

THE DETERMINANTS OF PRODUCTIVE EFFICIENCY OF THE BANKS

APPLICATION TO TUNISIAN BANKS



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Banks, in their role of financial intermediaries, significantly contribute to the economic activities particularly in developing countries where they represent the main source of capital flow. The performance of a country's banking system has become a strategic issue to strengthen the resilience of the whole financial system to economic shocks. Moreover, the phenomena of liberalization and deregulation gradually obliged developing countries to introduce major structural reforms aiming at improving banks' efficiency and encouraging the competitive practices.

The Tunisian banks currently operate in a very competitive environment. The long-term viability of the banking depends on its degree of efficiency. Thus, a study relating to the determinants of productive efficiency in Tunisian banks is of major interest.

There is a varied literature devoted to the efficiency measurement of the banks where multiple approaches have been employed. Many studies have been carried out in the United States and developed countries. While are rare the studies relating to the productivity of the banks in developing countries. Among the 130 studies listed by Berger and Humphrey (1997) only seven relate to the developing countries. None of these studies have considered Tunisia as context of research.

Concerning the Tunisian context, the work of Chaffai (1997) is the first to have analyzed the efficiency of the Tunisian commercial banks. In his paper, he evaluated the experiment of the deregulation of the Tunisian banking structure and concluded that the overall efficiency of the banks increased following the liberal process initiated in 1986.

Another study conducted by Chaffai and Dietsch (1998) assigned the analysis of the efficiency evolution in Tunisia and Morocco.

Joumady (2000), prolonged the analysis of Chaffai and Dietsch (1998). He adopted a broader scope, making it possible to take into account the technology evolution which did not fail to make the banking operations progress. He showed that in Tunisia, the commercial

banks are more efficient than the development banks. He however, concluded that in the absence of competition, there is no clear tendency of the efficiency evolution over 1989-1995 period.

This review of the empirical literature which relates to the Tunisian banking environment is focused on the measuring of efficiency according to various estimation methods without explaining the principal factors which can influence the efficiency scores in the Tunisian banks.

Thus, the objective of our research is to measure the efficiency of the Tunisian commercial banks during the period 1989-2005 and identify the internal and external determinants of efficiency level in these banks. Instead of concentrating on the analysis of the scale efficiency, we concentrate on the analysis of managerial efficiency¹. Thus, we aim at our paper to showing how the characteristics of the banks and the financial environment affect the efficiency of the Tunisian banks.

In this study, we employ an extension of the traditional Stochastic Frontier Approach "SFA"², initially presented by Battese and Coelli (1995), in order to estimate cost efficiency in the Tunisian banking environment. This approach is based on the decomposition of the error in two terms: a component of inefficiency and a component of random error combining the errors of measurement and the exogenic shocks.

In the majority of the studies which employed the "SFA", including those in the American banking environment, the estimations of the efficiency scores for each bank are given by assuming a normal distribution truncated into zero, with a common value planned for all the banks in industry.

These estimations are made in two stages. In the first stage, the inefficiency scores are derived through the use of appropriate methodology. These estimated inefficiencies are then regressed on a certain number of explanatory variables, which supposedly, are correlated with the inefficiencies of the regression in the first stage.

The principal disadvantage of this approach is that the estimations of cost efficiency are not obtained as a result of a simultaneous interaction with the variables which characterize the activity of the bank. It is thus impossible to know in advance the devices of these estimations.

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Thus, our principal effort in this study is to overcome the majority of the imperfections mentioned above. For that, the parameter of truncation is given for each bank separately, on the basis of variables characterizing the activity of each bank as well as environmental variables.

Our specification includes two principal advantages compared to the traditional formulation "SFA". Firstly, the model explicitly introduces the possibility that the efficiency scores can vary over time.

Secondly, and more importantly, the efficiency estimations are determined within a simultaneous equation system according to explanatory variables specific to each bank, and external variables such as the economic growth, the level of risk incurred in its activity, inflation, etc.³

The rest of the paper is organized as follows: section I presents the data and definitions of the variables used in the efficiency estimation. Section II describes the econometric specification. Section III discusses the empirical results. Section IV concludes the paper.

I. PRESENTATION OF THE DATA AND DEFINITIONS OF THE VARIABLES

To choose a suitable definition of the production of the bank is a significant question for research in the cost efficiency recorded by the banks. Although the multi-producing nature of the banking company is largely recognized, there is still no agreement on an explicit definition of the inputs and the outputs of a bank and the way they are measured.

Generally, each definition of input and output includes a particular number of banking concepts which influence and limit the analysis of the production characteristics of this industry.

The data relating to the bank's characteristics come from the management reports and the data base of the Tunisia's Professional Association for Banks and Financial Institutions (APTBEF). These reports include balance sheets and income statements published by the banks. As for the macroeconomic data, they are extracted from the International Financial Statistics and the publication of the World Bank (WDI 2005). This study covers the period 1989-2005, using annual data.

