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Is Bigger Better for Egyptian Banks? An Efficiency Analysis of the Egyptian Banks during a Period of Reform 2000-2006

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Abstract: This study contributes to the banking efficiency literature by using a three input-five output stochastic frontier translog cost function specification to investigate cost efficiency, scale economies, and technological progress in the Egyptian banking sector. The study analyzes the efficiency of Egyptian banks in the period 2000–2006 which witnessed major regulatory and structural changes. The analysis is based on a panel data of 34 commercial banks representing about 75% of the banking sector in Egypt. The results show that the banks suffer significantly from internal X-inefficiency with an average cost reduction potential of 12%. Increasing economies of scale are found to exist up to a bank size of about EGP30 bn, implying that all but the four largest banks in Egypt could reduce their average costs by growth. Surprisingly, Egyptian commercial banks did not benefit from technological change; instead they faced a negative dynamics of the cost frontier. Further regression analysis conducted to explain the different efficiency levels of the banks revealed a positive impact of size, growth, and merger activities on efficiency, which implies bigger is better for Egyptian Banks.

Keywords: banking, X-inefficiency, stochastic frontier, Egypt, mergers and acquisitions

JEL Classification: G21, L89, M21

1 Introduction

The banking sector plays a pivotal role in national economies; consequently continuous assessment of the performance of banks is essential for the soundness of the economy. For Egypt, which has undergone frequent banking sector

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reforms to cope with internal and global challenges, this assessment is crucial. In 2004, the country embarked on a comprehensive financial sector reform program (FSRP) to build a strong and competitive financial sector. The five main pillars of this reform included: enhancing the supervisory role of the Central Bank of Egypt (CBE), financial and managerial restructuring of stateowned banks, addressing the non-performing loans (NPLs) problem, privatizing and divesting state-owned banks' stakes in private and joint-venture banks, and consolidating the banking sector.

By 2009, many of the reform goals had been achieved. For example, the government had successfully divested the shares of public banks in 13 jointventure banks. Furthermore, the banking sector witnessed a very large number of mergers and acquisitions: almost a quarter of all independent banks operating in Egypt have disappeared between the years 2000 and 2008. The reforms have certainly changed the face of the country's financial services industry.

Even though Egypt is the second largest economy in Africa and has one of the oldest financial systems in the Middle East since the nineteenth century, the number of studies examining the efficiency of Egyptian banks is small. Similar to most developing countries, lack of firm-level data has prevented a significant stream of research output. Only two studies have assessed the performance of Egyptian banks from an efficiency perspective, namely El-Shazly (2011) and Poshakwale and Qian (2011). In addition, Reda (2012), as well as Badreldin and Kalhoefer (2009), focused on the effect of mergers on bank performance using Data Envelopment Analysis (DEA) and financial analysis, respectively. On the macroeconomic level, Abu-Bader and Abu-Qarn (2008) found evidence for a bidirectional causality between the efficiency of the financial sector and growth in Egypt, concluding that further efficiency increases of the financial sector are necessary to stimulate growth via the saving-investment relation.

This study follows the stream of banking literature - for an overview see Amel et al. (2004) – that attempts to gauge banks' performance through assessing their efficiency. The study was conducted using a panel data set of 34 commercial banks representing about 75% of the Egyptian banking industry. The panel includes observations for the period from 2000 to 2006, therefore including the big banking reform of 2004. Our data set includes a variety of variables that go beyond the scope of the few earlier studies on the Egyptian banking sector. Specifically, three inputs and five outputs of the 34 banks are

¹ Examining the impact of these reforms is beyond the scope of our paper. These were studied by Abdel-Baki (2010).

used. The study estimates banks' efficiency utilizing a stochastic frontier cost function of the translog type. This allowed for the estimation of individual bank cost and scale efficiency scores, as well as technological progress.

The research questions addressed are: Do Egyptian banks suffer cost inefficiency? Do banks witness technological progress? Do big or small banks enjoy cost advantages? Is there a relationship between ownership and cost efficiency? Is the merger policy suitable for Egyptian banks? To answer those questions, individual bank X-efficiency scores and optimal bank size are estimated. In addition, the existence of economies of scale is tested. Further, Ordinary Least Squares (OLS) regressions analyzed the effect of different variables including the effect of mergers on bank cost efficiency. The last issue is especially important for weighing the potential benefits of consolidation against possible market power effects or the systemic risk of "too big to fail" institutions.

The rest of the paper is organized as follows: Section 2 presents the theoretical background. The methodology describing the model and estimation method is in Section 3. The data is explained in Section 4, and Section 5 reports the empirical results. Finally, Section 6 concludes.

2 Theoretical Background

This paper assesses the efficiency of the Egyptian banks from a triad of perspectives: cost efficiency, 2 scale efficiency, and technical change. In a first step, we estimate the cost frontier of the Egyptian banking industry, which is defined as the best-practice costs necessary to operate at given output levels and input prices. An important characteristic of cost frontiers is their ability to allow for firm-level inefficiency. The deviation of actual cost, corrected by pure randomness, from its minimum possible level as defined by the cost frontier captures the cost inefficiency. This inefficiency may be both allocative (wrong input mix) and productive (waste of inputs) inefficiency. Another important characteristic of cost functions is their duality³ to production functions, which allows the determination of economies of scale and the measurement of technical change. Finally, in contrast to production functions, it is easy to consider the multi-output character of banks within a cost function framework.

² The study uses the terms cost efficiency and X-efficiency interchangeably in line with similar studies (cf. Berger 1998; Gjirja 2003).

³ For duality refer to Chambers (1988).

The empirical implementation of the cost efficiency is based on the pioneering work of Aigner, Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977), which led to the development of several empirical approaches to assess the efficiency of firms. Broadly these approaches can be divided into: non-structural (accounting) approaches and structural (frontier) approaches (Hughes and Mester 2008). Structural approaches can be subdivided into parametric and non-parametric approaches. The parametric approaches encompass three techniques: the Stochastic Frontier Analysis (SFA), the Thick Frontier Analysis (TFA), and the Distribution Free Approach (DFA); while the non-parametric approaches encompass the DEA and the Free Disposable Hull (Berger and Humphrey 1992). The two most common approaches for investigating overall bank efficiency are the non-parametric DEA and the parametric SFA (Coelli et al. 2005, 161). Considerable debate remains concerning the choice between DEA and SFA due to the fact that each approach possesses its own merits and disadvantages (Ahmed 2008).

