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Measuring cost efficiency in the Algerian banking system : A comparison of parametric and non-parametric frontier methodologies

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Abstract
The aim of this paper is twofold. First, we provide an empirical assessment of technical and cost efficiency based on a panel dataset of fourteen (14) Algerian commercial banks over the 2003-2012 period using the parametric technique of Stochastic Frontier Approach SFA and the non-parametric Data Envelopment Analysis DEA. Second, in a purpose to demonstrate the robustness of the obtained efficiency scores, we check the consistency conditions among the two frontier techniques by analyzing the correlation between efficiency estimates, rank order and the correlation with accounting measures of performance. Empirical results indicate the presence of a relative consistency between the two approaches in contrast with standard performance measures. We find that Algerian banks are efficient about 45,74 % (SFA) , and 62.60 % (DEA) in average, and efficiency scores vary according to the size and the ownership status . In fact, public banks outperform private banks affected by their high allocative inefficiency. We also notice that the Algerian banking efficiency has gradually deteriorated from 65,72 % in 2003 to 36,28 % in 2012.

Key words: Technical Efficiency,Economic (Cost) Efficiency, Algerian Banking System, Stochastic Frontier Approach SFA, Data Envelopment Analysis DEA .

الملخص
الهدف من هذه الورقة البحثية مزدوج.أولا،تهدف إلى قياس الكفاءة الفنية و الاقتصادية لعينة مكونة من 14 بنك تجاري جزائري خلال الفترة 2003 -2012باستعمال التقنية البرمترية المتمثلة في تحليل الحدود الستوكاستكية SFA و الطريقة غير البرمترية المتمثلة في التحليل التطويقي للبياناتDEA .
ثانيا،بغرض إثبات مدى ثبات درجات الكفاءة التي تم الحصول عليها، نتحقق من ظروف الاتساق بين التقنيتين من خلال تحليل الارتباط بين نسب الكفاءة , درجة الترتيب و الارتباط مع المقاييس المحاسبية للأداء. تشير النتائج إلى وجود اتساق نسبي بين المقاربتين و لكنها تتعارض مع مقاييس الأداء المحاسبية. بحيث تشير النتائج إلى أن البنوك الجزائرية تحقق كفاءة بنسبة 45،74٪ (SFA) و 62،60٪ (DEA) على المتوسط. كما تتباين مستويات الكفاءة حسب حجم و طبيعة الملكية بحيث تتفوق البنوك العمومية على البنوك الخاصة التي تتأثر بتدهور كفاءتها التخصيصية ، كما سجلنا تدهور الكفاءة الاقتصادية للبنوك التجارية من 70.65% الى 28.36 %خلال فترة الدراسة.

الكلمات المفتاحية: الكفاءة الفنية, الكفاءة الاقتصادية(التكلفية), تحليل الحدود الستوكاستكية, SFA التحليل التطويقي للبيانات, DEA النظام البنكي الجزائري.

1. Introduction

Over the past several years, substantial research has fueled the literature related to the measurement of banking efficiency. The methodology focused mainly on estimating an efficient frontier and measuring the distance as inefficiency between

the observed banks and banks on the frontier. Assessing the banking efficiency is of vital importance from a microeconomic perspective, Due to improvements in institutional, supervision and regulatory framework, and from a macroeconomic perspective since the cost of financial intermediation remained affected by the efficiency of banking industry. In fact, a better allocation of financial resources reflects improvement in overall bank performance within efficiency, increasing investment that favors growth (Delis, Koutsomanoli, Staikouras, and Gerogiannaki, 2009).

Bank's managers as well as regulators need to be accurately informed about the effect of their policy decisions regarding the financial institutions they manage or regulate. According to Bauer , Ferrier and Humphrey (1998) a rigorous empirical research over the banking efficiency would provide regulators of different financial institutions (commercial banks , thrifts ; credit unions and insurance companies) pertinent knowledge regarding whether the increases in equity capital ratio required will result in significant higher costs and reduce the supply of intermediation services . It is also important to know the effects of mergers , acquisitions , market concentration on banking efficiency and whether one type of organizational form in terms of size or ownership lead to more cost or profit efficiency. Similarly, it is important to assess the way inefficiency is manifested (poor production decisions or risk management decisions), or both (BergerandMester, 1997). This would substantially help regulator authorities observe the probability of financial institutions failure, which potentially could be used to reallocate scarce supervisory resources to where they are most needed (Bauer et al, 1998).

