The Egyptian Banking Sector

Assessing Efficiency Using a Stochastic Frontier Cost Function

by

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Abstract
This paper analyzes the cost efficiency of Egyptian banks in a period that witnessed major regulatory and structural changes. Using the full set of Egyptian commercial banks over the period 2000 to 2006, a multi-output cost function is specified and estimated by a stochastic frontier model. The results show that the banks suffer significantly from internal X-inefficiency, where the average distance to the frontier is about 12%. Increasing economies of scale are found to exist up to a bank size of about EGP 30bn ($5bn), implying that all but the four largest banks in Egypt could reduce their average costs by growth. Surprisingly, Egyptian banks did not benefit from technological change, but instead faced a negative dynamics of the cost frontier. Second-stage regressions, conducted to explain the different efficiency levels of the institutions, revealed a positive impact of size, growth, and merger activities on inefficiency. Summarizing, the statement “the bigger, the better” describes pretty well the current status of the Egyptian banking industry, encouraging further growth and consolidation by mergers and acquisitions.

JEL classification
G21, L89, M21

Keywords
Banking, Egypt, translog cost function, panel, X-efficiency, economies of scale, technological change, mergers and acquisitions
1. Introduction

It did not need the global financial crisis of 2008 to know that the banking sector plays a pivotal role in the economic system of countries. Consequently, the continuous assessment of the performance of banks is essential for the soundness of the economy. For Egypt, which has undergone frequent banking system reforms to cope with internal and global challenges, this assessment is even more important than for developed countries. In 2004, the country has 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 state-owned 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.

Five years later, many of the reform goals have been achieved. For example, the government has successfully divested the shares of public banks in 13 joint-venture 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 undergone reforms have certainly changed the face of the country's financial services industry. However, did we go the right direction, and what should be our next steps?

Surprisingly, our knowledge about the technology and efficiency of the Egyptian banking industry is still very modest. Although Egypt is the second largest economy in Africa and one of the oldest financial systems in the Middle East since the 19th century, the number of empirical bank studies is small. As for 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). A more recent study, directly assessing the impact of the Egyptian banking reform 2004 (for details see AmCham 2005 and 2008), was written by Abdel-Baki (2010). Badreldin and Kalhoefer (2009) investigated the effect of mergers on bank performance using financial analysis, finding very heterogenous results of the bank mergers. On the macroeconomic level,
Abu-Bader and Abu-Quarn (2008) find evidence for a bi-directional 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 example of El-Shazly (2011) and the stream of literature for developed countries (for an overview see Amel et al., 2004), attempting to estimate the cost function as well as the efficiency for a panel of Egyptian banks. For the first time, individual bank efficiency scores are estimated. This was conducted using a panel data set that covers 80% of the Egyptian banks over the period 2000 to 2006, therefore including the big banking reform of 2004. Our data set includes a variety of variables that deploys a very flexible approach and goes beyond the scope of the few earlier studies. To be more specific, three inputs and five outputs of 34 commercial banks that were observed over the seven-year-period are used to estimate a stochastic frontier cost function of the translog type.

The research questions addressed are: Do Egyptian banks suffer cost inefficiency? Do banks witness technological progress? Do bigger banks enjoy cost advantages over their smaller counterparts? Is there a relationship between ownership and cost efficiency? Is the merger policy suitable for Egyptian banks? To answer those questions, individual bank efficiency scores are estimated, the existence of economies of scale and the optimal bank size is investigated, the effect of different variables on bank efficiency is analyzed, and the effect of mergers on cost efficiency is estimated. 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, and 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
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. Also, the cost function provides all information necessary to determine economies of scale and technical change. In a second stage, we use information obtained on cost efficiency and conduct several regressions to investigate the influence of several independent factors such as mergers on banks’ cost efficiency.

Based on the pioneering work of Aigner et al. (1977) and Meeusen & Van den Broeck (1977), several empirical approaches assessing the efficiency of firms have been developed. Broadly spoken, they 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 namely the Stochastic Frontier Analysis (SFA), the Thick Frontier Analysis (TFA), and the Distribution Free Approach; while the non-parametric approaches encompass the Data Envelopment Analysis (DEA) and the Free Disposable Hull (Berger and Humphrey, 1997). 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).