The selected exogenous variables are defined in table 1 with the expected signs.

The analyzed sample consists of all the commercial banks except for two banks lately created, such as the Tunisian Solidarity Bank (BTS) and Arab Banking Corporation (ABC) which did not have a regular activity during the period of our study. Moreover, for the sake of statistical homogeneity, we have excluded another small bank: Citibank (C-B) from the field of our study⁴.

We have chosen the deposit banks exclusively for two reasons. On the one hand, the difference between the accounting and financial structures of two categories of the banks (development banks and deposit banks) makes the interpretation of the results difficult. On the other hand, the deposit banks occupy the most significant place in the financing of the Tunisian economy. Indeed, more than 90% of the saving is collected by the commercial banks and more than 80 % of the loans are granted by these banks.

Our final sample comprises observations made on 11 Tunisian commercial banks over 1989-2005 period.

In methodological terms, we are inclined to use the intermediation approach⁵. In the Tunisian context, the banks use the funds at their disposal to pursue a massive policy of loans. Then, it seems judicious to regard the liability of the Tunisian banks as input rather than output. From this perspective, the intermediation

Table 1. Definitions, notation and expected signs of the internal and external determinants of the banking productive efficiency

		Variables	Measure	Notation	Expected Signs
Determinants	Internal	Commercial policies	Loans/total assets Deposits/total assets	LTA DTA	+ -
		Overheads Control Ratio	Overheads/(Loans+Deposits)	OHCR	-
		The managerial capacity of personnel	Senior executive/Total employees	RSE	+ +
		Transformation Ratio	Loans/Deposits	TR	+
	Macro-economic	Inflation Rate	Index of the Consumer Price	INF	+/-
		GDP per capita (constant 2000 US\$)	Ln (GDPC)	GDPC	+
	Market structure	Banking concentration*	$\sum_{i=1}^N (MS_i)^2$	HHI	+/-

* MS: Market share is measured annually by the relationship between the total assets of each bank and the total assets of all banks.

Table 2. Descriptive statistics of the variables of the translog cost function over 1989-2005 period

	Average	Standard Deviation	Minimum	Maximum
Q*	1 160 850	505 158	513 814	2 102 888
L	1 390	133	1 116	1 523
K*	26 597	11 876	11 008	45 959
F*	898 209	445 525	388 783	1 754 428
TC*	87 652	20 813	46 259	125 974
PL	15,0114	5,965	6,794	25,940
PK	0,854595	0,375	0,432	1,403
PF	0,063345	0,028	0,036	0,120
B	71	39	4	158

* In thousands of dinars

approach would be adopted. The bank is then regarded as a financial intermediary between ultimate lenders and ultimate borrowers. It collects resources from the public and transforms them into long term loans.

For our study and according to the availability of the data, we could retain two outputs and three inputs. The outputs offered by the Tunisian commercial banks are classified in two categories: the Total of Loans (TL) which includes all the types of loans and the Titles Portfolios (TP) which represents the activities of placement and investment considered as services carried out by the bank.

In our study, we took as an indicating variable the aggregate output (Q) obtained thanks to the method of aggregation suggested by Benston, Hanweck and Humphrey (1982) which can be presented as follows:

$$Q_i = \frac{\sum_s n_{si} \bar{Q}}{\sum_s n_s}$$

- With Q_i : the aggregate output of bank i ;
- s : banking services referred to above (TL and TP);
- n_{si} : quantity of the output s of bank i ;
- \bar{Q} : a geometric mean of the sum of the different banking outputs definite as follows:

$$\bar{Q} = \prod_i \left[\sum_s n_{si} \right]^{1/m}$$

- m : the number of the banks in the sample;
- n_s : a geometric mean of the banking outputs defined as follows:

$$\bar{n}_s = \prod_i [n_{si}]^{1/m}$$

The outputs quoted above are produced thanks to the combination of the factors of production, namely: the labour factor (L), the physical capital factor (K) and the financial capital factor (F). The labour factor (L) is measured by the number of employees; the physical capital factor (K) is measured by the book value of premises and fixed assets and the financial capital factor (F) is measured by the various forms of deposits.

Furthermore, in conformity with most previous studies on banking efficiency, we select the following three input prices: the unit price of labour (PL) calculated by dividing the personnel expenses by the number of employees; the unit price of the physical capital (PK) calculated by dividing the expenditures on plant and equipment (i.e. overhead expenses net of personnel expenses) by the book value of premises and fixed assets; and the unit price of the financial

capital (PF) is computed by the total interest expenses of deposits divided by the sum of deposits.

Finally, a way of taking account of the structure effect in the modelling of the cost function consists in adding a supposed indicator of size to bring information about the structural differences between the banks, namely the number of agencies. Thus, the homogenization variable is reduced to its simpler expression, namely the banking number of agencies, noted "B".

Table 2 presents the descriptive statistics (average, standard deviation, minimum and maximum) of total cost, the aggregate output, the inputs and their prices.