This paper opted for the SFA technique to estimate the efficiency of Egyptian banks. The choice of SFA over DEA is justified on the grounds that the SFA technique is more adequate to the nature of bank studies. The SFA allows for the separation of random noise from inefficiency. This characteristic of the SFA is particularly important in the case of bank data where measurement error is a main problem (Kasman 2002, 3). Also, this technique generates firm-specific efficiency estimates which are essential for bank managers' operational efficiency (Sarsour and Daoud 2015, 60). In contrast, the usage of the DEA would not allow for separating between inefficiency and data problems, perhaps seriously overstating the degree and fluctuation of the inefficiency term.

The SFA approach is a parametric technique that necessitates the specification of a functional form. In the literature, a broad range of functional forms from the Cobb-Douglas to the transcendental-logarithmic (translog) to the Fourier flexible forms (e.g., Altunbas and Chakravarty (2001); Vennet (2002)) and Box-Cox transformations (Pulley and Humphrey 1993) - can be found. However, the cost of using very flexible forms is the higher number of parameters to be estimated, consequently, a rich data set is required which is often rarely available. Actually, many studies⁴ concur that the translog specification is the most appropriate functional form and well-suited to characterize the banking sector characteristics. With about 140 observations available, we follow these predecessors and apply the translog functional form.

⁴ Cf. Lawrence (1989), Noulas, Ray, and Miller (1990), and Noulas, Miller, and Ray (1993).

3 Methodology

3.1 Econometric Specification

The stochastic translog function utilized to construct the cost frontier for Egyptian banks is specified as follows:

$$\ln C_{kt}(w_{kt}, y_{kt}, br_{kt}.t) = a_0 + \sum_{i=1}^{3} a_i \ln w_{ikt} + \sum_{m=1}^{5} b_m \ln y_{mkt}$$

$$+ 0.5 \sum_{i=1}^{3} \sum_{j=1}^{3} a_{ij} \ln w_{ikt} w_{jkt} + \sum_{i=1}^{3} \sum_{m=1}^{5} g_{im} \ln w_{ikt} \ln y_{mkt}$$

$$+ \sum_{m=1}^{5} \sum_{n=1}^{5} b_{mn} \ln y_{mkt} \ln y_{nkt} + c_0 \ln br_{kt} + 0.5 c_1 (\ln br_{kt})^2$$

$$+ e_0 t + 0.5 e_1 t^2 + \sum_{i=1}^{3} f_i (\ln w_{ikt}) t + u_k + v_{kt}$$
[1]

According to eq. [1], total costs C of an individual bank k at period t are given as a function of: three factor prices w_i , i = 1, 2, 3; five output levels y_m , m = 1, ..., 5; the number of branch offices br; and the time index t. The branching variable (br) is included as control variable, as the size of the branching network not only has a direct impact on costs, but also influences the shape of economies of scale (Lang and Welzel 1996, 1005). Moreover, the study considers possible technical change by including the time component *t*.

The duality condition of a cost function requires monotony in input prices and output levels, linear homogeneity in input prices, and concavity in input prices (Chambers 1988). As in similar studies, linear homogeneity in input prices and parameter symmetry is ex ante imposed into the estimation process:

$$a_{ij} = a_{ji}$$
 $i, j = 1, 2, 3,$ $b_{bn} = b_{nm}$ $m, n = 1, ..., 5,$

$$\sum_{i=1}^{3} a_i = 1, \quad \sum_{i=1}^{3} f_i = 0, \quad \sum_{j=1}^{3} a_{ij} = 0 \quad i = 1, 2, 3, \quad \sum_{i=1}^{3} g_{im} = 0 \quad m = 1, ..., 5.$$
[2]

An important characteristic of eq. [1] is the specification of the residual term ε_{kt} , which is broken down into the inefficiency term u_k and the standard random term v_{kt} . Systematic deviations from the cost frontier are described by u_k which captures both technical and allocative inefficiency, where u_k is assumed to

follow a half-normal distribution⁵ as follows: $u\tilde{i}idN^+(0,\sigma_u^2)$. This assumption of a certain distribution is the reason for the term "stochastic" frontier. To account for measurement errors and cost determinants beyond the control of management, the random term v_{kt} is used. This random term is the usual residual in econometric studies and follows the standard normal distribution $\tilde{viid}N(0,\sigma_n^2)$. Because the inefficiency part u_k is strictly positive, the aggregate residual ε_{kt} has a positive rather than a zero expected value.

To estimate the parameters β and the variance elements σ_u^2 and σ_v^2 of the stochastic frontier cost function (1), we follow Battese and Coelli (1992)⁶ and maximize the following log-likelihood function:

$$\ln L(\beta, \sigma^{2}, \gamma) = -\frac{1}{2} \left[\sum_{k=1}^{K} T_{k} (\ln(2\pi) + \ln(\sigma^{2})) \right] - \frac{1}{2} \sum_{k=1}^{K} (T_{k} - 1) \ln(1 - \gamma)$$

$$- \frac{1}{2} \sum_{k=1}^{K} \ln(1 - \gamma - \gamma T_{k}) - K \ln\left(\frac{1}{2}\right)$$

$$+ \sum_{k=1}^{K} \ln\left(1 - \Phi\left(\frac{-\gamma \sum_{t=1}^{T} \varepsilon_{kt}}{\sqrt{\gamma(1 - \gamma)\sigma^{2}[1 + (T_{k} - 1)\gamma]}}\right)\right)$$

$$+ \frac{1}{2} \sum_{k=1}^{K} \left(\frac{-\gamma \sum_{t=1}^{T} \varepsilon_{kt}}{\sqrt{\gamma(1 - \gamma)\sigma^{2}[1 + (T_{k} - 1)\gamma]}}\right)^{2} - \frac{1}{2} \sum_{k=1}^{K} \frac{\varepsilon'_{k} \varepsilon_{k}}{(1 - \gamma)\sigma^{2}}$$
[3]