Actually, this paper opted for the SFA technique to estimate the aforementioned triad of efficiency concepts. The SFA was considered more adequate for the aim of our research because it is superior to the DEA in that the first technique allows for the separation of random noise from inefficiency. This characteristic of the SFA is a particular advantage in the case of banks.

\footnote{The study uses the terms cost efficiency and X-efficiency interchangeably in line with similar studies (cf. Berger, 1998; Gjirja, 2003).}
where data is usually taken from the balance sheets and profit & loss statements: Because bank managers always enjoy some freedom in the financial assessment of assets, output and input values are subject to discretionary decisions. In Egypt, a developing country, additional measurement errors may occur (Kasman, 2002: 3). 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 which needs 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 price of using more and more flexible forms is a higher number of parameters to be estimated and, consequently, a rich dataset which only rarely is available. For example, the study by Lawrence (1989) rejected both the restrictive Cobb-Douglas specification and the extremely flexible Box-Cox transformation in favor of the translog specification; also, studies by Noulas et al. (1990) and Noulas et al. (1993) show that the Box-Cox transformation redeems instable results. Actually, many studies concur that the translog specification is the most appropriate functional form and well-suited to characterize the banking sector characteristics. Having about 140 observations available, we follow these predecessors and apply the translog functional form.

3. Methodology

3.1 Econometric Specification

Since this study relies on the intermediation approach with multiple outputs, a cost function rather than a production function is used. Inefficiency in cost function considers both allocative (wrong input mix) as well as productive (waste of inputs) inefficiency. The stochastic frontier translog cost function specific for Egyptian banks is specified as follows:
ln \( C_{kt}(w_{kt}, y_{kt}, b_{kt}, t) = a_0 + \sum_{i=1}^{3} b_{im} \ln y_{mkt} \)
\[+ 0.5 \sum_{i=1}^{3} a_{ij} \ln w_{ikt} + \sum_{i=1}^{3} \sum_{m=1}^{5} g_{im} \ln w_{iim} + \sum_{m=1}^{5} \sum_{n=1}^{5} b_{mn} \ln y_{nkt} \ln y_{nkt} \] 
\[+ c_{l}\ln b_{lkt} + 0.5 c_{l}(\ln b_{lkt})^2 + e_{l}t + 0.5 e_{l}t^2 + \sum_{i=1}^{3} f_{i}(\ln w_{iik})t + u_{k} + v_{lt} \] (1)

According to (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). In addition to factor prices, output levels and the number of branch offices, 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 all studies, linear homogeneity in input prices and parameter symmetry is ex-ante imposed into the estimation process:

\[ a_{ij} = a_{ji}, \quad i, j = 1, 2, 3, \quad b_{im} = b_{mn}, \quad m, n = 1, ..., 5, \]
\[ \sum_{i=1}^{3} a_{i} = 1, \quad \sum_{i=1}^{3} f_{i} = 0, \quad \sum_{j=1}^{3} a_{ij} = 0, \quad i = 1, 2, 3, \quad \sum_{i=1}^{3} g_{im} = 0, \quad m = 1, ..., 5. \] (2)

The inefficiency term \( u_{k} \) captures both technical and allocative inefficiency, where \( u_{k} \) is assumed to follow a half-normal distribution\(^2\) as follows: \( u \sim iidN^+(0, \sigma_u^2) \). Finally, to account for measurement errors and cost determinants beyond the control of management, a random term \( v_{lt} \) is added. This random term is the usual residual in econometric studies and follows the standard normal distribution \( v \sim iidN(0, \sigma_v^2) \). The sum over \( u_{k} \) and \( v_{lt} \) is the aggregate residual \( \epsilon_{kt} \) with a positive, i.e. a non-zero, expected value.

\(^2\) 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).
Following Battese and Coelli (1992), the log-likelihood function for the stochastic frontier cost function as given in equation (1) and an unbalanced panel data set can be expressed as follows:

\[
\ln L(\beta, \sigma^2, \gamma) = -\frac{1}{2} \left[ \sum_{k=1}^{K} T_k \ln (2\pi) + \ln (\sigma^2) \right] - \frac{1}{2} \sum_{k=1}^{K} (T_k - 1) \ln (1 - \gamma) \\
- \frac{1}{2} \sum_{k=1}^{K} \ln (1 - \gamma T_k) - K \ln \left( \frac{1}{2} \right) \sum_{k=1}^{K} \ln \left( -\gamma \sum_{t=1}^{T_k} \varepsilon_{kt} \right) \sqrt{\gamma (1 - \gamma) \sigma^2 [1 + (T_k - 1) \gamma]} \\
+ \frac{1}{2} \sum_{k=1}^{K} \left( -\gamma \sum_{t=1}^{T_k} \varepsilon_{kt} \right)^2 \left( \frac{1}{\sqrt{\gamma (1 - \gamma) \sigma^2 [1 + (T_k - 1) \gamma]} \right) \\
- \frac{1}{2} \sum_{k=1}^{K} \varepsilon_{kT} \varepsilon_{kT} \\
(3)
\]