The efficiency measurement techniques are based on either parametric or non-parametric frontiers. The parametric methods involve the estimation of an economic function (e.g., production, cost or profit) and the derivation of efficiency scores from either the residuals or dummy variables. This method includes Three econometric approaches - the stochastic frontier approach (SFA), thick frontier approach (TFA), and distribution-free approach (DFA)[1].However, the nonparametric methods often referred to as Data Envelopment Analysis DEA and Free Disposal Hull (FDH) , involve solving linear programs, in which an objective function envelops the observed data; then efficiency scores are derived by measuring how close an observation is situated from the "envelope" or frontier (Delis et al, 2009).

Despite intense research efforts, there is no consensus on the best frontier technique to assess efficiency. Almost all scholars argue that it is unnecessary to have a consensus on which is the single best frontier approach for measuring efficiency.

Bauer et al, (1998) proposes a set of consistency conditions that efficiency measures derived from tie various approaches should meet to be most useful for regulators or other decision makers. The efficiency scores generated by the different approaches should be consistent in their efficiency levels, rankings, and identification of best and worst firms, consistent over time and with competitive conditions in the market, and consistent with standard non frontier measures of performance.

While the literature related to banking efficiency would reveal extensive studies, surprisingly there have been few attempts to compare alternative techniques of efficiency measures. To the best of our knowledge, this is the first study that undertakes both parametric and nonparametric techniques in assessing the banking efficiency of an Arabic country (Algeria). In consequence, the above discussion regarding the various efficiency concepts strongly motivates a comparison of the results obtained by the corresponding methodologies.

Given the above, the aim of this paper is twofold: First, we provide an empirical assessment of technical and cost stochastic frontiers based on a panel dataset of Algerian commercial banks over the 2003-2012 period. In addition, we examine the effect of certain bank specific factors (such as profitability, bank size ownership status and credit risk)on differences in efficiency. Second, the study aims to add to the limited literature by comparing on the basis of the same data set, the most widely used parametric and non-parametric techniques to cost efficiency measurement in a purpose to demonstrate the robustness of the explanatory results obtained, as suggested by Berger and Humphrey (1997).

In this study, we address two fundamental questions: ***Q1***. At what level Algerian banks are more efficient? (*Economic optimization Vs technological optimization*) and what are the determinants of this efficiency? **, *Q2***. Do frontier efficiency approaches meet the consistency conditions in the case of the Algerian Banking system, especially in terms of efficiency levels, rankings, identification of best and worst banks and the consistence with standard measures of performance?

This paper is organized as follows. After a brief survey of literature devoted to earlier efficiency comparisons of frontier techniques in Section 2, we present the research methodology, data and variables in Section 3. Section 4 is divided in three subsections , the first and the second outline, respectively , the parametric and non parametric frontier methodology employed in this study , and discuss the results . The third subsection deals with correlation results to check the conditions of consistency. Finally, Section 5 concludes.

2. Literature review

Despite the vast literature on banking efficiency , only few attempts have been made in recent literature to compare the proximity of both types of frontier approaches, usually by applying two efficiency methods to the same data set and thus for a more better analysis. Therefore, there is not much information available on consistency conditions mentioned above, because most studies applied either a parametric or a non parametric approach.

In this regard, one of the pioneering comparative studies is that of Ferrier and Lovell (1990). Both authors measure the cost-efficiency of US banks using a sample of 575 units with five outputs and three inputs each. For parametric analysis, they specify a double cost of stochastic frontier function with a Translog specification. The cost frontier is estimated by a maximum likelihood procedure. The non-parametric approach is deterministic and follows the DEA- BCC of Banker, Charnes and Cooper (1984).The authors find a lack of harmony between the two sets of efficiency scores. But, but, more similar results regarding returns to scale properties. According to their interpretation of the results, the differences are explained by the fact that the stochastic specification was compared with a deterministic specification.

Bauer et al, (1998) perform extensive research on the consistency of frontier approaches to estimate cost efficiency of 683 U.S banks. The authors apply three parametric approaches (SFA, DFA and TFA)[2] and one non-parametric approach (DEA), and then compare their results on the basis of several consistency conditions. their main conclusion is that all parametric approaches provide efficiency measures that are consistent with one another for the distributional characteristics (means and standard deviations) , the rank order , the identification of the best and the worst units and correlation with non frontier techniques. However, the non parametric DEA does not provide results consistent with parametric approaches. Weill (2004) notice that these findings may be only relevant for U.S. banking data. Indeed, some evidence comparing parametric and non-parametric approaches on European banking data tend to suggest very different results regarding the consistency of frontier measures. For instance ,Resti (1997) measures cost efficiency for a sample of 270 Italian banks with SFA and DEA. The author mainly observes similarities between both approaches such as comparable mean values and high positive correlation for scores and scores rankings