The value of the likelihood function (3) depends on the parameters estimated from eq. [1] β , the variance of the aggregate residual $\sigma^2 = \sigma_u^2 + \sigma_u^2$, and the share of the inefficiency variance relative to the total variance $\gamma = \sigma_u^2 / - \sigma^2$. Thus, if $\gamma = 0$, deviations from the frontier are entirely due to noise; while in the case of y = 1, deviations from the frontier are entirely due to inefficiency. Note that estimating σ^2 and γ is sufficient to determine $\sigma_u^2 = \gamma \cdot \sigma^2$ and subsequently $\sigma_v^2 = \sigma^2 - \sigma_u^2$. Finally, T_k is the number of observations for bank k which might be smaller

⁵ The half-normal distribution assumption is the most common one found in the efficiency literature. Alternatives are the exponential or the gamma distributions (Greene 1990).

⁶ Battese and Coelli (1992) allowed for a dynamic trend in the level of inefficiency but the inefficiency term as defined by the log-likelihood function [3] is assumed to be time invariant. This reduction in the flexibility of the function was inevitable to stabilize the estimation process since the number of observations in our study is relatively small.

than T because of the unbalanced nature of the panel, and $\Phi()$ denotes the cumulative distribution function of the standard normal distribution.

An alternative to using the maximum likelihood (ML) estimator is a fixed effects specification, which has the advantages that the assumption of independence of error term and regressors is relaxed and no specific assumption about the distribution of the inefficiency variable is necessary. Still, the majority of efficiency articles prefer ML-based estimators because the fixed effects approach is less efficient and must assume that the most efficient firm in the sample is exactly on the frontier. That is problematic because the best-practice firm may be outside the sample, or the best-practice firm is indeed covered by the sample but is not exactly on the frontier. Furthermore, a Hausman test for the null hypothesis that error terms are uncorrelated with the regressors returned a test statistics of 30.2, which is insignificant even at the 10% level. We therefore continue with the ML approach, confirming Schmidt and Sickles (1984) who point out that correlation is often rejected empirically in relatively short panels.

3.2 Cost Efficiency, Economies of Scale, and Technical Change

Maximizing the likelihood function [3] we obtain:

- all parameters of the cost function [1]. That is, the estimated parameter vector β includes $a_0, a_1, a_2, a_3, b_1, \dots, f_1, f_2, f_3$. Subsequently, the aggregate residuals ε_{kt} can be obtained by substituting the estimated parameters in the translog cost function and taking the difference between actual costs and predicted costs.
- the variance terms σ^2 and γ . Battese and Coelli (1992) have shown that the inefficiency term u_k and the scaled cost efficiency measure X-EFF_k can be determined from the results by the following transformations:

$$X - EFF_k = \frac{\hat{C}_k^{frontier}}{C_k} = \frac{\exp^{(\ln \hat{C}_{kt} + \nu_{kt})}}{\exp^{(\ln \hat{C}_{kt} + \mu_k + \nu_{kt})}} = e^{-u_k} = \frac{\Phi(\mu_k^*/\sigma_k^* - \sigma_k^*)}{\Phi(\mu_k^*/\sigma_k^*)} e^{-\mu_k^* + \frac{1}{2}\sigma_k^{*2}},$$
 [4]
$$\text{where} \quad \mu_k^* = \frac{-\sigma_u^2 \sum_{t=1}^T \varepsilon_{kt}}{\sigma_v^2 + T_K \sigma_u^2} \quad \text{and} \quad \sigma_k^{*2} = \frac{\sigma_v^2 \sigma_u^2}{\sigma_v^2 + T_K \sigma_u^2}.$$

In eq. [4], Φ () denotes the cumulative distribution function of the standard normal distribution. As shown in eq. [4], the stochastic frontier is the sum over the frontier plus random error, whereas total cost is the sum over frontier plus random error plus inefficiency. The cost efficiency measure X-EFF $_k$ specific for each bank *k* is scaled between zero and one and it can be interpreted as the cost ratio of the fully efficient bank to that of the actually observed unit (Lang and Welzel 1999, 5). That is, if a bank scores a cost efficiency ratio of 0.8, this bank is 80% efficient. Thus this bank could reduce its costs by 20% (to operate at the frontier) and still produce the same level of output without reducing input prices, output levels, the branching network, or technological improvement. The inefficiency is the result of a structural organization problem, i.e., management failure.

In addition to the cost efficiency, measures of economies of scale and technical change can be derived from the estimated cost function. Scale economies in multi-output environments measure the relative change in a firm's total cost for a given proportional change of all outputs. Scale economies can arise, e.g., from improved specialization and division of labor or due to the effects of a larger loan portfolio that allows for enhanced risk diversification. The translog function is non-homothetic and thus allows for a wide range of scale effects including a relationship between input prices and economies of scale (Chambers 1988, 73; Ray 1988). Empirically, the overall economies of scale or ray economies of scale (RSCE) can be estimated as the elasticity of total cost C obtained in eg. [1] with respect to all outputs:

$$RSCE_{kt} = \sum_{m=1}^{5} \frac{\partial \ln C_{kt}}{\partial \ln y_{mkt}} = \sum_{m=1}^{5} b_m + \sum_{i=1}^{3} \sum_{m=1}^{5} g_{im} \ln w_{ikt} + \sum_{m=1}^{5} \sum_{n=1}^{5} b_{mn} \ln y_{nkt}$$
 [5]

Values of RSCE which are less than one imply cost increases are less than proportionate to output increases implying increasing economies of scale. Subsequently, banks with RSCE values lower than one are operating below their optimal scale levels and can reduce costs by increasing output further, e.g., by a growth or a consolidation strategy. On the other hand, if RSCE is higher than one indicating diseconomies of scale, then banks should reduce their output level to achieve optimal scale and thus reduce their costs.

