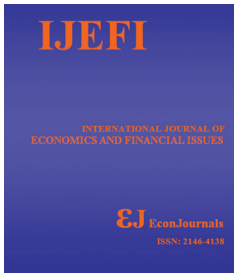

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Cost Efficiency of the Egyptian Banking Sector: A Panel Data Analysis

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ABSTRACT

Based on a two stage method this paper investigates the determinants of the cost efficiency (CE) of Egyptian banking sector. Employing data envelopment analysis (DEA). We compare the CE of large, medium and small banks and the CE of foreign and domestic banks using a balanced panel which cover 14 banks operating in Egypt from 1997 to 2013. In the first stage, CE scores are computed using an input-oriented DEA. At the second stage, CE scores are regressed on a set of potential explanatory variables in a logit model. While the CE scores show large improvements in the early and third phases of financial deregulation. Over the entire sample period, CE has declined at the rate of 0.963% per annum. Our finding indicates that age, loan to net interest margin, return on equity and good management practices positively affects banks CE and number of bank branches negatively affects bank CE.

Keywords: Cost Efficiency, Two-stage Data Envelopment Analysis, Egyptian Banks
JEL Classifications: D22, D24, D61, G21

1. INTRODUCTION

Measuring banks' performance have recently received great attention especially after the banking and financial crisis which started in 2007. Two basic questions in banking are whether banks outperform or underperform their benchmarks and whether superior performance persists? With the Egyptian economy's slowdown, bank efficiency has become a concern for policymakers and Egyptian banks have had to find creative ways to optimize their cost structures. There is a large body of literature dealing with the measurement of banking efficiency in the developed economies, but studies on banking efficiency relating to Middle Eastern economies are few. Up to our knowledge, there is a no research related directly to the cost efficiency (CE) of banks in Egypt. One of the reasons for the lack of this research is that most Middle Eastern countries including Egypt did not introduce financial and banking sector reforms until the 1990s. Until then, financial systems tended to be heavily regulated and dominated by the public sector (United Nations, 2005). However, over the past two decades, the majority of Middle East countries have gradually moved towards more liberalized financial systems. This has created interest among policy makers, managers and economists in assessing the efficiency performance of banks in Middle Eastern countries over time. In specific, the banking efficiency is essential for the survival of banks in Egypt as the Egyptian government accrue unprecedented outstanding loans during the last few decades. However, the ultimate ramifications of the high, yet debt-backed growth were uncontrollable inflation and enormous outstanding debts.

Evaluating CE of banks is significant for many reasons. First, to investigate weather banks are successful in their field of both individual banks and banking industry as a whole. Second, efficiency is considered to be a vital factor for financial institutions wishing to maintain and monitor their business successfully, given the increasing global competition in financial markets. Third, in a rapidly changing and more globalized financial marketplace, governments, regulators, managers and investors are concerned about how efficiently banks transform their expensive inputs into various financial products and services. Finally, it may be noted that efficiency measures are critical aspects of banking industry that enable us to distinguish

banks that will survive and prosper from those that will fail and have problems with competitiveness. The efficiency of banks and other financial institutions is assessed based on summary measures which are technical in nature. These measures are quite crucial to understand and compare the efficiency estimates of banks of different sizes and over time.

The aim of this research is to fill the gap to the existing literature on banking efficiency in Egypt. The era of our sample is very rich with many aspects that influenced the Egyptian banking system, starting with 2003 when the Egyptian government decided to fully liberalize the currency exchange rate where the rate is set according to the market forces. The Egyptian government believed that floating the Egyptian pound against the US dollar will help the economy to be more competitive. In 2004, the Central Bank of Egypt (CBE) started a new program to restructure the banking sector and deal with non-performing loans by encouraging a wave of mergers and acquisitions which enabled large and strong banks to acquire many small banks. The number of banks decreased from 65 banks in 1997 to only 39 banks in 2013. However, the global financial crises and the Egyptian Revolution in 2011 brought about great changes in practices of Egyptian banks from 2009 to 2013. This research will provide a new perspective to the field of banking efficiency in Egypt.

The primary objective of this research is to undertake in-depth evaluation and examination the CE of banks operating in Egypt for a balanced panel which covers 14 banks operating in Egypt (3 large, 5 medium, 3 small and 3 foreign) for the period 1997-2013, by estimating a non-parametric approach data envelopment analysis (DEA). The study compares the CE levels between the foreign banks and domestic banks, between large banks, medium and small banks during the sample period. The empirical results are obtained by running an input-oriented DEA model using the software package, DEAP Version 2.1 (Coelli, 1996).

The paper is organized as follows. Section 2 provide overview on the financial reforms and banking sector in Egypt. Section 3 provide a review of literature on the Egyptian banking efficiency. The concept of CE and its estimation based on DEA approach discusses providing the DEA results in Section 4. Section 5 provide the data as well as input and output variables. Determinants of banks efficiency and the related estimation results are presented in Section 5. Section 6 presents some conclusions.

2. FINANCIAL REFORMS AND BANKING SECTOR IN EGYPT

The Egyptian banking industry has important achievements at the local and global levels in the last two decades. It played a great role in developing the Egyptian economy through the activation of financial system, providing funds for mega projects in infrastructure and social services and inventing new services and products to move surpluses to sectors which has deficits. The Egyptian economy has changed greatly in the last two decades. The Egyptian government has altered its attitude towards a fully market-oriented economy. The government embarked upon a major program of economic reform that stimulated banking industry. This new program aimed generally at expanding the private sector's ownership base, integrating into the global economy, and accelerating the pace of privatization of the public sector (Central Bank of Egypt, 1996). Consequently, the government issued Public Enterprise Companies Law No. 203/1991 to facilitate the implementation of the privatization program. Additionally, in 1992, the government developed the legislations and legal regulations of the Egyptian Stock Exchanges through the passage of capital market law No.95/1992. In specific, this program designed with help of International Monetary Fund and the World Bank to decrease the government's role in the financial sector, to encourage private sector investments, to introduce market-oriented banking mechanisms, to promote foreign direct investment in Egypt and to enhance competition in the banking sector. However, there was a weak economic growth as a consequence of several economic and political shocks.