Weill (2004) investigates the consistency of efficiency frontier methods on five European countries using two parametric techniques SFA and Distribution Free

Approach DFA, and the non parametric DEA. The author observes strong differences in the distribution properties of the efficiency scores provided by the three techniques in all the five countries which conflict with the consensus of US studies about efficiency scores across parametric approaches. The author also noticed that the SFA and DFA are positively correlated but not positively correlated with DEA efficiency scores and all efficiency estimates provided by the frontier techniques are correlated with standard measures of performance. Delis et al, (2008) provide an empirical assessment of both cost and profit efficiency on the Greek banking system applying the parametric Stochastic Frontier Approach SFA and the non parametric Data Envelopment Analysis DEA. Their findings show lower levels of cost efficiency than profit efficiency. The results suggest also that mean inefficiency scores and average standard deviation derived from the DEA are superior (almost the double) that those calculated with SFA .

3. Research methodology, Data and Variables

A fundamental decision in measuring banking efficiency is which concept to use. This depends of course on question being addressed. In this study, we measure the cost efficiency rather than technical efficiency[3]. Economic efficiency (cost efficiency) is a broader concept than technological efficiency, because it involves the optimal choice of levels and combinations of inputs and/or outputs based on reactions to market prices (Berger et al. 1997). To be economically efficient, a firm has to choose its input and/or output levels and mixes to optimize an economic goal, usually cost minimization or profit maximization[4]. The cost efficiency measures how close a bank's cost is to what a best practice bank's cost would be for producing the same output bundle under the same conditions (Berger et al. (1997). It is based on the specification of a cost function in which variables costs depend on input prices variables, the quantities of variable outputs and any fixed inputs or outputs, environmental factors, and random error, as well as efficiency. Cost efficiency is measured as the ratio between the minimum cost at which it is possible to attain a given volume of production and the observed costs for firm. A cost efficiency score of 0.60 would mean that the bank could potentially reduce its costs by 40 % compared to best practice bank under the same market conditions and within the observed data.

Some scholars propose a set of consistency conditions that frontier efficiency measures should meet to be most useful for regulatory analysis (that the efficiencies generated by these approaches be consistent with each other in terms of their efficiency levels, rankings, and identification of best and worst firms) help determine the degree to which the different approaches are consistent with each

other. The latter three conditions (that the efficiencies are consistent over time ,consistent with competitive conditions in the market, and consistent with standard non frontier measures of performance) help determine the degree of which the efficiencies generated by the different approaches are consistent with reality and are believable, which is necessary for the efficiency estimates to be useful.

3.2. Data and variables

The dataset comprises financial statements of fourteen (14) commercial banks operating in Algeria during the 2003-20123 period. After reporting data from errors and other inconsistencies, we obtain a balanced panel data consisting of 140 bank-level observations. The table 1 describes the variables adopted in our study. For the definition of inputs and outputs, we follow the intermediation approach proposed by Sealey and Lindley (1977).

A total cost is defined as the sum of interest expenses and overheads (personnel and operating expenses). Two outputs are specified, total loans and other earning assets. Financial capital,physical capital and Labor are the inputs. The price of labor is defined as the ratio of personnel expenses to total assets(Jiang, 2008); the price of physical capital is defined as the ratio of operating expenses over the fixed assets. Whereas, the price of funds is calculated as the ratio of interest expenses to deposits and short term liabilities (see descriptive statistics in table 28).

Table 1: Variable definitions and notation

Variables	Definition
Dependent variable	
Total Cost TC	Interest expenses + Noninterest expenses (personnel expenses + other operating expenses)
Input prices output variables	
Price of fund PK	Interest expenses divided by deposits and short term funds
Price of labor PL	Personnel expenses divided by total assets
Price of physical capital PF	Other operating expenses divided by fixed assets
Total Outputs Y	Total loans + Other earning assets

Table 2: Descriptive statistics

Variables	N obs	Mean	Std	max	min
Input and Output variables					
Input 1 (Personnel expenses)	140	1661,83	1983,01	11414,1	29
Input 2 (Operating expenses)	140	2949,15	3975,32	17121,2	0,1
Input 3 (Interest expenses)	140	3459,49	7489,15	78936	34,116
Output 1 (Total loans)	140	131792,19	196942,26	1134166	195,3
Output 2 (Other earning Assets)	140	148971,99	339252,73	1764867,1	30
Netput (Total Equity)	140	5626,03	43898,78	212558,9	463
Price of Labor	140	0,009	0,004	0,032	0,002
Price of Funds	140	0,108	0,472	3,770	0,0001
Price of Fixed Assets	140	0,773	0,601	3,697	0,088