To flexibly account for possible changes of the technology over the observation period, linear and squared time trends interacting with input prices were included in the specification of the cost function [1]. Because technological change is represented by a shift of the cost function over time, we can estimate the dynamics of this shift as the elasticity of total cost with respect to time. Accordingly, technological change η_{kt} is measured as

$$\eta_{kt} = \frac{\partial \ln C}{\partial t} = e_0 + e_1 t + \sum_{i=1}^{3} f_i \ln w_{ikt}$$
 [6]

Technological progress implies decreasing costs over time, all else given, that is, when η_{kt} is negative (Kasman 2002, 12), while there is technological recess if η_{kt} is positive. Examples of technological changes that can influence banks are electronic payment technologies, internet banking, and information exchanges (Berger 2003, 146). Of course, changes in the regulatory regime like equity requirements (Basel) also have an impact on production costs.

3.3 Potential Determinants of Cost Efficiency

Once the efficiency estimations are generated for the data set, the question for the reasons of inefficiency and its dispersion among banks presents itself. Accordingly, several studies extend the hypothesis testing to investigate reasons why financial firms suffer from inefficiency and why the degree of inefficiency may differ among banks. These studies often cite bank size, management structure, ownership, and structural changes such as mergers as the most influential factors. We follow cited studies by investigating whether variations in X-efficiency values estimated according to eq. [4] can be explained by potential factors which can be grouped into bank size variables, bank growth, ownership, and merger activity.

Bank size is proxied alternatively by the volume of total assets (TA), the number of employees (empl), the number of bank branches (br), and the evaluated measure for scale economies (RSCE). These proxies for bank size are in line with several other studies like Cavallo and Rossi (2001), Isik and Hassan (2002), or Fuentes and Vergara (2003). If larger institutions are more difficult to organize and to run, then there should be a negative relationship between bank size and efficiency. In addition, to investigate the relation between cost efficiency and bank growth, average growth in TA (growth) was used as an indicator of the latter. High growth rates may impose a challenge for management and could therefore be accompanied by lower efficiency values.

To analyze the role of ownership, we differentiate between private and stateowned banks. A dummy variable (Own) taking the value one for private banks versus zero for non-private banks is defined and used as regressor to explain X-EFF. Standard economic theory points to lower incentives for efficiency in state-owned banks, implying that the parameter of the ownership dummy should be positive. Finally, to investigate the relationship between efficiency

⁷ Cf. Berger and Mester (1997); Harker and Zenios (2000, 110); Ncube (2009, 12); Pilloff and Santemoro (1998); Wheelock and Wilson (1995).

and mergers, we also define a merger dummy (Merg). This variable is categorized into the value of zero in case of no merger activity over the observation period, and one if the bank under consideration was involved in a merger or acquisition. Like high growth rates, mergers and acquisitions are an institutional shock which could lower the efficiency for some time.

Furthermore, several multiple regressions were conducted to investigate the relation between efficiency and multiple variables such as regressing efficiency on TA, ownership, and mergers. Running the analysis using multiple and simple regressions yielded the same results, therefore only results of the simple OLS regressions are reported in Section 5.

4 Description of the Data

The quantitative analysis is based on a panel data set of 34 Egyptian banks covering the period 2000-2006.8 According to the CBE, there were 58 banks active in 2000 and 41 banks active in 2006, but some banks were not included in our sample because of missing input prices or output quantities. Also, some of the banks in the CBE list are specialized banks or branches of foreign banks. These were not included because, specialized banks are technology outliers not representative of Egypt's banking industry, whereas branches of foreign banks were excluded due to lack of sufficient data. Accordingly, the analysis is applied to commercial banks (public and private and joint-venture), which covers about 76% of the banking sector in Egypt. To be more specific, the sample consists of the four public commercial banks: BanqueMisr (BM), Banque du Caire (BC), National Bank of Egypt (NBE), and Bank of Alexandria (BoA) plus 30 private and joint-venture commercial banks listed in Table 5. The commercial banks used for our estimations do not only cover the largest share of Egyptian banks but were also heavily involved in the merger activities that were responsible for the disappearance of almost a quarter of the banks between 2000 and 2006 (see Tables 6 and 7 for details). Summarizing, our data allowed for the construction of an unbalanced⁹ panel data set consisting of 147 observations used for estimating the cost frontier in eq. [1].

⁸ Source for the data variables is Kompass Egypt from several issues from 2000 to 2008. Data about the merger activities of Egyptian banks were compiled by the researchers based on data from the American Chamber in Egypt.

⁹ The number of observations in the balanced panel data was 238 but due to consolidation and closure activities that the banks had undergone, an unbalanced panel was constructed.

The measurement of output and productivity is not straightforward for a bank due to the multi-output, intangible nature of banks' products, coupled with the difficulty to account for the quality of bank services (Heffernan 2005, 473). Even though several studies have emerged to examine bank productivity, they failed to provide a harmonized definition of inputs and outputs. To overcome this definitional problem, authors adopt either the production or the intermediation approach (Mlima and Hjalmarrson, 2002, 13). Given that the study focuses on the efficiency of the banking industry as banks are financial intermediaries, the study therefore follows the "intermediation approach" 10 that treats loans as outputs and deposits as inputs. Description of the data is illustrated in Table 1 where the dependent variable of the cost function [1] is total costs (C) defined as operating costs measured as follows:

total costs (C) = administration and general expenses + i-paid + provivions

The three input prices w_i and five outputs y_i representing the multi-output character of banks are defined respectively as follows:

- w_1 labor price, measured as administration and general expenses divided over the number of employees at the annual average.
- w_2 capital price, generated as the opportunity costs of capital divided by the equity of the bank. Opportunity costs are measured as the ratio of interest earned from loans to the volume of loans, reflecting the forgone interest in the use of equity.
- w_3 deposit price, calculated by dividing interest paid by the amount of the deposits.
- y_1 loans to other banks;
- y_2 loans to non-banks, i.e., loans to firms and households;
- y_3 securities, e.g., corporate or government bonds;
- y_4 fees and commissions for banking services;
- y_5 assets not covered by y_1 to y_4 , e.g., reserves held at the central bank. It is determined as a residual by taking the difference between TA and outputs one to four.