In contrast to Battese and Coelli (1992) who allowed for a common trend in the level of inefficiency, the inefficiency term as defined by the log-likelihood function (3) is assumed to be time invariant. This reduction in the flexibility was necessary to stabilize the estimation process. Actually, the number of observations in our study turned out to be not large enough to introduce dynamic efficiency. There is also a theoretical argument supporting time-invariant efficiency, however: Firm inefficiency is a structural problem of the institutions which will not be solved in the short run. Shifting the own position relative to the frontier is perhaps not abrupt, but requires a long run re-organization.

In equation (3), the variance of the joint residual term \( \varepsilon_{kt} = \mu_k + \nu_{kt} \) is defined as \( \sigma^2 = \sigma_{\nu}^2 + \sigma_{\mu}^2 \), where the gamma parameter represents the share of the inefficiency variance relative to the total variance: \( \gamma = \sigma_{\mu}^2 / \sigma^2 \). Thus, if \( \gamma = 0 \), deviations from the frontier are entirely due to noise; while in the case of \( \gamma = 1 \), deviations from the frontier are entirely due to inefficiency.

Note that estimating \( \sigma^2 \) and \( \gamma \) is sufficient to determine \( \sigma_{\nu}^2 = \gamma \cdot \sigma^2 \) and, subsequently, \( \sigma_{\mu}^2 = \sigma^2 - \sigma_{\nu}^2 \). Finally, \( T_k \) is the number of observations for bank \( k \) which might be smaller than \( T \) because of the unbalanced nature of the panel, and \( \Phi(\cdot) \) denotes the cumulative distribution function of the standard normal distribution.
3.2 Cost Efficiency, Economies of Scale, and Technical Change

The maximum likelihood estimation of (1) generates estimates of all parameters of the frontier cost function, as well as $\sigma^2$ and $\gamma$. Subsequently, the aggregate residuals $\varepsilon_{kt}$ can be obtained by substituting the estimated parameters in the translog cost function. Battese and Coelli (1992) have shown that the inefficiency term $u_k$ and the scaled efficiency measure $X_{EFF_k}$ can be determined from the results by the following transformations:

$$X - EFF_k = \frac{\hat{C}_{k,\text{frontier}}}{C_k} = \frac{\exp^{(\ln \hat{C}_{k,\text{frontier}} + u_k)}}{\exp^{(\ln C_k + u_k)}} = e^{-\mu_k} = \frac{\Phi(\mu_k / \sigma_k)}{\Phi(\mu_k / \sigma_k)} e^{-\frac{\mu_k^2}{2\sigma_k^2}},$$

where

$$\mu_k = \frac{-\sigma_u^2 \sum_{i=1}^{T} \varepsilon_{ki}}{\sigma_v^2 + T \sigma_u^2} \quad \text{and} \quad \sigma_k^2 = \frac{\sigma_v^2 \sigma_u^2}{\sigma_v^2 + T \sigma_u^2}.$$ (4)

In (4), $\Phi(\ )$ denotes the cumulative distribution function of the standard normal distribution. As shown in (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 $X_{EFF}$ specific for each bank $k$ 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 percent efficient; thus this bank could reduce its costs by 20 percent (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. It is the result of a structural organization problem, i.e. management failure. $X_{EFF_k}$ is scaled to the interval between zero and one.