Consequently, several banking laws had been relaxed which was the first step to be taken by the Egyptian government to remove many barriers toward market-oriented mechanisms. For example, interest rate ceilings have been removed, public companies permitted to deal with private and foreign banks and restrictions on banking fees and commissions have been eradicated. These new laws enabled both foreign and private banks to operate in parallel with public banks. It also obliged state-owned banks to face sever outside competition and to improve the quality of their credit. In 1996, the government issued new laws that permit 100% foreign ownership of banks and allow banks to do business in both foreign and local currencies (Central Bank of Egypt, 2001). These new laws enabled both private and foreign banks to operate in a competitive environment. In 2003, the CBE started its comprehensive reform plan to promote the banking sector by consolidating and enhancing the overbanked and under-branched banking sector. The government seeks to enhance banking competition, diminish nonperforming loans, raise capital adequacy and ensure devotion to prudential regulations through specific banking restructuring programs (Reda, 2013). As a result, A non-performing loans (NPL) monitoring unit was established by the CBE in 2004 to restructure the state owned banks, consolidate banking systems through mergers and acquisitions of small and weak banks, privatize some state-owned banks, divest public sector shares in joint venture banks, resolve non-performing loans and strengthen the supervisory authority of the CBE (Central Bank of Egypt, 2010). The CBE required the big four public banks which own more than 50% of the banking sector' assets to sell their stakes in joint-venture banks and to raise paid up capital requirements to a minimum of USD 50 million for branches of foreign banks (Central Bank of Egypt, 2005). It also refrained from issuing new banking licenses which effectively direct foreign banks to form a partnership with a local bank. This program helped the Egyptian banks to comply with the guidelines of Basel Accord II (Central Bank of Egypt, 2010). Moreover, the government started to privatize state-owned banks to decrease the oligopolistic appearance of these banks, to prevent further market fragmentation and to improve know-how through the participation of foreign banks. As a result, the number of banks operating in Egypt plunged from 65 in 2003 to 40 in 2014 (Central Bank of Egypt, 2014).

3. A REVIEW OF LITERATURE ON THE EGYPTIAN BANKING EFFICIENCY

The last few decades have witnessed an ever-growing volume of various studies in the field banking efficiency worldwide. However, this study is by no means the first to focus on the CE of the Egyptian banking sector. There have been a number of papers concerned with the CE in developed and developing countries. Ferrier and Lovell (1990) apply parametric stochastic frontier analysis (SFA) and non-parametric DEA on a sample of 575 US banks to estimate CE. Their results suggest both similarities and differences between the approaches. Both techniques broadly agree on the average value of CE: 74% with SFA and 79% with DEA. However, they observe a very different decomposition of cost inefficiencies between technical and allocative inefficiencies: Technical inefficiencies dominate with DEA, while allocative inefficiencies are stronger with SFA. Gulati (2015) investigates the trends of CE of Indian banking sector in response to financial deregulations in the beginning of 1990s. Gulati finds that deregulation programme affected positively on CE and the increase of cost was due to improvements in technical efficiency. He also finds that public and foreign banks are better than private banks. He concluded that the size of banks and off-balance sheet activities are the key drivers of CE. Jaffry et al. (2012) examine the trends in the efficiency levels of Indian and Pakistani commercial banks from 1985 to 2003 after a significant change in regulations in both countries. They find that the efficiency levels has decreased post reform period and then increased gradually. They concluded that banks need a period of initial adjustment after regulations followed by a subsequent correction period. In addition, Chen et al. (2004) examined the cost, technical and allocative efficiency (AE) of 43 Chinese banks covering the deregulation era from 1993 till 2000 by running input oriented DEA approach. They employed the intermediation approach for choosing three inputs prices (price of labor, price of deposits and price of capital) with three outputs (loans, deposits and non-interest income). The study investigated the change in the efficiency of Chinese banks' after the initiation of a program of deregulation in 1995. It was found that large state-owned banks and smaller banks were more efficient than medium sized Chinese banks. Moreover, Chinese banks during the financial deregulation of 1995 were recorded improvement in CE levels including both technical and AE. Hassan et al. (2004) investigated efficiency of the banking sector in Bahrain based on data for a panel of 31 banks in 1998 and 2000. Their study estimated allocative and technical efficiencies, scale efficiency and overall CE. The model used three inputs, namely, labor, capital, and loanable funds and two outputs, namely, short term loan and long term loans. The input prices were: Price of labor, price of capital, and interest rate on loanable funds. Their result indicated that the average AE was about 73%, whereas the average technical efficiency was about 56%. Recently, Jreisat et al. (2015) examined the CE levels of Jordanian banks during the reform period from 1996 to 2007. They suggest that both the domestic and foreign banks have shown slight improvements over the years of deregulation era and this led to improvement in the efficiency of the Jordanian banking sector. They also investigated whether ownership structure, size, number of branches and ATM, bad loan and age of the bank significantly affect the CE levels of Jordanian banks. Interestingly, their finding on the effect of number of ATM on the CE is a statistically significant with positive impact on CE in Jordanian banks. In addition, the results reveal that the relationship between bad loan (credit risk) and CE seems to be very strong, in which bad loan is significantly negatively related to CE. AlKhathlan and Malik (2010) investigated both technical and scale efficiencies of Saudi commercial Banks for the period, 2003-2008. Their sample covered ten out of twelve commercial banks. They employed the DEA intermediation approach. The result indicated that the majority of Saudi banks operated at higher levels of efficiency and managed their financial resources adequately.

Jreisat et al. (2015), this paper aims to measure and evaluate the CE for 17 Jordanian banks (2 large, 8 medium, 4 small and 3 foreign) for the period 1996-2007 covering the deregulation era, by employing a parametric estimation approach also known as a SFA. In addition, this paper analyze the sources of the CE method developed by Papke and Wooldridge (1996). The empirical result for the CE are obtained by running an input-oriented SFA model using the computer program, Frontier Version 4.1., developed by Coelli (1996). The paper findings suggest that both the domestic and foreign banks have shown over the years of deregulation era slight improvements and this led to improvement in the efficiency of the Jordanian banking sector. In addition, this paper investigates whether ownership structure, size, number of branches and ATM, bad loan and age of the bank significantly affect the CE levels of Jordanian banks. Results show that differences in ownership structure significantly affect Jordanian banks‟ performance in terms of CE. Another study done by Jreisat and Paul (2010), provided a review of banking efficiency in the Middle East economies with a special emphasis on measuring the efficiency of banking sector in Jordan, they find that majority of studies have used DEA approach; only few have used SFA methodology to compute efficiency estimates. These studies have revealed that banks have achieved some levels of efficiency. Also, they presented a detailed analysis of banking efficiency in Jordan using data for the period 1996-2007. The input oriented DEA methodology is applied to obtain estimates of technical efficiency decomposed into pure technical and scale efficiency. An attempt is also made to check whether banks are operating at most efficient scale size. Their analysis reveals that the Arab bank which is one of the large banks has performed at the highest level of technical efficiency during the sample period. The small banks are found to be more efficient than the medium sized banks. The foreign banks have shown the lowest technical efficiency indicating a large scope for cost reduction.