All the data concerning output quantities were extracted from the banks' balance sheets except for fees and commissions which were extracted from the banks' income statements. The GDP deflator (World Bank 2009) is used to deflate all nominal values, i.e., outputs, TA, and input prices.

¹⁰ For a comprehensive overview of the intermediation approach refer to Sealey and Lindley (1977).

Table 1: Statistical description of the data, 2000-2006.

Variable	Description	Mean value	Standard deviation	Minimum	Maximum
С	Total cost (million EGP)	1,073	1,951	30	12,190
<i>y</i> ₁	Output 1: loans to bank (million EGP)	3,753	6,649	122	41,518
<i>y</i> ₂	Output 2: loans to non-banks (million EGP)	6,255	10,809	144	50,504
<i>y</i> ₃	Output 3: T-Bills and T-Bonds (million EGP)	1,804	3,527	5	17,766
<i>y</i> ₄	Output 4: fees and commissions (million EGP)	149	239	6	1,098
y ₅	Output 5: other assets (million EGP)	2,276	4,500	12	21,155
<i>X</i> ₁	Input 1: labor (number of employees)	2,363.3	3,762	140	13,014
<i>X</i> ₂	Input 2: capital (million EGP)	918	1,223	77	6,857
<i>X</i> ₃	Input 3: deposits (million EGP)	14,016	25,984	286	155,188
<i>W</i> ₁	Price of labor (thousand EGP/ employee)	94.6	95.5	16.6	1,072
W_2	Price of capital	0.07	0.02	0.04	0.12
W_3	Price of deposits	0.07	0.02	0.01	0.16
br	Number of branch offices	65.4	116.8	3	450
Number	of observed banks: $k = 34$ of observation periods: $T = 7$ (years 20)	00–2006)			

Total number of observations: n = 147

Note: The statistical description of the data is calculated for the 34 banks in the sample in year 2003 because the banks in the sample underwent several structural changes throughout the sample period that by year 2006 the statistical data would have been calculated for only 25 banks that existed

Source: Computed by the researcher based on financial information from Kompass Egypt, Financial Year Book, several issues.

Our data, as described in Table 1, provide means, minimum, maximum, and standard deviation of each variable. Significant discrepancies between Egyptian banks in terms of total costs with a minimum of EGP 38.8 mn to a maximum of around EGP 8.4 bn can be noted. This suggests disparities in the cost management efficiency between banks. Also, there are significant size differences among Egyptian banks, for example, loans to non-banks range from EGP 122 mn to around EGP 50 bn. In fees and commissions, small banks earn less than 1% compared to the largest player (NBE). Similarly, input prices are also quite heterogeneous, where the interest rates paid on deposits range from 1% to 16%. Moreover, Egyptian banks' employability varies vastly from a few hundred to thousands of employees. Likewise, the number of bank branches varies from four to 450 branches.

5 Empirical Results

This section presents our estimations of the cost frontier [1], generated by numerically maximizing the log-likelihood function [3]. We used Gauss software for all estimations and calculations of X-EFF, RSCE, and η . Table 2 provides the parameter estimates showing that most are statistically significant. The use of a stochastic frontier is clearly supported by highly significant σ^2 - and γ -parameters, rejecting the hypothesis that only random error occurs. Likelihood ratio tests rejected the null hypothesis of constant economies of scale technology in the Egyptian banking industry.

Table 2: Maximum likelihood estimates for the parameters of the cost function.

Variable	Parameter symbol	Parameter	Std. error	<i>t</i> -Ratio
Constant	a_0	8.5951***	2.0130	4.2698
$ln w_1$	a_1	-0.1097	0.2176	-0.5044
ln w ₂	a_2	2.0855**	0.4689	4.4474
ln w₃	a_3	-0.9758**	0.4622	-2.1109
$ln y_1$	b_1	0.6068*	0.4352	1.3944
ln y ₂	b_2	-0.6469*	0.4661	-1.3878
ln y ₃	b_3	0.0601	0.1145	0.5247
ln y ₄	b_4	0.5283**	0.2429	2.1747
ln y ₅	b_5	-0.4776**	0.2706	-1.7647
$0.5 \times \ln w_1 \times \ln w_1$	a_{11}	0.0159	0.0228	0.6986
$0.5 \times \ln w_1 \times \ln w_2$	a_{12}	0.1943***	0.0687	2.8271
$0.5 \times \ln w_1 \times \ln w_3$	a ₁₃	-0.2103***	0.0649	-3.2391
$0.5 \times \ln w_2 \times \ln w_2$	a ₂₂	-0.6220***	0.1540	-4.0396
$0.5 \times \ln w_2 \times \ln w_3$	a ₂₃	0.4276***	0.0952	4.4922
$0.5 \times \ln w_3 \times \ln w_3$	a ₃₃	-0.2174***	0.0672	-3.2342
$ln w_1 \times ln y_1$	g_{11}	0.0349	0.0337	1.0348
$\ln w_1 \times \ln y_2$	g_{12}	0.1081***	0.0399	2.7091
$ln w_1 \times ln y_3$	g_{13}	-0.0258*	0.0192	-1.3411
$ln w_1 \times ln y_4$	g_{14}	-0.0946***	0.0387	-2.4461
$\ln w_1 \times \ln y_5$	g_{15}	-0.0356**	0.0192	-1.8584
$\ln w_2 \times \ln y_1$	g_{21}	-0.0288	0.0653	-0.4416
$\ln w_2 \times \ln y_2$	g_{22}	-0.2775**	0.1242	-2.2342
$\ln w_2 \times \ln y_3$	g_{23}	0.0276	0.0529	0.5221
$\ln w_2 \times \ln y_4$	g_{24}	0.2453**	0.1387	1.7692
$\ln w_2 \times \ln y_5$	g ₂₅	-0.0477	0.0447	-1.0673
$\ln w_3 \times \ln y_1$	g ₃₁	-0.0061	0.0729	-0.0832
$\ln w_3 \times \ln y_2$	g ₃₂	0.1694*	0.1066	1.5884
$\ln w_3 \times \ln y_3$	g ₃₃	-0.0018	0.0540	-0.0336

(continued)

Table 2: (continued)