II. ECONOMETRIC SPECIFICATION

II.1. THE TRANSLOG COST FUNCTION

The modelling of the cost function of the banks is a preliminary and necessary stage for the measurement of the efficiency.

Due to the disadvantages of the Cobb-Douglas model⁶, we will use the translogarithmic model in our analysis. The use of the disaggregated translog model, as used in the American studies, involves a number of explanatory variables higher than the size of the Tunisian banking population. For this reason we cannot use this model. So, we will be satisfied with the estimate of the productivity efficiency while supposing that the technology of the Tunisian banks is represented by an aggregate translogarithmic cost function. Thus, we use the following translog specification for the cost function⁷:

$$\ln(TC)_{it} = \alpha_0 + \beta_Q \ln(Q_{it}) + \frac{1}{2} \beta_{QQ} [\ln(Q_{it})]^2$$

$$\begin{aligned}
& + \sum_j \alpha_j \text{Ln}(Pj)_{it} \\
& + \sum_j \beta_{jQ} \text{Ln}(Pj)_{it} \text{Ln}(Q_{it}) \\
& + \frac{1}{2} \sum_j \sum_k \beta_{jk} \text{Ln}(Pj)_{it} \text{Ln}(Pk)_{it} \\
& + \beta_Q \text{Ln}(B_{it}) + \frac{1}{2} \beta_{BB} [\text{Ln}(B_{it})]^2 \\
& + \beta_{BQ} \text{Ln}(B_{it}) \text{Ln}(Q_{it}) + v_{it} + u_{it}
\end{aligned} \tag{1}$$

$i \in (1 \rightarrow 11)$: Indicate the number of the banks;

$t \in (1 \rightarrow 17)$: Indicate the years of study (1989 → 2005).

With:

TC_{it} : The functions of the cost to estimate bank i at the year t .

Q_{it} : The aggregate output of bank i at the period t .

PL_{it} : The price of the labour factor of bank i at the period t .

PK_{it} : The price of the physical capital factor of bank i at the period t .

PF_{it} : The price of the financial capital factor of bank i at the period t .

B_{it} : The number of agencies of banks i at the period t .

v_{it} : The random error term is independently and identically distributed according to standard normal distribution, $N(0, \sigma_v^2)$.

u_{it} : The asymmetrical error term measuring the bank inefficiency components: $u_{it} \rightarrow N(m_{it}, \sigma_u^2)$.

Our approach aims not only at estimating the efficient cost frontier but also at identifying the internal and external determinants of efficiency score allotted to each bank in our sample. For that, and in order to avoid the limits of a step in two stages, we implement the single step approach recommended by Battese and Coelli (1995) where we include a linear function of a set of variables at the inefficiency level to influence the bank's efficiency. Thus, the bank inefficiency components u_{it} is distributed according to a normal-truncated distribution with standard deviation of σ_u^2 and expected value m_{it} defined by: $m_{it} = Z_{it} \delta$.

Where, δ is a vector of p parameters to be estimated and Z_{it} a vector of p variables which can assign the efficiency of bank i to the period t . However, for Hessian of cost function is symmetrical, the equality

$$\frac{\partial^2 TC}{\partial x_i \partial x_j} = \frac{\partial^2 TC}{\partial x_j \partial x_i}$$

must be suitable for any pair of variables x_i and x_j . Symmetry results in the following restrictions: $\beta_{jk} = \beta_{kj}$, $j, k \in \{L, K, F\}$.

Moreover, any cost function must be homogeneous in degree one in the inputs price. Thus, a proportional increase in all the prices increases the total cost in the same proportion without affecting the factors' supply. This condition of homogeneity implies other constraints which are expressed in the following way:

$$\begin{cases} \sum_j \alpha_j = 1 \\ \sum_j \beta_{jk} = 0 & \text{with } j, k \in \{L, K, F\}. \\ \sum_j \beta_{jQ} = 0 \end{cases}$$

The constraint of homogeneity is taken into account by standardizing the total cost (TC), the prices of the physical capital (PK) and the price of the financial capital (PF) by the price of the labour capital (PL). This choice does not affect any of the results insofar as the estimators are obtained by the maximum likelihood method.

By respecting these constraints, we obtain the following transformed model:

$$\begin{aligned}
\text{Ln}\left(\frac{TC}{PL}\right)_{it} &= \alpha_0 + \alpha_Q \text{Ln}(Q_{it}) + \frac{1}{2} \beta_{QQ} [\text{Ln}(Q_{it})]^2 \\
& + \alpha_K \text{Ln}\left(\frac{PK}{PL}\right)_{it} + \alpha_F \text{Ln}\left(\frac{PF}{PL}\right)_{it} \\
& + \beta_{KQ} \text{Ln}\left(\frac{PK}{PL}\right)_{it} \text{Ln}(Q_{it}) + \beta_{FQ} \text{Ln}\left(\frac{PF}{PL}\right)_{it} \text{Ln}(Q_{it}) \\
& + \beta_{LK} \left[\text{Ln}(PL_{it}) \text{Ln}(PK_{it}) - \frac{1}{2} [\text{Ln}(PL_{it})]^2 \right. \\
& \quad \left. - \frac{1}{2} [\text{Ln}(PK_{it})]^2 \right] \\
& + \beta_{LF} \left[\text{Ln}(PL_{it}) \text{Ln}(PF_{it}) - \frac{1}{2} [\text{Ln}(PL_{it})]^2 \right. \\
& \quad \left. - \frac{1}{2} [\text{Ln}(PF_{it})]^2 \right] \\
& + \beta_{KF} \left[\text{Ln}(PK_{it}) \text{Ln}(PF_{it}) - \frac{1}{2} [\text{Ln}(PK_{it})]^2 \right. \\
& \quad \left. - \frac{1}{2} [\text{Ln}(PF_{it})]^2 \right] \\
& + \beta_B \text{Ln}(B_{it}) + \frac{1}{2} \beta_{BB} [\text{Ln}(B_{it})]^2 \\
& + \beta_{BQ} \text{Ln}(B_{it}) \text{Ln}(Q_{it}) + v_{it} + u_{it}
\end{aligned} \tag{2}$$

We start first with the test of total homogeneity: the latter is noted in the form of the test of Fisher $\mathbf{A}; \mathbf{B} = \mathbf{A}; \mathbf{B}_1$ in the file result of TSP. Letter \mathbf{A} indicates the constants, while the letter \mathbf{B} indicates the vector of the coefficients of the explanatory variables⁸.

$$H_0^1 : \beta_i = \beta \quad \alpha_i = \alpha \quad \forall i \in [1, N]$$

$$H_a^1 : \exists (i, j) \in [1, N] / \beta_i \neq \beta \text{ ou } \alpha_i \neq \alpha_j$$

Within the framework of our sample, the realization of the Fisher statistics associated with the test H_0^1 noted F_1 is 0.96684; TSP software directly gives us the p -value associated with this test. In fact, this p -value states that until the level of 56%, the null hypothesis cannot be rejected. Therefore our panel concerning the equation (2) is completely homogeneous (pooled model)⁹.

Table 3. Descriptive statistics of the explanatory variables of the inefficiency term

	LTA	DTA	TR	OHCR	RSE	GDPG	INF	HHI
Average	0,6637	0,6112	1,1399	0,0168	0,1023	7,5171	0,0426	0,1260
Maximum	0,7513	0,7433	2,4474	0,0188	0,1788	7,7906	0,0819	0,1411
Minimum	0,5492	0,4982	0,5506	0,0144	0,057	7,263	0,0198	0,1125
Standard Deviation	0,0646	0,0956	0,3261	0,0013	0,1191	0,0391	0,1625	0,0100

II.2. EXPLANATION OF INEFFICIENCY LEVEL

Together with the efficiency estimation of the Tunisian banks, our objective is to highlight the relation between the productive performance and the variables under banking control (interns) on the one hand and of the external variables on the other hand.

A. Internal determinants

Among the variables under control that are to explain the efficiency level, we have retained:

Variables of commercial policies: to examine the relation between the efficiency and the commercial policies of the banks, we retained the two following ratios: loans to total assets "LTA"¹⁰ and deposits to total assets "DTA".

The "LTA" ratio indicates the quality of the credit. This indicator is considered as a performance since it is related to the deposits collected, the capacity of refinancing on the monetary market and the importance of the equity. Thus a positive repercussion of this ratio on banking efficiency is expected.

Moreover, the internal financing of the bank is ensured by the various types of deposits. This type of financing can involve weak loads of interests and it is expensive since the deposits require a high number of branches and other expenditures. Thus, we expect a negative relationship between "DTA" ratio and efficiency.

Transformation Ratio "TR": the loans of the Tunisian commercial banks come mainly from the deposits collected by the networks; we can say that the banks often seek to grant loans, to initially cover the costs caused by the deposits and to ensure the most advantageous possible result of the intermediation function. This effort of producing more loans starting from a given amount of deposits could be expressed by the ratio of the loans to the deposits, qualified in the banking industry of transformation ratio and whose its final impact on banking efficiency is positive.

Overheads Control Ratio "OHCR": measured by the ratio of overheads to the sum of the loans and the deposits. It is a ratio of productivity which measures the capacity of a bank to control its overheads. Moreover, the weaker this ratio is, the better the bank's situation is.

Thus a negative impact on efficiency is expected.

The managerial capacity of the personnel: this capacity is appreciated by the share of the senior executive compared to total employees "RSE". Contrary to many studies, we did not retain the average number of employees per agency, but rather the share of the senior executive which is lower in numbers but whose added value is more significant. The more highly qualified personnel the bank employs, the better it controls its inputs use and consequently it maximizes its outputs level. A high quality training of the banks staff is very likely insure a better productivity and more significant managerial capacity. Therefore, the "RSE" ratio influences the efficiency level positively.