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 $C$ with respect to all outputs:

$$RSCE_{kr} = \sum_{m=1}^{5} \frac{\partial \ln C}{\partial \ln y_m} = \sum_{m=1}^{5} b_m + \sum_{i=1}^{3} \sum_{m=1}^{5} g_{im} \ln w_{ik} + \sum_{m=1}^{5} \sum_{n=1}^{5} b_{mn} \ln y_{nk}$$

(5)

Values of RSCE of less than one imply cost increases are less than proportionate to output increases. They are often called 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 merger/acquisition 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 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. Aggregate firm-specific technical change $\eta_{kt}$ is calculated as the elasticity of total cost with respect to time:

$$\eta_{kt} = \frac{\partial \ln C}{\partial t} = \epsilon_t + \epsilon_t t + \sum_{i=1}^{3} f_i \ln w_{ik}$$

(6)

Technological progress implies decreasing costs over time, all else given, that is when $\eta_{kt}$ is negative (Kasman, 2002: 12), while there is technological recess if $\eta_{kt}$ 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 Second Stage Regression Analysis

Once the efficiency estimations are generated for the dataset, the question for the reasons of inefficiency and its dispersion among the firms appears. As the literature shows, many other
studies (see, e.g., Berger and Mester, 1997; Harker and Zenios, 2000:110; Ncube, 2009:12; Pilloff and Santemoro, 1998; Wheelock and Wilson, 1995) have also investigated the reasons why financial firms suffer from inefficiency, and why the degree of inefficiency is typically very different. These studies often cite bank size, management structure, ownership, and structural changes such as mergers as the most influential factors.

We follow the cited articles by running a number of second-stage OLS regressions, explaining the estimated inefficiency values by potential factors which can be grouped into bank size variables, bank growth, ownership, and merger activity. As for bank size variables, the analysis was conducted using the full unbalanced panel of 147 observations for the 34 banks over the years 2001 until 2006. 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.
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Table 1: Second-Stage Regressions to Explain Inefficiency

<table>
<thead>
<tr>
<th>explained variable</th>
<th>explaining variable</th>
<th>controlling for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\ln TA$</td>
<td>bank size</td>
</tr>
<tr>
<td></td>
<td>(total assets)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\ln empl$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(employees)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\ln br$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(no. of branches)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$RSCE$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(measure of economies of scale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$growth$</td>
<td>bank growth</td>
</tr>
<tr>
<td></td>
<td>(average growth rate of TA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$own$</td>
<td>ownership</td>
</tr>
<tr>
<td></td>
<td>(ownership dummy: public vs. private)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$Merg$</td>
<td>External growth by mergers or acquisitions</td>
</tr>
</tbody>
</table>

All regressions also included a constant term.

In addition, to investigate the relation between efficiency and bank growth, where year over year (YOY) change in banks total assets was used as an indicator of the previous variable, an OLS cross-section estimation was conducted for the 34 banks over the period (2001-2006) regressing average bank efficiency over average growth in total assets ($growth$). High growth rates are a challenge for each management and could therefore be accompanied by lower efficiency values of these banks.

To analyze the role of ownership, we differentiate between private and state-owned banks. A dummy variable 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 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.

Table 1 provides an overview to these second-stage regressions. Also, several hierarchal regressions were conducted to investigate the relation between efficiency and multiple variables such as regressing efficiency on TA, ownership, and mergers. All the hierarchal regressions confirmed the results obtained from simple regressions and are therefore not shown in chapter 4 providing the empirical results.

4. Description of the Data

The quantitative analysis of the efficiency of the Egyptian banks was conducted using the full set of Egyptian commercial banks (listed in Table A-1) for the period 2000-2006. According to the CBE (2008), there were 41 banks active in Egypt, but the not-considered banks are either branches of foreign banks or public specialized banks, i.e. technology outliers which are not are barely representative for Egypt’s banking industry. To be more specific, our data includes all public sector commercial banks namely the four banks: Banque Misr (BM), Banque du Caire (BC), National Bank of Egypt (NBE), and Bank of Alexandria (BoA). The remaining 30 banks are private & joint-venture commercial banks. The commercial banks are of special interest because: (i) they constitute the majority of the banks registered with the Central Bank of Egypt (CBE); (ii) they were involved heavily in the merger activities that have been intense (see Table A-2). Summarizing, our data allowed for the construction of an unbalanced panel data set consisting of 147 observations used for estimating the cost frontier in equation (1).

The measurement of output and productivity is not straight forward for a bank due to the multi-output, intangible nature of banks products, and the difficulty to account for the quality of bank services (Heffernan, 2005: 473). Consequently, to overcome this definitional problem authors

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3 Source for the data variables is Kompass Egypt, several issues 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.

