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An Analysis of Cost Efficiency in the Jordanian Banking Sector

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This paper investigates the level of cost efficiency in 17 Jordanian banks during the period 1996-2007 in which financial deregulation took place. The cost efficiency scores for each bank are obtained using the input-oriented DEA model. The cost efficiency is decomposed into allocative and technical efficiency levels. The allocative efficiency is quite high in the Jordanian banking sector. The average cost efficiency score of banks is 0.74, which implies that they could reduce the cost of production by 26 percent without reducing the level of output. The large banks are found most efficient in terms of cost efficiency (86%), allocative efficiency (92.7%) and technical efficiency (93%). The small banks rank second in terms of efficiency level. The cost efficiency of foreign banks is much lower than that of the domestic banks. While the cost efficiency shows a decline during the early and middle phase of deregulation, it shows large improvements in the final phase of financial deregulation in Jordan. Over the sample period, cost efficiency has increased at the rate of 1.55% per annum; the improvement in allocative efficiency has contributed about 60% of this.

Keywords: Cost Efficiency, Deregulation, Data Envelopment Analysis, Jordanian Banks
JEL Codes: D22, D24, D61 and G21

1. Introduction

There is a large body of literature dealing with the measurement of banking efficiency in the Western economies, but studies on banking efficiency relating to Middle Eastern economies are few. The reasons for this can be attributed to three factors. First, the financial systems of many Middle Eastern countries are highly regulated and outdated. Second, they are dominated by the public sector and do not face any competition. Third, reliable data on banks are not available for many countries. However, during the last fifteen years, many Middle Eastern economies have moved towards liberalising their financial systems. This has encouraged researchers to undertake studies of banking efficiency in some of the countries; see, for example, Hassan et al. (2004) and Al-Muharrami (2007).

The measurement of efficiency of the banking industry is important for several reasons. First, the measures of efficiency are considered indicators of the success of performance, both of individual banks and of the industry as a whole. Second, efficiency is a vital factor for financial institutions wishing to maintain and monitor their business successfully, given the increasing competition in financial markets. Third, in a rapidly changing and more globalised financial marketplace, governments, regulators, managers and investors are concerned about how efficiently banks transform their

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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 have problems with competitiveness.

The present study examines the cost efficiency in the banking sector of Jordon during the period of financial deregulation, 1996–2007. Before the 1980s the Jordanian banking sector was highly regulated, and economic policies were directed towards prevention of and protection from any foreign competition. The financial authorities put in place measures to limit foreign entry; as a result, domestic banks in Jordan operated in an oligopolistic environment, and interest rates on credits and deposits were determined in a monopolistic manner. In August 1989, Jordan experienced a crisis in its banking system following the collapse of Petra Bank and the financial difficulties of six other financial institutions linked to it. The crisis was a result, among other factors, of inadequate banking regulations, over-exposure of the banking system to the real estate market and imprudent speculations in foreign exchange (Canakci, 1995).

The 1989 crisis led to closer cooperation between the government, the International Monetary Fund (IMF) and the World Bank to develop the Jordanian banking sector and initiate a reform program. The government took various steps from 1993 to enhance system efficiencies and to create competition among banks. The reform program consisted of removing restrictions on interest rates, reducing direct governmental lending, promoting deregulation and reducing the restrictions on foreign exchange transactions and the movement of capital. In addition, the government adopted trade liberalisation policies to enhance economic growth and promote exports (Maghyereh, 2004; CBJ, 2005).

This study focuses on the measurement of cost efficiency in 17 Jordanian banks during the period of financial deregulation, 1996–2007. Our sample consists of 14 domestic (two large, eight medium and four small) and three foreign banks for which adequate data were available. These banks cover close to 90 per cent of banking output in Jordon (Association of Banks in Jordan, Annual Report, 2007).

The paper is organised as follows. Section 2 presents review of the literature on efficiency in the banking sector. Section 3 discusses the concept of cost efficiency and its estimation using DEA approach. Data are discussed in Section 4. The results on banking cost efficiencies are discussed in Section 5. Section 6 concludes the study.

2. Literature Review

Almost all the existing studies of banking efficiency in the Middle East economies have been based on DEA. For example, Hassan et al. (2004) investigated cost 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 cost efficiency. The model used three inputs, namely, labour, capital, and loanable funds and two outputs, namely, short term loan and long term loans. The input prices were: price of labour, price of capital, and interest rate on loanable funds. Their result indicated that the average allocative efficiency was about 73%, whereas the average

technical efficiency was about 56%. This indicated that the dominant source of inefficiency in Bahrain banks was due to technical inefficiency rather than allocative inefficiency, which was mainly attributed to diseconomies in scale.

Ahmad (2000) has analysed the cost efficiency of 20 Jordanian banks for the period 1990–1996. The study applied both DEA and SFA to a data set consisting of 20 banks, domestic and foreign. For the DEA approach the outputs used were total loan, other investments (defined as investment in bonds and securities plus deposits at foreign banks); the inputs were the number of full-time workers and total deposits. In addition, the study used prices of labour and capital. In the SFA approach, cost efficiency was estimated based on the Cobb-Doglas cost function which employed two banking outputs (loans and other investments) and prices of labour and capital, in addition to the number of branches. Total Cost was defined as interest expenses plus wages and benefits for workers. An attempt was also made to estimate profit function. The study revealed that the large banks were more profit efficient than other banks. The efficiency scores obtained using DEA were higher than those obtained from the SFA.