B. External determinants

To isolate the effects of the internal characteristics of the bank on efficiency, it is necessary to control it by other factors which have been previously employed as determining causes of banking efficiency. We expect that two sets of control variables influence the bank's execution: macroeconomic indicators and the banking market structure.

Macroeconomic variables

Studies of the effects of the macroeconomic variables on banking efficiency are relatively limited. But as they are the key variables of the banks' economic environment, they thus appear as significant determinants to explain the banking performance. For instance two macroeconomic variables are used, in our study.

The GDP per capita "GDPG" (constant 2000 US\$), is a general index of the economic activity development and it thus reflects the differences in banking technologies and the whole of banking opportunities. Following previous studies that focused on banks' performance, GDP per capita should have a positive association with banking efficiencies (Claeys and Vander Vennet, 2004; Hassan and Sanchez, 2007).

The inflation rate "INF" is a macroeconomic indicator which touches the whole financial system, since it is directly related to the prices. More particularly, this monetary indicator affects the banking environment through its influence on the bank credit market. Some studies found a positive relation between inflation and the banking performance (Demirguç and Huizinga, 1999; Brock and Suarez, 2000). High rates of inflation are generally associated with to the interest rates on the high loans and this leads to higher incomes. However, if inflation is

not anticipated and the banks quickly do not adjust their interest rates, the total costs are likely to increase more quickly than the incomes and this will consequently reduce the banking efficiency: a negative relationship between inflation and efficiency is thus expected (Kasman and Yildirim, 2006). As result, the expected final impact of this variable on efficiency is ambiguous.

Banking Market Structure

We also examine how the efficiency of the banking industry is related to the banking market structure. So, we analyze the competition of the Tunisian banks by the indicial approach, and more precisely by the Herfindahl Hirshman Index of concentration "HHI" defined as the sum of the squared market shares of each bank. Let us note that the stronger the concentration is, the weaker the competition is.

Some studies have found a negative relation between the concentration and efficiency (Fecher and Pestieu, 1993; Berger and Hannan, 1997). While other literature reviews released a positive relation. Indeed, the model of Cournot of the oligopolistic behaviour, considers that the power of the market is positively related to profitability and efficiency, because banks with significant market shares can impose higher prices, discourage competition and be more productive (Berger, 1995; Berger and Mester, 1997; Weill, 2004; Isik and Hassan, 2003; Isik et al., 2005). The expected final impact of the concentration on efficiency is, therefore, ambiguous.

Thus, the expectation of the random term u_{it} relating to the measurement of the inefficiency is defined by:

$$m_{it} = \delta_0 + \delta_1 LTA_{it} + \delta_2 DTA_{it} + \delta_3 OHCR_{it} + \delta_4 TR_{it} + \delta_5 RSE_{it} + \delta_6 GDPC_{it} + \delta_7 INF_{it} + \delta_8 HHI_{it} \quad (3)$$

A broad description of the characteristics of the explanatory variables of the term of inefficiency is given in table 3.

II. RESULTS

III.1. ESTIMATED PARAMETERS

The estimated parameters of the cost function frontier (2) and the expectation of the inefficiency (3) appear in table 4.

The coefficients and the degrees of efficiency of each bank are estimated by the method of the maximum likelihood by using software "FRONTIER 4.1" (Coelli, Rao and Battese, 1998). The latter uses the alternative parameterization of the likelihood function, which substitutes:

$$\sigma_u^2 \text{ and } \sigma_v^2 \text{ by } \sigma^2 = \sigma_u^2 + \sigma_v^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \in [0, 1].$$

In particular a null value of γ indicates that the deviations around the frontier are completely due to the noise, while a value equal to the unit indicates that all the deviations are due to the inefficiency.

The estimated values are sometimes positive and sometimes negative. The positive values indicate that any increase

in the estimated parameter implies an increase in the total cost, and conversely for the negative parameters which show that any increase in the estimated parameter tends to reduce the total cost.

The estimation quality is satisfactory and the variables' coefficients are partly significant to the level of 1%. The two principal results which emerge by reading table 4 are:

With regard to the ratio test of the maximum likelihood, it makes it possible to check if a model is thoroughly explanatory. When the empirical value of the ratio in question (LR) is higher than the theoretical value of χ^2 to the level of 1%, we conclude that the adjustment considered is overall explanatory. In our case, the model is overall explanatory, the theoretical value of χ^2 is 26.22, to the level of 1% and 12 degrees of freedom, being lower than the respective empirical ratio¹¹.

The parameter γ is significantly different from zero. This result rejects the hypothesis that the variance of efficiency σ_u^2 is null. Consequently the term u_{it} cannot be isolated from regression and the estimation of the parameters by the Ordinary Least Squares method (OLS) is inadequate.

III.2. TESTING HYPOTHESES FOR THE PARAMETERS OF THE MODEL

Before interpreting the results we carry out various specification tests. Table 5 presents a number of statistical tests based on the likelihood ratio, which are intended to test the "Improved SFA" in comparison with more limited forms.

