Assessing cost and profit efficiency by a joint application of parametric and non parametric approaches: Evidence from the Algerian Banking system

Benzai Yassine[1] and Aouad Hadjar Soumia[2]

Abstract

The aim of this paper is twofold: First, we provide an empirical assessment of cost and profit 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 (profitability , bank size and ownership status) on differences in efficiency .Second, on the basis of the same data set, we also compare the most widely used parametric (Stochastic Frontier Approach SFA) and non-parametric (Data Envelopment Analysis DEA) techniques to cost efficiency measurement in a purpose to demonstrate the robustness of the explanatory results obtained .We check the consistency conditions among frontier techniques by comparing efficiency means , rank order, correlation coefficients and the correlation with accounting measures of performance. Our most striking results is that Algerian bank are more efficient at generating profits (score of 70,39 %) than controlling costs (score of 45,74 %) and that cost efficiency worsened while profit efficiency improved substantially during the study period. While all banks perform similarly in terms of profits , The cost efficiency scores vary considerably according the size and the ownership status . In fact public banks perform private banks which are disadvantaged by their allocative efficiency. The results indicate also the presence of a relative consistency between the two approaches; in contrast with standard performance measures making our empirical findings derived from the frontier methods more informative about the reality of the Algerian banking industry performance.

Keywords: Cost Efficiency, Profit efficiency, Algerian Banking System, Stochastic Frontier Approach, Data Envelopment Analysis.

[1]**Corresponding Author** Faculty of Business and Economics, University of Dr Moulay Tahar, Saida, Algeria. byassine20@gmail.com
[2]Faculty of Business and Economics, University of Dr Moulay Tahar, Saida, Algeria. aouad.hadjar@gmail.com

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 also 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 2008).

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 (Berger and Humphrey 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).*[i] 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 2008) .

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 (1998) proposed 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 cost and profit 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).

This study raises two fundamental questions: *Q1*. At what level Algerian banks are economically more efficient ? in generating profits or reducing costs , 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 measured the cost-efficiency of US banks using a sample of 575 units with five outputs and three inputs each. For parametric analysis, they specified 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 (*Banker, Charnes and Cooper, 1984*). They found a lack of harmony between the two sets of efficiency scores, 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.

Other studies that undertake multiple techniques reported fairly close average efficiencies generated by the two approaches (Bauer, Berger, and Humphrey 1993, Hasan and Hunter 1996, Berger and al 1997, and Resti 1997) . However, Bauer and *al* (1998) insisted on the potential problem that the levels of efficiency under DEA may be sensitive to “self-identifiers” or “ near-self-identifiers” when there are too few observations relative to the number of constraints in DEA (The average SFA scores was 79 % and the average efficiency

for DEA is somewhere between very low (54%) and relatively high (83%). Concerning the consistent order , the results from the literature are contradictory. While Ferrier and Lovell (1990) found a very week correlation of only 0 .02 between the SFA and DEA rank order, Resti (1997) found very high correlations (0.73 to 0.89), and Eisenbeis, Ferrier, and Kwan (1997) found fairly high rank correlations (0.44 and 0 .59) With regard to consistency conditions over time and consistency with standard (non frontier) measures of performance , the evidence suggested very low (but positive) correlation ((Eisenbeis, Ferrier, and Kwan 1997).

Bauer et *al*. (1998) performed extensive research on the consistency of frontier approaches to estimate cost efficiency of 683 U.S banks. They apply three parametric approaches (SFA, DFA and TFA) and one non-parametric approach (DEA), 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 (2006) noticed 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 tends 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. He 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 . He observed 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. He 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 showed 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 . These findings are consistent with Eisenbeis et al. (1997) for a study over US bank holding companies .

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 [ii] , profit efficiency rather than technical efficiency. In fact, according to many authors, economic efficiency (cost and profit) 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. Economic 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 so as to optimize an economic goal, usually cost minimization or profit maximization.[iii] 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 because they are based on economic optimization in reaction to market prices and competition , rather than being solely on the use of technology .