Maghyereh (2004) examines the efficiency and productivity change in eight domestic banks over the period 1984–2001. Isik et al. (2004) analysed managerial and scale efficiencies in the Jordanian banking sector (commercial, investment and Islamic) operating in Jordan over 1996–2001. They used two DEA Models. The first applied the production approach and specified banks as multi-product firms producing credits, investment securities and deposits services by employing labour and capital; the second model took an intermediation approach which defined banks as financial intermediaries where labour, capital and deposits served as inputs, and credits and investments securities served as outputs. The results indicated that Jordanian banks would obtain significant cost savings (as much as 40%) should they catch up with the best practice banks. The findings from the first model (production approach) estimated managerial efficiency at 71%, pure technical efficiency at 89% and scale efficiency at 79%; from the second model (intermediation approach) the managerial efficiency, pure technical efficiency and scale efficiency turned out to be 89%, 96% and 92% respectively. Most of the managerial inefficiency was found to be due to scale inefficiency rather than pure technical inefficiency. The study also found that most banks in Jordan experienced increasing returns to scale in their operations under both models, suggesting that the Jordanian banks could have expanded their operations by either internal or external growth. The Arab Bank was found to be most efficient bank.

More recently, Bdour and Al–Khouri (2008) evaluated the efficiency of 17 domestic commercial Jordanian banks during the liberalisation period, 1998–2004. The study used DEA with an intermediation approach, with three inputs (net-operating expenses, total assets and number of employees) and three outputs (net operating income, demand deposits, and net direct credits). They found that the liberalisation program had improved the efficiency of the Jordanian banks for all years except 2003 and 2004, when a decline in efficiency occurred, possibly due to the adverse effects of the Gulf War.

None of these studies covered the entire period of deregulation. Our study makes a significant contribution to the Jordanian literature on banking efficiency by covering almost the entire sector, as well as the deregulated period not encompassed in earlier

studies. The results of this study may help policy makers and bankers understand the ways in which regulatory changes may influence a bank's efficiency.

3. Cost Efficiency: Concept and Measurement

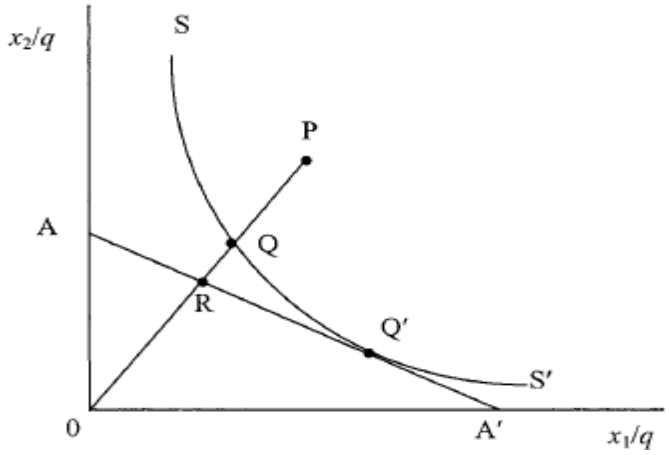
A bank is considered cost efficient if it find a combination of inputs that enables it to produce the desired (given) outputs at the minimum cost. Cost efficiency (CE) is the product of technical and allocative efficiencies. A firm/ bank is considered technically efficient if it is not possible to reduce 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. Allocative efficiency (AE) refers to the selection of inputs to produce a certain level of outputs at a certain level of input prices such that the cost of production is minimum (Al-Delaimi & Al-Ani, 2006).

Cost efficiency is defined as the ratio of minimum (optimum) cost to the observed cost for producing a level of output by a firm. Thus, if the cost efficiency score for a firm is 0.75, the firm is using only 75% of its resources efficiently: in other words, the firm wastes 25% of its costs relative to the best-practice firm (Berger & Mester, 1997).

Figure 1, reproduced from Coelli et al. (2005, p.52), explains how cost efficiency can be conceptualised and measured using input-oriented measures.[i] 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 $\hat{\mathrm{x}}$ and x^* refer to the input vectors associated with the technically efficient point Q and the cost minimising input vector at Q' respectively. Thus, cost efficiency can be defined as the ratio of input costs associated with input vectors $\mathbf{x}$ and x^* associated with points P and Q'.:

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

Figure 1: Cost, Technical and Allocative Efficiencies



Source: Coelli et al. (2005)

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:

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

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

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 cost efficiency can be expressed as the product of technical and allocative efficiency measures:

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

DEA efficiency scores assign numerical values (between 0 and 1 or 0 and 100%) to the cost efficiency level of a DMU relative to others. Cost efficiency (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 cost efficiency. The cost efficiency is also often called economic efficiency. A discussion on required linear programming is provided in Coelli et al. (2005, p.184).

4. The Data

The estimation of cost efficiency requires data not only on real values of inputs and outputs but also on input prices.

There is no agreement on the choice of bank inputs and outputs; in fact, the choice of input and output variables for the banking sector remains controversial. The literature provides three distinct approaches used for selecting inputs and outputs: the production approach, the intermediation approach, and the value-added approach. The first views financial institutions as producers who use inputs of labour and capital to generate outputs of deposits and loans. This approach is used by, among others, Sathye (2001) and Neal (2004). The intermediation approach views financial institutions as intermediaries that convert and transfer financial assets from surplus units to deficit units. Ahmad (2000) views banks as intermediaries and uses two inputs, labour and deposits; and two outputs, total loans and other investments, for measuring efficiency in Jordanian banks during 1990–1996. In another conceptualisation of the intermediation approach, Paul and Kourouche (2008) and Kourouche (2008) use interest expenses and non-interest expenses as inputs and interest income and non-interest income as outputs. In the value-added approach, high-value-creating activities such as making loans and taking deposits are classified as outputs, whereas labour, physical capital and purchased funds are classified as inputs (Wheelock & Wilson, 1995).

The intermediation approach is quite popular in empirical research particularly that based on cross-sectional data (Colwell & Davis, 1992; Favero & Papi, 1995). The production approach, also used in empirical studies, is known to have a limitation as it excludes interest expenses, which are considered a vital part of banking.