Variable	Parameter symbol	Parameter	Std. error	<i>t</i> -Ratio
$\ln w_3 \times \ln y_4$	g_{34}	-0.1507	0.1358	-1.1098
$\ln w_3 \times \ln y_5$	g_{35}	0.0833**	0.0403	2.0689
$ln y_1 \times ln y_1$	b_{11}	0.1220**	0.0723	1.6862
$ln y_1 \times ln y_2$	b_{12}	-0.2375***	0.0200	10.7034
$ln y_1 \times ln y_3$	b ₁₃	-0.0140	0.0170	-0.8265
$ln y_1 \times ln y_4$	b_{14}	0.1227***	0.0250	4.9149
$ln y_1 \times ln y_5$	b ₁₅	0.0101	0.0291	0.3465
$ln y_2 \times ln y_2$	b ₂₂	0.4057***	0.1002	4.0479
$ln y_2 \times ln y_3$	b ₂₃	-0.0042	0.0179	-0.2372
$ln y_2 \times ln y_4$	b_{24}	-0.1419**	0.0812	-1.7462
$ln y_2 \times ln y_5$	b ₂₅	-0.0103	0.0246	-0.4182
$ln y_3 \times ln y_3$	b ₃₃	0.0089	0.0091	0.9825
$ln y_3 \times ln y_4$	b ₃₄	0.0010	0.0220	0.0487
$ln y_3 \times ln y_5$	b ₃₅	0.0134	0.0158	0.8532
$ln y_4 \times ln y_4$	b_{44}	0.0225	0.0698	0.3219
$ln y_4 \times ln y_5$	b_{45}	-0.0113	0.0226	-0.5005
$ln y_5 \times ln y_5$	b ₅₅	0.0470***	0.0162	2.8975
ln <i>br</i>	c_0	0.1658***	0.0636	2.6064
$0.5 \times (\ln br)^2$	c_1	-0.0166	0.0193	-0.8594
T	e_0	0.0602***	0.0208	2.8938
$0.5 \times t^2$	e_1	0.0078**	0.0039	1.9895
$ln w_1 \times t$	f_1	-0.0053	0.0079	-0.6704
$ln w_2 \times t$	f_2	-0.0479**	0.0248	-1.9353
$ln w_3 \times t$	f_3	0.0532***	0.0225	2.3664
Variance parameters				
$\gamma = \sigma_{\mu}^2 / \sigma^2$	γ	0.8901***	0.0057	155.4985
$\sigma^2 = \sigma_u^2 + \sigma_u^2$	σ^2	0.0476***	0.0019	24.5476
Log-likelihood		157.62		
Number of observations		147		

Notes: *, **, and *** represent a significance level of 10%, 5% and 1%, respectively (two-sided). All calculations were run using GAUSS software.

In line with similar bank efficiency studies, the degree of cost inefficiency turned out to be economically relevant for Egyptian banks. According to our estimations, the mean cost efficiency of all Egyptian banks is at 88.2%, implying an average cost reduction potential of 12%. For an international comparison, Table 8 displays the results of some recent studies on cost efficiency of banks in other developing countries. According to these estimates, the mean efficiency of South African banks is at 92%, making them the closest to the Egyptian banks. Estimates for the other countries are significantly below these figures, indicating a higher variation in cost efficiency because all banks are ranked relative to the bestpractice technology. Note that cost savings could be realized with the given technology, outputs, input prices, and the current network of branches.

The derived X-efficiency, RSCE, and technical change measures specific to each bank are shown in Table 3. For the bank-specific X-efficiency values, our estimations range from 0.691 to 0.998. This indicates that the least efficient bank (Alexandria Commercial and Maritime Bank, ACMB) could reduce its costs by approximately 31% relative to the actual position if it operates on the frontier, while the most efficient bank (National Bank of Egypt) is more or less operating on the frontier. As for the rest of the banks, 15 institutions are below the average efficiency score of 0.882, whereas 18 institutions are above the average.

The optimal bank size was analyzed by determining the cost-output elasticity (RSCE), a measure for economies of scale. Our results, provided in Table 3, show

Table 3: Cost efficiency, ray scale economies, and technological change.

Bank name	X-Efficiency	RSCE	Technical change
National Bank of Egypt	0.9978	1.1040	0.0826
Misr Iran Development Bank	0.9910	0.8890	0.0931
Delta International Bank	0.9906	0.8202	0.0610
Banque Misr	0.9834	1.0892	0.0757
Ahli United Bank-Egypt	0.9824	0.8083	0.0753
Commercial International Bank	0.9750	0.9567	0.0601
Cairo Barclays	0.9714	0.7763	0.0484
Misr International Bank	0.9621	0.9398	0.0670
Barclays Bank Egypt	0.9619	0.8553	0.0781
Arab African International Bank	0.9561	0.8384	0.0856
National Société Générale Bank	0.9532	0.8451	0.0581
Crédit Agricole Indosuez Egypt	0.9467	0.7715	0.0748
Société Arabe Internationale de Banque	0.9377	0.7898	0.0858
Nile Bank	0.9287	0.8060	0.0869
Misr America International Bank	0.9128	0.7694	0.0633
Export Development Bank	0.9010	0.9013	0.0836
Audi Bank	0.9008	0.7686	0.1100
Banque du Caire	0.8984	1.0451	0.0755
Cairo Far East Bank	0.8820	0.7792	0.1048
Suez Canal Bank	0.8778	0.9798	0.0893
National Bank for Development	0.8624	0.9631	0.0789
BNP Paribas	0.8594	0.7617	0.0862
Misr Romania Bank	0.8558	0.8340	0.0761
Crédit Agricole Egypt	0.8556	0.8357	0.0721
Bank of Alexandria	0.8328	1.0371	0.0879

(continued)

Table 3: (continued)