4. Empirical Investigation

4.1 The Cost efficiency estimation based on parametric analysis

4.1.1 The stochastic Frontier Approach SFA

The stochastic Frontier Approach is the most common econometric method based on regression analysis which is applied to measure efficiency. The method was independently developed by Aigner , Meeusen and van den Broeck in 1977. The method uses explicit assumptions about the inefficiency component's distribution and tries to decompose the residual of thefrontier into inefficiency and noise. Usually the cost (profit) function is specified with a Translog form that allows for random error(Berger , Hunter and Timmer, 1993) . According to the SFA, total cost assumes the following specification:

$TC_{it}=f(P_{it},Y_{it},Z_{it},)+v_{it},+u_{it},(1)$

Where *TC* denotes observed operating and financial cost for bank *i* at year *t*, *P* is a vector of input prices, *Y* is a vector of outputs of the bank, and *Z stands* for a set of control variables (fixed netputs). This approach decomposes the error term in two components. The first (*v*), corresponds to the random fluctuations, *which is*

assumed to follow a symmetric distribution (usually the standard normal distribution) around the frontier, capturing all phenomena beyond the control of management incorporating error measurement effects of the explanatory variables or external shocks (good or bad luck). The second (u), accounts for bank's inefficiencies, *which follow an asymmetric distribution usually a truncated or half normal distribution*.The translog stochastic cost takes the following form:

$$Ln(CT_{it}) = \beta_0 + \beta_y Ln(Y_{it}) + {}^1\!/_2\,\beta_{yy}[Ln(Y_{it})][LnY_{it}] + \sum_{j=1}^{m} \beta_{jit} Ln(P_{it}) + \sum_{j=1}^{m} \beta_{jy} Ln(P_{jit}) Ln(Y_{it}) + {}^1\!/_2 \sum_{j=1}^{m}\sum_{k=1}^{n} \beta_{jk} Ln(P_{jit}) Ln(P_{kit}) + V_{it} + U_{it} \quad (2)$$

Where i denotes banks and t time horizon and $LnCT$the natural log of total costs,LnY is the natural log of aggregated output values,LnP the natural log of input prices.β are parameters to be estimated .$V_{it} + U_{it} = \varepsilon_{it}$ and is the composite error term.

The general procedure for estimating cost efficiency from Equation (2) is to estimate equation coefficients and the error term $\varepsilon_{it} = v_{it} + u_{it}$ .First, and then calculateefficiency for each observation in the sample. The cost frontier can be approximated by maximum likelihood ML, and efficiency levels are estimated using the regression errors. The variability, σ, can be used to measure a firm's mean efficiency, where$\sigma^2 = {\sigma_u}^2 + {\sigma_u}^2$.

We introduce some restrictions to reduce the number of parameters to be estimated and gain in terms of degree of freedom. We impose constraints of symmetry to ensure that the cost frontier estimated is well behaved (Friesand Taci, 2005).

$\beta_{jk} = \beta_{kj}$ and $\alpha_{hj} = \alpha_{jh} \forall jkh$.

Homogeneity in prices: $\sum\beta_k = 1$; $\sum\beta_{hj} = 0$;$\forall$ h ;$\sum\lambda jk = 0$; $\forall$j

Linear homogeneity conditions are additionally impose by normalizing total cost *CT* , price of capital *PK* and price of physical capital *PF* by the price of labor *PL* before the Log transformation . This choice has no incidence on the results since the estimation is obtained by the Maximum likelihood model. These restrictions allow us reduce the number of coefficients to be estimated from 15 to 10 coefficients. The stochastic frontiers for cost efficiency are estimated using

Frontier 4.1software developed by Tim Coelli (1996). The software estimates in a single step the cost model using the maximum likelihood estimation technique, and identifies potential correlates of the cost efficiency scores.

4.1.2 Discussion results of parametric efficiency estimates

The Table 3 reports the stochastic translog cost frontier parameter estimates from the maximum-likelihood model. The estimation results show relatively good fit and the signs of some variables conform to the theory. Four (04) coefficients are statistically significant. The value of the log-likelihood function of the cost estimate and the sigma squared are high enough and fit the statistical significance[5]. Similarly, the parameter γ is significant. That means that some residual estimates consist of bank specific inefficiency.