There are other practical issues or reasoning governing the selection of inputs and outputs. If one's aim is to estimate a unit's production efficiency, then the production approach might be appropriate. However, if the interest of the researcher is in examining intermediation efficiency, then the intermediary approach is more appropriate. The choice of variables may also depend on the availability of required data.

Following intermediation approach, we consider two inputs, labour (x_1) and total deposit (x_2) and their prices and two outputs, total loans (y_1) and other investments (y_2). Labour is measured in terms of full time workers; *total deposits* are the total amount of customers' deposits. Total loans are the total credit facilities as they appear in the balance sheets of the banks. Other investments consist of investments in bonds and securities, shares, treasury bills, and investment in affiliate and subsidiary companies. The price of labour is obtained as: wages and personal expenses and benefits of employees divided by number of employees. The price of funds is obtained as: interest expenses divided by total deposits. All the monetary variables are expressed in 2000 Jordanian Dinar (JD) using a GDP deflator. Ideally an investment price deflator should

be used to express other investments at constant prices. Since information on investment deflators is not available, we use a GDP deflator to express investment at constant price. This adjustment does not apply to labour, as this is measured by the number of employees (workers).

The data are collected for 17 banks – consisting of 14 domestic and 3 foreign banks. The data for domestic firms which are listed on the Amman Stock Exchange are collected from the Annual Reports of individual banks and the Central bank of Jordon. The foreign banks are not listed on the Amman Stock Exchange. Hence we had to collect data for them from libraries and the Association of Banks in Jordan.

For a comprehensive analysis, the domestic banks are classified into three categories, based on their assets size in 2007, measured in Jordanian Dinar (JD) millions.

Large domestic banks: (Assets size ≥ JD 4000 million)
Medium domestic banks: (700 ≤ Assets size < JD 4000 million)
Small domestic banks: (Assets size < JD 700 million).

The banks' assets have changed over the years but none have changed their categories, facilitating their comparison over the sample period. The banks are listed in Table 1.

Table 1: Assets of Domestic and Foreign Banks, 2007
(Measured in JD Millions)

Bank Category	Serial number	Bank Name	short Name	Total Assets
Large	1	Arab Bank	AB	6093
	2	The Housing Bank for Trade and Finance	HBTF	4132.6
Medium	3	Jordan Kuwait Bank	JKB	1752
	4	Jordan Islamic Bank For Finance and Investment	JIBF	1596.83
	5	Jordan National Bank	JNB	1548.58
	6	Bank of Jordan	BOJ	1276
	7	Cairo Amman Bank	CAB	1085.36
	8	Union Bank for Saving and Investment	UBJ	1056.3
	9	Capital Bank	CPB	896.82
	10	Jordan Investment and Finance Bank	JIFB	707.37
Small	11	Arab Banking Corporation	ABC	574
	12	Jordan Commercial Bank	JCB	533.92
	13	Arab Jordan Investment Bank	AJIB	516
	14	Societe Generale De Banque-Jordanie	SGBJ	222.58
		Foreign Banks		
	15	HSBC Bank	HSBC	587.07
	16	Bank Standard Charter	BSC	483.89
	17	Citi Bank	CB	241.8

Source: The Association of Banks in Jordan, Annual Report 2007.

5. Empirical Results on Cost Efficiency

The estimates of cost efficiency for banks are obtained by running an input-oriented DEA model using the software package, DEAP Version 2.1 (Coelli, 1996). The average efficiency scores for the banking sector for each year are presented in Table 2. The average efficiency scores are the weighted geometric means of bank-specific scores where weights are their shares in total output. The table reveals that the average cost efficiency scores vary from 48.7% in 2003 to 66.5% in 2007; this suggests that the average bank in the sample could have reduced its costs by approximately 33% to 51%, to achieve 'best practice' performance. Similarly, the minimal cost efficiency scores range from 23.8% in 1998 to 40.8% in 2007. The yearly average cost efficiency scores are plotted in Figure 2. The average cost efficiency shows a declining trend with some fluctuations up to 2003 and an improvement thereafter. This implies that the later phase of financial deregulation has had a positive effect on the cost efficiency of banks in Jordan.

Table 2: Yearly DEA Estimates of Cost, Allocative and Technical Efficiency 1996–2007

	Cost Efficiency				**Allocative** Efficiency				Technical Efficiency			
Year	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD
1996	1.000	0.260	0.564	0.179	1.000	0.421	0.839	0.141	1.000	0.365	0.675	0.174
1997	0.861	0.307	0.549	0.135	0.985	0.698	0.871	0.074	0.946	0.325	0.634	0.159
1998	1.000	0.238	0.572	0.176	1.000	0.419	0.866	0.144	1.000	0.397	0.659	0.162
1999	1.000	0.373	0.564	0.159	1.000	0.620	0.895	0.098	1.000	0.433	0.633	0.164
2000	0.927	0.343	0.509	0.171	0.993	0.518	0.878	0.115	1.000	0.408	0.584	0.184
2001	0.964	0.332	0.553	0.207	0.994	0.540	0.861	0.121	1.000	0.377	0.644	0.213
2002	1.000	0.249	0.525	0.215	1.000	0.571	0.850	0.122	1.000	0.325	0.617	0.219
2003	0.893	0.246	0.487	0.179	0.990	0.575	0.833	0.134	0.922	0.282	0.588	0.187
2004	1.000	0.265	0.543	0.224	1.000	0.583	0.818	0.159	1.000	0.288	0.664	0.222
2005	0.995	0.335	0.599	0.216	0.997	0.489	0.850	0.151	1.000	0.377	0.703	0.193
2006	1.000	0.369	0.663	0.225	1.000	0.519	0.891	0.131	1.000	0.399	0.742	0.205
2007	1.000	0.408	0.665	0.202	1.000	0.632	0.914	0.099	1.000	0.449	0.723	0.184