4. THE CE: CONCEPT AND MEASUREMENT

A bank is considered cost efficient if it can find a combination of inputs that enables it to produce the desired (given) outputs at the minimum cost. The CE is the product of technical and allocative efficiencies. A firm/bank is considered technically efficient if it is not possible to reduce the level of inputs to produce a given level of output. To put in other words, the existence of technical inefficiency would mean that some inputs can be reduced without

affecting the level of output. The AE refers to the selection of inputs to produce a certain level of outputs at given input prices such that the cost of production is minimum. CE is defined as the ratio of minimum (optimum) cost to the observed cost for producing a level of output by a firm. If the CE score for a firm is 0.75, then it would mean that the bank could have achieved the same level of output with 75% of its costs. In other words, the firm wastes 25% of its costs relative to the best-practice firm (Berger and Mester, 1997).

Figure 1, reproduced from Coelli et al. (2005. p. 52), explains how CE can be conceptualized and measured using input-oriented measures[1]. The working of this is explained by Farrell (1957), who used a simple example of a firm requiring two inputs x_1 and x_2 for producing one output q, assuming constant return to scale. Let w refer to input price vector and x to the observed vector of inputs used associated with point P; and let $\hat{x}$ and x* refer to the input vectors associated with the technically efficient point Q and the cost minimizing input vector at Q' respectively. Thus, CE can be defined as the ratio of input costs associated with input vectors x and x^* associated with points P and Q'.

$$CE = \frac{w'x^*}{w'x} = OR/OP \quad (1)$$

As shown in Figure 1, the slope of the isocost line AA' represents the proportion of input prices. AE and TE can be calculated as follows:

$$AE = \frac{w'x^*}{w'\hat{x}} = \frac{OR}{OQ} \quad (2)$$

$$TE = \frac{w'\hat{x}}{w'x} = \frac{OQ}{OP} \quad (3)$$

Thus, if the firm sets its inputs at the point Q on the isoquant curve SS', then it can be said that this firm is technically efficient but allocatively inefficient. If the firm wishes to be technically and allocatively efficient it should reduce the production cost represented by the distance RQ, which would occur at the allocatively (and technically) efficient point Q', instead of at the technically efficient but allocatively inefficient point Q.

It follows from this that CE can be expressed as the product of technical and AE measures:

$$TE \times AE = (OQ/OP) \times (OR/OQ) = (OR/OP) = CE \quad (4)$$

DEA efficiency scores assign numerical values (between 0 and 1 or 0 and 100%) to the CE level of a DMU relative to others. CE of one represents a fully cost efficient bank; (1−CE) represents the amount by which the bank could reduce its costs and still produce at least the same amount of output. To measure CE, two sets of linear programs are required, one to measure technical efficiency and the other to measure CE. The CE is often called economic efficiency or overall efficiency. The details of linear programming required to estimate CE is provided in Coelli et al. (2005. p. 184) and hence is not repeated here.

1 Coelli et al. (2005) discussed input-oriented and output-oriented measures, for more details see p51-57.

4.1. Choice of Variable for DEA Model

The intermediation approach is quite popular in empirical research particularly based on cross-section data (Colwell and Davis, 1992; Favero and Papi, 1995). In the DEA approach, the number of inputs and outputs is always determined by the number of DMUs (banks in the present context) in the sample. The ability of DEA to distinguish between efficient DMUs and inefficient DMUs depends on a number of inputs and outputs incorporated in the DEA model. It is widely recognized that product of the number of inputs and outputs should not exceed the number of DMUs in the sample (Cooper et al. 2000). This study uses the intermediation approach originally suggested by Sealey and Lindley (1977), in which banks are viewed as intermediaries. In other word, intermediation approach views financial institutions as intermediaries that convert and transfer financial assets from surplus units to deficit units. The estimation of CE requires data not only on real values of inputs and outputs but also on input prices. The inputs and outputs variables used in this paper are listed in Table 1. The input prices for each bank for each year are calculated as follows.

4.2. Data Sources

The data used in this study covers 1997-2013 period and are taken from, auditing annual report of individual banks CBE. The data were collected from 14 banks operating in Egypt, 11 domestic banks, and 3 foreign banks. Assets of these banks are given in Table 2.

4.3. Empirical Results on CE

The CE scores of banks are obtained by running an input-oriented DEA model using the software package, DEAP Version

Figure 1: Cost, technical and allocative efficiencies

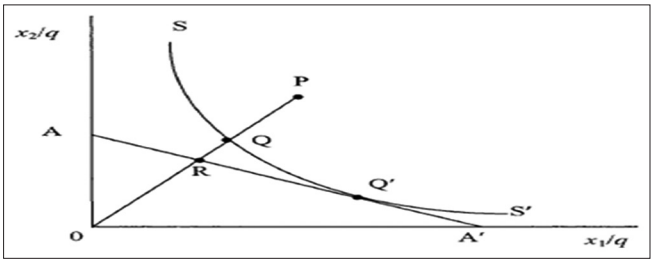

Table 1: Variable definitions banks' input prices and outputs for Egypt

Variables	Description
Outputs	
Total loan: y_1	Total customers' loan
Other investments: y_2	Investments in bonds and securities, shares, treasury bills, and investment in affiliate and subsidiary companies
Inputs	
Labour: x_1	Number of employee
Total Deposit: x_2	Total customers deposit
Input prices	
Price of labour: P_L	Wages and personal expenses and benefit of the banks staff divided by number of staff
Price of fund: P_F	Interest expense divided by total deposits