They define the cost efficiency as a measure of 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 .It is derived from a cost function in which variables costs depend on the prices of input 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 is using 60% of its resources efficiently or alternatively wastes 40 % of its costs relative to a best-practice bank . The profit efficiency measures how close a bank is to Producing the maximum possible profit given a particular level of input prices and output

prices (and other variables). In contrast to the cost function, the standard profit function specifies variable profits in place of variable costs and takes variable output prices as given, rather than holding all output quantities statistically fixed at their observed, possibly inefficient, levels. That is, the profit dependent variable allows for consideration of revenues that can be earned by varying outputs as well as inputs. Output prices are taken as exogenous, allowing for inefficiencies in the choice of outputs when responding to these prices or to any other arguments of the profit function (Berger et Al 1997) . A ratio of 0.80 would indicate that , because of excessive costs , deficient revenues or both , the firms are losing about 20 % of the profits it could be earning.

Bauer et *al*. (1998) suggest that it is not necessary to have a consensus on which is the single best frontier approach for measuring efficiency. Moreover, efficiency scores obtained from various techniques deliver different information , multiple sets of efficiency scores might be used as the basis for decision maker . So , the efficiency scores derived from different methods could be assigned different weights based on how much information they convey to the decision maker (Delis et *Al*. 2008).

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 o 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 2003-2013 period. After reporting data from errors and other inconsistencies, we obtain a balanced panel data consisting of 140 bank-level observations. overall our sample accounts for a significant proportion of the total banking assets (around 95 %) .

Table 1 : Variable definitions and notation

Variables	Definition
Dependent variable	
Total Cost TC	Interest expenses + Noninterest expenses (personnel expenses + other operating expenses)
Total Profit π	Total income – total cost
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
Inefficiency determinants	
Bank size LNS	Natural logarithm of total assets
Capital adequacy EQ	Total equity over total assets
Profitability ROA	Profit on total average Assets
Credit Risk CR	Loans to total assets

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) [iv] . Total costs is defined as the sum of interest expenses and overheads (personnel and operating expenses) and total profit (before txes) is defined as total income minus total cost. 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 personnel expenses to total assets [v] , 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 . The treatment of equity is relatively standard in banking efficiency estimation. It captures the level of capitalization, insolvency risk and different risk preferences across banks. (Delis et *Al.* 2009).

3.2 Determinants of efficiency

In this study we explore also some internal factors that may explain bank inefficiency rather than estimating the cost efficiency scores , following previous studies (Weill 2004 ; Pasiouras 2008) , we include in the cost function four bank-specific variables : profitability , size , capital adequacy and ownership status .

Table 2 : Descriptive statistics

Variables	N obs	Mean	Std	max	min
Dependant variables					
Total costs	140	8070,47	10598.24651	79009.305	145.3
Total profits (before taxes)	140	4943.95	10011.16	47032.00	-7350.70
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
Determinants of efficiency					

Profitability ROA	140	1,97	1,21	4,43	0,46
Bank size SI	140	11,35	1,82	16,43	7,80
Capital adequacy EQ	140	12,31%	13,05%	59,75%	2,64%
Crédit Risks CR	140	36,30%	16,68%	78,10%	4.02 %

The bank profitability is captured by Return on Assets (ROA). The ratio is positively correlated with efficiency . Thus, improving the bank's efficiency requires a reducing cost policy . The bank size is proxied by the natural logarithm of total assets (SI) . The literature related to the relationship between the size and efficiency remain mitigated. According to Berger , Hunter and Timmer (1993) , Miller et Noulas (1996) larger banks are more cost efficient than smaller banks because large size allows wider penetration of markets and increase in revenue at a relatively less cost because due to a gain in economies of scales .However some studies (*e.g,* Isik and Hassan 2002) found a significant negative relationship. Other recent studies even report the inexistence of a significant effect of the size on efficiency (Bannour and Labidi 2013) .