4 The number of observation in the balanced panel data were 238 but due to consolidation and closure activities that the banks had undergone an unbalanced panel was constructed.
adopt either the production or the intermediation approach (for a discussion see Berger and Humphrey, 1992; Mlima and Hjalmarrson, 2002:13; Sealey and Lindley, 1977). Given that the main concern of this paper is the efficiency of the banking industry in view that banks are financial intermediaries, we follow the majority of the literature and use the “intermediation approach”.

Table 2 describes our data set. Five outputs are defined as follows: $y_1$ loans to banks, $y_2$ loans to non-banks, $y_3$ T-bills and government bonds, $y_4$ fees and commissions, and $y_5$ a residual output calculated as total assets less the four previously mentioned outputs. 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, total assets, and input prices.

The dependent variable of the cost function, total costs $C$, is defined as the aggregate of administration expenses, provisions, and interest paid. Accordingly, inputs are defined as labor, capital, and deposits. We use the annual average number of employees, the values of equity, and the volume of deposits from non-banks as input quantities $x_i$, $i=1,\ldots,3$. Factor prices $w_i$, $i=1,\ldots,3$ that correspond to the three inputs are measured as follows: The price of labor is measured as administration and general expenses divided over the number of employees. The price of capital, generated as the ratio of interest earned from loans to the volume of loans, reflects the forgone interest in the use of equity (opportunity costs). The price of deposits is calculated in a straightforward way by dividing interest paid through volume of deposits.
Table 2: Statistical Description of the Data for 2003

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean Value</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Total cost (million EGP)</td>
<td>922.7</td>
<td>1772</td>
<td>38.8</td>
<td>8379.5</td>
</tr>
<tr>
<td>y₁</td>
<td>Output 1: loans to bank (million EGP)</td>
<td>3035</td>
<td>5275</td>
<td>122</td>
<td>24799</td>
</tr>
<tr>
<td>y₂</td>
<td>Output 2: loans to non-banks (million EGP)</td>
<td>5092</td>
<td>9785</td>
<td>144</td>
<td>48987</td>
</tr>
<tr>
<td>y₃</td>
<td>Output 3: T-Bills and T-Bonds (million EGP)</td>
<td>1386</td>
<td>3374</td>
<td>9.4</td>
<td>17362</td>
</tr>
<tr>
<td>y₄</td>
<td>Output 4: fees and commissions (million EGP)</td>
<td>123</td>
<td>220</td>
<td>5</td>
<td>1019</td>
</tr>
<tr>
<td>y₅</td>
<td>Output 5: residual [= total assets- (Y₁+Y₂+Y₃+Y₄)] (million EGP)</td>
<td>1675</td>
<td>3785</td>
<td>23</td>
<td>16636</td>
</tr>
<tr>
<td>x₁</td>
<td>Input 1: labor (number of employees)</td>
<td>1898.6</td>
<td>3380</td>
<td>168</td>
<td>13000</td>
</tr>
<tr>
<td>x₂</td>
<td>Input 2: capital (million EGP)</td>
<td>776.5</td>
<td>1234.8</td>
<td>76.6</td>
<td>632.6</td>
</tr>
<tr>
<td>x₃</td>
<td>Input 3: deposits (million EGP)</td>
<td>10378</td>
<td>20070</td>
<td>315</td>
<td>92572</td>
</tr>
<tr>
<td>w₁</td>
<td>Price of labor (thousand EGP/employee)</td>
<td>89.4</td>
<td>50.2</td>
<td>16.6</td>
<td>197.2</td>
</tr>
<tr>
<td>w₂</td>
<td>Price of capital</td>
<td>0.06</td>
<td>0.02</td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>w₃</td>
<td>Price of deposits</td>
<td>0.06</td>
<td>0.02</td>
<td>0.01</td>
<td>0.15</td>
</tr>
<tr>
<td>br</td>
<td>Number of branch offices</td>
<td>51.1</td>
<td>101.7</td>
<td>4</td>
<td>450</td>
</tr>
<tr>
<td>TA</td>
<td>Total assets (million EGP)</td>
<td>13007.2</td>
<td>25310</td>
<td>453.9</td>
<td>123000</td>
</tr>
</tbody>
</table>

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

This section presents our estimations of the cost frontier as shown in (1), generated by numerically maximizing the log-likelihood function (3). We used Gauss Version 7 for all estimations and the calculations of $X-EFF$, $RSCE$, and $\eta$. Table A-3, which provides the parameter estimates, their standard errors and their significance, shows that most parameters are statistically significant. The use of a stochastic frontier is clearly supported by highly significant $\sigma^2$- and $\gamma$- parameters, rejecting the hypothesis that only random error occurs. Following Greene (2003), the contribution of the variance $u$ to that of the composite error term $\varepsilon$ is $\left[\left(\pi/2\right)^{-1}\right] \frac{\sigma_u^2}{\left[\left(\pi/2\right)^{-1}\right] \sigma_u^2 + \sigma_\varepsilon^2}$, implying a 82% share of inefficiency for the residual variance. A likelihood ratio tests rejected the null-hypothesis of a constant-economies-of-scale technology in the Egyptian banking industry.