Table 2: Assets of domestic and foreign banks in Egypt, (1997-2013)

Bank category	Bank name	Short name	Total assets (US millions)
Domestic			
Large	National Bank of Egypt	NBE	15905295
	Banque Misr	BM	14758047.9
	Bank du Caire	BDC	8446256.8
Medium	Commercial International Bank	CIB	4011017.1
	Suez Canal Bank	SCB	2180494
	Faisal Islamic Bank	FIB	1838888
	Housing and Development Bank	HDB	1590305
	Misr Iran Development Bank	MIDB	1160970
Small	Export Development Bank of Egypt	EDB	691101.18
	Al Baraka Bank Egypt	ABE	461254.73
	Societe Arabe Internationale de Banque	SAIB	401020
Foreign	National Societe Generale Bank	NSGB	1164457
	Arab African International Bank	AAIB	997995
	HSBC Egypt	HSBC	636343.2

Source: Annual report for each bank 1997

2.1 (Coelli, 1996). While the bank specific yearly scores are presented in Appendix Table A1, The sample period mean estimates of cost, allocative and technical efficiencies for the banking sector as a whole as well as for each bank category are presented in Table 3. The CE score of banks is 51.7%, which implies that the banking sector could have reduced the cost of production by 41.7% without affecting the level of output. In other words, banks have wasted 41.7% of resources in producing their levels of output. The AE is quite high (91.1%). This is consistent with the estimates reported for banks in most of the countries. The group of large banks is found to be least efficient in terms of CE as well as in terms of technical efficiency. The CE of foreign banks is found to be the most efficient for the entire groups (64.4%).

The time series estimates of the CE by bank categories presented in Table 4 also reveal that the group of foreign banks has performed better than domestic banks in terms of CE and TE in each year of the sample period. The gap in their efficiency levels has widened, especially from 2008 onwards. The AE of domestic banks is higher than the foreign banks. This implies that in terms of input use in response to input prices, the domestic banks are more efficient than their foreign counterparts. The group of small banks has outperformed all other domestic bank categories in terms of CE in almost all the sample years.

The annual efficiency scores for the banking sector as a whole. The latter are the weighted geometric mean of bank-specific scores where their shares in total output serve as weights. The CE score was low (53.9%) in the beginning of the sample period. The efficiency scores show an improvement trend with some fluctuations till 2000 and a declining thereafter until 2005, the reason for declining the cost and technical efficiency for the period (2000-2005) may be due to firstly, The Egyptian economy faced a serious currency liquidity crisis in 1999 prior to bank privatization. Secondly, in 2003 the Egyptian government decided to float the Egyptian pound against the US$ which increased the banks' foreign exchange losses, particularly, those that have significant proportion of their investment portfolio in foreign currency. The CE for the whole banking sector showing improvement from 2005 till 2010. However, the CE declined

Table 3: Sample period mean CE, AE and TE in Egypt (1997-2013)

Bank categories	CE	AE	TE
Large	0.457	0.927	0.488
Medium	0.548	0.852	0.636
Small	0.641	0.879	0.722
Foreign banks	0.644	0.862	0.744
Domestic banks	0.490	0.907	0.537
All Banks	0.517	0.911	0.570

CE: Cost efficiency; AE: Allocative efficiency; TE: Technical efficiency

again from 2011 till 2013 and may be due the revaluation in Egypt in 2011. The highest CE score of 65.1% in the year (2000) of the sample period. While the bank timeline of major financial reforms in Egyptian banks from 1991 to 2013 are presented in Appendix Table A2.

To understand how efficiency has changed over the sub-periods of financial reforms and how changes in allocative and technical efficiencies have contributed to it, we decompose the growth of CE as the sum of the growth of allocative and technical efficiencies using the relationship $AE \times TE = CE$ (see Equation 5). The decomposition estimates for broad categories of banks for the full period under study as well as four sub-periods 1997-2000, 2001-05, 2006-2010 and 2011-13, are presented in Table 5. These sub-periods represent the phases of financial deregulation/reform in Egyptian economy.

$$\ln\left(\frac{CE_{CRS(t)}}{CE_{CRS(t-1)}}\right) = \ln\left(\frac{AE_{VRS(t)}}{AE_{VRS(t-1)}}\right) + \ln\left(\frac{TE_{(t)}}{TE_{(t-1)}}\right) \quad (5)$$

The banking sector as a whole has experienced a decline in CE at the rate of 7.41% and 4.23% per annum respectively in the second and fourth phases of financial deregulation due to the decision of the Egyptian government to float the Egyptian pound against the US$ which increased the banks' foreign exchange losses, particularly, those that have significant proportion of their investment portfolio in foreign currency in 2003, and due the revaluation in Egypt in 2011. In the early and middle phases, CE has increased at the rate of 6.31% and 3.08% per annum respectively, two thirds of this improvement from an improvement in technical efficiency.