Capital adequacy (EQ) is measured as equity over total assets , it captures the regulation constraints in terms of capital and the level of risk aversion , this variable has a positive impact on efficiency . Banks with higher ratio of equity to total assets have lower cost and profit inefficiency (Casu and Girardone 2004 , Pasiouras 2008) . We use Loans to total assets (CR) to define the Credit Risks [vi]. Banks that provide more loans are expected to be less efficient in terms of costs as they take more risks. Ariff and Can (2008) find an inverse relationship between this variable and efficiency. They argue that banks which have a higher ratio of loan to total assets incur higher credit risk, and thus higher loan-loss provision, and are less efficient. Moreover, these banks provide a large proportion of loans to some inefficient state owned firms.

The bank's inputs and outputs , and bank determinants were obtained mainly from *Bankscope Fitch international database* published by *Bureau VanDijk (2013*) and the missing information were completed by banks' individual annual report via their official websites. The above Table 2 reports descriptive statistics of variables adopted in this study .

4. Empirical Investigation

4.1 The Cost and profit efficiency estimation based on parametric analysis

4.1.1 The stochastic Frontier Approach

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 [vii]. The method was applied to banking for the first time by Ferrier and Lovell (1990) . The method uses explicit assumptions about the inefficiency component's distribution and tries to decompose the residual of the frontier into inefficiency and noise. Usually The cost (profit) function is specified with a Translog form that allows for random error. According to the SFA, total cost assumes the following specification:

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

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 disentangles 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 [viii] . Our translog stochastic cost takes the following form, Moreover, it includes, as a particular case, the Cobb-Douglas specification (Carvallo and Kasman 2005).

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

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

In order to identify factors that are correlated with bank inefficiency, we use the model of Battese and Coelli (1995) which permits in a single step to calculate individual bank

efficiency score (Eq. 2) and to investigate the determinants of inefficiency (Eq.3). Specifically, *u* is assumed to be a function of a set of bank-specific characteristics. we use the following auxiliary model:

$$u_{ijt} = \psi Z_{ijt} + w_{ijt} \quad (3)$$

Where *Z* is a vector bank specific determinants , *w* represents a random variable which has a truncated normal distribution , and ψ is a vector of unknown parameters to be estimated .

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 calculate efficiency for each observation in the sample. The cost frontier can be approximated by maximum likelihood, and efficiency levels are estimated using the regression errors. The variability, σ, can be used to measure a firm's mean efficiency, where $\sigma^2 = \sigma_u{}^2 + \sigma_u{}^2$. Bank-specific estimates of inefficiency terms can then be calculated by using the distribution of the inefficiency term conditional to the estimate of the composite error term.

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 (Fries and 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 .

In this study we also employ the profit efficiency concept that implies that managers should not only pay attention to reducing a marginal dollar of costs, but also to raising a marginal dollar of revenue. Our model follows Berger , Hancock and Humphrey (1996), Srairi (2010) and Delis et Al. (2009) by assuming that firms have some market power in output markets. Hence we choose Alternative Profit Function (*APE)* . Efficiency here is measured by how close a bank comes to earning maximum profits given its output levels rather than its output prices. The APE function employs the same dependent variable as the standard profit function and the same exogenous variables as the cost function So we use the same Translog

form of the cost function, except that total costs in Eq. 2 are replaced by total profits before tax. Thus, instead of counting deviations from optimal output as inefficiency, as in the standard profit function, variable output is held constant as in the cost function while output prices are free to vary and affect profits.