![Figure 1: Bank Specific Cost Efficiency Scores](image)

As in most studies about banking efficiency, the degree of cost inefficiency turned out to be economically relevant, too: The mean cost efficiency of all Egyptian banks was estimated at 88.2%, implying an average cost reduction potential of 12%. Note that these cost savings could be realized with the given technology, outputs, input prices, and the current network of branches.
Our estimations for the bank-specific X-efficiency parameters 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 when it would operate on the frontier, while the most efficient bank (National Bank of Egypt, NBE) 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. Figure 1 shows the estimated X-efficiency values for all banks in the dataset.

In a next step, the question for the optimal bank size was analyzed by determining the cost-output elasticity (RSCE), a measure for economies of scale. Our results show 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 by only 0.87%, what, in turn, will decrease average costs. Table A-4, which shows the empirical results broken down to the single institutions, 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 dataset. 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. 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 a RSCE value of 0.77.

As a conclusion of these results, the majority of the Egyptian banks should operate at a larger or at a much larger scale. For many Egyptian banks, the advantage of growth is even more significant as – 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 EGP 30bn, which is equivalent to $5bn.

In Table A-4, we also present the results for technological change which is captured by the trend term in the cost function. All relevant parameter, 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 bank-specific interval ranges from 0.04 to 0.11. Whereas such a result would very surprising for developed countries, it is not unusual for developing countries (see, e.g. 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 adopt 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). In the long-run, i.e. when talking about decades and not seven years which is our panel length, the results should probably redeem technological progress, however.

In Table 4 we finally present results about the relationship between cost efficiency and potential explanatory variables. First, we conducted several regressions on some bank size variables, all of them turning out to be significant, and all of them rejecting our initial expectations: According to our estimates, 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, so far at least, cannot benefit from their advantage of higher flexibility and lower information costs of smaller institutions. Therefore, the cost-disadvantage of small banks for operating far below the optimal scale is multiplied, not diminished, by not operating very efficient.
Table 4: Second-Stage Regressions to Explain Inefficiency

<table>
<thead>
<tr>
<th>inefficiency explained by …</th>
<th>parameter estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(intercept)</td>
</tr>
<tr>
<td>bank size</td>
<td>-0.387</td>
</tr>
<tr>
<td></td>
<td>(0.0991) **</td>
</tr>
<tr>
<td></td>
<td>-0.251</td>
</tr>
<tr>
<td></td>
<td>(0.0516) ***</td>
</tr>
<tr>
<td></td>
<td>-0.2122</td>
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<tr>
<td></td>
<td>(0.0214) ***</td>
</tr>
<tr>
<td></td>
<td>0.7600</td>
</tr>
<tr>
<td></td>
<td>(0.0687) ***</td>
</tr>
<tr>
<td>bank growth</td>
<td>0.8682</td>
</tr>
<tr>
<td></td>
<td>(0.0174) ***</td>
</tr>
<tr>
<td>ownership</td>
<td>0.9323</td>
</tr>
<tr>
<td></td>
<td>(0.0197) ***</td>
</tr>
<tr>
<td>external growth by</td>
<td>0.8471</td>
</tr>
<tr>
<td>mergers or acquisitions</td>
<td>(0.0093) ***</td>
</tr>
</tbody>
</table>

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

Similarly to the surprising result about size and efficiency, all other regressions to explain cost efficiency also showed results which do not follow conventional wisdom. To be more specific, faster growing banks turned out to be more efficient than banks with a low growth rate. Bank mergers have a positive impact on the efficiency score, not a negative one, where mergers trigger a jump of 0.074 closer to the frontier. Finally, ownership matters, too, but public sector banks are closer at the frontier than private sector 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 et al. (2007), higher cost efficiency scores of public banks relative to private banks are due to a higher willingness of public banks to incur higher costs in return for better quality and higher revenues. Actually, our results as well as the latter argument is in line with El-Shazly
(2011) and Poshakwale and Qian (2011), who also find state-owned banks more cost and profit efficient than their private counterparts.

