The Cost-Efficiency of French Banks*

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Abstract

The paper addresses the issue of French banks efficiency, compared to their homologous from Europe and the United States. The analysis is realized on a sample formed by the ten biggest banks from France, Germany, Italy, Spain, the United Kingdom and the United States, over the period 1994-2006. The Data Envelopment Analysis (DEA) method is employed. The results show an improvement in cost-efficiency of French and Spanish banks, while in the other countries a decline in cost-efficiency is noted. We proceed to several tests of convergence, showing that inefficient banks have reduced the gap during the period 1994-2006. In a second step analysis, we focus on the factors standing behind the efficiency scores obtained through DEA methodology. These are bank-specific variables, the macro environment, the regulatory regime and the non-bank financial sector development. We use a standard censured Tobit model and show that capitalized, newly established banks, with tighter ratios of Tier 1 capital and operating in a country with a lower GDP per capita record the highest cost-efficiency scores.

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Keywords: Cost-efficiency; Banking systems; Data envelopment analysis

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1 Introduction

The harmonization of the European market of financial services and the increasing globalization of financial markets bring about the prime importance of banks competitiveness in different countries. Interesting perspectives can be obtained through analyzes carried out on banking systems of several countries[1]. The existence of differences in banks behavior in the European economies is a key factor that might explain the velocity of convergence in the European banking system or the probability of future cross-border mergers and acquisitions.

The European banking system encountered important changes since 90s. The Second Banking Directive (1989)[2] established the single banking license: any bank authorized to provide banking services in a EU state is allowed to provide banking services in any EU state (commonly called the European passport). By reducing legal barriers to entry on foreign banking markets, this directive was expected to favor the cross-border expansion of banking services, through either the creation of branches or the supply of cross-border financial services.

Another step towards an integrated European banking market consists of the single currency creation, in 1999. This has reduced the exchange risk for banks in the cross-border acquisitions and in the supply of cross-border services. Meanwhile, several legal obstacles continue to exist in the process of banking markets integration. The Financial Services Action Plan (FSAP, 1999-2004) was launched in 1999, having three main objectives: i) the creation of a single EU wholesale market for financial services and products; ii) the creation of an open and secure financial retail market; and iii) the implementation of common prudential and supervision rules. The fragmentation of banking supervision, at national levels, continues to be one of the main obstacles to bank strengthening in Europe.

According to the European Commission, the Financial Services Action Plan has been entirely respected and realized within the required time, representing "an important success for a European program of such magnitude and complexity". At the end of 2004, 93% of the 42 measures of the FSAP have been adopted in the shortest possible time by presidents and governments[3]. The FSAP has allowed important advances in financial markets integration process, especially by the Markets in Financial Instruments Directive (MIFID) and the improved competition between market participants (stock markets, platforms and big banks), as well as the international dimension of orders in investment banking (set up the 1st of November 2007). Meanwhile, the European integration contains two fields that deserve further advances; these are the post-market operations (clearing and delivery settlement) and the asset management. Nowadays, retail banking has still a national dimension. Several obstacles continue to exist, especially related to consumers' protection and fiscal rules (Weill, 2008).

The White Paper of financial services policy for the period 2005-2010 presents the European Commission's objectives in terms of financial services policy: (i) the strengthening of the

[1] According to Berger and Humphrey (1997), an area of research deserving additional attention concerns efficiency comparisons among countries.

[2] Directive no. 89/646 of December 15, 1989 (JOCE L 386 from December 30, 1989, p. 1).

[3] The European Council of Lisbon, 23-24 March 2000, confirmed by prior European Councils, of whom the European Council of Brussels, 20-21 March 2003.

advances carried out for an integrated, open, inclusive, competitive and economically efficient European financial market; (ii) the elimination of last significant obstacles, in order to obtain the free circulation of financial services and of capital everywhere in the EU, at the lowest costs - with a level of prudential control and behavior rules that guarantee a high degree of financial stability for consumers; (iii) the introduction, respect and continue evaluation of existing legislative framework and rigorous application of a "better regulation" approach for all future initiative; (iv) the improvement in cooperation and convergence in terms of control in the EU, the improvement of relationships with other financial markets of the world and the strengthening of European influence in the world.

Highly active on the European banking and financial landscape, European banks have always been favorable to the European integration. The large majority of recent studies show the positive effect of integration on economic growth and employment in Europe. An analysis published by London Economics in 2002 shows that financial integration of bonds and equities markets might lead to: (i) an increase of 1.1% in European GDP; (ii) an increase of 6% in productive investment and 0.8% in private consumption; (iii) an increase of 0.5% in total employment.

The IMF carried out several analyzes in 2007, estimating the benefits of the European financial integration. A comparison of the sector-based productivity growth rates in the Euro area and the United States has been realized; over the period 1996-2003, half of the difference in growth rates (less than 0.5% per year) was due to financial integration (except for the insurance sector). Nevertheless, it is difficult to quantify the indirect effects of intermediation on productivity; according to IMF, these latter effects might be higher.

When talking about financial services, the integration suppose: (i) for the banking industry - important economies of scope and scale, a better risk spreading, incentives for innovation and an improved competition in a competitive, henceforth worldwide, context; (ii) for consumers - the harmonization of the protection rules providing a fair level of protection everywhere in Europe, a better comparability of supplies, a fall in prices, as well as a larger range of products and services; (iii) for the European economy - an important contribution to the objectives of growth, competition and employment, defined in March 2000 by the European Council of Lisbon; (iv) the creation of a huge and liquid financial market, capable of supporting economic growth by a reduction in the cost of credit for borrowers (firms and households).

In this context, we consider important the examination, at a microeconomic level, of the influence that all these evolutions might have on the performance of the European banking system. Even though the FSAP measures have been just recently implemented (their appraisal started in 2005 by European Commission), we can today stand back to assess them, compared to early 1989 (the Second Banking Directive). Therefore, the present study intends to measure the cost-efficiency of French banks (i.e. the ability of a bank to minimize its costs in order to produce a fixed combination of outputs), compared to their homologous from Europe and the United States. The questions that we raise are the following: are French banks competitive compared to their foreign homologous? Are we witnessing an improvement in efficiency, in France and other countries, since 1994? Can we talk about the efficiency convergence in the analyzed countries? What are the factors standing behind the efficiency scores?

Our work stresses the performance of the French banking system in the context of cross-border movements (in 2008, approximately half of the output of the three biggest French banks was obtained outside France, of whom an important part in Europe), compared to the banking systems of other European and American countries.

The analysis of cost performance evolution in the French banking system is an important issue for several reasons. First, the improvement in cost performances should allow for a reduction in interest rates on lending and, consequently, this will encourage an increase in investment. Second, French banking system performance is a key element in future cross-border expanding of French banks. Basically, weak results of French banks signify lower possibilities of setting up abroad compared to cost efficient competitors; it equally means the possibility of easier entries of foreign banks on the French market.

Based on these aspects, we apply the cost efficiency approach (i.e. the ability of a bank to minimize its costs in order to produce a fixed combination of outputs) over the period 1994-2006, for a sample formed by European and American banks. The methodology used is the efficiency frontier. We intend to calculate the cost efficiency of banks from France, Germany, Italy, Spain, the United Kingdom and the United States and to examine its evolution over a longer span of time compared to previous studies (a brief presentation is realized in table 1).

We start by estimating national cost frontiers, specific to each country. This choice is motivated by at least two reasons:

- first, important differences exist in the economic conditions of each country. The measures of efficiency vary with regulation and supervision interventions in the financial system. The transposition in national law of European directives allows for differences among EU member states. At the same time, important differences exist within countries, in terms of the intensity of competition between financial institutions, the level and quality of services associated to financial products, the financial market development; all these aspects affect the measures of efficiency. Therefore, a high level of efficiency for institutions from a considered country does not necessarily imply that they are more efficient in the environment of other countries.

- second, even though there are no differences in economic conditions or these differences are controlled by the econometric methodologies, the performance of institutions abroad cannot be representative. If some institutions are efficient in their country of origin, they can encounter some difficulties in other countries because of organizational limits in the functioning and supervision of institutions from distance or because of the difficulties related to differences of language, culture, money, regulation and others.

We use the Data Envelopment Analysis (DEA) approach and we determine the cost-efficiency scores for banks from the six analyzed countries, annually, over the period 1994-2006. Our work is in line with Weill (2006b) and consists of a comparative analysis of the efficiency trend of the ten biggest banks from France, the United Kingdom, Germany, Spain, Italy and the United-States. In a first step analysis we determine the cost-efficiency scores of banks for each country, year by year, using the DEA technique and the DEA-Solver program. The results show an improvement in the cost efficiency of French and Spanish banks, opposed to other countries from the sample, where a decline in efficiency is obtained.