The table 3 shows a negative insignificant relationship between total outputs and the cost efficiency, (output and price logarithms should not have significantly negative signs). This makes a sense becausehigher outputs generate higher costs which increases cost inefficiency. The price of fund is significantly positive whereas the price of fixed assets is negative but insignificant statistically.

Table 3: Estimation results for the cost frontier.

Parameters	**Notation**	**coefficients**	**t-Ratio**
β_0	Constant	0.57 (0.31)	0.18
β_1	Ln (Y)	-0.33 (0.25)	-1.52
β_{11}	Square Ln (Y)	-0.28 (0.10)	-1.60
β_2	Ln (Pk/PL)	0.11 (0.10)	1.30 *
β_{22}	Square Ln (Pk/PL)	0.11 (0.12)	1.28*
β_3	Ln (PF/PL)	-0.15 (0.88)	-0.17
β_{33}	Square (PF/PL)	0.10 (0.90)	0.11
β_4	Ln (Y)*Ln(PK/PL)	-0.43 (0.51)	-1.35*
β_5	Ln(Y)*Ln (PF/PL)	0.37 (0.28)	0.13
β_6	Ln (Pk/PL)* Ln (PF/PL)	-0.34 (0.26)	-1.80**
Diagnostics			
$\boldsymbol{\sigma^2 = \sigma^2 u + \sigma^2 v}$ (sigma-squared)		0.23 (0.14)	1.36*
$\gamma = \boldsymbol{\sigma^2 u / \sigma^2 u + \sigma^2 v}$ (gamma)		0.99 (0.61)	1.38*
LR likelihood Function			210,25***
LR Test(one sided error)			12.23
Number of iterations		64	

* Significant at 10 % level; ** Significant at 5 % level; *** Significant at 1 % level

Table 4 summarizes the cost efficiency score for the Algerian industry banking during the period 2003-2012 estimated by the stochastic frontier. The panel A provides information about the level of bank efficiency by year. Panel B and C provide efficiency scores about types of banks, ownership status and size,respectively. Looking at the overall mean we notice that cost efficiency is equal to 45,74 % which implies that Algerian commercial banks could potentially reduce their costs by 54,26 % comparing to the best practice bank (or to match its performance with the best practice bank) .This score is significantly lower compared to cost efficiency levels obtained in different studies carried out in different countries of the MENA region, particularly in Moroccan and Tunisian banking industry that display cost efficiency scores varying between 70% and 80% (see Ben Naceur, Ben-Khediri and Casu, 2011 ; Olson and Zoubi, 2011 ; Bannour and Labidi , 2013 and Srairi , 2010). Algerian banks inefficiency is mainly due to bad quality of assets and the importance of operating costs, including personnel costs. Most public banks remain penalized by overstaffing that weighs on productivity.

Table 4:SFA cost efficiency scores (%)

	Nbr of Obs	Mean efficiency	Mean Inefficiency	Rank
Panel A: mean by year				
2003	140	65,72	34,28	
2004	140	58,47	41,53	
2005	140	52,09	47,91	
2006	140	46,48	53,52	
2007	140	41,54	58,46	
2008	140	45,54	54,46	
2009	140	38,71	61,29	
2010	140	37,78	62,22	
2011	140	36,85	63,15	
2012	140	36,28	63,72	
Panel B : mean by ownership				
Public Banks	50	54,42	45,57	1
Private Banks	90	42,97	56,81	2
Panel C : mean by size				
Large Banks	50	54,42	45,57	1
Medium size Banks	40	42,97	56,81	2
Small size Banks	50	21,38	69,46	3
Panel D : mean by bank				
B. N. A	10	56,79	43,21	2
C.P. A	10	49,51	50,49	6
B .A. D. R	10	52,24	47,76	3
B .D. L	10	62,44	37,56	1
B. E. A	10	51.15	48,85	5
BARAKA	10	38,43	61,57	10
B.N.P	10	41.38	58,62	9
Société Générale	10	49,17	50,83	7
GULF Bank	10	42,64	57,36	8
NATEXIS	10	52,07	47,93	4
A.B.C	10	26,27	73,73	11
MAGHREB Bank	10	10,80	89,2	14
TRUST Bank	10	26,17	73,83	12
HOUSING Bank	10	21,88	78,12	13
Overall mean	**140**	**45,74**	**54,26**	

Large banks Total assets >1000 Billion Dinars ; Medium sized banks : 100 Milliard DZD < Total assets <1000 Milliard DZD ; Small sized banks Total assets < 100 Milliard DZD

