	1.49	0.46	0.55	1.18	0.47	1.96	1.40	1.40	2.53	1.10	2.29	1.00	1.00	1.00	1.00	1.73	0.58	1.66	1.46	1.13
France	1.02	0.66	1.55	0.70	0.86	0.80	1.82	0.68	2.66	1.96	0.81	2.42	2.54	0.64	3.98	1.00	0.58	1.73	1.00	1.00	1.00	1.66	0.85	1.96
Belgium	0.61	0.78	0.79	0.42	1.02	0.41	1.09	0.81	1.35	1.18	0.96	1.23	3.73	0.75	4.94	0.60	0.68	0.88	0.60	1.18	0.51	1.00	1.00	1.00

M: Malmquist index; MC: relative efficiency; DF: distance between frontiers.

The fifth and sixth columns in section C of Table 2 contain the decomposition of the Malmquist index into its two multiplicative components as shown by Eq. (4) above, namely, the catching up effect MC (relative efficiency) and the distance to the frontier or technological parameter DF. A low value for the catching up effect means that the weighted average of the banks belonging to a particular country shows a relatively higher domestic efficiency score than Spain. In other words, the set of banks lie relatively far from their own efficiency frontier if compared with those of Spain. A coefficient lower than one in column 5 of the table (France = 0.86) means a higher internal efficiency level in France than in Spain. On the contrary, values greater than one (UK = 1.49, Austria = 1.35, USA = 1.31, Germany = 1.26, Italy 1.06) mean lower levels of domestic efficiency in declining order of the countries of comparison.

The relative position of the efficiency frontier of each country is shown in column 6 by the factor measuring the distance between each of the frontiers and that of the country of reference, namely, Spain. A value smaller than one means that the country of comparison enjoys a more productive frontier than Spain. The value is nothing but a factor saving parameter by which the inputs of Spain can be multiplied and still produce the same level of output. According to the values shown in the table, Austria has the frontier in the highest position (0.20), followed by Germany (0.30), Italy (0.33), UK (0.46), US (0.52), France (0.8) and Spain (1.0).

It is interesting to note how the decomposition of the Malmquist index gives rise to distinct combinations for different banking systems. Thus, for example, Spain performs poorly in the Malmquist index but, as shown by the low value of the catching up effect (a value of 1 when almost all other countries have values greater than one), this is not due so much to a lack of efficiency within its own banking system but, instead, to a great technological disadvantage (a value of 1 when all other countries have values much lower than 1). On the opposite side, the UK performs relatively better on the technical aspect (0.46) than on efficiency terms (1.49). A similar decomposition is found in Austria and Germany, and to a lesser degree in the US and Italy. France, on the other hand, shows a more compensated decomposition of the productivity Malmquist index. Any two

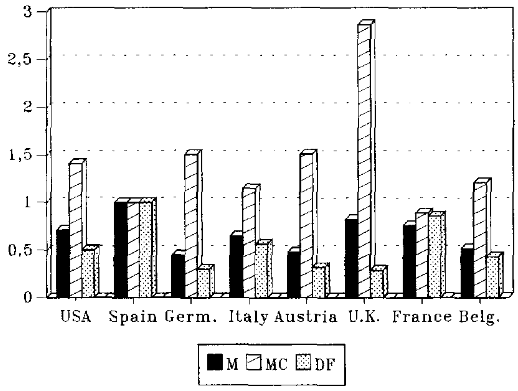

Fig. 3. Decomposition of the Malmquist index Median Bank.

countries in the sample can be compared in Table 2 under each of the three ways of measuring the aggregate behavior of the sector.

Figs. 3 and 4 show the results of Table 2 corresponding to the median bank and the weighted average of banks taking Spain as the reference country. The different decomposition by country of the Malmquist index into the two components of catching up and technological effects appears clearly in the graphs.

9. Concluding remarks

We have compared the efficiency of different European and US banking systems. We find the

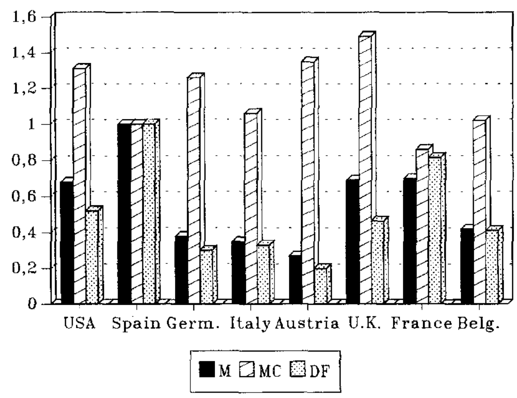

Fig. 4. Decomposition of the Malmquist index weighted average by total assets.

values of the efficiency parameters for different countries to be quite different. France, Spain and Belgium appear as the countries with the most efficient banking systems, whereas the UK, Austria and Germany show the lowest efficiency levels. We have found some evidence of scale inefficiencies in the Austrian, German and US banking systems and almost no trace of scale inefficiency in France and the UK.

As for productivity, Malmquist indexes of comparison show ratios of productivity that reach values of up to 4 to 1. More specifically, the set of Austrian banks could reduce up to four times their use of factors and still reach the same level of output as the Spanish banks. Banking systems can be classified by productivity into two groups: Austria, Italy, Germany and Belgium belong to the more productive one, and the USA, the UK, France and Spain to the less productive one. By decomposing the Malmquist productivity index into the two components of catching up and distance to the frontier we find banking systems with very different combinations of both factors. Some countries (Spain, France) have banking systems showing, simultaneously, relatively high efficiency and a relatively low level of technology, whereas other countries (Austria, Germany) combine a very productive technology with a low level of efficiency.

The results show that the obtained efficiency measures are much more homogeneous than those corresponding to differences in productivity and technology. The explanations of these discrepancies can be found in the technique as well as in the data that we have used. Regarding to the technique, we must consider that efficiency measures are obtained comparing each firm with its own frontier, while indicators of differences on productivity and technology are obtained comparing each firm with a frontier of other banking system. Regarding to the data, we have selected wide definitions of variables (outputs and inputs) in order to avoid accounting discrepancies. This procedure, although allowing us to obtain a homogeneous sample, cannot capture the different productive specializations of each banking system and, as a result, the internal measures (efficiency) are less heterogeneous than those obtained throughout international comparisons (differences in productivity and technology).

The Spanish case needs additional considerations. The Spanish Banking System, although quite efficient internally, shows a very low degree of productivity. There are at least two reasons that could explain such a poor performance. First, the measurement of output does not include the set of services (like the convenience of the proximity to the customer) provided by a dense network of branches throughout the country. This characteristic of the supply of banking services in Spain is a response to the a demand of this kind of banking services that some authors have related to low income and saving levels (see Fuentelsaz and Salas, 1992). Second, the fact that banks keep a high level of capitalization — throughout the use of their own resources — may not signify the excessive use of one productive factor but, on the contrary, to a prudent response of the Spanish Banking System to a high risk economic national environment.

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