Bank name	X-Efficiency	RSCE	Technical change
Piraeus Bank-Egypt	0.8022	0.8758	0.0943
Bloom Bank	0.8017	0.8743	0.0917
HSBC Bank Egypt	0.7866	0.8805	0.0622
Egyptian Gulf Bank	0.7756	0.8188	0.0655
Egyptian Commercial Bank	0.7716	0.8439	0.0671
Al Watany Bank	0.7602	0.9122	0.0776
Mohandes Bank	0.7255	0.8800	0.0719
Egyptian Saudi Finance Bank	0.7006	0.8506	0.0747
Alexandria Commercial & Maritime Bank	0.6912	0.8731	0.0918
Overall	0.8821	0.8757	0.0781

strong evidence of increasing economies of scale, where the mean value of RSCE is at about 0.87. That is, a proportional growth by 1% of all outputs will increase total costs on average by only 0.87%, which in turn will decrease average costs. Table 3 demonstrates that almost all banks exhibit economies of scale with the exception of two. The first bank suffering from diseconomies of scale is NBE, which is the biggest public sector commercial bank in the data set. Our estimate of RSCE for NBE is close to 1.10, implying that NBE could increase its margin by reducing its output: A reduction of all output levels by 1% would decrease total costs by 1.10%, i.e., more than proportional. Even though NBE might slightly suffer from diseconomies of scale, this institution seems to be pretty well managed because X-EFF is estimated at 0.998, indicating that there is barely any waste of resources. In short, NBE is close to the estimated optimal cost frontier, but not at the best position along the frontier (suboptimal size). The second bank with diseconomies of scale is BM, which is the second largest public bank.

In contrast, there are two public banks operating close to the optimal scale, namely Banque due Caire and Bank of Alexandria (acquired by the Italian bank Sanpaolo in 2006). The Suez Canal Bank, the National Bank for Development, and the Commercial International Bank (CIB) are somewhat below the optimal scale with RSCE estimates of 0.98, 0.96, and 0.96, respectively. At the lower end of the RSCE results, a group of mainly foreign subsidiaries could benefit the most from an aggressive growth strategy. BNP Paribas, Audi Bank, Misr America International Bank, Credit Agricole Indosuez, Cairo Barclays, Cairo Far East Bank, and Societe Arabe Internationale de Banque are all clustering around an RSCE value of 0.77. Accordingly, the majority of the Egyptian banks should operate at a much larger scale. For many Egyptian banks, the advantage of growth is even more significant than - to take an example from a developed country - for small German co-operative banks, where RSCE values of around 0.84 were found (Lang and Welzel 1999, 1017). Roughly speaking, the optimal bank size is at around EGP30 bn, which is equivalent to \$5 bn.

Finally, the results on technological change η are also shown in Table 3. All relevant parameters, i.e., the time trend, the quadratic time trend, and the interaction between the time trend and input prices, are - with one exception - highly significant. Our results suggest the existence of technological recess for all banks over time, where the mean value is about 0.078 (7.8% year over year). The bankspecific interval ranges from 0.04 to 0.11. In addition, it was found that cost control of large banks over time (0.0736) is better than their smaller counterparts, where costs grow by approximately 0.08% in medium and small banks. These results emphasize the argument that failure to catch up in adopting more advanced new technologies and financial services may slow down the small banks' performance in the longer term. Whereas such a result would be very surprising for developed countries, it is not unusual for developing countries (c.f. El-Shazly (2011) for Egypt; Kasman (2002) for Turkey). It has to be kept in mind that the Egyptian banks are incurring high costs to adapt to modern information technologies and are operating within an ever tighter regulatory framework requiring a lot of information (e.g., a continuous valuation of all assets at market prices). However, in the long run, in a time frame much larger than seven years, the results on the dynamics of technological progress may differ.

Further hypothesis testing to investigate the relationship between cost efficiency and potential explanatory variables is shown in Table 4. First, several regressions relating X-efficiency to bank size variables were conducted, all of them turning out to be significant, and all of them confirming our surprising result: The larger the institution, the higher is the degree of cost efficiency. Obviously, larger Egyptian banks are better organized than their smaller rivals, which may be a consequence of the better qualified staff in larger institutions. Small banks are thus not benefiting from the advantages of higher flexibility and lower information costs of smaller institutions. In this respect, RSCE results have shown that small banks are not operating very efficiently as they operate below the optimal scale. Other potential reasons for this interesting result may be a lower educational level of the employees, lack of the ability to attract high managerial skills, the lack of an incentive system, or a relatively weak endowment of information technology.

Regressions analyzing the relationship between cost efficiency and mergers showed that faster growing banks are more efficient than banks with a low growth rate. Bank mergers have a positive impact on the efficiency score, where mergers trigger a jump of 0.074 closer to the frontier. It is worth mentioning that a study conducted by Badreldin and Kalhoefer (2009) investigated the effect of

Table 4: Potential determinants of cost efficiency.

Explained variable	Explaining variable	Controlling for	Parameter estimates		
variable			Intercept	Slope parameter	
X-EFF	In TA (total assets)	Bank size	-0.387 (0.0991)**	0.0163×ln TA (0.0064)**	
	In empl (employees)		-0.251 (0.0516)***	0.0171×ln empl (0.0075)**	
	In <i>br</i> (no. of branches)		-0.2122 (0.0214)***	0.0261×ln br (0.0065)***	
	RSCE (measure of economies of scale)		0.7600 (0.0687)***	0.1359×RSCE (0.0768)*	
	Growth (average growth rate of TA)	Bank growth	0.8682 (0.0174)***	0.0160 × Growth (0.0092)*	
	Own (ownership dummy: public vs. private)	Ownership	0.9323 (0.0197)***	-0.0624×0wn (0.0212)***	
	Merg (merger dummy)	External growth by mergers or acquisitions	0.8471 (0.0093)***	0.0738 × Merg (0.0139)***	

Notes: Standard errors in parentheses. *, **, and *** represent a significance level of 10%, 5%, and 1%, respectively (two-sided).

mergers on bank performance from a financial perspective which showed mixed results concerning the merger effect. It is also found that more efficient banks tend to acquire less efficient ones in the majority of cases. In 67% of the merger cases, the acquiring bank was more efficient than the acquired one as can be seen in Figure 1. This result is in line with the majority of research concerned with efficiency differences between acquiring and acquired institutions. However, the difference in the efficiency score between the acquirer and the acquired one is not very large, signaling that merger motives other than enhancing cost efficiency might be important. Probably, NPLs, avoiding insolvency, and conforming to higher minimum capital requirements of the CBE were the main reasons behind the consolidation process.