To avoid a log of negative number, the profit variable is transformed as follows: $Ln\ (\pi+\theta+1\ ),$ where θ indicates the absolute value of the minimum value of profit (π) over all banks in sample. Thus for the bank with the lowest profit value for the year, the dependent variable of profit function will be equal to $Ln\ (1) = 0$. Also for measuring efficiency score under the profit function the composite error is $\varepsilon_{it} = v_{it\ ,} + u_{it\ ,}$. The measure of profit efficiency is defined as $PE_{it} = exp\ (-\ U_{it})$, in this case efficiency scores take a value between 0 and 1 with values closer to one indicating a fully efficient bank. (Coelli 1996)

The stochastic frontiers for cost and profit efficiency is estimated using *Frontier V 4.1* developed by Tim Coelli (1996) . The software estimates in a single step the cost and profit 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 . Seven (7) coefficients are statistically significant . The value of the log-likelihood function of both cost and profit estimate and the sigma squared are high enough and fit the statistical significance [ix] . Similarly ,the parameter γ is significant . This 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 cannot (or should not) have significantly negative signs) This makes a sense Because higher outputs generates higher costs which increases cost inefficiency . The price of fund is significantly positive whereas the price of fixed assets is negative but insignificant statistically for the cost estimate . Nevertheless , All price coefficients are significantly negative as expected sine higher input prices incur lower profits .

Concerning the bank determinants .The table reports the disconnection of the cost efficiency with profitability and capital adequacy . As unexpected , the coefficient of the bank size is significantly negative (larger banks should be more cost efficient than smaller banks because large size allows wider penetration of markets and increase in revenue at a relatively less cost because due to a gain in economies of scales) and the negative impact of the credit risks on cost efficiency is confirmed .

Cost and alternative profit inefficiency scores are obtained from the estimation of cost and profit frontiers as described above . Table 4 summarizes the average cost and profit efficiency scores for the Algerian industry banking during the period 2003-20013. 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

Table 3 : Estimation results for the cost frontier.

Parameters	***Notation***	***Cost efficiency***		***Profit efficiency***	
		coefficients	*t-Ratio*	*coefficients*	*t-ratio*
β_0	Constant	0.57 (0.31)	0.18	0.16 (0.32)	0.50
β_1	Ln (Y)	-0.33 (0.25)	-1.52	-0.11 (0.15)	-0.74
β_{11}	Square Ln (Y)	-0.28 (0.10)	-1.60	-0.14 (0.42)	-0.33
β_2	Ln (Pk/PL)	0.11 (0.10)	1.30 *	-0.31 (0.13)	-1.29*
β_{22}	Square Ln	0.11	1.28*	-0.16	-0.10

	(Pk/PL)	(0.12)		(0.16)	
β_3	Ln (PF/PL)	-0.15 (0.88)	-0.17	-0.83 (0.97)	-1.85**
β_{33}	Square (PF/PL)	0.10 (0.90)	0.11	0.16 (0.85)	0.27
β_4	Ln (Y)*Ln(PK/PL)	-0.43 (0.51)	-1.35*	0.81 (0.30)	0.26
β_5	Ln(Y)*Ln (PF/PL)	0.37 (0.28)	0.13	0.72 (0.27)	1.26*
β_6	Ln (Pk/PL)* Ln (PF/PL)	-0.34 (0.26)	-1.80**	-0.21 (0.46)	-0.46
Regressors					
ψ_0	Constant	-0.53 (0.95)	-0.56	-0,25 (0 ,54)	-0,87
ψ_1	ROA	-0.51 (0.40)	-0.12	0,56 (0,87)	0,95
ψ_2	SI	-0.12 (0.75)	-1,29 *	0,56 (0,52)	-1,40*
ψ_3	CDC	-0.84 (0.52)	-0.16	1,01 (0,90)	-1,11
ψ_4	DA	- 0.26 (0.67)	1.34*	-0.51 (0.40)	-0,98
Diagnostics					
$\sigma^2 = \sigma^2u + \sigma^2v$ **(sigma-squared)**		0.23 (0.14)	1.36*	0.27 (0.42)	1.63**
$\gamma = \sigma^2u / \sigma^2u + \sigma^2v$ **(gamma)**		0.99 (0.61)	1.38*	0.90	1,30*