Table 4: Estimates of CE by category of banks and ownership, 1997-2013

Banks	Eff	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mean
Domestic banks																			
Large	CE	0.484	0.504	0.579	0.622	0.579	0.542	0.457	0.419	0.402	0.405	0.395	0.392	0.397	0.414	0.410	0.452	0.412	0.457
	AE	0.961	0.964	0.985	0.991	0.984	0.966	0.922	0.891	0.913	0.916	0.895	0.876	0.908	0.906	0.887	0.896	0.913	0.927
	TE	0.503	0.523	0.588	0.627	0.587	0.558	0.492	0.470	0.439	0.441	0.435	0.436	0.424	0.446	0.452	0.498	0.447	0.488
Medium	CE	0.649	0.751	0.767	0.686	0.642	0.575	0.490	0.442	0.458	0.471	0.494	0.430	0.479	0.555	0.575	0.568	0.448	0.548
	AE	0.950	0.929	0.923	0.881	0.893	0.847	0.802	0.795	0.803	0.830	0.830	0.765	0.796	0.883	0.849	0.864	0.871	0.852
	TE	0.678	0.808	0.830	0.772	0.713	0.668	0.598	0.553	0.567	0.567	0.592	0.551	0.593	0.622	0.659	0.642	0.508	0.636
Small	CE	0.746	0.695	0.884	0.899	0.851	0.738	0.514	0.500	0.538	0.590	0.587	0.631	0.697	0.699	0.553	0.463	0.540	0.641
	AE	0.941	0.941	0.950	0.957	0.920	0.908	0.885	0.885	0.835	0.871	0.875	0.867	0.909	0.911	0.810	0.773	0.742	0.879
	TE	0.779	0.730	0.913	0.926	0.909	0.802	0.576	0.568	0.657	0.681	0.663	0.709	0.752	0.753	0.677	0.584	0.723	0.722
Foreign banks	CE	0.737	0.749	0.700	0.730	0.670	0.593	0.496	0.447	0.554	0.546	0.651	0.791	0.720	0.727	0.663	0.675	0.618	0.644
	AE	0.891	0.896	0.914	0.864	0.894	0.835	0.816	0.817	0.834	0.882	0.872	0.882	0.862	0.867	0.837	0.846	0.853	0.862
	TE	0.830	0.837	0.763	0.834	0.742	0.705	0.605	0.551	0.664	0.622	0.746	0.887	0.831	0.831	0.790	0.794	0.719	0.744
Domestic banks	CE	0.528	0.564	0.630	0.647	0.605	0.558	0.467	0.428	0.420	0.428	0.425	0.416	0.442	0.476	0.465	0.487	0.435	0.490
	AE	0.958	0.956	0.971	0.968	0.962	0.937	0.894	0.868	0.884	0.895	0.880	0.851	0.878	0.900	0.871	0.877	0.884	0.907
	TE	0.550	0.592	0.651	0.669	0.628	0.594	0.519	0.494	0.478	0.481	0.479	0.479	0.494	0.519	0.524	0.547	0.490	0.537
ALL banks	CE	0.539	0.574	0.634	0.651	0.608	0.560	0.469	0.450	0.449	0.454	0.469	0.487	0.499	0.524	0.508	0.521	0.462	0.517
	AE	0.955	0.953	0.968	0.963	0.959	0.932	0.890	0.907	0.913	0.917	0.898	0.865	0.880	0.888	0.864	0.871	0.880	0.911
	TE	0.564	0.605	0.656	0.676	0.634	0.600	0.524	0.522	0.514	0.510	0.531	0.557	0.564	0.580	0.582	0.592	0.524	0.570

CE: Cost efficiency; AE: Allocative efficiency; TE: Technical efficiency

Table 5: Average annual growth rates of CE by bank category in sub periods

Bank type	Period	Growth of CE	Growth of AE	Growth of TE
Domestic banks				
Large banks	1997-2000	8.385	1.026	7.309
	2001-2005	−8.746	−1.644	−7.138
	2006-2010	0.614	−0.141	0.324
	2011-2013	−0.221	0.241	0.058
	1997-2013	−1.010	−0.320	−0.748
Medium banks	1997-2000	1.837	−2.509	4.327
	2001-2005	−8.103	−1.853	−6.171
	2006-2010	3.856	1.885	1.860
	2011-2013	−7.140	−0.459	−6.728
	1997-2013	−2.321	−0.546	−1.797
Small banks	1997-2000	6.213	0.547	5.764
	2001-2005	−10.277	−2.710	−6.860
	2006-2010	5.239	1.731	2.708
	2011-2013	−8.620	−6.852	−1.362
	1997-2013	−2.025	−1.488	−0.471
Foreign banks	1997-2000	−0.304	−1.003	0.187
	2001-2005	−5.502	−0.718	−4.568
	2006-2010	5.412	0.779	4.483
	2011-2013	−5.392	−0.556	−4.805
	1997-2013	−1.096	−0.273	−0.892
Domestic banks	1997-2000	6.803	0.340	6.540
	2001-2005	−8.627	−1.804	−6.739
	2006-2010	2.460	0.353	1.654
	2011-2013	−2.953	−0.600	−1.867
	1997-2013	−1.205	−0.502	−0.712
All banks	1997-2000	6.313	0.305	6.032
	2001-2005	−7.410	−1.064	−5.498
	2006-2010	3.084	−0.565	2.421
	2011-2013	−4.238	−0.318	−3.395
	1997-2013	−0.963	−0.511	−0.467

CE: Cost efficiency; AE: Allocative efficiency; TE: Technical efficiency

Over the entire sample period, CE has decreased at the rate of 0.96% per annum.

5. DETERMINANTS OF CE

In this section, we identify a set of variables that may affect the CE level of a bank. The potential variables of interest are drawn from a number of recent international studies on banking efficiency (e.g., Cavallo and Rossi, 2002; Hermes and Nhung, 2010; Pasiouras et al. 2009; Casu and Girardone, 2004; and Vu and Turnell, 2011). Our choices of variables may effects on the CE of the banks as follow:

LTD: It is the ratio of loans to deposits. It assesses a bank's ability to transform deposits into loans. The higher this ratio, the more efficient the process of financial intermediation provided by the bank. For example, Vu and Turnell (2011) found a positive and statistically significant relationship between LTD and CE.

NIETA: It is the ratio of non-interest expense to total assets. NIETA measures the magnitude of administrative expenses. Banks that employ good management practices should be able to achieve lower administrative costs. Thus, it is expected that the higher the NIETA, the lower the CE of a bank.

ROE: It is the return on equity. The higher the return on equity will lead the bank to be more efficient.

NIM: Net interest margin. This variable is defined as the difference between interest income and interest expenses divided by total assets. This variable is expected to have a positive effect on efficiency, that is, the higher the NIM, The higher the NIM, the bank will be efficient.

Branches: Number of branches for each bank refers to network density. A high network density leads to higher structural overheads and thus may lower CE. The increase in the number of

branches also enables the banks to use their branch network as a barrier against the entry of new banks, which may lead to higher profit. Thus the effect of this variable on efficiency could be in either direction depending on the effectiveness of service provided to the consumers. In their dataset, for medium sized bank Maudos et al. (2002) find a negative and significant relationship between number of branches and CE. At the same time, for all other bank categories, they find that the number of branches does not have any significant effect on CE. Also there is a correlation between total assets (proxy for bank size) and number of branches. In other word, size of the bank can be known from the number of branches.

Age: The age of the bank is used to reflect the maturity of bank. We expect that ceteris paribus, more mature banks would be more efficient than the younger or newly opened banks.