Figure 2: Average Efficiency Over Time for DEA Model (1996–2007)

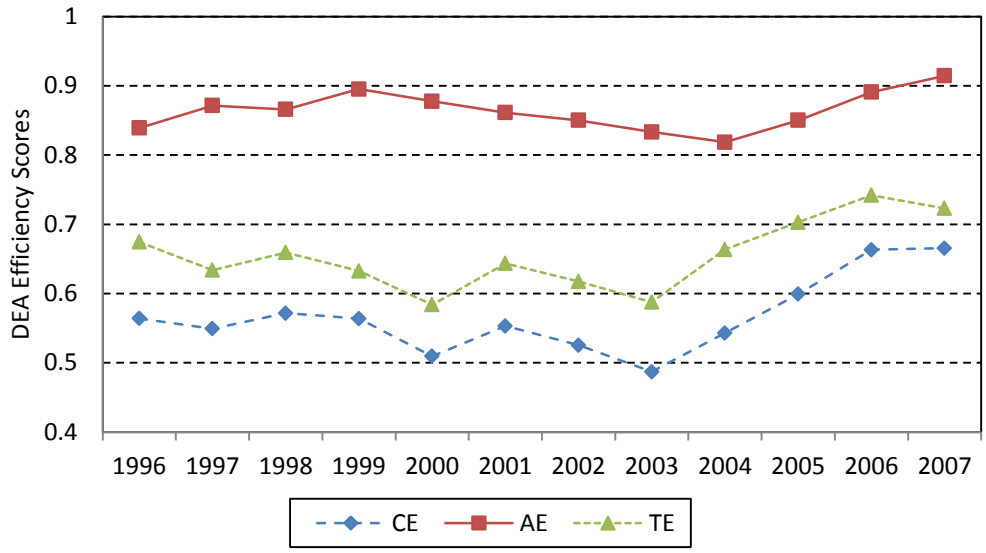


Table 3 presents the sample period mean estimates of cost, allocative and technical efficiencies for the banking sector as a whole as well as for different bank categories.

Table 3: Mean DEA Estimates of Cost, Allocative and Technical Efficiency by Category, 1996–2007

Bank type	CE	AE	TE
Large	0.863	0.927	0.930
Medium	0.495	0.848	0.584
Small	0.528	0.858	0.616
Foreign Banks	0.460	0.904	0.508
All Domestic Banks	0.749	0.905	0.823
All Banks	0.737	0.906	0.814

The average cost efficiency of banks is 0.74, which implies that the banking sector could reduce the cost of production by 26 percent without affecting the level of output. This implies that banks have wasted 26 percent of resources in producing their levels of output. The allocative efficiency is quite high (90%), consistent with the estimates of allocative efficiency reported in studies on banking in other countries.

The large banks are found to be most efficient in terms of cost efficiency (86%), allocative efficiency (92.7%) and technical efficiency (93%) during the sample period. The small banks rank second in terms of their efficiency level. The cost efficiency of foreign banks is much lower than that of domestic banks.

The average estimates of CE, AE and TE (weighted geometric mean over the period) for individual banks are presented in Table 4. These estimates reveal that the medium-sized bank CPB ranked first in terms of all three efficiencies; the Arab Bank, the largest bank, ranked second and JIFB (a medium-sized bank) third. The medium-sized banks CAB and BOS were found to be the lowest performers in cost efficiency.

It is worth noting that medium-sized banks showed wide variations in efficiency, while the foreign banks seemed very similar in terms of their cost/ economic efficiency performance.

The time series estimates of the cost efficiency of different bank categories are presented in Table 5. and displayed in Figures 3 through 8. It follows from this table and figures that in terms of CE and TE, domestic firms performed better than foreign banks in each year over the sample period. The gap in their efficiency levels has widened, especially from 2000 onwards. However, in terms of allocative efficiency, there is hardly any significant difference in the performance of banks. The group of large banks has outperformed all other bank categories in terms of cost efficiency in almost all the sample years.

Table 4: Mean DEA Estimates of Cost, Allocative and Technical Efficiencies, 1996–2007

Banks	CE	AE	TE
Domestic Banks			
Large			
AB	0.896	0.948	0.945
HBTF	0.664	0.802	0.829
Medium			
JKB	0.579	0.937	0.618
JIBF	0.401	0.826	0.485
JNB	0.460	0.865	0.532
BOJ	0.377	0.714	0.528
CAB	0.362	0.747	0.485
UBJ	0.567	0.952	0.596
CPB	0.942	0.971	0.970
JIFB	0.717	0.967	0.742
Small			
ABC	0.523	0.902	0.580
JCB	0.545	0.797	0.684
AJIB	0.481	0.894	0.539
SGBJ	0.561	0.791	0.709
Foreign			
HSBC	0.440	0.981	0.449
BSC	0.480	0.947	0.507
CB	0.449	0.588	0.764

Note: CE: cost efficiency, AE: allocative efficiency, TE: technical efficiency

Table 5: DEA Estimates of Cost Efficiency by Category of Banks and ownership, 1996–2007