Panel B: the results show that the most efficient banks on average are public banks. In fact this does not corroborate with the literature that confirms the positive effect of private property as an explanatory factor on bank's efficiency. Panel C : we

notice that small and medium size banks (the size being captured by total assets) in our sample displayed lower average efficiency levels than those made by large banks , reflecting the dominance of state owned banks and the important role of economies scale in reducing operating costs. The inter-temporal comparison of the scores (panel A) suggests that the average cost efficiency ranges between 65,72 % (2003) and 36,28 % (2012). This gradual deterioration in efficiency may be due to problems caused by a colossal amount of non-performing loans.

4.2 The Cost efficiency estimation based on non parametric analysis

4.2.1 Data envelopment Analysis

In this study we also follow the non-parametric Data Envelopment Analysis (DEA) to estimate bank specific efficiency levels. DEA is a linear programming technique that allows calculating relative efficiency of a business unit. It was developed by Charnes, Cooper and Rhodes in 1978 (CCR) in order to measure relative efficiency without knowing what variables are more important or what their relationship is (Hasan, 2004). The non-parametric measurement of DEA creates a piecewise linear convex frontier that envelops input and output data, relative to which costs are minimized or profit/revenue is maximized. Efficiency scores are then calculated from the frontier generated by a sequence of linear programs(Christopher. Parmeter and Kumbhakar , 2014) .

We adopt an input-output orientation, based on the assumption that during periods of regulatory changes an increased completion market participants focus strategically on cutting costs(Ben Naceur et al, 2011). The input-orientationin technical efficiency measure improves efficiency through proportional reduction of input quantities,without altering produced output quantities. This is in accordance with the estimated technical efficiency for cost frontier.

The input-oriented DEA model under the assumption of variable return to scale can be used for calculation of input-oriented technical efficiency and cost efficiency. Input-oriented model under the assumption of variable return to scale is often termed as BCC model, which can be written in the following form (Coelli, 1996):

min θ^*_q subject to

$$\sum_{j=1}^{n} \lambda_j x_{tj} \leq \theta^*_q x_{iq} i = 1,2,\dots,m; \qquad (5)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rq} \; r = 1,2, \dots s;$$

$$\sum_{j=1}^{n} \lambda_j = 1 \; \lambda_j \geq 0 \qquad j = 1,2,..n$$

Where θ^*_q is the input-oriented technical efficiency of Decision Making (DMU_q), y_{rq} is the produced amount of r^{th} output *(r= 1,2,…,s)* for DMU_q , $x_{iq}$is the consumed amount of i^{th} input ($i = 1,2, \dots, m$) for $DMU_j (j = 1,2,..n)$, λ_j is weight assigned to the $DMU_j (j = 1,2,..n)$. To calculate cost efficiency, it is necessary to solve the following cost minimization DEA model(Coelli, 1996):

$$\min \quad \sum_{i=1}^{m} w_{iq} x_{iq}{}^{*} \text{ Subject to} \qquad 06$$

$$\sum_{j=1}^{n} x_{ij} \lambda_j \leq x_{iq}{}^{*} \qquad i = 1,2, \dots m$$

$$\sum_{j=1}^{n} y_{rj} \lambda_j \geq y_{rq} \qquad r = 1,2, \dots s$$

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad \lambda_j \geq 0 \qquad j = 1,2,..n$$

Where w_{iq} is the vector of input prices of $DMU_q$and $x_{iq}{}^{*}$ is the cost minimizing of input quantities for $x_{iq}{}^{*}$, given the input prices w_{iq} and the output level y_{rj}.The overall cost efficiency (CE) is defined as the ratio on minimum cost of producing the outputs to observed cost of producing the outputs for theDMU_q.

$$CE_q = \frac{\sum_{i=1}^{m} w_{iq} x_{iq}{}^{*}}{\sum_{i=1}^{m} w_{iq} x_{iq}} \quad (7)$$

The overall cost efficiency can be expressed as a product of technical and allocative efficiency measures. Therefore, the allocative efficiency of theDMU_q can be calculated as ratio of overall cost efficiency (CE_q) to input-oriented technical efficiency(TE_q). These three measures (technical, allocative and overall cost

efficiency) can take values ranging from zero to one, where a value of one in case of TE, AE and CE indicates full efficiency.