We test for the existence of β convergence, to see whether there was a convergence trend in banking efficiency over the analyzed period of time (as in Weill, 2006b, 2008).

In a second step analysis, we look for factors standing behind the efficiency indicators previously obtained. These are some bank specific variables (equity as a share of total assets, ownership, size and age), the macroeconomic environment, the regulatory framework and the development of non-banking financial sector. Due to the limited nature of the dependent variable (note that the DEA index ranges between 0 and 1), a censured Tobit regression model is used for the estimations (performed with the help of Stata program).

The analysis of the convergence, realized separately for each country, shows a "catching-up" process by the least efficient banks, except for banks from the United Kingdom. The main results are the following: capitalized, newly established banks or banking groups, with a tighter ratio of Tier 1 capital and operating in a country with a lower GDP per capita record the highest cost-efficiency scores.

Our paper makes several contributions to the literature on banking efficiency. First of all, we proceed to an international comparison analysis and we seek to cover a larger period of time, compared to the existing studies. Second, by looking at the evolution of the efficiency score, we show the existence of the convergence, since least efficient banks are catching-up their efficient homologous. Third, our analysis is extended by an examinations of the factors standing behind the efficiency scores and this brings about the originality of our work, as we take a deeper look at the figures on efficiency, seeking to explain them.

The remainder of the paper is organized as follows. Section 2 provides an overview of the literature on bank efficiency analysis. Section 3 introduces and describes the methodology used in this study. The data set and variables are presented in Section 4. Section 5 presents the results of Data Envelopment Analysis and explains the differences in cross-bank efficiency indicators. Finally, Section 6 concludes.

2 Review of literature

The first study on efficiency and productivity at a micro level is that of Farrel (1957) (section 3.1 below presents the concept of efficiency), but the literature on cost-efficiency started to be applied to banks only during the 90s. Berger and Humphrey (1997) inventory 130 studies applying efficiency frontiers to financial institutions from 21 countries.

A reduced number of studies focused on the efficiency of French banks. We can however distinguish two categories: studies that focus entirely on French banks; and studies consisting of international comparisons of bank efficiency.

We mention four analyzes that belong to the former category.

Dietsch (1996) performs the first analysis on the efficiency of French banks. The author uses a parametric method (the Free Distribution Approach, DFA) and estimates the cost-efficiency of 375 commercial and savings banks, over the period 1988-1992. The results show the existence of an average cost-efficiency of 56.1% and 70.7%, with a truncation of 1%

and, respectively, 5%. The analysis of the relationship between the cost efficiency and the risk-taking supports the assumption that less efficient banks take excessive risks.

Dietsch and Weill (1999) use a nonparametric method, the DEA technique, for measuring the technical efficiency of 93 French deposit banks in 1994. The average scores vary between 78% and 91%, depending on the retained productive combination. The inputs are: personnel expenses, interest expenses relative to total borrowed funds and other non-financial expenses; the outputs are: credits, demand deposits, savings and other remunerated assets. The analysis of the determinants of French banks' efficiency shows the lack of a clear relationship with the size and the existence of a negative relationship with the risk-taking.

Chauveau and Couppey (2000) examine the technical efficiency on a sample of 38 French banking groups, over the period 1994-1997, and use the DEA technique. Their results show the lack of major problems of productive inefficiency in the sample of banks.

Weill (2006b) analyzes the evolution of cost-efficiency of 93 French banks, over the period 1992-2000. The author uses two parametric approaches to calculate the cost-efficiency scores: the Stochastic Frontier Approach (SFA) and a system of equations composed of a Fourier-flexible cost function and its associated input cost share equations derived using the Sheppard's lemma. The results show an increase in cost-efficiency between 1992 and 2000, the average scores going from 77.20% to 83.98%. According to the Rosse-Panzar test of competition, the increase in efficiency is not related to the increase in competition. Weill (2006b) equally tests for the convergence in French banks' efficiency, showing its existence over the period 1992-2000; this translates the catching-up process of the least efficient banks over the last decade.

Besides studies entirely orientated toward French banks, an important number of international comparisons of banks' efficiency exist. The latter have become abundant these last years, being characterized by the use of BankScope database. Two categories of international comparisons can be distinguished: those estimating a national frontier for each country, opposed to those estimating common frontiers to several countries as a whole.

A reference from the first category is the analysis of Berger et al.(2000). The authors use the Stochastic Frontier Approach (SFA) and estimate the cost and production frontiers for five countries (France, Germany, Spain, the United Kingdom and the United States), separately for each country. The efficiency of domestic and foreign banks is estimated, over the period 1993-1998 for the US and, respectively, 1992-1997 for the European economies. The results show an average cost-efficiency of 70.9% in France, 79.3% in Germany, 91.5% in Spain, 79.1% in the United Kingdom and 77.4% in the United States. The main result is that domestic banks present higher cost and higher production efficiency scores, compared to foreign banks that operate in these countries.

Weill (2004) measures the cost-efficiency of banks from 5 European countries (France, Germany, Italy, Spain and Switzerland), over the period 1992-1998 and uses three approaches: SFA, DFA and DEA. The analysis is based on the measure of national frontiers (and not of a common frontier), showing the consistency of technical frontiers of efficiency in five different frameworks. The author compares the means and coefficients of correlation, two aspects of public policy and the correlation with the standard value of performance. The conclusion is that of a lack of robustness among approaches.

Weill (2008) calculates the cost efficiency of banks from ten EU countries (Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, Portugal, Spain and the United Kingdom), over the period 1994-2005 and uses the Stochastic Frontier Approach. The results show an improvement in the efficiency of the entire EU banking systems, and the existence of convergence in efficiency of all EU countries.

The second category of studies estimates a common frontier, allowing for a comparison of bank efficiency within different countries; all banks are compared with the best banks from all the analyzed countries. The main assumption of these studies is that all the banks have the same technology, and this may lead to efficiency gaps resulting from different technologies. In reality, the gaps of efficiency between countries might be caused by different economic environments and not necessarily by differences in managerial performance (Dietsch and Lozano-Vivas, 2000).

Allen and Rai (1996) estimate the overall cost function of 194 international banks (from 15 countries), over the period 1988-1992, in order to determine the inefficiencies of inputs and outputs. According to their analysis, the inefficiencies of inputs are higher than those of outputs. Another result is that the DFA approach overestimates the size of inefficiency scores, compared to the SFA approach. Large banks have the highest value of inefficiency of inputs (27.5% of the cost) and significant levels of diseconomies of scale. For the other banks, the inefficiency is of 15% of the cost, with reduced economies of scale for small banks.

Pastor, Pérez and Quesada (1997) compare the efficiency of several European banks (Spain, Austria, Germany, the United Kingdom, Italy, Belgium and France) to that of American banks, in 1992. Under the hypothesis of constant returns of scale, French banks are the most efficient (with an average efficiency of 95%), followed by Spanish, Belgian, Italian, German, American, Austrian and English banks. On the other hand, the reduced productivity of French banks is underlined (they are in the second last position, in front of Spanish banks).

Chaffai and Dietsch (1999) propose the breaking down of cost inefficiency in technical and allocative inefficiencies, based on the methodology of distances in inputs. The authors use the stochastic frontier approach. The application on a sample of European banks from 11 countries (Austria, Belgium, Germany, Denmark, Spain, France, the United Kingdom, Italy, Luxembourg, Netherland and Portugal), over the period 1992-1996, shows that on average the allocative inefficiency increases bank costs by 25%, and so does technical inefficiency. Another result is the existence of a negative correlation between technical and allocative inefficiencies.

Dietsch and Lozano-Vivas (2000) analyze, by the DFA approach, the effect of the environment conditions on the cost-efficiency of French and Spanish banking industries, over the period 1988-1992. The results are the following: without taking into account the environmental variables, the cost-efficiency scores of Spanish banks are more reduced than those of French banks; the introduction of the environmental variables in the model reduces the differences between the two banking industries.

Altunbas et al. (2001) proceed to an analysis on a large sample of European banks (from 15 countries), over the period 1989-1997; they use the SFA approach. The results show that on average English and Swedish banks are more inefficient than other European banks. The most efficient banking systems are those of Austria, Denmark, Germany and Italy. Another

important result is the rise in the impact of technical progress on reducing bank costs, with banks size. Over the entire period of analysis, an increase in banks efficiency is observed.

Chaffai, Dietsch and Lozano-Vivas (2001) propose a Malmquist index that allows for measuring the differences in productivity among banks from different countries and distinguish two components: differences caused by purely technological effects and, respectively, differences caused by environmental effects. This index is used for explaining differences in productivity among banks from four Euro area countries (France, Germany, Italy and Spain), over the period 1993-1997. The results show that, on average, differences caused by environmental conditions are higher compared to differences in banks technology.