	(0.13)	
LR likelihood Function	-210,25*	-100,25*
LR Test(one sided error)	12.23	11.65
Number of iterations	64	64

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

The profit figures in the four panels of Table 4 show a dramatically different picture from the cost figures . In fact, Looking at the overall mean (Panel D)we notice that cost are profit efficiency estimates are equal to 45,74 % and 70,39 % which implies that Algerian commercial banks could potentially reduce their costs by 54,26 % , and enhance their profits by 29,61% comparing to the best practice bank (or to match their performance with the best practice bank) *for* the given conditions within the observed data .The cost efficiency 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%. . The inter-temporal comparison of the scores (panel A) suggests that the average cost efficiency ranges between 65,72 % (2003) and 36,28 % (2012) . Algerian banks cost 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. Inversely, the profit efficiency has substantially improved from 41, 87 % to 79,73 % during the period. For that reason , it is worth mentioning that Algerian banks are more efficient at generating profits than controlling costs. These findings corroborate with some studies conducted in Arabic countries (*e.g.* , Srairi 2010) but differ from the most studies carry out in developed countries (*e.g* Maudos, Pastor and Perez 2002 ; Ariff and Can 2008) . According to Berger and Mester (1999) , the most likely explanation concerns some weaknesses of the cost minimization approach as applied to the banking industry . The cost approach and other approaches that do not consider revenues may not account well for unmeasured changes in output quality or may fail to adequately capture the profit maximization goal of banks , which requires that effort be spent to raise revenues as well as reduce costs . Accordingly , Berger and Mester (1999) hypothesis suggest that the decrease of cost efficiency and the increase of

profit efficiency may reflect an increase in quality of banking services which led to an improvement of revenues.

Another possible explanation of the conflicting cost versus profit efficiency was suggested by Srairi (2010) . The author pointed out that imperfect competition hypothesis may explain this result. Indeed, he noticed that the dominant position of banks in the Arabic countries , particularly in Algeria , and the high demand of financial services may lead to higher monopoly power resulting in higher profit efficiency and, consequently , the banks face less pressure to decrease costs and restructure their activities.

Table 4 : SFA cost efficiency scores (%)

	Nbr of Obs	Cost Mean efficiency	Profit Mean efficiency	Rank cost	Rank profit
Panel A: mean by year					
2003	140	65,72	41,87		
2004	140	58,47	46,74		
2005	140	52,09	51,61		
2006	140	46,48	56,39		
2007	140	41,54	61,00		
2008	140	45,54	65,37		
2009	140	38,71	69,45		
2010	140	37,78	73,21		
2011	140	36,85	76,64		
2012	140	36,28	79,73		
Panel B : mean by ownership					
Public Banks	50	54,42	71,04	1	1
Private Banks	90	42,97	70,47	2	2
Panel C : mean by size					

Large Banks	50	54,42	71,04	1	1
Medium size Banks	40	42,97	69,47	2	3
Small size Banks	50	21,38	70,48	3	2
Panel D : mean by bank					
B. N. A	10	56,79	82,68	2	1
C.P. A	10	49,51	75,78	6	5
B .A. D. R	10	52,24	42,60	3	14
B .D. L	10	62,44	75,87	1	4
B. E. A	10	51.15	78,28	5	3
BARAKA	10	38,43	64,72	10	12
B.N.P	10	41.38	80,41	9	2
Société Générale	10	49,17	72,04	7	8
GULF Bank	10	42,64	60,72	8	13
NATEXIS	10	52,07	70,27	4	9
A.B.C	10	26,27	66,84	11	11
MAGHREB Bank	10	10,80	74,11	14	6
TRUST Bank	10	26,17	72,50	12	7
HOUSING Bank	10	21,88	68,69	13	10
Overall mean	**140**	**45,74**	**70,39**		

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 both public and private banks display the same profit efficiency estimates , but the most cost 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 .