5.1. The Model and Estimation Strategy

Consider a random sample of $i=1,\ldots, N$ banks observed over a duration of T consecutive years with time index $t=1,\ldots, T$ years and let CE be represented by CE, the fractional variable of interest, $0\leq CE\leq 1$, and $x=$ ($LTA, LTD, NIETA, ROE, NIM, BRANCHES$) be a vector of six covariates discussed above. Let β be the vector of parameters to be estimated and $f(CE \mid x,\beta)$ denote the conditional density of CE.

Many applied economists assume a linear conditional mean model for CE:

$$E(CE / x) = x\beta \tag{6}$$

However, given that the dependent variable CE is strictly bounded from above and below, it is not reasonable to assume that the effect of any explanatory variable is constant throughout its entire range. Further, the linear specification does not automatically guarantee that the predicted values of CE lie between 0 and 1 without severe constraints on the range of x or arbitrary modifications to fitted values outside the unit interval.

In order to tackle this problem empirical economist use logistic relationship:

$$E(CE / x) = \frac{e^{x\beta}}{1+e^{x\beta}} \tag{7}$$

Since it ensures that $0 < E(CE / x) <1$. However Equation (7) is not directly estimated but it is transformed into log-odds model,

$$E\left(\ln \frac{CE}{1-CE} \middle| x \right) = x\beta \tag{8}$$

And then the estimation is done using OLS. There are two major shortcomings of the above model; (i) Recovering $E(CE / x)$ from (8) is not straight foreword (see Papke and Wooldridge, 1996 on p. 620 for details) and (ii) Equation (8) is not well defined for boundary values 0 and 1 of CE. Since the DEA based frontier estimator always classifies at least one firm to be fully efficient (with CE=1), Equation (8) cannot be used in this case.

Some authors use two-limit Tobit model in order to restrict the predicted efficiency scores to be between 0 and 1. However, this model can only be applied if observations are available for both limits, which is often not the case[2] in most efficiency studies. Furthermore, the Tobit model imposes restrictive assumptions on the dependent variable. That is, it assumes normality and homoskedasticity of the dependent variable, prior to censoring.

For fractional dependent variables, Papke and Wooldridge (1996) have developed a simple estimation methodology. Their methodology does not require manipulating the dependent variable, when it takes the extreme value of zero or one. The conditional expectation of dependent variable given the independent variables can be estimated in a straightforward manner. Furthermore, the predicted values of the dependent variable always lie between zero and one.

Papke and Wooldridge (1996) use the following Bernoulli log-likelihood function:

$$l_{it}(\beta) \equiv CE_{it} \log\left[G\left(x_{it}\beta\right)\right] + \left(1-CE_{it}\right)\log\left[1-G\left(x_{it}\beta\right)\right] \tag{9}$$

Where $0 < G(.) < 1$ is a logit function. The estimates[3] for the parameter β can be obtained by maximizing the log-likelihood for the entire sample of 14 Egyptian banks covering the deregulation period 1996-2007. In other word, the maximization problem can be written as:

$$\max_{\beta} \sum_{t=1}^{12}\sum_{i=1}^{17} l_{it}(\beta) \tag{10}$$

The estimated variance-covariance matrix is given by

$\hat{V} = \hat{A}^{-1}\hat{B}\hat{A}^{-1}$ where A and B are given by

$$\hat{A} = (N\times T)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{g}_{it}^2 x_{it}^{'} x_{it}[\hat{G}_{it}(1-\hat{G}_{it})]^{-1} \text{ and}$$

$$\hat{B} = (N\times T)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{u}_{it}^2 \hat{g}_{it}^2 x_{it}^{'} x_{it}[\hat{G}_{it}(1-\hat{G}_{it})]^{-2}$$

respectively, Where $\hat{G}_{it} = G(x_{it}\hat{\beta})$, $\hat{g}_{it} = g(x_{it}\hat{\beta})$, $g(x\beta) = \partial G(x\beta)/\partial x\beta$ and $u_{it} = CE_{it} - \hat{CE}_{it}$.

5.2. Results

The regression estimates obtained using method developed by Papke and Wooldridge (1996). Presented in Table 6 are the regression coefficients obtained from OLS and quasi-maximum likelihood estimator based on Equation (9).

The coefficient of age is estimated to be positive and significant, indicating that more mature banks would be more efficient than the younger or newly opened banks. The negative and significant coefficient of NIETA implies that higher administrative cost leads to a decrease in CE.

2 In the efficiency studies where DEA estimator is used to compute the efficiency scores, at least one would be classified to be fully efficient. However, in most DEA based efficiency studies, one rarely comes across a firm whose estimated efficiency score is 0.

3 The Stata comm and for this estimator can be downloaded from the following link: https://www.msu.edu/~ec/faculty/papke/flogitinstructions.pdf.

Table 6: Estimates of regression model

Variables	Coefficient (OLS)	Coefficient (QMLE)
Constant	0.5889549 (0.0659131)***	0.3659191 (0.2709631)***
Age	0.0032742 (0.0012548)***	0.0139137 (0.0038142)***
LTD	0.0360087 (0.0355351)	0.1498649 (0.1137172)
NIETA	−15.47607 (2.734173)***	−65.26083 (11.30865)***
ROE	0.1969922 (0.1167623)*	0.8418186 (0.4150223)***
NIM	5.689282 (1.465611)***	23.931 (5.490801)***
BRANCHES	−0.0010105 (0.0002143)***	−0.0042571 (0.0006776)***
No of observation R^2	238	238
Log pseudo-likelihood	0.2667	−110.8870283

***.**.*Indicate 1%, 5% and 10% significance levels, respectively. Asymptotic standard errors in parentheses, QMLE: Quasi-maximum likelihood estimator

The positive and significant sign of ROE suggests that banks which are more profitable are more cost efficient. At the first instance this result means that higher the ROE, the more cost efficient the bank is. ROE indicates how well bank management is using the investors' capital. However, it turns out, that a bank can grow earnings faster than its current ROE without raising additional cash. That is, a bank that now has a 5% ROE can increase its earnings faster than 5% annually without borrowing funds or selling more shares.

Further, as expected the positive and significant sign of NIM indicates that banks which are more profitable are more cost efficient. Finally, a negative and significant coefficient on Branches suggests banks with a bigger network of branches are relatively cost inefficient possibly due to higher structural overloads.