Lozano-Vivas, Pastor and Hasan (2001) estimate the production frontier over a sample of 612 banks from ten EU countries (Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherland, Spain and the United Kingdom) for 1993. First, the authors proceed to the estimation of technical efficiency for each country in the sample, by the non-parametric approach (DEA) only with banking variables. Then, they build a DEA model, including some environmental factors (per capita GDP, per capita wage, population density, demand density, capital ratio and profitability) and banking variables, in order to normalize the environmental conditions, specific to each country. The results show that adverse (favorable) environmental conditions are a positive (negative) factor for banking industry of the country of origin. Being technically efficient is a dissuasive element for foreign competition. Globally, banks from Spain, Portugal and Denmark are relatively more efficient and successful in maintaining high scores of efficiency if they decide to move and install in another European country from the sample. At the same time, it would be more difficult for banks from other countries to settle profitable networks in Spain, Portugal and Denmark because of adverse environmental conditions. Furthermore, Italian and French banks are the least efficient abroad.

Vander Vennet (2002) analyzes the cost and production efficiencies in financial conglomerates and universal banks from Europe. The analysis is carried out on a sample of 2375 banks from 17 EU countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherland, Norway, Portugal, Spain, Sweden, Switzerland and the UK), for 1995 and 1996 and uses the SFA approach. The relationship between profitability and several variables is equally analyzed for different subgroups of European banks. The results show that financial conglomerates are more efficient in term of income compared to their specialized competitors, while universal banks are the most efficient in terms of cost and production.

The last two studies conclude on the existence of important differences in banks efficiency among the EU member states.

By the brief presentation of these studies, we conclude of a dispersion in the average efficiency scores, depending on the efficiency concept and the method analyzed. As one can see in table 1 below, the results of the large majority of studies consist of an average efficiency score between 70% and 80%. As far as the applied approach is concerned, both parametric (SFA and DFA), and nonparametric (DEA) methods have been used in estimating the efficiency of French banks.

Our work adds to the existing literature on cost-efficiency of French banks; we estimate it compared to the cost-efficiency of other European and American banks, over the period 1994-2006 and we use a nonparametric method- the DEA approach.

Table 1: Analyzes on French banks efficiency.

Authors	**Characteristics (approach, estimated frontier, period)**	**Estimation of the average annual efficiency (France)**
	France	
Dietsch (1996)	DFA, cost frontier, 1988-1992	56.1% - 70.7%
Dietsch and Weill (1999)	DEA, production frontier, 1994	78-91%
Chauveau and Couppey (2000)	DEA, production frontier, 1994-1997	89% (1994), 94% (1995, 1996), 95% (1997)
Weill (2006b)	SFA, cost frontier, 1992-2000	77.2% (1992) - 83.98% (2000)
	International comparisons (national frontier)	
Berger et al. (2000)	DFA, cost and profit frontier, 1992−1997	70.9%
Weill (2004)	DEA, DFA, SFA, cost frontier, 1992-1998	40.16% (DEA), 49.76% (FDA), 70.58% (SFA)
Weill (2008)	SFA, cost frontier, 1994-2005	78.9% (1994) - 85.48% (2005)
	International comparisons (common frontier)	
Allen and Rai (1996)	DFA, SFA, cost frontier, 1988-1992	73.4% (small banks); 84.3% (large banks)
Pastor et al. (1997)	DEA, production frontier, 1992	95%
Chaffai and Dietsch (1999)	SFA, cost frontier, 1992-1996	74% (Cobb-Douglas frontier); 83% (translog frontier)
Dietsch and Lozano-Vivas (2000)	DFA, cost frontier, 1988-1992	77.5%
Altunbas et al. (2001)	SFA, cost frontier, 1989-1997	71.2%(in 1989) - 75.6% (in 1997)
Chaffai et al. (2001)	SFA, production frontier, 1993-1997	French banks might increase their productivity by 20% (without differences in environment) and, respectively, by 18% (with differences in environment), by using the technology of German banks.
Lozano-Vivas et al. (2001)	DEA, production frontier, 1993	24.23% (without considering the differences in environment); 40.98% (when considering the differences in environment)
Vander Vennet (2002)	SFA, cost and profit frontier, 1995, 1996	Cost efficiency: -traditional banking activity: 68.2% (financial conglomerates), 70.8% (specialized banks); - traditional and non-traditional banking activity: 81.5% (financial conglomerates); 79.2% (specialized banks). Profit efficiency : 68.7% (financial conglomerates); 67.1% (specialized banks)

Note. DEA: data envelopment analysis; DFA: distribution free analysis; SFA: stochastic frontier analysis.

We further present the concept of efficiency, as well as the methodology applied for its estimation.

3 Efficiency: concepts and measurement

3.1 Concepts

Farrell (1957) laid the foundation to measure productivity and efficiency studies at the micro level. His main contributions consisted of two issues: the definition of the efficiency and productivity, and the calculation of the benchmark technology and efficiency measures. The fundamental assumption is that of a perfect input-output allocation that allows for inefficient operations. Inefficiency is defined as the distance of a firm from a frontier production function accepted as benchmark. The radial contraction/expansion connecting inefficient observed points with (unobserved) reference points on the productivity frontier is the basis for this

measure. If a firm's actual production point lies on the frontier, it is perfectly efficient. If it lies below the frontier then it is inefficient. The ratio of the actual to potential production defines the level of efficiency of the individual firm (Decision Making Unit, DMU).

Two components are proposed by Farrel for defining the efficiency: the technical efficiency and the allocative efficiency. The former reflects the ability of a DMU to minimize input use in order to produce a given amount of output. The latter reflects the ability of a DMU to use inputs in optimal proportions, given their respective prices and production technology. Considered together, these two measures represent a total efficiency measure (Coelli et al., 1997). Efficiency ratios take a value between zero and one, where one indicates that the DMU is fully efficient. For instance, an efficiency score measured against a cost frontier of 90% signifies that the DMU could have reduced costs by 10% without altering its output vector.

The estimation of efficiency can be categorized according to the assumptions and the techniques used to construct the efficient frontier. On one hand, parametric methods estimate the frontier with statistical methods. On the other hand, nonparametric methods rely on linear programming to calculate piecewise linear segments of the efficient frontier. Parametric methods impose an explicit functional form for both the frontier and deviations from it (i.e. the inefficiency). In contrast, nonparametric methods do neither impose any assumptions about functional form of the frontier, nor about inefficiency. The main drawback of nonparametric methods is that they do not include the random error in the estimation of efficiency, so that the distance to the efficiency frontier is entirely measured as inefficiency.

We will further present the nonparametric methods, insisting on the methodology employed in our work - the DEA technique. This technique has been first used in industrial economy studies; it started to be applied to financial institutions, namely to banks, at mid 90s (Chauveau and Couppey, 2000). The work of Sherman and Gold (1985) is presented as the first application of this method to banks. Afterwards, the contributions multiplied. Cook and Seiford (2009) provide a very detailed review of major research thrusts in DEA that have emerged over the past three decades, since the seminal work of Charnes et al. (1978). The focus of their work is on methodological developments, insisting on: various models for measuring efficiency; approaches to incorporating restrictions on multipliers; considerations regarding the status of variables; and modeling of data variation. The authors present various DEA models, such as: the CRTS model, the VRTS model, the additive measures, the Slacks-based measures, the Russel measures and other non-radial models. The detailed presentation of all these models is beyond the scope of our work, but the reader can report to Cook and Seiford (2009) for a further look.

3.2 Data envelopment analysis (DEA)

The DEA technique was introduced by Charnes et al. (1978), allowing the measurement of the efficiency of a DMU by comparing it to the most efficient units; these way, the measures of performance obtained are relative. The initial model has an input orientation and assumes constant return to scale (we will further use the CCR notation for this model).

In the case of a constant return to scale (CRTS) technology, the linear programming method establishes which of the decision-making units (in our case banks) determines the

envelopment surface. The latter is referred to as the empirical production function or efficient frontier. This benchmark frontier is a linear combination of the efficient banks in the sample. The set of best frontier observations are those for which no other DMU or linear combination of units has as much or more of every output (given a fixed amount of inputs - for an output orientated model) or as little or less of every input (given a fixed amount of outputs - for an input orientated model). The DEA frontier is formed as the linear combination that connects the set of these best practice observations, yielding a convex production possibility set. The DEA provides an analysis of relative efficiency for multiple input/output situations, by evaluating each DMU and measuring its performance relative to an envelopment surface composed of best practice units. The units that do not lie on the surface are considered inefficient. This way, the method provides a measure of relative efficiency.