Banks	Efficiency	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Domestic Banks														
Large														
	CE	0.798	0.824	0.811	0.778	0.828	0.864	0.918	0.830	0.938	0.900	0.920	0.965	0.863
	AE	0.906	0.907	0.918	0.934	0.894	0.901	0.936	0.915	0.944	0.949	0.951	0.976	0.927
	TE	0.882	0.908	0.885	0.833	0.927	0.959	0.981	0.907	0.993	0.949	0.967	0.989	0.930
Medium														
	CE	0.502	0.513	0.502	0.526	0.433	0.469	0.416	0.400	0.433	0.552	0.639	0.620	0.495
	AE	0.745	0.857	0.780	0.858	0.873	0.881	0.854	0.851	0.818	0.848	0.897	0.926	0.848
	TE	0.674	0.599	0.643	0.614	0.496	0.532	0.488	0.470	0.529	0.651	0.712	0.669	0.584
Small														
	CE	0.512	0.477	0.507	0.491	0.577	0.553	0.493	0.439	0.473	0.550	0.650	0.667	0.528
	AE	0.849	0.865	0.882	0.899	0.910	0.892	0.839	0.788	0.746	0.821	0.908	0.913	0.858
	TE	0.603	0.551	0.575	0.546	0.634	0.620	0.587	0.558	0.634	0.670	0.716	0.730	0.616
Foreign Banks														
	CE	0.485	0.571	0.561	0.521	0.390	0.392	0.386	0.409	0.435	0.444	0.458	0.517	0.460
	AE	0.920	0.934	0.936	0.935	0.886	0.804	0.851	0.873	0.907	0.931	0.947	0.939	0.904
	TE	0.527	0.612	0.599	0.557	0.440	0.487	0.454	0.468	0.480	0.477	0.484	0.550	0.508
All Domestic Banks														
	CE	0.709	0.727	0.713	0.696	0.714	0.744	0.760	0.695	0.774	0.772	0.815	0.841	0.749
	AE	0.866	0.894	0.882	0.914	0.890	0.896	0.915	0.897	0.907	0.915	0.933	0.959	0.905
	TE	0.819	0.813	0.808	0.761	0.802	0.830	0.831	0.775	0.853	0.844	0.873	0.876	0.823
ALL Banks														
	CE	0.700	0.721	0.707	0.689	0.704	0.736	0.750	0.687	0.765	0.764	0.805	0.831	0.737
	AE	0.868	0.896	0.884	0.915	0.890	0.895	0.913	0.896	0.907	0.915	0.933	0.958	0.906
	TE	0.807	0.805	0.800	0.753	0.791	0.822	0.822	0.767	0.843	0.835	0.863	0.867	0.814

. Notes*:* CE: cost efficiency; AE; allocative efficiency; TE: technical efficiency. The cost efficiency estimates for each bank category are the weighted average means of bank specific efficiencies, where the weights are their shares in the aggregate output of the bank category they belong to. The weights vary from year to year.

The annual estimates of cost efficiency scores and the components for each bank, presented in Table 6, show yearly fluctuations in cost efficiency over the deregulation era from 1996 until 2007. Despite annual fluctuations, most estimates of cost efficiency reveal an improvement after 2003, revealing that banking deregulation had a positive impact on efficiency in the later phase of deregulation.

Table 6: DEA Estimates of Cost Efficiency for Domestic and Foreign Banks, 1996–2007

Bank	Cost Efficiency	1996	1997	1998	1999	2000	2001	2002
Large								
AB	CE	0.827	0.861	0.840	0.799	0.854	0.878	0.953
	AE	0.910	0.910	0.923	0.939	0.896	0.914	0.964
	TE	0.909	0.946	0.911	0.851	0.953	0.960	0.989
HBTF	CE	0.637	0.608	0.637	0.641	0.625	0.758	0.662
	AE	0.879	0.888	0.882	0.902	0.872	0.799	0.727
	TE	0.725	0.684	0.723	0.711	0.717	0.948	0.911
Medium								
JKB	CE	0.522	0.530	0.474	0.446	0.437	0.491	0.488
	AE	0.877	0.883	0.900	0.909	0.944	0.952	0.935
	TE	0.595	0.600	0.526	0.491	0.463	0.516	0.522
JIBF	CE	0.712	0.684	0.595	0.564	0.371	0.350	0.249
	AE	0.827	0.816	0.809	0.775	0.731	0.715	0.765
	TE	0.861	0.838	0.736	0.728	0.508	0.489	0.325
JNB	CE	0.563	0.558	0.681	0.602	0.458	0.428	0.359
	AE	0.753	0.883	0.868	0.871	0.943	0.952	0.889
	TE	0.748	0.632	0.784	0.691	0.486	0.450	0.404
BOJ	CE	0.260	0.392	0.238	0.461	0.394	0.399	0.385
	AE	0.421	0.819	0.419	0.816	0.818	0.785	0.786
	TE	0.617	0.479	0.568	0.566	0.482	0.508	0.490
CAB	CE	0.428	0.359	0.422	0.373	0.343	0.332	0.319
	AE	0.822	0.864	0.838	0.851	0.821	0.836	0.728
	TE	0.521	0.415	0.503	0.438	0.417	0.397	0.439
UBJ	CE	0.460	0.503	0.444	0.438	0.439	0.516	0.534
	AE	0.930	0.918	0.940	0.967	0.961	0.975	0.941
	TE	0.495	0.547	0.472	0.453	0.457	0.530	0.568
CPB	CE	1.000	0.697	1.000	1.000	0.927	0.927	1.000
	AE	1.000	0.809	1.000	1.000	0.927	0.994	1.000
	TE	1.000	0.862	1.000	1.000	1.000	0.932	1.000
JIFB	CE	0.532	0.513	0.613	0.735	0.517	0.964	0.800
	AE	0.830	0.913	0.997	0.991	0.965	0.964	0.999
	TE	0.641	0.561	0.615	0.741	0.535	1.000	0.801
Small								
ABC	CE	0.572	0.538	0.514	0.477	0.475	0.481	0.474
	AE	0.917	0.927	0.927	0.929	0.974	0.941	0.896
	TE	0.624	0.580	0.555	0.513	0.487	0.511	0.530
JCB	CE	0.557	0.534	0.577	0.573	0.663	0.657	0.422
	AE	0.756	0.768	0.820	0.853	0.883	0.872	0.796
	TE	0.737	0.695	0.703	0.671	0.751	0.754	0.531
AJIB	CE	0.334	0.307	0.373	0.407	0.595	0.485	0.576
	AE	0.917	0.944	0.939	0.939	0.906	0.895	0.849
	TE	0.365	0.325	0.397	0.433	0.657	0.542	0.679
SGBJ	CE	0.725	0.628	0.681	0.526	0.409	0.527	0.505
	AE	0.835	0.826	0.823	0.860	0.844	0.766	0.716
	TE	0.869	0.760	0.828	0.611	0.484	0.688	0.706
Foreign								
HSBC	CE	0.510	0.641	0.563	0.466	0.411	0.366	0.357
	AE	0.995	0.985	0.995	0.999	0.993	0.971	0.974
	TE	0.513	0.651	0.566	0.466	0.414	0.377	0.367
BSC	CE	0.453	0.536	0.588	0.571	0.378	0.407	0.381
	AE	0.952	0.961	0.978	0.998	0.924	0.769	0.918
	TE	0.476	0.557	0.601	0.572	0.408	0.530	0.415
CB	CE	0.495	0.447	0.476	0.507	0.365	0.436	0.467
	AE	0.642	0.698	0.662	0.620	0.518	0.540	0.571
	TE	0.771	0.641	0.719	0.818	0.705	0.808	0.818