4.2.2 Discussion of results on non parametric efficiency estimates

The DEA software *DEAP V.4* used in this study allows us to decompose the cost efficiency into technical and allocative efficiency. we divide banks into two groups based on their size, in order to test whether DEA and the SFA offer similar insights regarding the effect of ownership status and bank size on efficiency , and It is noteworthy that The public banks outperform private banks in terms of cost efficiency , which corroborates with the parametric analysis results , But , a detail reading over DEA results provide us other relevant remarks regarding the source of inefficiency. Indeed, we notice that the private banks (especially small banks) have obtained almost the same technical efficiency scores than large public banks, reflecting their ability to manage the technical aspects of production to provide the maximum of services with the less possible resources. However, the deterioration of their cost efficiency is mainly caused by the decline of their allocative efficiency. In fact, Private banks, facing the predominance of pubic banks and the banking system opacity, fail to choose the combinations of the less expensive inputs, or fail to provide the most effective services due the lack of economies of scale, imperfect competition …, etc

Table 5: DEA cost efficiency scores (%)

	Nbr Obs	T E	A E	C E	Mean Inefficiency	Rank
Panel A :mean by ownership						
Public Banks	50	100.0	99.3	93.5	6.50	1
Private Banks	90	89.9	42.9	36.0	63.40	2
Panel B : mean by size						
Large Banks	50	100.0	99.3	93.5	3.50	1
Medium size Banks	40	77.4	52.62	38.92	61.08	2
Small size Banks	50	100.0	35,28	33.71	66.28	3
Panel C : mean by bank						
B. N. A	10	100.0	100.0	**100.0**	000.0	**1**
C.P. A	10	100.0	71.24	**71. 44**	28.66	**5**
B .A. D. R	10	100.0	96,80	**96.20**	3.80	**4**
B .D. L	10	100.0	100.0	**100.0**	00.0	**1**
B. E. A	10	100.0	100.0	**100.0**	00.0	**1**
BARAKA	10	42.0	88.30	**37.10**	52.90	**10**
B.N.P	10	100.0	56.70	**56.70**	43.30	**6**
Société Générale	10	86.50	39.30	**39.30**	60.70	**8**
GULF Bank	10	81.10	26.20	**22.60**	87.40	**14**
NATEXIS	10	100.0	41.50	**33.70**	66.30	**11**
A.B.C	10	100.0	28.70	**28.70**	71.30	**12**
MAGHREB Bank	10	100.0	28.00	**28.00**	82.00	**13**
TRUST Bank	10	100.0	37.30	**37.30**	63,83	**9**
HOUSING Bank	10	100.0	40.9	**40.88**	59,12	**7**
Overall mean	**140**	**93.5**	**66.2**	**61.60**	**39.40**	

***T.E** : Technical Efficiency . ; **A.E** : Allocative Efficiency (C.E / T.E) ; **C.E :** Cost Efficiency*

4.3 Correlation results

Despite the fact that efficiency estimates from the two methods are quite different across bank, we observed that correlation between the efficiency estimates derived by DEA and SFA methods is positive and significant(0.69). The ranking of banks is also positively correlated (0.64) (but we obtain a 100% correlation for subgroups). Considering the wide differences in the engineering assumptions of the two methods, these correlation results are very satisfactory. Concerning the identification of best and worst banks, both methods yielded almost the same

results with a positive correlation of 0.85. Indeed, parametric and nonparametric analysis identified BDL Bank and BNA Bank as the best banks. However, the SFA has identified the Maghreb Bank and Trust Bank as the worst units in the sample, whilst DEA has identified Maghreb Bank and Société Générale bank .The ambiguity is noticed at the Natexis bank that is among the best banks according to the SFA approach and the worst according to the DEA. In this case, we trust more the results of the parametric approach because the DEA is very sensitive to extreme values and outliers. These results demonstrate a certain consistency between the parametric method and nonparametric in the assessment of the banking efficiency.

The results suggest also that correlation between cost efficiency and bank's profitability s is not obvious. The negative correlation observed between the frontiertechniques and Return on Assets ROA is misleading because of ROA method of calculation. Indeed private banks recorded a higher ratio because of their small size of assets in contrast with public banks. Therefore, return on equity ratio ROE is more appropriate to compare with efficiency scores where we observed a significant weak correlation with both cost efficiency scores.

Table 6: Correlation of efficiency scores and rank order.