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.

DEA identifies the efficient frontier from the linear combination of those units or observations that (in a production space) use comparatively fewer inputs to produce comparatively more outputs. The DEA frontier corresponds to the set of efficient observations for which no other unit or linear combination of units employs as little or less of every inputs without changing the output quantities produced - input orientation -or produces as much or more of every output without changing the input quantities - output orientation- (Ben Naceur , Ben-Khediri and Casu 2011) .

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 **.** The input-orientation in 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.

Another issue needs to be addressed is the assumption of the Constant Return on Scale CRS, even if frequently used , is appropriate only when all DMUs operate at an optimal scale . In vast majority of cases, including banking sector , this assumption is violated due to multiple reasons , such an imperfect competition , diverse regulations and restrictions , etc ; then the measure of technical efficiency is co-founded by Scale Efficiencies (SE). That is why efficiency scores assuming Variable Return on Scale VRS in estimation are larger or equal to the CRS estimation scores .Following the consistency conditions of Bauer et *al.* (1998), in this subsection we use the same efficiency concept (cost inefficiency-technical inefficiency)

and apply a VRS DEA on the same sample of banks, the same period and the same specification of inputs and outputs (*We note that processing the profit efficiency with DEA is not permitted since data in output prices are unavailable*).

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

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

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

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

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) :

$$\min \quad \sum_{i=1}^{m} w_{iq} x_{iq}^* \tag{6}$$

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

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

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

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 the DMU_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 the DMU_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 . The results (see Table 5) suggest somewhat higher levels of efficiency in average than the previous approach . The mean efficiency from SFA method is 45,74% while the mean efficiency from DEA method is 61,60 % . These results are not consistent with studies that compare bank inefficiency between parametric and non parametric approaches for example Delis et Al (2008) , Eisenbeis et al. (1999) found that calculated programming inefficiency scores of Greek commercial banks and US bank holding companies , respectively , are two times larger than those obtained using a stochastic frontier .In our case ,Thus, the inefficiency trend under the parametric approach appears more reasonable.

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	Rank
Panel A :mean by ownership					
Public Banks	50	100.0	99.3	93.5	1
Private Banks	90	89.9	42.9	36.0	2
Panel B : mean by size					
Large Banks	50	100.0	99.3	93.5	1
Medium size Banks	40	77.4	52.62	38.92	2
Small size Banks	50	100.0	35,28	33.71	3
Panel C : mean by bank					
B. N. A	10	100.0	100.0	**100.0**	**1**
C.P. A	10	100.0	71.24	**71. 44**	**5**
B .A. D. R	10	100.0	96,80	**96.20**	**4**
B .D. L	10	100.0	100.0	**100.0**	**1**
B. E. A	10	100.0	100.0	**100.0**	**1**
BARAKA	10	42.0	88.30	**37.10**	**10**
B.N.P	10	100.0	56.70	**56.70**	**6**
Société Générale	10	86.50	39.30	**39.30**	**8**
GULF Bank	10	81.10	26.20	**22.60**	**14**
NATEXIS	10	100.0	41.50	**33.70**	**11**

A.B.C	10	100.0	28.70	**28.70**	**12**
MAGHREB Bank	10	100.0	28.00	**28.00**	**13**
TRUST Bank	10	100.0	37.30	**37.30**	**9**
HOUSING Bank	10	100.0	40.9	**40.88**	**7**
Overall mean	**140**	**93.5**	**66.2**	**61.60**	

***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 frontier techniques 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 Subgroup	DEA Subgr
DEA Rank	*1.00*	***0.64****						
SFA Rank	*64.44**	*1.00*						
SFA scores			*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 many studies which demonstrate 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 do not have the motivation 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 and profit efficiency . A translog 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 same period . 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 .