We proceed to a brief description of the underlying linear programming model. We assume that there are K inputs and M outputs for every DMU. For the ith DMU the inputs and outputs are represented by vectors x_i and y_i. For each DMU we intend to obtain a measure of the ratio of all outputs over all inputs, such as $u_i^{'}y_i/v_i^{'}x_i$, where u_i and v_i are vectors of weights. The following problem is proposed in order to select the optimal weights:

$$\begin{aligned}
&\max_{u_{ik},v_{im}} \frac{u_i^{'}y_i}{v_i^{'}x_i} \\
&s.t. \frac{u_i^{'}y_j}{v_i^{'}x_j} \leq 1 \\
&u_{ik}, v_{im} \geq 0 \\
&i, j = 1, 2, ...N \\
&k = 1, 2, ...K \\
&m = 1, 2, ...M
\end{aligned} \tag{1}$$

Such a problem has an infinite number of solutions. This can be avoided by introducing a constraint $v^{'}x_i = 1$, and, this way, we obtain the multiplier form of the linear programming problem:

$$\begin{aligned}
&\max_{\mu_{ik},\sigma_{im}} \mu_i^{'}y_i \\
&s.t. \sigma_i^{'}x_i = 1 \\
&\mu_i^{'}y_i - \sigma_i^{'}x_j \leq 0 \\
&u_{ik}, v_{im} \geq 0 \\
&i, j = 1, 2, ...N \\
&k = 1, 2, ...K \\
&m = 1, 2, ...M
\end{aligned} \tag{2}$$

where $u^{'}$ and $v^{'}$ are replaced with μ and σ. We use the duality property of this linear programming problem, and we can derive an equivalent envelopment form:

$$\begin{aligned}
&\min_{\theta,\lambda} \theta_i \\
&s.t. - y_{ik} + Y\lambda \geq 0 \\
&\theta_i x_{im} - X\lambda \geq 0
\end{aligned} \tag{3}$$

$$\lambda_i \geq 0$$

where λ is a $N \times 1$ vector of constants and θ, a scalar, is the efficiency score for the ith DMU[4]. Note that $0 \leq \theta_i \leq 1$ if i is equal to 1, the DMU is located on the efficiency frontier and is globally efficient. Due to fewer numbers of constraints, this formulation is usually used for computations.

However, this approach is simplified, as it assumes a constant return to scale. This assumption is appropriate only when all banks are operating at an optimal scale. Nevertheless, we can mention several factors that may determine banks not to operate at an optimal scale; these might be: imperfect competition, leverage concerns, certain prudential requirements, etc. The fact that banks face non-constant returns to scale has been documented empirically by McAllister and McManus (1993), and Wheelock and Wilson (1997). This phenomenon led Banker et al. (1984) (BCC) to suggest an extension of the model to account for a variable return to scale (VRTS). They added a convexity constraint $N1'\lambda = 1$ to problem (3) above (where $N1$ is a $N \times 1$ vector). This condition ensures that an inefficient bank is "benchmarked" against similar size banks. Consequently, the VRTS technology envelops the data more closely than CRTS technology and leads to higher technical efficiency scores than CRTS technical efficiency scores.

The CCR model focuses on the technical-physical aspects of production. It is appropriate if we cannot made behavioral assumption of firms' objectives (like cost or profit maximization). Alternatively, the model may prove useful if unit price and unit cost information are either unavailable or of questionable quality (for instance, due to substantial measurement error). If economic objective functions are reasonable and if reliable price information is available, DEA can also be used to identify allocative efficiency.

We assume that banks minimize cost and we consequently consider in this work the input orientated efficiency with variable return to scale (VRTS). The cost model can be written as it follows:

$$\begin{aligned}
&\min \sum_{i=1}^{m} c_{i0} x_{i0} \\
&x_{i0} \geq \sum_{j=1}^{n} x_{ij} \lambda_j, (i = 1, ..., m) \\
&y_{r0} \leq \sum_{j=1}^{n} y_{rj} \lambda_j, (r = 1, ..., s) \\
&\sum_{j=1}^{n} \lambda_j = 1 \\
&\lambda_j \geq 0, \forall j
\end{aligned} \tag{4}$$

where $j = 1, .., n$ are the number of bank, $i = 1, ..., m$ are input volumes used by bank j, $r = 1, ..., s$ measures the volume if output r and c_{i0} is the unit cost of the input i of bank DMU_0 (which is the benchmark projection), that can be different from one bank to another. The minimization problem is calculated for each bank of the sample, identifying for each a

[4] $X = [x_1, ..., x_n]$ is a $K \times N$ input matrix with columns x_i and $Y = [y_1, .., y_m]$ is a $M \times N$ output matrix with columns y_i.

benchmark combination of inputs and cost. Every DEA model assumes a returns-to-scale characteristic that is represented by $L \leq \lambda_1 + \lambda_2 + ... + \lambda_n \leq U$. In this case, we compute variable returns to scale and use $L = U = 1$, i.e. we consider a convex hull representation. Our model allows substitutions in inputs. Based on an optimal solution of the problem (4), (x^*, λ^*), the cost efficiency of DMU_0 is defined as:

$$CE_0 = \frac{c_0 x^*}{c_0 x_0} \tag{5}$$

where CE_0 is the ratio of minimum cost to observed cost for the 0th firm. This approach implies that all observed input-cost combinations are measured with no error. Outliers may be considered as very efficient since data error implies no comparison unit for these institutes or they may be simply unique. The hypothetical bank co-determines the frontier relative to which all other peers are evaluated, mean efficiency may be low as the majority of banks are located far above this benchmark. By assuming that measurement errors occur randomly, a stochastic approach can alleviate the problem.

After presenting the efficiency concept and the DEA technique, in the next session we present the data and variables used in our analysis.

4 Data and variables

BankScope is the main data set used. Financial indicators of individual banks have been collected by BankScope using the audit reports of banks, completed by internationally reputable auditing firms. When data was not available, we used the annual reports published by banks in their relations with investors. We dispose of a relatively homogenous sample, formed by the ten biggest banks from six countries: France, Germany, Spain, Italy, the United-Kingdom and the United States. The span of time is the interval 1994-2006.

4.1 Variables definition and measurement

We start by defining a bank's objectives and specifying its respective inputs and outputs. There is long-standing debate on the definition of the banking output. Humphrey (1991) proposed three definitions of the banking output: the number of transactions processed in deposit and loan accounts (a flow measure); the real or constant value of funds in deposit and loan accounts (a stock measure); and the numbers of deposits and loan accounts serviced by bank (a stock measure). According to Humphrey (1991), the output is typically a flow (not a stock), so that the preferred measure is an output flow. As flow measures are unavailable, the other two stock measures are usually used.

According to Fixler and Ziechang (1992), the output consists of "transaction services and portfolio management services that banks provide to depositors while acting as their intermediaries". The range of services could be wide and largely dependent on the degree of financial development of the economy. The variety and complexity of financial services available to general public change as economy develops, so that we expect it to differ across countries. As in Grigorian and Manole (2002), we assume that there are no systemic differences among banking systems considered in the analysis, other than differences explained by macroeconomic indicators and general business environment. The precise definition of bank's 'mandate' is

important, as the definition of inputs and output results from the functions exerted by a bank. This latter aspect is essential in the construction of our model.

There are three approaches generally used in defining the bank production: the asset approach (or intermediation approach), the user-cost approach and the value added approach (or production approach).

Under the *asset approach* (or *intermediation approach*), banks are considered as financial intermediaries between the liability holders and the fund beneficiaries (i.e. debtors). Loans and other assets are considered to be the banks' outputs, while deposits and other liabilities are inputs in the intermediation process. This approach seems appropriate for large banks that purchase their funds in big quantities from other banks and large institutional depositors. Nevertheless, it is not appropriate for all the banks. In the case of small banks, this method does not account for transaction services delivered by the latter to their depositors, underestimating the overall value added of banking activities.

Under the *user-cost approach*, the net revenue generated by a particular asset or liability item determines whether the financial product is an input or output. Hancock (1991) was among the first to apply the user-cost approach to banking. The author stated that it is not clear ex ante whether monetary goods are inputs or outputs in the production process. According to Hancock (1991), if the financial returns on an asset exceed the opportunity cost of funds (or if the financial cost of a liability is less than the opportunity cost), then the instrument is considered to be a financial output. Otherwise, it is considered to be an input. According to this rule, demand deposits would be classified as outputs, while time deposits would be classified as inputs. Nevertheless, the approach presents some limitations. First, the user cost fluctuates and so do interest rates. An item considered to be an output in one period can turn into an input in the next period if the sign of its user cost changes. Second, it is difficult to measure marginal revenues and costs for each individual liability item. Thus, the answer to the question whether an item is an input or output becomes subject to significant measurement error and it is sensitive to changes in data over time.