Note: CE: Cost Efficiency; AE: allocative Efficiency; TE: technical efficiency

Table 6 (Continued): DEA Estimates of Cost Efficiency for Domestic and Foreign Banks, 1996–2007

Bank	Cost Efficiency	2003	2004	2005	2006	2007	Mean
Large							
AB	CE	0.877	1.000	0.947	0.942	1.000	0.896
	AE	0.951	1.000	0.997	0.981	1.000	0.948
	TE	0.922	1.000	0.950	0.960	1.000	0.945
HBTF	CE	0.527	0.603	0.693	0.826	0.815	0.664
	AE	0.665	0.636	0.736	0.826	0.870	0.802
	TE	0.793	0.949	0.942	1.000	0.937	0.829
Medium							
JKB	CE	0.519	0.592	0.826	1.000	0.912	0.579
	AE	0.936	0.953	0.992	1.000	0.967	0.937
	TE	0.555	0.621	0.833	1.000	0.944	0.618
JIBF	CE	0.246	0.265	0.335	0.369	0.408	0.401
	AE	0.874	0.922	0.888	0.924	0.907	0.826
	TE	0.282	0.288	0.377	0.399	0.449	0.485
JNB	CE	0.361	0.329	0.387	0.451	0.477	0.460
	AE	0.888	0.856	0.795	0.801	0.901	0.865
	TE	0.406	0.384	0.487	0.563	0.529	0.532
BOJ	CE	0.359	0.353	0.418	0.494	0.464	0.377
	AE	0.714	0.633	0.792	0.869	0.941	0.714
	TE	0.503	0.558	0.527	0.569	0.493	0.528
CAB	CE	0.261	0.266	0.422	0.454	0.438	0.362
	AE	0.689	0.583	0.590	0.683	0.741	0.747
	TE	0.379	0.456	0.714	0.665	0.591	0.485
UBJ	CE	0.526	0.710	0.859	0.828	0.765	0.567
	AE	0.945	0.913	0.950	0.998	0.995	0.952
	TE	0.557	0.778	0.904	0.830	0.768	0.596
CPB	CE	0.893	0.947	0.995	0.974	1.000	0.942
	AE	0.985	0.989	0.995	0.974	1.000	0.971
	TE	0.907	0.957	1.000	1.000	1.000	0.970
JIFB	CE	0.649	0.861	0.828	1.000	0.814	0.717
	AE	0.990	0.974	0.995	1.000	0.998	0.967
	TE	0.656	0.884	0.832	1.000	0.816	0.742

Table 6 (Continued): DEA Estimates of Cost Efficiency for Domestic and Foreign Banks, 1996–2007

Bank	Cost Efficiency	2003	2004	2005	\2006	2007	Mean
Small							
ABC	CE	0.430	0.472	0.583	0.664	0.650	0.523
	AE	0.819	0.828	0.870	0.906	0.899	0.902
	TE	0.525	0.571	0.670	0.732	0.723	0.580
JCB	CE	0.482	0.396	0.531	0.608	0.617	0.545
	AE	0.699	0.586	0.739	0.928	0.937	0.797
	TE	0.690	0.675	0.719	0.655	0.658	0.684
AJIB	CE	0.423	0.512	0.555	0.684	0.725	0.481
	AE	0.828	0.802	0.877	0.918	0.923	0.894
	TE	0.511	0.639	0.633	0.745	0.786	0.539
SGBJ	CE	0.465	0.511	0.505	0.649	0.696	0.561
	AE	0.696	0.677	0.790	0.820	0.868	0.791
	TE	0.668	0.754	0.639	0.791	0.802	0.709
Foreign							
HSBC	CE	0.384	0.369	0.398	0.446	0.458	0.440
	AE	0.988	0.943	0.976	0.997	0.961	0.981
	TE	0.388	0.391	0.408	0.447	0.476	0.449
BSC	CE	0.426	0.487	0.520	0.485	0.602	0.480
	AE	0.925	0.989	0.982	1.000	0.996	0.947
	TE	0.460	0.493	0.530	0.485	0.604	0.507
CB	CE	0.453	0.556	0.383	0.400	0.439	0.449
	AE	0.575	0.630	0.489	0.519	0.632	0.588
	TE	0.787	0.883	0.783	0.771	0.694	0.764

Note: TE: technical efficiency; PTE: pure technical efficiency; SE: scale efficiency.