6. CONCLUSIONS

Our research adopt two-stage approaches, in which CE scores are estimated in the first stage using input oriented DEA, and in the second stage we study the potential determinants of CE. We estimate the level of CE in 14 Egyptian banks using annual data for 1997-2013. The CE is decomposed into allocative and technical efficiency levels.

The CE score was (53.9%) in the beginning phase of the sample period. The efficiency scores show an improvement trend with some fluctuations till 2000 and a declining thereafter until 2005, the reason for declining the cost and technical efficiency for the period (2000-2005) due to the serious currency liquidity crisis faced by Egyptian economy in 1999 prior to bank privatization, in the other hand, the Egyptian government decided to float the Egyptian pound against the US$ in 2003 which increased the banks' foreign exchange losses, particularly, those that have significant proportion of their investment portfolio in foreign currency. The CE for the whole banking sector showing improvement from 2005 till 2010. However, the CE declined again from 2011 till 2013 and may be due the revaluation in Egypt in 2011. The highest CE score of 65.1% in the year (2000) of the sample period. While the bank timeline of major financial reforms in Egyptian banks from 1991 to 2013.

In the second stage we further analyze the factors rolling critically in shaping the CE of Egyptian banks. The results reveal that net interest margins and bank branches are the main determinants cost efficiencies of Egyptian banks. Thus, the policy implications for the banking sector to improve CE are: (a) To minimize administrative and the overhead cost, (b) to develop an understanding of the forces affecting the net interest margin in order to avoid major surprises.

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APPENDIX

Table A1: DEA estimates of cost efficiency for domestic and foreign banks of Egypt, 1997-2013

Bank	Eff	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mean
Large																			
NBE	TE	0.559	0.59	0.714	0.768	0.71	0.652	0.575	0.547	0.515	0.553	0.575	0.57	0.49	0.50	0.489	0.529	0.465	0.571
	AE	0.992	0.992	0.992	0.999	0.999	0.998	0.974	0.896	0.944	0.926	0.934	0.941	0.996	0.984	0.988	0.963	0.992	0.971
	CE	0.554	0.585	0.708	0.767	0.709	0.65	0.56	0.49	0.486	0.512	0.537	0.536	0.488	0.492	0.483	0.51	0.462	0.554
BM	TE	0.385	0.414	0.478	0.499	0.47	0.455	0.413	0.379	0.328	0.279	0.28	0.255	0.233	0.256	0.306	0.365	0.35	0.352
	AE	0.951	0.964	0.993	0.978	0.97	0.942	0.885	0.90	0.898	0.91	0.848	0.798	0.737	0.732	0.633	0.732	0.736	0.852
	CE	0.366	0.40	0.474	0.488	0.455	0.429	0.365	0.341	0.294	0.254	0.237	0.203	0.172	0.187	0.193	0.267	0.257	0.300
BDC	TE	0.61	0.587	0.508	0.529	0.464	0.496	0.449	0.462	0.463	0.495	0.445	0.54	0.575	0.579	0.507	0.529	0.494	0.511
	AE	0.913	0.905	0.955	0.997	0.969	0.918	0.864	0.85	0.861	0.886	0.912	0.877	0.831	0.84	0.771	0.788	0.778	0.875
	CE	0.557	0.531	0.485	0.527	0.45	0.456	0.388	0.393	0.399	0.438	0.406	0.473	0.478	0.486	0.391	0.417	0.384	0.447
Medium																			
CIB	TE	0.851	1.00	1.00	0.94	0.797	0.698	0.651	0.637	0.64	0.649	0.639	0.521	0.594	0.676	0.703	0.707	0.501	0.704
	AE	0.997	0.942	0.924	0.885	0.888	0.839	0.795	0.766	0.77	0.805	0.791	0.675	0.745	0.851	0.866	0.891	0.793	0.833
	CE	0.849	0.942	0.924	0.831	0.707	0.586	0.517	0.488	0.492	0.522	0.506	0.352	0.442	0.575	0.609	0.63	0.397	0.586
SCB	TE	0.749	0.781	0.853	0.867	0.899	0.899	0.805	0.683	0.677	0.706	0.551	0.56	0.609	0.524	0.544	0.474	0.436	0.667
	AE	0.99	0.977	0.989	0.98	0.972	0.952	0.945	0.924	0.93	0.866	0.798	0.818	0.811	0.831	0.745	0.807	0.795	0.886
	CE	0.741	0.763	0.844	0.85	0.873	0.856	0.761	0.631	0.63	0.611	0.44	0.458	0.494	0.436	0.405	0.382	0.346	0.591
FIB	TE	0.49	0.69	0.692	0.568	0.53	0.493	0.389	0.371	0.39	0.367	0.518	0.496	0.539	0.548	0.611	0.576	0.508	0.507
	AE	0.89	0.907	0.875	0.753	0.819	0.759	0.701	0.752	0.725	0.822	0.794	0.72	0.856	0.974	0.955	0.876	0.909	0.825
	CE	0.436	0.626	0.606	0.428	0.434	0.374	0.273	0.279	0.282	0.302	0.411	0.357	0.461	0.534	0.583	0.504	0.462	0.418
HDB	TE	0.442	0.469	0.528	0.557	0.509	0.514	0.486	0.455	0.447	0.523	0.61	0.569	0.38	0.327	0.302	0.278	0.27	0.438
	AE	0.995	0.988	0.99	0.993	0.968	0.942	0.907	0.876	0.938	0.911	0.986	0.975	0.676	0.723	0.579	0.585	0.59	0.844
	CE	0.439	0.463	0.523	0.553	0.492	0.484	0.441	0.399	0.419	0.477	0.601	0.554	0.257	0.236	0.175	0.163	0.16	0.370
MIDB	TE	0.639	0.698	0.678	0.633	0.543	0.635	0.613	0.668	0.78	0.68	0.711	0.868	1.00	1.00	0.988	0.994	0.885	0.751
	AE	0.355	0.388	0.444	0.436	0.427	0.382	0.416	0.571	0.757	0.802	0.995	0.996	0.953	1.00	0.999	0.999	0.985	0.645
	CE	0.227	0.271	0.301	0.276	0.232	0.242	0.255	0.381	0.591	0.545	0.708	0.864	0.953	1.00	0.987	0.993	0.871	0.485
Small																			
EDB	TE	0.874	0.738	1.00	1.00	1.00	0.851	0.537	0.463	0.494	0.541	0.547	0.58	0.593	0.59	0.604	0.539	0.521	0.652
	AE	0.982	0.985	1.00	1.00	0.952	0.956	0.986	1.00	0.973	0.998	0.764	0.685	0.789	0.784	0.695	0.71	0.708	0.871
	CE	0.858	0.726	1.00	1.00	0.952	0.813	0.529	0.463	0.48	0.54	0.418	0.397	0.468	0.463	0.42	0.383	0.369	0.567
ABE	TE	0.868	0.89	0.892	0.919	0.902	0.917	0.843	0.853	0.868	0.92	0.982	1.00	0.995	1.00	0.745	0.404	0.911	0.862
	AE	0.964	0.973	0.983	0.991	0.994	0.935	0.881	0.875	0.882	0.917	0.936	1.00	0.995	0.997	0.749	0.714	0.735	0.908
	CE	0.836	0.866	0.877	0.91	0.897	0.858	0.743	0.746	0.766	0.843	0.919	1.00	0.99	0.997	0.558	0.288	0.669	0.783
SAIB	TE	0.384	0.503	0.576	0.604	0.535	0.573	0.464	0.497	0.71	0.651	0.532	0.631	0.745	0.753	0.712	0.769	0.83	0.604
	AE	0.794	0.775	0.71	0.722	0.718	0.746	0.553	0.643	0.598	0.669	0.945	0.991	0.978	0.992	0.981	0.891	0.782	0.781
	CE	0.305	0.39	0.409	0.436	0.384	0.428	0.257	0.32	0.425	0.435	0.502	0.625	0.729	0.746	0.699	0.685	0.649	0.471
Foreign																			
NSGB	TE	0.813	0.81	0.751	0.781	0.668	0.602	0.522	0.529	0.606	0.577	0.626	0.767	0.713	0.718	0.758	0.767	0.674	0.681
	AE	0.985	0.984	0.988	0.901	0.979	0.842	0.718	0.66	0.83	0.89	0.892	0.792	0.823	0.803	0.746	0.741	0.76	0.837
	CE	0.801	0.797	0.742	0.704	0.655	0.508	0.375	0.349	0.503	0.513	0.559	0.608	0.587	0.577	0.565	0.568	0.512	0.570
AAIB	TE	0.859	0.85	0.723	0.756	0.654	0.691	0.543	0.484	0.722	0.637	0.899	1.00	0.918	0.928	0.829	0.817	0.771	0.757
	AE	0.769	0.757	0.708	0.69	0.602	0.721	0.921	0.983	0.878	0.934	0.912	1.00	0.969	0.981	0.998	0.981	0.948	0.858
	CE	0.661	0.644	0.512	0.522	0.394	0.498	0.50	0.476	0.635	0.595	0.82	1.00	0.89	0.911	0.828	0.802	0.731	0.649
HSBC	TE	0.796	0.863	0.816	1.00	0.888	0.845	0.773	0.667	0.69	0.725	0.763	0.923	0.931	0.914	0.805	0.834	0.778	0.820
	AE	0.972	0.955	0.999	0.986	0.971	0.918	0.841	0.803	0.778	0.768	0.759	0.846	0.796	0.848	0.84	0.944	0.989	0.879
	CE	0.774	0.824	0.815	0.986	0.862	0.776	0.651	0.536	0.536	0.556	0.578	0.78	0.741	0.775	0.676	0.788	0.769	0.720