The *value-added approach* (or *production approach*) considers that both liability and asset categories have some output characteristics. Nevertheless, only those categories that have substantial added value are treated as outputs, while the others are treated as either inputs or intermediate products, depending on the specific attributes of each category. The value added approach differs from the user cost approach, since it is based on actual operating cost data rather than determining these costs explicitly. This approach has been widely used in studies of the banking industry (Berger et al., 1987; Berger and Humphrey, 1997; Pastor, Pérez and Quesada, 1997; Altunbas, Gardener, Molyneux and Moore, 2001; Grigorian and Manole, 2002 etc.). It is appropriate for studies on the activity of banking groups, the local agencies being "transparent from a financial point of view". According to Mörttinen (2002), a major drawback of this approach is that it ignores many important aspects of banking activities. This is problematic when the number of transactions cannot capture the quality of these services. Banks that generate large transaction flows and make large short term profits by grating loans to bad quality customers or to customers with questionable motives (ready to pay high rate of interest) are not as productive in the long term as a bank that makes less short term profits but screens more rigorously its customers. The adoption of information

technologies is at the heart of this, since new technology should benefit the bank by allowing it to process information on its customers more efficiently.

Taking into account the advantages and disadvantages of each method and the fact that our analysis is performed on the biggest banks from six countries (France, Germany, Spain, Italy, the United-Kingdom and the United-States), we follow the asset (or intermediation) approach[5]. This approach considers that banks collect deposits for transforming them in loans, incorporating labor and capital in the transformation process. The list of banks of each country is presented in Appendix 1.

To define input and output items we follow the intermediation approach of Sealey and Lindley (1977): the primary function of bank is to channel financial funds from savers to investors. To provide output y_r banks demand input quantities x_i at given prices c_i, that minimize total operating costs C.

For measuring costs we consider the fact that a competitive and efficient institution would minimize the total cost of operating and interest costs for any given output. The total cost is therefore the sum of interest expenses and general operating expenses.

We define three input and output categories. Input quantities are fixed assets x_1; labor x_2, measured as full-time equivalents; and borrowed funds x_3, measured as the long term and subordinated debt. Input prices c_i are derived per bank as depreciation relative to fixed assets, personnel expenses relative to FTE and interest expenses relative to total borrowed funds. As outputs we define the volume of customer deposits y_1, the volume of customer credits y_2 and the net fee and commission income y_3.

[5]The asset approach has been equally employed by Mester (1997); Fioretino, Karmann and Koetter (2002); Fries and Taci (2005); Weill (2006a, b), etc.

Table 2: Cost and production variables by country between 1994 and 2006.

Variables			Germany	Spain	US	France	Italy	UK
Customer deposits	y_1	Mean	94 700 000	48 000 000	151 000 000	94 900 000	33 800 000	153 000 000
		SD	6 454 133	4 382 258	115 000 000	89 500 000	3 189 268	9 454 309
		Min	*1 859 700*	*5 828 700*	*5 247 080*	*7 400*	*1 923 400*	*19 421 752*
		Max	*408 782 000*	*284 206 500*	*540 652 731*	*349 695 000*	*287 978 500*	*680 966 056*
Customer loans	y_2	Mean	138 000 000	56 500 000	142 000 000	89 500 000	50 600 000	162 000 000
		SD	6 639 944	5 127 829	107 000 000	72 900 000	4 656 768	8 104 784
		Min	*1 800 600*	*4 028 500*	*4 631 511*	*8 000*	*1 937 100*	*21 590 617*
		Max	*431 485 000*	*531 509 312*	*536 437 857*	*406 658 000*	*456 758 500*	*701 774 924*
Commission&fee	y_3	Mean	1 621 068	918 988,5	2 902 312	1 349 212	967738,4	2661 434
		SD	196 022,7	102794,3	3 080 181	1 471 847	93968,82	200590,2
		Min	*-26 900*	*42 700*	*3 294*	*-428 700*	*22 700*	*141 383*
		Max	*11 693 000*	*7 223 300*	*17 693 377*	*6 853 000*	*8 347 600*	*13 046 293*
Fixed assets	x_1	Mean	1 965 591	1 983 462	2 785 838	2 225 689	1 402 750	3 974 915
		SD	159 930,2	184 487	2 230 094	2 376 596	109 108,6	342 468,3
		Min	*29 700*	*195 000*	*75 253*	*200*	*155 000*	*380 000*
		Max	*10 384 000*	*10 585 000*	*10 094 000*	*12 470 000*	*8 615 000*	*27 455 000*
Employees	x_2	Mean	23 885	25 844	74 740	30 651	19 389	57 392
		SD	2 046	2 836	63 625	30 363	1 736	4 246
		Min	*568*	*2 607*	*2 657*	*28*	*1 098*	*5 045*
		Max	*98 311*	*129 749*	*327 000*	*132 507*	*139 061*	*298 704*
Borrowed funds	x_3	Mean	84 700 000	14 100 000	31 100 000	39 700 000	17 600 000	32 600 000
		SD	2 947 898	1 309 188	29 800 000	37 100 000	1 633 745	2 045 725
		Min	*1 088 000*	*54 000*	*45 083*	*1 639 100*	*2 000*	*243 000*
		Max	*241 680 000*	*184 798 000*	*219 053 000*	*572 354 000*	*232 301 000*	*266 669*
Price of fixed assets	c_1	Mean	28,52	12,56	161,59	18,14	15,88	26,44
		SD	1,21	0,25	41,50	11,42	0,68	0,99
		Min	*0,26*	*4,36*	*51,91*	*1,46*	*-7,02*	*13,44*
		Max	*238,31*	*25,19*	*475,46*	*107,92*	*83,43*	*52,91*
Price of labor	c_2	Mean	87297,62	47728,55	55525,5	73338,93	61359,3	47211,28
		SD	2 157,309	553,5726	16310,6	9586,79	571,4155	806,432
		Min	*39 812*	*29 874*	*26 108*	*33 322*	*27 901*	*37 125*
		Max	*223 932*	*74 852*	*141 453*	*157 572*	*114 886*	*66 490*
Price of funds	c_3	Mean	24,61	81,7	62,24	50,21	241,7	124,34
		SD	2,85	4,83	48,39	29,37	47,4	18,63
		Min	*2,84*	*3,74*	*5,19*	*3,36*	*2,94*	*26,14*
		Max	*1 226,53*	*774,63*	*987,38*	*190,48*	*1 109,21*	*757,96*
Total cost	C	Mean	14 400 000	4 629 146	17 600 000	12 800 000	3 868 155	11 600 000
		SD	824 021,5	538 249,6	17 000 000	9 785 125	347 374,2	623788,2
		Min	*1 951 600*	*471 700*	*371 124*	*289 322*	*333 200*	*2 420 492*
		Max	*65 932 000*	*32 396 900*	*91 718 343*	*46 343 800*	*96 900 000*	*27 981 016*
Total Assets		Mean	327 000 000	100 000 000	298 000 000	289 000 000	96 900 000	301 000 000
		SD	16 000 000	10 100 000	267 000 000	247 000 000	9 990 851	18 300 000
		Min	*36 595 801*	*8 227 000*	*7 064 132*	*3 776 600*	*4 012 400*	*34 457 000*
		Max	*1 571 768 000*	*833 873 000*	*1 430 763 000*	*1 440 343 000*	*823 284 000*	*1485 306 000*
Observations	N		130	130	117	104	130	130
No. of banks	N		10	10	9	8	10	10

Note. All variables measured in thousands of euro, except x_2 (in FTE), c_1 and c_3 (percentage points) and c_2 (in euro).

The data in table 2 illustrates the summary statistics for inputs, outputs, the price of inputs and some other elements. The average total assets have the same magnitude in the case of banks from Germany, the United States, France and the United Kingdom; nevertheless, the indicator is lower for banks from Spain and Italy. The data in the table above shows that mean sizes in both input and output dimensions vary considerably across banking groups in the six countries, especially in France and Italy (where the dispersion is very large). For France, this is due to the inclusion in the analysis of very different types of institutions[6].

According to the 2007 CECEI annual report, France is among the high-concentrated banking system western EU countries, while Italy and Germany present a fragmented banking

[6]The French banking system presents a concentrated structure, 52% of the banking assets belonging to the five biggest banks, while the "top ten" banks hold 71% of the total banking assets.

system. At the end of 2006, the five biggest French banks held 52.3% of the total banking assets, while the figures are of 22% in Germany, 26.3% in Italy, 35.9% in the United Kingdom and 40.4% in Spain. In the UK, the high presence of foreign banks, whose main services are not orientated towards the residents, is a bias that diminishes the share of the five biggest banks (these banks, except for HSBC, are more concentrated on the retail domestic market). In Germany, another specific factor that diminishes the share of the five biggest banks is the fact that mutualist and saving banks are not considered as being a unique group (even though they supply the same range of products on their area). In Italy the situation is equally influenced by the structure of the mutualist banks.

5 Results

In this section we present and interpret the evolution of the cost-efficiency scores for the analyzed banks, as well as the determinants of bank efficiency.