The most striking result that parametric analysis revealed is that Algerian banks are more efficient at generating profits than controlling costs .Beside the fact that an increase of profit efficiency and a decrease of cost efficiency would reflect a relative improvement in quality of services provided by Algerian commercial banks , in general . The imperfect competition hypothesis is pointed out to explain these results .Hence , the dominant position of public banks in Algeria , and the high demand of financial services may lead to higher monopoly power resulting in higher profit efficiency and, consequently , the banks face less pressure to decrease costs and restructure their activities.

Moreover , our findings suggest that both the two techniques yielded fairly close average cost 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 *to match their performance with the best practice bank.* The inter-temporal comparison of the scores showed that the average cost efficiency appeared to have gradually declined from 65,72 % in 2003 to 36,28 % in 2012. However , the profit efficiency has substantially improved from 41, 87 % to 79,73 % during the period.

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. Exploring the sources of banks' inefficiencies , we noticed the disconnection of the cost efficiency between the capital adequacy and profitability . Whereas , the non performing loans exercised a negative effect . Overall 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, a burden for the productivity.

Finally , the comparison between the two approaches revealed satisfactory results. In fact , we have observed 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 . Yet , 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 .

References

Ariff M, Can L (2008) ,Cost and profit efficiency of Chinese banks: a non-parametric analysis. *China Econ Rev 19:260–273*

Bauer P., Berger A., Ferrier G., & Humphrey D (1998) Consistency conditions for regulatory analysis of financial institutions: A comparison of frontier efficiency methods. *Journal of Economics and Business, vol. 50, N° 2, pp. 85-114.*

Ben Naceur, S., Ben-Khediri, H., & Casu,B. (2011), What drives the performance of selected MENA banks? A meta- frontier analysis. *IMF Working paper, 11/34.*

Bauer, P.W., Berger A.N., and Humphrey D.B. (1993) Efficiency and productivity growth in U.S. banking, pp. 386-413, in H.O. Fried, C.A.K. Lovell, and S.S. Schmidt, eds., *Measurement of productive efficiency: Techniques and applications. New* York: Oxford University Press.

Berger, A.N., Hunter, W.C., & Timmer, S.G (1993) The efficiency of financial institutions: A review and preview of research past, present and future. *Journal of Banking and Finance ,vol. 17, N° 2-3, pp. 221-249.*

Berger AN, Hancock D, Humphrey DB (1996) Do consumers pay for one-stop banking? Evidence from an alternative revenue function. *J Bank Finance 20:1601–1621*

Berger, A.N and Mester, L. J (1997) Inside the black box: What explains differences in the efficiencies of financial institutions?.*Journal of Banking & Finance, vol. 21, N°. 7, pp. 895-947.*

Berger AN, Mester LJ (1999) What explains the dramatic changes in cost and profit performance of the U.S. banking industry. *Finance Econ Discuss Ser 13, Federal Reserve Board, Washington*

Casu B, Girardone C 2004, Financial conglomeration: Efficiency, productivity and strategic drive. *Applied Finance and Economics , vol. 14, pp.687–696.*

Coelli, T. (1996) A guide to DEAP version 2.1: A Data Envelopment Analysis, Computer Program. *CEPA Working paper 1996*(8).

Coelli, T. (1996) A guide to FRONTIER 4.1 : A computer Program for Stochastic Frontier Production and Cost Function Estimation CEPA Working Papers 1996 (7)

Delis, M.D., Koutsomanoli-Filippaki, A., Staikouras, C.K., &Gerogiannaki, K (2009). Evaluating cost and profit efficiency: A comparison of parametric and nonparametric methodologies. *Applied Financial Economics 19 2009, pp. 191-202.*

Eisenbeis, R.A., Ferrier, G.D. and Kwan S. (1997) The informativeness of linear programming and econometric efficiency scores: An analysis using US banking data, *Bureau of Business and Economic Research. University of Arkansas working paper.*

Ferrier, G.D and Lovell, C.A.K (1990) Measuring cost efficiency in banking -econometric and linear-programming evidence. *Journal of Econometrics, vol.46 N°1-2, pp.229-245.*

Fotios, P (2007) International evidence on the impact of regulations and supervision on banks' technical efficiency: An application of two-stage data envelopment analysis. *School of Management Working paper series 2007, N°01*.