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 cost efficiency as the sum of the growth of allocative and technical efficiencies using the relationship AE ×TE = CE (see Equation 5). The decomposition estimates for broad categories of banks for the full period under study as well as three sub-periods 1996–99, 1999–03 and 2003–07, are presented in Table 7. These sub-periods constitute the early, medium and later phases of financial deregulation/ reform in Jordanian economy.

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

As Table 7 shows, the banking sector as a whole experienced a decline in cost efficiency at the rate of 0.54 and 0.06 % per annum respectively in the early and middle phases of financial deregulation. In the latter phase, cost efficiency increased at the rate of 4.73 % per annum, two thirds of this improvement from an improvement in technical efficiency. Over the entire sample period, cost efficiency increased at the rate of 1.55% per annum; the improvement in allocative efficiency contributed about 60% of this figure.

In the early phase of deregulation, all bank categories except foreign banks showed deterioration in cost efficiency. However, in the later phase, 2003–2007, small, medium and foreign banks showed large improvements in cost, allocative and technical efficiencies.

Table 7: Average Annual Growth Rates of Cost Efficiency by Sub-group, 1996–2007 (Percentage)

Bank type	Period	Growth of CE	Growth of AE	Growth of TE
Domestic Banks				
Large Banks				
	1996–99	-0.861	1.040	-1.901
	1999–03	1.621	-0.521	2.142
	2003–07	3.752	1.603	2.149
	1996–2007	1.719	0.677	1.042
Medium Banks				
	1996–99	1.591	4.708	-3.117
	1999–03	-6.858	-0.203	-6.655
	2003–07	10.947	2.121	8.826
	1996–2007	1.920	1.981	-0.061
Small Banks				
	1996–99	-1.416	1.899	-3.315
	1999–03	-2.758	-3.283	0.525
	2003–07	10.416	3.688	6.728
	1996–2007	2.398	0.665	1.733
Foreign Banks				
	1996–99	2.370	0.520	1.850
	1999–03	-6.071	-1.712	-4.359
	2003–07	5.856	1.828	4.028
	1996–2007	0.568	0.184	0.384
ALL Domestic Banks				
	1996–99	-0.614	1.811	-2.425
	1999–03	-0.031	-0.487	0.456
	2003–07	4.748	1.679	3.069
	1996–2007	1.548	0.928	0.620
All Banks				
	1996–99	-0.541	1.773	-2.314
	1999–03	-0.066	-0.519	0.453
	2003–07	4.735	1.681	3.054
	1996–2007	1.550	0.906	0.644

Note: CE: cost efficiency; AE: allocative efficiency; TE: technical efficiency.