5.1 Results of efficiency analysis

The results of the DEA analysis, country by country, according to equation (4), are presented in table 3 below. They have been obtained by applying the DEA-Solver program, in accordance to Cooper, Seiford and Tone (2007).

Table 3: Average scores of cost efficiency by countries.

	France	**Germany**	**Spain**	**Italy**	**United Kingdom**	**United States**
1994	86.40	88.83	95.07	94.81	98.11	94.55
1995	90.91	86.87	94.43	97.85	96.42	94.12
1996	96.59	85.66	95.39	99.45	93.69	95.13
1997	94.77	86.85	95.43	99.44	93.46	99.18
1998	98.83	87.14	94.32	95.21	92.26	91.87
1999	97.09	91.81	96.23	93.52	89.58	96.64
2000	91.05	88.49	95.11	95.17	88.26	97.77
2001	86.55	87.3	95.02	97.17	93.41	100
2002	87.99	86.19	96.01	97.71	84.74	98.06
2003	87.61	83.18	93.92	96.05	84.85	96.17
2004	86.34	79.97	96.81	93.48	92.41	96.84
2005	86.14	78.86	97.3	88.28	85.03	95.23
2006	91.52	79.14	98.32	93.4	86.57	91.63
mean	90.90	85.41	95.64	95.50	90.68	95.93
variation	+4.50	-9.69	+3.24	-1.41	-11.54	-2.92

Note. This table presents the average scores of cost-efficiency for each year and country. These scores are estimated by DEA technique, with DEA-Solver program, and are expressed in percent. The variation is the difference between the average score of cost efficiency in 2006 and the average score of cost efficiency in 1994.

The major conclusion lies in an improvement in cost-efficiency over the analyzed span of time in France and Spain, while it declines in Germany, Italy, the United-Kingdom and the United States. The findings for France are in line with Weill (2006b). In our analysis, the cost-efficiency of French banks evolves from 86.40% in 1994 to 91.52% in 2006, that is to say an increase of 4.50%.

Table 3 equally presents the mean of cost-efficiency scores over the analyzed period of time. For the six countries, the average scores are situated between 85.41% (in Germany) and 95.9% (in the United-States).

The evolution of these scores is presented in figure 1, Appendix 3.

Both the economic environment and the banking systems evolved during the period under analysis. Despite the Asian and Russian crises of 1997 and, respectively, 1998, the 90s were years of economic growth, good financial conditions and intense restructuring of the banking system for the countries in the sample. The banks consolidated their position on the domestic market in Spain and Italy, following the trend initiated in the UK by the creation of big retail banking groups. A less specialized model is promoted in France, with the complementarity of products (retail and investment banking). After the internet bubble deflation, the global growth declined from 4.7% (in 2000) to 2.4% (in 2001) (IMF). This worsened the risks and damaged the economic conditions in some emerging countries. In that context, September 11 increased sectorial risks. Some other events added: the rapid financial downturn, combined with the collapse of Enron. The recovery carried on during 2003, with disparities across regions (particularly on a slower pace for the Euro area).

Common deviations in the efficiency scores computed for the countries in our study correspond to some important dates in the evolution and functioning of their banking sectors. Deregulation of the banking industry in Europe and the United States in the 1980s and 1990s stimulated an unprecedented merger and consolidation wave. In the Euro area, the introduction in circulation of the euro took place in 1999 (with coins and banknotes introduced in 2002), forcing the banks to make large investments to adapt. Another important aspect in the European Union is the changeover to the use of International Financial Reporting Standards (IFRS) in January 2005 for the listed groups; this changed the base for valuation of some indicators used in our analysis. After the 2000 and 2001 downturn, the results of European and US banks improved substantially from 2003 on, first in retail banking and then in investment banking.

We notice:

- a decreasing tendency in the efficiency scores, both in Germany and the United Kingdom. These countries have very different banking "business models". On one hand, Germany presents: a three-pilar banking structure (public, private, cooperative) characterized by the dominance of public banks; a poor profitability and a predominance of banks in the financing of the corporate sector. On the other hand, the UK presents a system of joint-stock and private banks (mainly a financial-based banking system).
  - according to Gabel (2006), the German banking system is characterized by: a reduced competition (a large number of saving and mutualist banks limit their activity to a district or a city, according to the regional principle, *Regionalprinzip*, so that there is no competition among them); a particulary high net interest spread; high costs (especially in the case of private banks, with 75% of gains being absorbed by internal costs). This can explain the relative reduced level of the efficiency scores that we obtain.
  - according to the 2006 Financial Stability Report of Bank of England, the UK financial system has weathered well a series of disturbances over the past months. Major UK banks' reported profitability and capital levels have remained strong, with a slight decrease in efficiency scores.

- a relatively stable evolution for the efficiency scores in Spain; these scores are high, being superior to 93%. The 90s have been marked by the concentration and the internationalization of the Spanish banking system. The results that we obtain are in line with the 2006 IMF Financial System Stability Assessment on Spain. According to this report, efficiency indicators of Spanish credit institutions rank among the best, reflecting competition and a combination of strong volume growth and cost containment.

- a relatively stable evolution for the efficiency scores in Italy, marked by an important decrease in 2005. This might be related to the economic situation encountered by Italy in the first quarter of 2005. Three events occurred: first, there was the entry of the Italian economy in recession; second - the publication by OECD of an alarmist report on the economic situation; and, third, the launching by the European Commission, for the first time since the existence of the Stability and Growth Pact, of a double procedure against Italy, both for excessive deficit and excessive debt (Grenet, 2005). All these might have influenced the banking sector.

- the decoupling of the efficiency scores for the French banks since 2000 (compared to 1999 and until 2005), then a slight rise in 2006. The French banking system faced a net improvement in profitability in the 90s, with a reinforcement in solvency. In the same time, the non performing loans ratio decreased, thanks to an improved credit risk level over the period. Banks diversified revenue sources and rationalized production structures; their operating ratio regularly decreased, allowing risk's costs to be better covered. Diversification in banking activities played the role of a "shock absorber" (during the 1997-1998 crisis time, 2002 and the following years). The acquisition of Credit Lyonnais by Credit Agricole in 2003 (effective in 2005), CDC Ixis and Eulia by Caisses d'Epargne and Finaref by Credit Agricole in 2004, increased further the concentration in banking industry. According to Gouteroux (2006), the consolidated activity of the main French banking groups, as measures by the total assets, has risen globally, by 21%, over 2005. This was coupled with a rise in the global charges and in the provisions for depreciation (of 8.5%). The charges of functioning rose more rapidly than the net banking product, the personnel expenses increasing by relatively 21% in 2005. There is an increase in efficiency in 2006, in line with the 2006 report of the Banking Commission of Bank of France that stated a new progression in the activity and the results of French credit institutions, as a result of the sustained demand of financing and the well-orientated international financial context.

- the high level of the efficiency score in the US. These are superior to 90% and there is a slight decrease in their evolution by the end of the period of analysis. Over the two decades, the structure of the U.S. banking industry underwent an unprecedented transformation, marked by a substantial decline in the number of commercial banks and savings institutions and by a growing concentration of industry assets among a few dozen extremely large financial institutions. According to Jones and Critchfield (2006), the rate of decline in the number of banking organizations appears to be slowing markedly[7].

[7]At the end of 1984, there were 15,084 banking and thrift organizations (defined as commercial bank and thrift holding companies, independent banks, and independent thrifts). By the end of 2008, the number had fallen to 7,380, a decline of more than 50 percent. Distributed by size, nearly all the decline occurred in the community bank sector (organizations with less than $1 billion in assets in 2002 dollars) and especially among the smallest size group (less than $100 million in assets in 2002 dollars). Yet the community banking sector still accounts for 92 percent of banking organizations.

As far as the monetary policy is concerned, the Fed decreased the money market rate from 6.5% in 2000 to 1% in 2003, to stamp out the financial crisis born from the 2000 internet bubble (Brack, 2009). A brutal increase in the money market rate took place until 2006, followed by a decline. The low interest rates in the US mean reduced costs of the borrowed resources, and this might explain the high efficiency of the banks.

We cannot proceed to comparative analyzes of scores between countries, as they are determined country by country and reflect the specific conditions of banks from each country. Nevertheless, we can analyze their evolution by a test of convergence, as in Weill (2006b, 2008).

We proceed to the analysis of β convergence within each country. In order to do this, we estimate the growth rate of efficiency indicators over their initial level for the analyzed period, as in Weill (2006b):

$$\left[\ln\left(EFF_{i,2006}\right) - \ln\left(EFF_{i,1994}\right)\right]/t = \alpha + \beta \ln\left(EFF_{i,1994}\right) + \varepsilon_i \tag{6}$$

where $EFF_{i,2006}$ is the efficiency score of bank i in 2006; $EFF_{i,1994}$ the efficiency score of bank i in 1994, t the number of years; ε_i the error term of bank i and α and β are the parameters to be estimated. There is β convergence if the coefficient of the initial level, β, is negative and significant.