The paper also found that mergers have a positive impact on banks’ efficiency. It is worth mentioning that a study conducted by Badreldin and Kalhoefer (2009) investigated the effect of mergers on bank performance from a financial perspective which concluded mixed results concerning the merger effect. It was 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 2. This finding is consistent with the majority of the findings about the acquiring bank efficiency in the literature. However, we do not believe that efficiency differences are a motive for the merger process. More probably, non-performing loans, avoiding insolvency, and conforming to higher minimum capital requirements of the Central Bank of Egypt are the main reasons for the consolidation process.

6. Conclusion

In the past few years and especially with the initiation of the Financial Sector Reform Program (FSRP) in 2004, the banking sector in Egypt has witnessed dramatic developments that changed the landscape of this industry. Using an unbalanced panel of all commercial banks in Egypt over
the period 2000 to 2006, this study attempted to gauge efficiency and other core characteristics of the banking sector in Egypt. To not predetermine the results, we use a flexible approach based upon a multi-output translog cost function and a stochastic frontier panel estimator. The empirical results of this setup provided detailed insights into the Egyptian banking sector and were – to some degree – unexpected and surprising.

Addressing the question of X-efficiency, our results are very similar to what has been found for many other countries: Cost inefficiency turned out to be statistically and economically significant. On average, commercial banks in Egypt could reduce their costs by approximately 12% without decreasing input prices, reducing output levels, or trimming their branching network. The large public sector banks in Egypt tend to be more cost efficient than their private (relatively smaller) counterparts. This could be attributed to the fact that public banks dominate more market shares over their smaller private counter parts; or private sector banks tend to be more willing to incur higher costs on financial intermediation to provide superior services in return for higher revenues and profits. We also found strong evidence for economies of scale for the majority of banks. The optimal bank size is estimated to be at about EGP 30bn to 35bn, which is – using the exchange rate of 2011 – equivalent to roughly $ 5bn. The time trend, often interpreted as technological change, was actually found to have a cost-increasing, not cost-decreasing, effect. However, it should be kept in mind that banks in developing countries have to adapt to modern information technologies and tougher public regulation.

To closer analyze the bank-specific X-efficiency parameters, second-stage regressions were conducted to explain the differences among Egyptian banks. The analysis confirmed the above result of a significant positive relationship between bank size and cost efficiency, whether size is measured by total assets, the number of employees, the size of the branching network, or by RSCE. The positive role of public ownership for cost efficiency was also statistically confirmed. Finally, growth as well as mergers and acquisitions were found to have a significant positive impact on X-efficiency, where more efficient banks tend to acquire less efficient ones.

Summarizing, the big picture of our empirical results is “bigger is better”. Therefore, Egyptian banks should continue to focus on growth strategies, supplemented by mergers & acquisitions. Because larger banks tend to be more cost efficient than their smaller competitors, an important
side-effect of growth is a higher degree of cost efficiency. Further research should more explicitly address the reasons for this surprisingly good performance of larger institutions. Another interesting question is the “wrong” sign of the trend variable: Is our result only an artifact of the relatively short observation period and the policy reforms during that time, or would a longer dataset resemble our surprising result?

References


AmCham (2005), Banking Sector Developments in Egypt, AmCham Egypt, Business Studies and Analysis Center.

AmCham (2008), Banking Sector Developments in Egypt, AmCham Egypt, Business Studies and Analysis Center.


Heffernan, S. (2005), Modern Banking, John Wiley and Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, UK.


Kompass Egypt, several issues (2000-Financial Year Book, Fiani and Partners.