	DEA Rank	SFA Rank	SFA scores	DEA scores	ROA	ROE	SFA Subgr	DEA Subgr
DEA Rank	*1.00*	***0.64****						
SFA Rank	*64.44**	*1.00*						
SFA score			*1.00*	***0.69****	***-0.57****	***0.38****		
DEA scores				*1.00*	*-0.75*	***0.01****		
ROA					*1.00*	***0.30****		
ROE						*1.0*		
SFA subgr							*1.0*	***0.85****
DEA subgr								*1.0*

Note:* ,**,*** Denote an estimate significantly different from 0 at 10 %, 5% , 1%.

This is consistent with manystudies that demonstrate the fact that correlation between cost efficiency and profitability is not obvious, and the most efficient institutions in terms of costs, are not necessarily the most efficient in terms of profit and inversely, institutions with high profit efficiency does not always have the best cost efficiency. Overall, it seems that inefficiency on one area offset the favorable effects due to the efficiency of the other. Two factors may explain this:

- Algerian state owned banks making the best profits is not motivated to reduce their management costs. Thus, the productivity may be adversely affected by problems of internal organization;

- Second, private banking institutions well positioned in terms of costs may choose (under the competition pressure) an aggressive commercial policy, detrimental to profitability.

5. Conclusion

In response to deregulation, globalization and a more uncertain environment, various reforms have been implemented in the Algerian banking system over the last two decades. These measures included gradual liberalizing of interest rates, according new licenses to foreign banks, implementing progressive legal and regulatory reforms and reducing the direct government control. And thus, in purpose to improve the overall banking sector performance including efficiency. In this context,we provide in this study an empirical assessment about measuring technical and economic efficiency of the Algerian Banking industry over the 2003-2012 period.

To perform this task we proceeded in three stages. First, we applied the parametric stochastic Frontier Analysis to measure the cost efficiency. A translog cost function was estimated .We followed the Battese and Colli (1996)specification called *First step analysis* to explore some determinants of the bank efficiency; this would help to examine sources of bank's inefficiencies. Second, based on the same methodology assumptions as the parametric analysis, we use the non parametric Data Envelopment Analysis DEA on the same data set and over the sameperiod. Moreover, we analyzed the effect of size and of the ownership status (public vs. private) on the cost measures of efficiency. Finally, we check the consistency conditions between the two methods through a correlation analysis.

Our findings suggest that both the two techniques yielded fairly close average efficiency levels (45, 74 % for the SFA, 61,60 % for the DEA, average : 53,65%) . This would imply that Algerian commercial banks could potentially reduce their costs by almost the half *tomatch their performance with the best practice bank.* The inter-temporal comparison of the scores showed that the average cost efficiency appeared to have gradually declinedfrom 65,72 % in 2003 to 36,28 % in 2012.

Both DEA and SFA approaches offer similar insights regarding the effect of ownership status and bank size on efficiency .Actually , state owned banks outperform private banks in terms of cost efficiency , which corroborates with parametric analysis results , But , the non parametric approach revealed that private banks are as technically efficient as public banks. However, the deterioration of their cost efficiency is mainly caused by the decline of their allocative efficiency. Private banks, facing the predominance of pubic banks and

the banking system opacity, fail to choose the combinations of the less expensive inputs.

Finally, the comparison between the two approaches revealed satisfactory results. In fact, we observe that both methods meet some conditions of consistency, in terms of average efficiency levels, the rank order, the identification of the best and the worst banks during the same time period. Nevertheless, they remain inconsistent with the standard measures of performance, which makes our empirical findings derived from the frontier methods more informative about the reality of the Algerian banking industry performance.

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[1]These three techniques differ with regard to the assumptions about the shape of the efficient frontier, the existence of random error, and the distributional assumptions imposed on the inefficiency terms and random error in order to separate one from the other (Kambhakar and Lovell 2000).

[2] DFA reffers to Ditribution Frontier Approach and TFA reffers to Thich Frontier Approach.

[3]In fact, according to many authors, cost efficiency is a wider concept than technical efficiency, since it refers to both technical and allocative efficiency. In fact, a firm is called technologically efficient, when it minimizes its inputs given outputs or maximizes its outputs given inputs.

[4]Bauer et Al. (1998) noticed that is quite plausible that some firms technologically efficient may relatively be economically inefficient and vice versa, depending upon the relationship between managers' abilities to use the best technology and their abilities to respond to market signals. Accordingly, Berger et Al. (1997) believe that cost and profit efficiency are the best economic foundation for analyzing the efficiency of financial institutions.

[5]μparameter, the expected value of the inefficiency term u should be significantly different from zero [if μ highly insignificant, banks are (almost) on the efficient frontier, more than 99% efficient and there is no need for inefficiency estimation, SFA changes to simple ML or OLS.