Table 4: Convergence test of efficiency scores, country by country.

Dependent variable	**Country**					
Growth rate of efficiency scores	**France**	**Germany**	**Spain**	**Italy**	**United Kingdom**	**United States**
Constant	-0.0172***	-0.0158***	-0.0007***	-0.0097***	-0.012***	-0.0082***
	(0.003)	(0.001)	(0.0002)	(0.001)	(0.001)	(0.001)
Initial efficiency score	**-0.1141*** **	**-0.039*** **	**-0.0674*** **	**-0.1396*** **	-0.034	**-0.0855*** **
	(0.012)	**0.012**	**(0.0005)**	**0.010**	(0.021)	**(0.003)**
Number of observations	104	130	130	130	130	117
R^2	0.4588	0.0988	0.9538	04283	0.006	0.5010

*Note.**,**,*** denotes significance at 10%, 5%, 1% confidence levels. Standard errors are in parenthesis.

The results of the convergence tests are presented in table 4 above. The estimations have been performed by the Ordinary Least Squares (OLS) method. We find a negative and significant coefficient for the initial score of efficiency in France, Germany, Spain, Italy and the United-States, while the coefficient is not significant in the United Kingdom. The results confirm the existence of convergence in efficiency during 1994-2006 in French, German, Spanish, Italian and American banking systems. In other words, the initial level of efficiency (in 1994) is a key determining factor of the variation of efficiency during the period 1994-2006 for every bank of the sample, except for British banks.

Least but not last, we focus on the determinants of the efficiency scores obtained through DEA technique. We seek to determine whether the observed differences in efficiency scores are owed to differences in economic conditions among countries.

5.1.1 Second stage regression outcomes

The purpose of this subsection is to take a step further in analyzing banking sector efficiency indicators by looking at their potential determinants. As in Grigorian and Manole (2002), we assume that the provision of banking services could be presented in a simplified setting by the following function:

$$y_{ij} = f_i(B_{ij}, M_j, R_j, E_j) \tag{7}$$

where y_{ij} measures output or efficiency of ith commercial bank operating in country j; B_{ij} denotes bank specific variables; M_j describes the macroeconomic environment in country j; and R_j and E_j define the regulatory and general business environment.

We assume that these factors affect bank efficiency in additive fashion, so that the coefficient of interest could be estimated using the following specification:

$$DEA_{ij} = \alpha + \sum_p \beta_p B_{ij,p} + \sum_k \gamma_k M_{j,k} + \sum_m \eta_m R_{j,m} + \sum_n \lambda_n E_{j,n} + \varepsilon_{ij} \tag{8}$$

The dependent variable is the cost-efficiency index, calculated earlier, in subsection 5.1, by the DEA technique.

To control for bank-specific features (B_{ij}), we include: (a) equity as a share of total assets; (b) a dummy variable for foreign controlled banks (that takes the value of 1 if a bank is more than 30 percent foreign owned and 0 otherwise); (c) a dummy variable to account for new vs. old banks (that takes the value of 1 if a bank is newly established and 0 if it was established before 1990); (d) the size of banks[8] (measured by the log of total assets; this variable might influence the efficiency through the "too big to fail effect"). The macroeconomic environment (M_j) is described by: GDP per capita, annual average rate of inflation and monetary depth and size of the financial sector (measured by the ratio of broad money to GDP). Including inflation in equation (7) is intended to capture potential inefficiencies, which could take the form of both price - and non-price behavior, common for high inflationary environments (e.g., high interest margins, excessive branching). The regulatory environment (R_j) is described by the capital adequacy (Tier 1 capital ratio). Developments in capital markets and non-bank financial institutions and their effect on commercial bank performance (E_j) are captured by stock market capitalization (% of GDP). The variables are presented in Appendix 2.

The dependent variable has a limited nature (the DEA index ranges between 0 and 1); consequently, a censured Tobit regression model is used for estimating the equation (8). In cases with limited dependent variables, Tobit models generate consistent estimates of regression coefficients compared to conventional OLS estimation. The results are presented in table 5; in this table we equally present the OLS estimates for robustness checking.

[8]We thank an anonymous referee for pointing us in that direction.

Table 5: Second step regression outcomes: censored Tobit analysis.

Dependent variable	**Tobit DEA** (1)	**OLS DEA** (2)	**Tobit DEA** (3)	**OLS DEA** (4)
GDP per capita	-0.105**	-0.105**	-0.099***	-0.099***
	(0.034)	(0.032)	(0.037)	(0.036)
Inflation	-0.018	-0.018	-0.018	-0.018
	(0.016)	(0.016)	(0.016)	(0.016)
Equity/total assets	0.110***	0.110***	0.113***	0.113***
	(0.018)	(0.021)	(0.019)	(0.021)
News vs. Old	0.047***	0.047***	0.046***	0.046***
	(0.015)	(0.016)	(0.015)	(0.016)
Foreign	-0.022	-0.022	-0.022	-0.022
ownership	(0.015)	(0.020)	(0.015)	(0.020)
Size	0.007	0.007	0.007	0.007
	(0.005)	(0.005)	(0.006)	(0.005)
Tier 1	0.078***	0.078***	0.079***	0.079***
capital ratio	(0.024)	(0.026)	(0.024)	(0.027)
Market capitalization			-0.006	- 0.006
			(0.012)	(0.011)
Constant	0.528*	0.528	0.465	0.465
	(0.319)	(0.324)	(0.343)	(0.350)
Number of observations	602	602	602	602
R^2	0.1382	0.1383	0.1386	0.1387

Note. *,**,*** denotes significance at 10%, 5%, 1% confidence levels. Standard errors are in parenthesis.

First, the results suggest that well capitalized banks are ranked higher in terms of their ability to collect deposits than their poorly capitalized counterparts. This is in line with the wisdom of capital playing a role of implicit deposit insurance, which in turn encourages more deposits. The result is in line with most studies founding that well capitalized banks are more efficient (Berger and Mester, 1997).

Second, banks with controlling foreign ownership are likely to be more efficient than their domestically owned counterparts. Foreign owned banks are capable of capitalizing on their access to better risk management and operational techniques, which is usually made available through their parent banks abroad. In addition, foreign owned banks are less prone to typical corporate governance conflict between owners and the management. In our sample, these banks are subsidiaries of large international bank groups[9]. Well capitalized foreign banks are more likely to cherry-pick the best borrowers available on the market, improving the quality of their portfolio and increasing ex post returns. On the deposit side, foreign ownership plays a role of implicit deposit insurance. Despite all these aspects, the estimations show a non-significant coefficient for the dummy variable of foreign ownership, contrary to expectations.

Third, it appears that newly established banks, result of recent mergers and acquisitions (realized after 1990), are more efficient than those that existed prior to 1990.

Fourth, the size of banks does not influence their efficiency scores. The estimations show a positive but non-significant coefficient for this variable (measured by the log of the total assets). One should expect a positive and significant coefficient, as large banks are usually characterized by large economies of scale.

[9]For instance, in Italy, BNL (Banca Nazionale del Lavoro SpA) is a subsidiary of BNP Paribas; in France, HSBC is a subsidiary of HSBC Group, etc.

Fifth, prudential regulations have impact on the efficiency of banks. The Tier 1 capital ratio presents a positive and significant coefficient, as tighter capital ratios are associated with higher efficiency scores.

Sixth, the coefficient of GDP per capita indicates that banks in lower per capita income are more efficient in terms of attracting more deposits and generating strong cash flows than banks in relatively high income countries. This aspect is rather counterintuitive, as more developed countries (i.e., with higher per capita income) tend to generate more savings and hence more deposits. But, in our analysis, all the analyzed countries are "developed" economies. If we take a look at data in table 3, we see that the highest efficiency scores are obtained in Spain (95.64%) and Italy (95.50%)[10], countries that present the lowest per capita incomes from the sample (22,020 USD in Spain and, respectively, 24,205 USD in Italy, compared to 26,100 USD in Germany, 25,381 USD in the United Kingdom, 25,665 USD in France and 34,380 USD in the United States). As for the other elements of macro environment, the results show a reduced impact of inflation on efficiency; high inflation is not necessarily associated with large-scale inefficiencies. We could not introduce the M2/GDP ratio in our estimations because of the lack of data for European countries.

Market capitalization (% of GDP) does not seem to influence bank efficiency. One should expect a negative and significant coefficient, as the opportunity to raise funds on the stock market would reduce the demand for bank loans by the best borrowers on the market. Less credit would then determine lower ex post returns and result in lower efficiency of banking operations. On the other hand, more developed non-bank financial institutions (i.e., pension funds, insurance companies, brokerage firms, etc) would produce a greater demand for household savings, reducing the amount of bank deposits available to the banks and, eventually, transaction services rendered by the banks.