Finally, the results concerning efficiency and ownership do not also follow conventional wisdom: Public banks are found to be closer to the frontier than private banks. The mean cost efficiency score of public sector banks is 0.92, while the mean cost efficiency score of private banks is 0.87. According to Pasiouras, Tanna, and Zopounidis (2007), higher cost efficiency scores of public banks

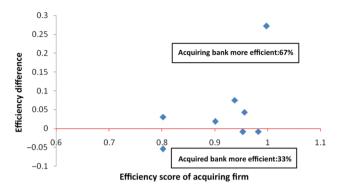


Figure 1: Difference in X-efficiency between acquiring and acquired bank.

relative to private banks are due to a higher willingness of the latter to incur higher costs in return for better quality and higher revenues. The previous argument is in line with El-Shazly (2011) and Poshakwale and Qian (2011), who also find state-owned banks more cost efficient than their private counterparts in Egypt.

6 Conclusion

In the past few years and with the initiation of the FSRP in 2004, the banking sector in Egypt has witnessed dramatic developments that changed the landscape of the industry. Using an unbalanced panel of 34 commercial banks covering around 75% of all banks over the periods 2000–2006, this study attempted to gauge the efficiency and other core characteristics of the Egyptian banking industry. To avoid predetermined results, a flexible multi-output translog cost function is specified and estimated using SFA. The empirical results of this setup provided detailed insights into the Egyptian banking sector which was – to some degree – unexpected.

Addressing the question of X-efficiency, our results are similar to what has been found for many other countries: Cost inefficiency turned out to be statistically and economically significant. On average, commercial banks could reduce their costs by approximately 12% without a decrease in input prices, output levels, or number of branches. Furthermore, strong evidence for economies of scale for the majority of banks is found. The optimal bank size is estimated to be at about EGP30–35 bn, which is – using the exchange rate of 2006 – equivalent to about \$6 bn. The time trend, often interpreted as technological change, was surprisingly found to have a cost-increasing effect.

In order to analyze potential determinants of cost efficiency, further regression analysis was conducted. The analysis confirmed a significant positive

relationship between bank size and cost efficiency. Evidence showed that the large public sector banks in Egypt tend to be more cost efficient than their private (relatively smaller) counterparts. Finally, both growth and consolidation were found to have a significant positive impact on X-efficiency, where more efficient banks tended to acquire less efficient ones.

The big picture of our empirical results is that "bigger is better," because larger banks tend to be more cost efficient than their smaller competitors. Therefore, Egyptian banks are recommended to continue focusing on growth strategies, supplemented by mergers & acquisitions. However, bank managers and the CBE should continuously monitor the impact of consolidations on bank performance. If banks grow too big, they might suffer diseconomies of scale, or worse, banks might have increased market power in setting interest rates.

Further research should more explicitly address the reasons for this surprisingly good performance of larger public institutions in comparison to the smaller private competitors. Another interesting question is the "wrong" sign of the time trend variable: Is our result only an artifact of the relatively short observation period and the policy reforms during that time? The answer can only be found once a study is done for longer data sets that would allow the modeling of longrun technological effects.

Appendix

Crédit Agricole Egypt

Table 5: Banks included in the sample.

Banque du Caire Banque Misr National Bank of Egypt Ahli United Bank-Egypt Al Watany Bank of Egypt Alexandria Commercial & Maritime Bank Arab African International Bank Audi Bank S.A.E. Bank of Alexandria (BoA) Barclays Bank Egypt S.A.E. Bloom Bank-Egypt BNP Paribas S.A.E. Cairo Barclays Cairo Far East Bank S.A.E Commercial International Bank Egypt S.A.E. Crédit Agricole Indosuez Egypt S.A.E.

Delta International Bank Egyptian Commercial Bank Egyptian Gulf Bank Egyptian Saudi Finance Bank Export Development Bank of Egypt HSBC Bank Egypt S.A.E. Misr America International Bank Misr International Bank Misr Iran Development Bank Misr Romania Bank Mohandes Bank National Bank for Development National Société Générale Bank S.A.E. Nile Bank Piraeus Bank-Egypt Société ArabeInternationale de Banque

Suez Canal Bank

Table 6: Total number of banks in Egypt, 2000-2006.

Year	2000	2001	2002	2003	2004	2005	2006
No. of banks	58	58	57	56	54	45	41

Source: Compiled from several issues of the annual report of the CBE.

Table 7: Mergers and acquisitions.

Bank 1	Bank 2 (acquired or merger with)
CréditLiones Branches	Crédit Agricole Indo Swiss-Egypt
Egyptian American Bank	American Express Bank
Arab African International Bank (AAIB)	Misr America International Bank
National Bank of Egypt (NBE)	Al Mohandes Bank
National Bank of Egypt (NBE)	Bank of Commerce and Development
Banque Misr	Misr Exterior
Arab African International Bank (AAIB)	Misr America International Bank (MAIB)
Piraeus Bank	Egyptian Commercial Bank (ECB)
Sociéte Arabelnternationale de Banque (SAIB)	Port Said National Development Bank
Bloom Bank	Misr Romania Bank
Industrial Development Bank of Egypt	Egyptian Workers Bank
United Bank of Egypt	Nile Bank and Islamic International Bank for
	Investment and Development
Calyon	Egyptian American Bank
National SociétéGénérale Bank	Misr International Bank
Bank Audi	Cairo Far East
Ahli United Bank	Delta International Bank

Table 8: Mean cost efficiency scores of some developing countries.

Author	Country	Sample	Period	Mean efficiency
Kasman (2002)	Turkey	60 commercial banks	1988-1998	0.76
Quayyum and Khan (2007)	Pakistan	29 commercial banks	1998-2005	0.83
Ncube (2009)	South Africa	8 banks	2000-2005	0.92
Samad (2009)	Bangladesh	44 commercial banks	2000	0.70
Sarsour and Daoud (2015)	Palestine	18 commercial banks	2000-2009	0.69

Source: Compiled by the authors.

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