Figure 3: DEA Estimates of Cost Efficiency by Bank Category, 1996–2007

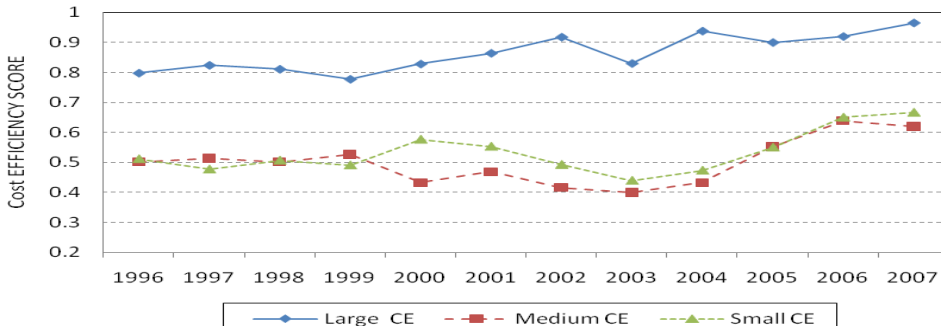


Figure 4: DEA Estimates of Allocative Efficiency by Bank Category, 1996–2007

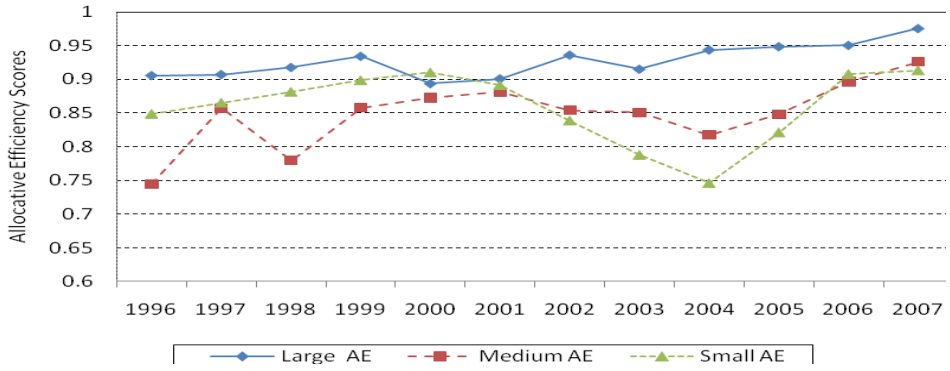


Figure 5: DEA Estimates of Technical Efficiency by Bank Category, 1996–2007

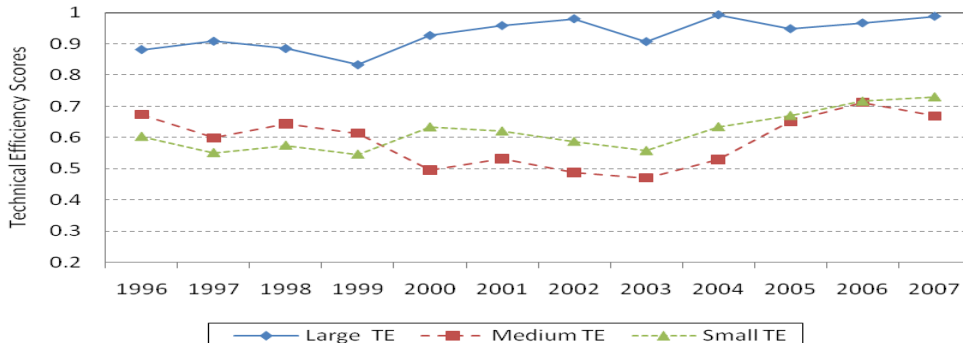


Figure 6: DEA Estimates of Cost Efficiency by Bank Ownership, 1996–2007

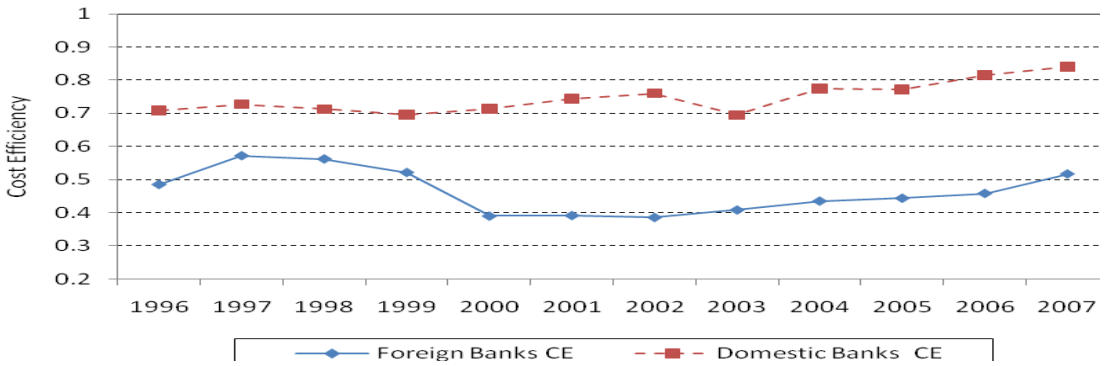


Figure 7: DEA Estimates of Allocative Efficiency by Bank Ownership, 1996–2007

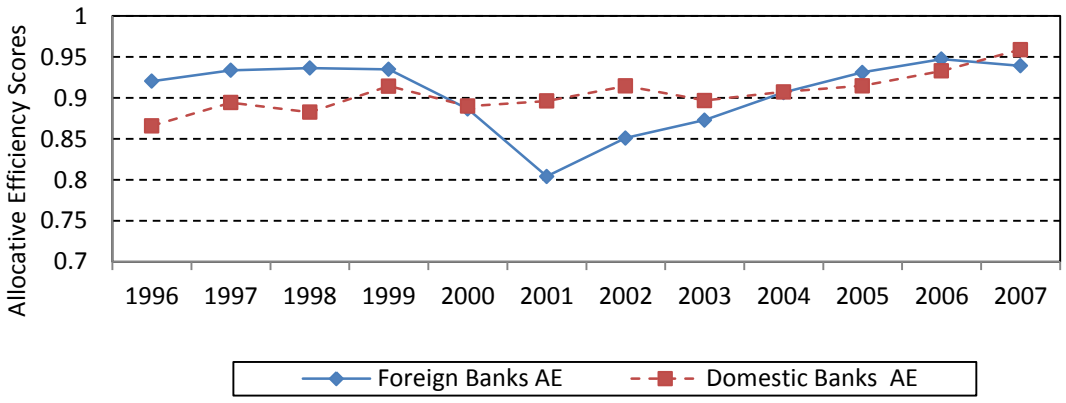
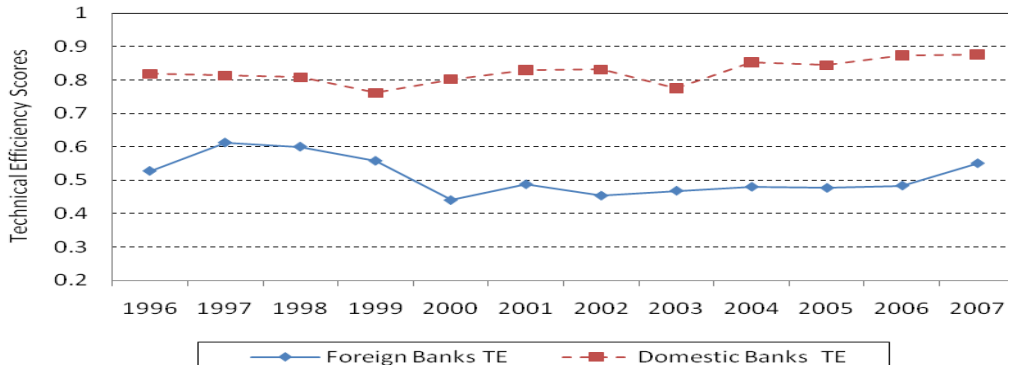


Figure 8: DEA Estimates of Technical Efficiency by Bank Ownership, 1996–2007



6. Conclusions

This paper has investigated the level of cost efficiency in 17 Jordanian banks using annual data for 1996-2007. The cost efficiency scores for each bank are obtained using the input-oriented DEA model. The cost efficiency is decomposed into allocative and technical efficiency levels. The average cost efficiency score of banks is 0.74, which implies that they could reduce the cost of production by 26 percent without affecting the level of output.

The large banks are found most efficient in terms of cost efficiency (86%), allocative efficiency (92.7%) and technical efficiency (93%) during the sample period. The small banks rank second in terms of efficiency level. The cost efficiency of foreign banks is much lower than that of the domestic banks.

Over the entire sample period, cost efficiency has increased at the rate of 1.55% per annum; the improvement in allocative efficiency has contributed about 60% of this. While cost efficiency shows a decline during the early and middle phase of deregulation, it shows large improvements in the final phase of financial deregulation in Jordan.

Endnotes

[i] Coelli et al. (2005) discussed input-oriented and output-oriented measures, for more details see pp.51-57.

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