Appendix

Table A-1: Banks included in the Sample

<table>
<thead>
<tr>
<th>Bank 1</th>
<th>Bank 2 (acquired or merger with)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banque du Caire</td>
<td>Delta International Bank</td>
</tr>
<tr>
<td>Banque Misr</td>
<td>Egyptian Commercial Bank</td>
</tr>
<tr>
<td>National Bank of Egypt</td>
<td>Egyptian Gulf Bank</td>
</tr>
<tr>
<td>Ahli United Bank-Egypt</td>
<td>Egyptian Saudi Finance Bank</td>
</tr>
<tr>
<td>Al Watany Bank of Egypt</td>
<td>Export Development Bank of Egypt</td>
</tr>
<tr>
<td>Alexandria Commercial &amp; Maritime Bank</td>
<td>HSBC Bank Egypt S.A.E.</td>
</tr>
<tr>
<td>Arab African International Bank</td>
<td>Misr America International Bank</td>
</tr>
<tr>
<td>Audi Bank S.A.E.</td>
<td>Misr International Bank</td>
</tr>
<tr>
<td>Bank of Alexandria (BoA)</td>
<td>Misr Iran Development Bank</td>
</tr>
<tr>
<td>Barclays Bank Egypt S.A.E.</td>
<td>Misr Romania Bank</td>
</tr>
<tr>
<td>Bloom Bank-Egypt</td>
<td>Mohandes Bank</td>
</tr>
<tr>
<td>BNP Paribas S.A.E.</td>
<td>National Bank for Development</td>
</tr>
<tr>
<td>Cairo Barclays</td>
<td>National Société Générale Bank S.A.E.</td>
</tr>
<tr>
<td>Cairo Far East Bank S.A.E.</td>
<td>Nile Bank</td>
</tr>
<tr>
<td>Commercial International Bank Egypt S.A.E.</td>
<td>Piraues Bank-Egypt</td>
</tr>
<tr>
<td>Crédit Agricole Indo Suez Egypt S.A.E.</td>
<td>Société Arabe Internationale de Banque</td>
</tr>
<tr>
<td>Crédit Agricole Egypt</td>
<td>Suez Canal Bank</td>
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Table A-2: Mergers and Acquisitions

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<td>American Express Bank</td>
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<td>Arab African International Bank (AAIB)</td>
<td>Misr America International Bank</td>
</tr>
<tr>
<td>National Bank of Egypt (NBE)</td>
<td>Al Mohandes Bank</td>
</tr>
<tr>
<td>National Bank of Egypt (NBE)</td>
<td>Bank of Commerce and Development</td>
</tr>
<tr>
<td>Banque Misr</td>
<td>Misr Exterior</td>
</tr>
<tr>
<td>Arab African International Bank (AAIB)</td>
<td>Misr America International Bank (MAIB)</td>
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<tr>
<td>Piraeus Bank</td>
<td>Egyptian Commercial Bank</td>
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<tr>
<td>Société Arabe Internationale de Banque(SAIB)</td>
<td>Port Said National Development Bank</td>
</tr>
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<td>Bloom Bank</td>
<td>Misr Romania Bank</td>
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<td>Industrial Development Bank of Egypt</td>
<td>Egyptian Workers Bank</td>
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<td>United Bank of Egypt</td>
<td>Nile Bank and Islamic International Bank for Investment and Development</td>
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<td>Calyon</td>
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<td>National Société Générale Bank</td>
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<td>Bank Audi</td>
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<tr>
<td>Ahli United Bank</td>
<td>Delta International Bank</td>
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Table A-3: Maximum Likelihood Estimates for the Parameters of the Cost Function

<table>
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<th>parameter symbol</th>
<th>parameter</th>
<th>std. error</th>
<th>t-ratio</th>
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<td>constant</td>
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<td>2.0130</td>
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<td>$\ln y_1$</td>
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<td>------------------</td>
<td>-----------</td>
<td>------------</td>
<td>---------</td>
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<tr>
<td>ln y₂ × ln y₅</td>
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<td>ln y₄ × ln y₄</td>
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<td>ln y₄ × ln y₅</td>
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<td>ln y₄ × ln y₆</td>
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<td>0.5 × (ln br)²</td>
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<tr>
<td>0.5 × t²</td>
<td>e₁</td>
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<td>0.0039</td>
<td>1.9895</td>
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<td>ln w₁ × t</td>
<td>f₁</td>
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<td>f₂</td>
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*, ** and *** represent a significance level of 10%, 5% and 1%, respectively (two-sided). All calculations were run by GAUSS.
Table A-4: Cost Efficiency, Ray Scale Economies, and Technological Change

<table>
<thead>
<tr>
<th>Bank Name</th>
<th>X-Efficiency</th>
<th>Mean RSCE</th>
<th>Technical Change</th>
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<td>National Bank of Egypt</td>
<td>0.9978</td>
<td>1.1040</td>
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<td>0.0931</td>
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<tr>
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