6 Conclusions

The paper adds to the existing literature on cost-efficiency in banking in France, making several important contributions.

The analysis widens the literature on bank costs modeling, using the DEA technique for a sample of European and American banks, during 1994-2006. It examines the cost efficiency evolution for the ten biggest French, English, German, Italian, Spanish and American banks. Our work is in line with Weill (2006b) and consists of a comparative evolution in the case of European and American banking systems.

The span of time has been characterized by important changes, especially related to the legislative framework of the European capital markets integration. We find an increase in cost-efficiency of French banks between 1994 and 2006, the average score evolving from 86.40% to 91.52%. A similar improvement is obtained in Spain, while in other countries we obtain a decline in cost-efficiency.

[10]Both Italy and Spain have registered important developments in their financial and banking sectors, catching-up the advanced EU countries (Spain entered the EU relatively late, in 1986, and, since then, important progress have been made in terms of economic and financial development).

The tests of convergence performed separately, country by country, show the convergence in efficiency of French, German, Italian, Spanish and American banks, over the period 1994-2006.

In a second step analysis we focus on differences in commercial bank efficiency across countries, against a wide array of variables describing the macro environment, regulatory regime and non-bank financial development. Through a censored Tobit regression we find that well capitalized, newly established banking groups (after 1990), having tighter capital ratio and operating in a country with a relatively lower GDP per capita record the highest cost-efficiency scores.

We are aware of the fact that the paper presents several limitations. First, the analysis may suffer from a sample selection bias problem resulting from the fact that the analysis is performed over the ten biggest banks of the six countries; the selection of banks is determined by the availability of data (only banks for which data was available for the entire period (1994-2006) were retained). Extending the analysis to a larger number of banks could then be useful. Then, it would be interesting to check whether a similar evolution in the efficiency scores would be obtained through a parametric method.

As a continuation of this work, it would be interesting to analyze banks from other countries. For instance, we should analyze banks from Japan in order to compare the evolution in efficiency scores for the triad (Japan, Unites-States, Euro area). Moreover, taking into consideration banking systems from all the Euro area countries could allow distinguishing the existence of potential "groups", sharing similar/different evolutions in terms of efficiency scores. Another possible continuation consists of a similar work performed over banks having different characteristics of ownership, such as cooperatives or public banks.

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Appendix

Appendix 1. List of banks in the sample

Germany
Deutsche Bank AG; Commerzbank AG; Bayerische Hypo-und Vereinsbank AG; Dresdner Bank AG; KfW Group-KfW Bankengruppe; Bayerische Landesbank; WestLB AG; Eurohypo AG; Norddeutsche Landesbank Girozentrale NORD/LB; Deutsche Postbank AG.

Spain
Banco Santander SA; Banco Bilbao Vizcaya Argentaria SA; Caja de Ahorros y Pensiones de Barcelona, LA CAIXA; Caja Madrid-Caja de Ahorros y Monte de Piedad de Madrid; Banco Espanol de Crédito SA, BANESTO; Banco Popular Espanol SA; Caja de Ahorros de Valencia Castellon y Alicante BANCAJA; Banco de Sabadell SA; Caixa d'Estalvis de Catalunya-Caja de Ahorros de Cataluña; Caja de Ahorros del Mediterraneo CAM.

United-States
Citigroup Inc; Bank of America Corporation; JP Morgan Chase & Co.; Wachovia Corporation; Wells Fargo & Company; US Bank National Association; Sun Trust Bank; Regions Bank; National City Bank.

France
BNP Paribas; Crédit Agricole S.A.; Société Générale; Groupe Caisse d'Epargne; Dexia; HSBC France; OSEO Financement; Caisse Centrale du Crédit Immobilier de France - 3CIF.

Italy
UniCredito Italiano SpA; Intesa Sanpaolo; Gruppo Monte dei Paschi di Siena-Banca Monte dei Paschi di Siena SpA; Banca Nazionale del Lavoro SpA - BNL; Antonveneta SpA-Banca Antonveneta SpA; Banca popolare dell'Emilia Romagna; Banca Popolare di Milano ScaRL; Banca Carige SpA; CREDEM-Credito Emiliano SpA; Banca Popolare Italiana - Banca Popolare di Lodi.

United Kingdom
Barclays Bank Plc; HSBC Holdings Plc; Royal Bank of Scotland Group Plc; Bank of Scotland Plc; Lloyds TSB Bank Plc; National Westminster Bank Plc - NatWest; Abbey National Plc; Nationwide Building Society; Standard Chartered Bank; Alliance & Leicester Plc.

Appendix 2. Summary of indicators used

Dependant variable - efficiency indicators
DEA - individual banking indicator DEA, with deposits, customer loans and net fee and commission income as outputs (obtained by DEA-Solver program).

Individual bank specific variables (BankScope)
Number of employees.
Value of fixed assets.
Borrowed funds.
Depreciation.
Personnel expenses.

Interest expenses relative to total borrowed funds.
Total value of customer deposits.
Total value of customer loans.
Total value of net fee and commission income.
Equity as a share of total assets.
Dummy for foreign ownership (1 if more than 30 percent owned; 0 otherwise).
Whether the bank is established before or after 1990 (1 if new; 0 if old).

Macroeconomic indicators
Per capita GDP, PPP adjusted, USD (World Development Indicators, World Bank).
Annual average rate of inflation (World Development Indicators, World Bank).

Prudential standards
Tier1 capital ratio (BankScope).

Capital markets/ Non-bank financial institutions
Market capitalization of listed companies, % of GDP (World Development Indicators, World Bank).

Appendix 3.

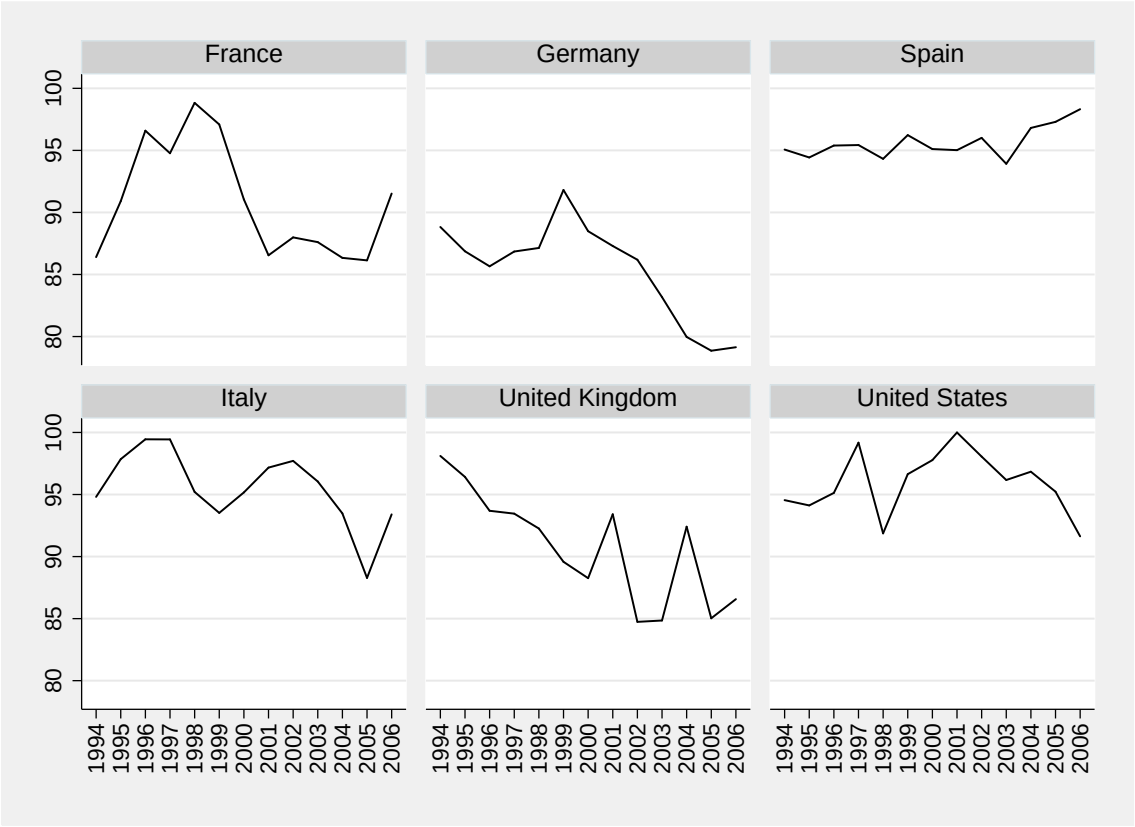

Figure 1: The evolution of average efficiency scores, 1994-2006.