Hasan, I., and Hunter, W.C. (1996) Efficiency of Japanese multinational banks in the U.S., in A.H. Chen, cd. *Research in Finance,Volume14, JAI Press, Greenwich, CT 157-73.*

Hasan Z (2004) Measuring the efficiency of Islamic banks: Criteria, methods and social priorities. *Rev Islam Econ, vol. 8, pp.5–30.*

Isik I and Hassan MK (2002) Technical scale and allocative efficiencies of Turkish banking industry. *J Bank Finance c, vol. 26,pp.719–766.*

Jiang, C (2008) *Analysis of bank efficiency of Chinese commercial banks and the effects of institutional changes on bank efficiency . PhD Thesis submitted at the Middlesex University .London . UK*

Kumbhakar, S.C and Lovell, C.A.K.(2000) *Stochastic frontier analysis*. Cambridge: Cambridge University Press.

Lovell, C.A.K., (1993). Production , in H.O. Fried, C.A.K.Lovell,and S.S. Schmidt, eds., The *Measurement of Productive Efficiency: Techniques and Applications,* Oxford University Press, U.K. 3-67

Maudos J, Pastor JM, Perez F et al (2002) Cost and profit efficiency in European Banks. J Int Finance Mark Inst Money 12:33–58

Miller SM, Noulas AG 1996, The technical efficiency of large bank production. *J Bank Finance, vol.20,pp.495–509.*

Resti, A. Feb, 1997. Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joint application of parametric and nonparametric techniques, *Journal of Banking and Finance, vol.20, pp. 221-250.*

Srairi, S . A (2010) Cost and profit efficiency of conventional and Islamic banks in GCC countries . *Journal of Productivity Analysis, vol. 34, pp.45–62.*

1.

[i] These approaches differ in the assumptions they make regarding the shape of the efficient frontier, the existence of random error, and (if random error is allowed) the distributional assumptions imposed on the inefficiencies and random error in order to disentangle one from the other.(Kambhakar and Lovell 2000).

[ii] Many authors argue that profit efficiency is more appropriate to capture economic efficiency since firms are more likely to operate in maximization levels. However the implementation of the profit function approach is rather difficult due to chronic data problems, as the profit function requires price data for outputs, which is hard to construct in banking.

[iii] Economic efficiency requires technological efficiency as well as allocative efficiency -- i.e, the optimal inputs and/or outputs are chosen based on both the production technology and the relative prices in the market.

[iv] The choice of the approach defining banking inputs and outputs is at center of debate .A variety of approaches have been proposed in the literature , i.e. the intermediation , the production , the profitability , the portfolio, the Risk-return approach . This is due to the nature and functions of financial intermediaries.

[v] Many studies have used the ratio of staff costs / number of the workforce. But Given the unavailability of data on the number of employees in most banks of our data set, we calculated the price of labor by the ratio of personnel costs / total assets, following the methodology Jiang Chunxia (2008) and Delis et al (2008).

[vi] The ratio of non-performing loans to total loans is usually used to define The credit risk However, lack of data on non-performing loans in our database oblige us to use the ratio Credits over total assets ,in line with some recent studies (Srairi 2010 and Pasiouras 2008) .

[vii]The primal approach estimates production function directly ; but recently, empirical frontier analysis turned to dual approach using cost and profit functions, reasons for which are provided by Battese and Coelli (1995).

[viii] The reason for this particular structure of the composite error term is that, by definition, inefficiencies cannot be negative. Both the inefficiencies and random errors are assumed to be orthogonal to input prices, outputs and country-level or bank-specific variables specified in the estimating equation.

[ix] μ parameter, 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.