The first null hypothesis examines whether the cost function can be represented by means of a Cobb-Douglas function. This hypothesis is rejected at the 99% significance level.

The other additional hypotheses presented below examine alternative specifications of the equation that determines cost inefficiency, given that the cost function remains in its translogarithmic form.

Thus, the second null hypothesis examines whether it is possible to assume a model in which cost inefficiency does not exist, that is, whether it is possible to contract it to an ordinary least squares model. This hypothesis is rejected with a level of 1%.

The third hypothesis examines the case in which the inefficiency is not a linear function of the independent variables. This hypothesis is strongly rejected with a level of 1%.

The fourth hypothesis examines the nature and the distribution of inefficiency term of the cost frontier. The null hypothesis, according to which the inefficiency term is distributed according to a semi-normal law, is rejected with a level of 1%. So, the distribution of the inefficiency term will be that of a normal law truncated into zero of variance σ_u^2 and expected value m_{it} .

To conclude, the proposed model represents an improvement when compared to the more limited functional specifications and especially when compared with those specifications in which the inefficiency component is not a function of the internal and external variables that characterize the bank's activity.

Table 4. Estimated parameters of the translog cost function

Parameters of the translog cost function				
Variable		Coefficient	Standard deviation	t- Ratio
Constant	α_0	- 5,603	2,600	- 2,155
LN (Q)	β_Q	1,701	0,537	3,169
LN (Q)* LN (Q)	β_{QQ}	- 0,086	0,057	- 1,502
LN (PKL)	α_{KL}	- 0,426	0,161	- 2,647
LN (PFL)	α_{FL}	0,390	0,174	2,246
PKQ	α_{KQ}	0,017	0,012	1,378
PFQ	α_{FQ}	0,028	0,010	2,806
BLK	BLK	0,019	0,019	1,023
BLF	BLF	- 0,009	0,023	- 0,411
BKF	BKF	- 0,094	0,027	- 3,495
LN (B)	β_B	- 1,163	0,591	- 1,967
LN (B2)	β_{BB}	- 0,215	0,091	- 2,352
LN (BQ)	β_{BQ}	0,152	0,068	2,231
Explanation of the productive inefficiency level				
Constant	δ_0	8,101	1,147	7,062
LTA	δ_1	- 0,265*	0,128	- 2,079
DTA	δ_2	0,399	0,172	3,320
OHCR	δ_3	15,935	2,310	6,898
TR	δ_4	- 0,274	0,075	- 3,677
RSE	δ_5	- 0,981	0,286	- 3,434
GDPC	δ_6	- 1,033	0,140	- 7,371
INF	δ_7	- 1,398	0,695	- 2,012
HHI	δ_8	1,321	1,715	1,770*
Square sigma	$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0,0049	0,0006	8,459
Gamma	γ	0,740	0,188	3,925
Log of Likelihood	239,439			
LR Test		257,947		
Number of restrictions		9		
Iteration count		52		

* Significance level of 10%.

♣ A negative and significant sign indicates a negative impact of the considered variable on the inefficiency score of the bank and thus a positive effect on productive efficiency.

Table 5. Test of hypothesis for parameters of the Stochastic Frontier Cost

Null hypothesis H_0	Log of Likelihood	LR Test [♣]	Critical value $\chi^2_{0,99}$ ^{♣♣}
(1) $H_0 : \beta_{QQ} = \alpha_{KQ} = \alpha_{FQ} = BLK = BLF = BKF = \alpha_B = \alpha_{BB} = \alpha_{BQ} = 0^1$	163,75	151,37	21,67
(2) $H_0 : \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0^2$	110,47	257,95	23,21
(3) $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0^3$	119,56	239,76	20,09
(4) $H_0 : \mu = 0^4$	234,38	10,12	6,64

Notes:

♣ The test of Likelihood Ratio is given by the following statistics: $LR = -2 \{ [\ln(\text{likelihood}(H_0))] - [\ln(\text{likelihood}(H_1))] \}$

Where $\ln(\text{likelihood}(H_0))$ and $\ln(\text{likelihood}(H_1))$ the logarithms of the Likelihood of the models estimated under the null hypothesis and the alternative hypothesis. These statistics follow asymptotically χ^2 having like degrees of freedom the number of restrictions under the null hypothesis.

♣♣ Value of the test of Likelihood Ratio given by the table.