CE: Cost efficiency; AE: Allocative efficiency; TE: Technical efficiency, NBE: National Bank of Egypt, BM: Banque Misr, BDD: Bank du Caire, CIB: Commercial International Bank, SCB: Suez Canal Bank, FIB: Faisal Islamic Bank, HDB: Housing and Development Bank, MIDB: Misr Iran Development Bank, ABE: Al Baraka Bank Egypt, SAIB: Societe Arabe Internationale de Banque, NSGB: National Societe Generale Bank, AAIB: Arab African International Bank, HSBC: HSBC Egypt

Table A2: Timeline of major financial reforms in Egypt from 1994 to 2013

Timeline	Major financial reforms
1994-1998	First stage of privatization program started (108 state-owned companies) and none of the public banks included in this stage
1996	The government issued new laws that permit 100% foreign ownership of banks and allow banks to do business in both foreign and local currencies The government advised the four public banks to reduce their majority stakes in joint venture banks to maximum of 20% ownership
1998	The passage of law No. 155/1998 allows the privatization of state-owned banks The passage of law 5/1998 to close a double tax 100% loophole which, for banks, led to almost no tax liability by investing in T-bills
1999	CBE introduced restrictions on credit facilities for certain imports that reduced the volume of LCs which represent, on average, 22% of banks off balance-sheet positions The Egyptian economy faced a serious currency liquidity crisis in 1999 prior to bank privatization
2002	the CBE raised the minimum capital adequacy ratio from 8% to 10% which created a problem for undercapitalized banks that have to raise their capital or merge with another capitalized bank
2003	the Egyptian government decided to float the Egyptian pound against the US$ which increased the banks' foreign exchange losses, particularly, those that have significant proportion of their investment portfolio in foreign currency The CBE started its comprehensive reform plan to promote the banking sector by consolidating and enhancing the overbanked and under-branched banking sector
2004	A NPL monitoring unit was established by the CBE to restructure the state owned banks, consolidate banking systems through mergers and acquisitions of small and weak banks, privatize some state-owned banks, divest public sector shares in joint venture banks, resolve non-performing loans and strengthen the supervisory authority of the central bank of Egypt
2005	The CBE required the big four public banks which own more than 50% of the banking sector' assets to sell their stakes in joint-venture banks and to raise paid up capital requirements to a minimum of USD 50 million for branches of foreign banks The Egyptian minister of finance affirmed a revamp of Egypt's income tax structure, on the personal and corporate levels, with the later constituting a unification of the taxation rate at 20% down from a 42% levy on service entities. The banking sector is considered a main beneficiary of this new law and also some banks exempted from another 10% of the listed entities paid-in capital in the Egyptian stock exchange
2008	The credit crunch crisis
2011	The Egyptian revolution I
2013	The Egyptian revolution II

CBE: Central Bank of Egypt, NPL: Non-performing loans