1 The cost function can be represented by a Cobb-Douglas function

2 The inefficiency term don't have an effect.

3 The inefficiency is not a linear function of the independent variables.

4 The inefficiency term is distributed according to the semi-normal law.

Table 6. Means sores of productive efficiency over 1989-2005 period

	Productive efficiency	Productive inefficiency
1989	0,5348	0,4652
1990	0,5914	0,4086
1991	0,6091	0,3909
1992	0,6275	0,3725
1993	0,6094	0,3906
1994	0,622	0,378
1995	0,6554	0,3446
1996	0,6459	0,3541
1997	0,6913	0,3087
1998	0,6677	0,3323
1999	0,6899	0,3101
2000	0,773	0,227
2001	0,8044	0,1956
2002	0,8264	0,1736
2003	0,8436	0,1564
2004	0,8704	0,1296
2005	0,8896	0,1104
Mean	0,7031	0,2969
Maximum	0,8896	0,1104
Minimum	0,5348	0,4652

III.3. THE ESTIMATED EFFICIENCY SCORES

The values estimated for the parameters of the cost function make it possible to calculate the distance from each observation compared to the efficient frontier. The degree of inefficiency calculated for each bank varies between zero and the infinite. The efficiency is measured by its reverse which varies between zero and one.

The evolution of the average efficiency scores of the banking environment over 1989-2005 period and the principal characteristics (average, minimum and maximum), are presented in table 6.

From this table, we note that the average efficiency knew a mitigated evolution between 1989 and 2005. Therefore, the efficiency of the Tunisian commercial banks is fluctuating. This result was checked by Chaffai and Dietsch (1998) and by Cook, Hababou and Roberts (2000). It was since 1999, that the Tunisian banking environment has witnessed a regular rise in its efficiency, recording increasing of efficiency scores and reaching in 2005 its highest level which amount to 88.96%¹². This improvement is certainly connected to the programme of reorganization and modernization of the Tunisian banking industry.

III.4. EXPLANATORY FACTORS OF THE PRODUCTIVE EFFICIENCY IN TUNISIAN BANKS

The variables selected to examine the relation between the inefficiency and the commercial and managerial policies of the banks are the ratio loans on the total assets "LTA" and the ratio deposits on the total assets "DTA". The value taken by the "LTA" ratio is negative and significant, therefore it has a positive impact on the efficiency of the Tunisian commercial banks. This result seems to indicate that the most active banks on the segment of loans to the customers tend to be more efficient: insofar as the Tunisian commercial banks are more concerned with the operations of loans granting and thus with the charged interests on these loans. Consequently, the preponderance of the activity of credit – compared to other outputs – represents a source of efficiency for the Tunisian banks.

This result is in conformity with that of Allen and Rai (1996) for which the most aggressive banks (which engage more in the activity of loans) tend to be better managed and it also falls in line with the work of Mohamed and Molyneux (2003) for the banks of the Gulf countries¹³.

As for the influence of the "DTA" ratio it is significantly positive for the Tunisian commercial banks. This source of inefficiency seems to be related to the critical size, *i.e.* with the presence of the scale diseconomies in the collection of the deposits. This negative result can be explained by the fact that the highest ratio is recorded by the large banks, which do not profit from the advantages of the rather significant scale economies compared to the other banks of lower sizes¹⁴.

Moreover, the results reveal that the transformation ratio "TR" acts positively on the efficiency of the banks. In this direction a bank having a certain rate of intermediation

can guarantee the possibility of covering the costs caused by the deposits and ensures the most advantageous result possible of the intermediation activity.

Concerning the ratio of productivity "OHCR", its sign is positive and significant, therefore it has a negative impact on the banking efficiency. This proves that the Tunisian commercial banks must control their overheads in order to operate at lower costs and thereafter improve their efficiencies.

As for the managerial capacity of the personnel "RSE", the latter seems to be interesting. Within the framework of our analysis, this factor would affect the efficiency of the banks positively, being given the high added value of the senior executive.

Concerning the macroeconomic indicators, our results show that the correlation between variable "GDPC" and efficiency is positive. A high GDP per capita level, which reflects the economic development, involves a keen demand of the banking service. The banks increase their production level and they will also have to control their costs to offer a more competitive service.

We detect also a positive relation between the inflation level and productive efficiency. Thus, in an inflationary environment, the banks gain higher profits. This positive relation is then explained by a faster increase in the income than that of the costs engaged by the Tunisian commercial banks.

Lastly, concerning the banking market structure which is measured by the Herfindahl Hirshman Index "HHI", its impact is negative on banking efficiency. This is contradictory with the theory of Structure-Behaviour-Performance which shows that the concentration improves the behaviours of the banks and thereafter their efficiencies.

This result can be supported by the fact that financial liberalization in the banking environment started in Tunisia seems to intensify competition, in order to improve the productive efficiency of the banks. Indeed, the three large Tunisian banks (BNA, STB and BIAT), which are the least efficient, hold on average 49.05% of the market share of the Tunisian banking industry. Thus the BNA strongly committed in the risky agricultural sector is subjected to climatic hazards. This implies that the contingency provisions of this bank will be rather higher than the profit margins. The STB perpetuates its role of centre piece of the economic policy of the State as regards financing of the companies of the industrial sector in difficulties. Moreover, the BIAT finances a significant number of small and medium-sized companies where the risk of failure in refunding is high.

This shows that the concentration is less salutary, in terms of efficiency in the Tunisian commercial banks, than competition. So these banks will be brought to diversify their activities and thereafter to intensify competition especially with the establishment of the international banking in Tunisia.

IV. CONCLUSION

The use of the Stochastic Frontier Approach with a deterministic model of the inefficiency has led to interesting

results. It made it possible to measure the evolution of the efficiency level in Tunisian commercial banks over 1989-2005 period and to identify the relations between the productive performance and a combination of the internal and external determinants.

The empirical results show that the mean level of productive efficiency in Tunisian banks is with the order of 70.31%. Thus, if the banks use the inputs available in an efficient way, they can reduce the production costs by approximately 29.69% while keeping the same level of production. This shows that the banks did not manage to maximize their outputs taking into account their inputs disposed (technical efficiency). In the same way, they use the factors of production in erroneous proportions taking into account their costs on the market (allocative efficiency).

By focusing on the internal determinants of the productive efficiency in Tunisian banks, our results show that the preponderance of the credit's activity – compared to other outputs – represents a source of efficiency for the banks. Whereas an increase in the deposits volume affects the efficiency level negatively owing to the fact that these deposits are not transformed suitably into loans.

Moreover, the increase in the staff training affects the efficiency level positively. This shows that the improvement of the productive efficiency in Tunisian banks is not a question of size, but rather a question of managerial capacity. Thus, these banks have to improve the performance of their human resources.

Among the internal factors which affect the efficiency level negatively, we can note the overheads control ratio "OHCR". This negative correlation proves that the Tunisian commercial banks must control their overheads more and more in order to improve their efficiencies.

Our study also shows that the economic conditions affect the efficiency level considerably. Thus, the GDP per capita level and the inflation rate affect positively the productive efficiency of the Tunisian banks.

Lastly, concerning the market structure, we find that it has a negative relationship with the banking efficiency. This shows that a competing environment is more beneficial in terms of efficiency for the Tunisian banks. ■

1. This idea is drawn from the recent research carried out on banking industry: Berger *et al.* (1993), Chaffai (2000); indicated that the awaited profits of productivity of an improvement of managerial efficiency are much more significant than those which would be carried out by the size effect.
2. Also called Improved Stochastic Frontier Approach "ISFA", which assumes a different parameter of truncation for each bank.
3. For a comprehensive reference of the efficiency measurement of firms using stochastic frontiers approaches see Coelli, Prasada Rao and Battese (1998), particularly chapters 8 and 9.
4. STB, Tunisian Banking Company; BNA, National Agricultural Bank; BH, Bank for Housing; BS, Bank of the South; BIAT, Arab International Bank of Tunisia; UBCL, Banking Union for Trade and Industry; UIB, International Banking Union; BT, Bank of Tunisia; AB, Amen Bank; ATB, Arab Tunisian Bank and BFT, Franco-Tunisian Bank.
5. Several studies on the efficiency of the banks adopted the intermediation approach (Aly *et al.*, 1990; Berger and Mester, 1997; Chaffai, 1997; Chaffai and Dietsch, 1998; Isik and Hassan, 2002; Allen and Liu, 2007).
6. Constant return of scale and does not make it possible to obtain a curve of average cost in U form, which is a successive simplification in the reality of the behavior of the banking cost function.
7. Some other studies rely on the Fourier Flexible specification to estimate efficiency (e.g. DeYoung and Hasan, 1998; Carbo *et al.*, 2002). Berger and Mester (1997) found that both the translog and the FF function form yielded essentially the same average level and dispersion of measure efficiency, and both ranked the individual banks in almost the same order. Vander Venet (2002) also finds similar results but reports the ones obtained from the translog model. We therefore use the translog specification as in several other recent studies such as Dietsch and Lozano-Vivas (2000) Cavallo and Rossi (2002), Bonin *et al.* (2005), Carvallo and Kasman (2005), Fries and Taci (2005), Bos and Kool (2006).
8. For more details of tests of specification of Hsiao (1986), see the course of Christophe, HURLIN. 2003. "L'économétrie des données de panel : modèles linéaires simples et modèles dynamiques." Doctoral school EDOCIF.
9. This homogeneity is explained by the fact that the banks of our sample are the same nature (commercial banks and we excluded the offshore and the development banks). Moreover these banks are indirectly controlled and subjected to the supervision of the State and apply the same banking reforms.
10. We chose this ratio insofar as the data on the values of the nonperforming loans are not available for each bank and each year (the quality of the credit can be represented by other ratios such as, the ratios of the nonperforming loans to the total loans, nonperforming loans in the total asset).
11. The degree of freedom corresponds to the number of exogenous variables in the model.
12. Indeed, average efficiency increased by 19.91% over 1999-2005 period.
13. However, our result differs from certain former studies (for example, Altunbas *et al.*, 2000 finds a positive relation between ratio LTA and the inefficiency scores in Japanese banks)
14. In 2003, the BIAT keeps the 1st place in term of deposits to the customers in front of the BNA and the STB. These three large banks share together 45.7% of the deposits to the customers.

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