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Evaluating the contribution of Bank-specific variables in the Cost Efficiency of the Jordanian Banks

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Abstract

This paper examines the cost efficiency of seventeen Jordanian banks during the period of financial deregulation, 1996-2007. This paper follows a two-stage approach. In the first stage, cost efficiency scores are computed using an input-oriented data envelopment analysis (DEA). At the second stage, cost efficiency scores are regressed on a set of potential explanatory variables in a logit model. While the cost efficiency scores show a declining trend during the early and middle phase of deregulation, they show large improvements in the final phase of financial deregulation. 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. In this sample I find that bank size, loan to deposit ratio and good management practises positively affects banks cost efficiency and return on equity and number of bank branches negatively affect bank cost efficiency.

JEL classification numbers: D22, D24, D61 and G21
Keywords: Cost Efficiency, Deregulation, Two-stage Data Envelopment Analysis, Jordanian Banks.

1 Introduction

There is an enormous body of literature on measuring banking efficiency in the Western economies. The studies of banking efficiency for the Middle East economies are few. The reasons for this can be attributed to two factors. First, the financial systems of many Middle Eastern countries are highly regulated and outdated. They are dominated by the public sector and do not face much competition. Second, reliable data on banks are not available for many countries. However, during the last fifteen years, many Middle East economies

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have gradually moved towards liberalising their financial systems. This has encouraged researchers to undertake studies of banking efficiency and productivity in some of the countries, see, for example, Hassan et al. (2004) for Bahrain and Al-Muharrami (2007) for GCC countries. The efficiency is a vital factor for financial institutions wishing to carry out their business successfully, given the increasing competition in the financial markets. Moreover, in a rapidly changing and more globalised financial marketplace, governments, regulators, managers and investors are concerned about how efficiently banks transform their expensive inputs into various financial products and services.

The present study examines the cost efficiency of banks operating in Jordon during the period of financial deregulation, 1996–2007. Jordan represents an example of a successful transformation from a highly regulated regime to a deregulated economy. Before the 1980s, the Jordanian banking sector was highly regulated, and economic policies were directed towards protecting them from 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 (Bdour and Al-khoury, 2008). In 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 inappropriate 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 of Jordan, the International Monetary Fund (IMF) and the World Bank in order to develop the Jordanian banking sector and to initiate a reform program. The government took various steps 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 restrictions on foreign exchange transactions and on the movement of capital. In addition, the government adopted trade liberalisation policies to enhance economic growth and promote exports (Maghyereh, 2004; Central Bank of Jordan, 2005).

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

One of the earliest studies of technical efficiency in the Jordanian banking sector was Al-Shammari and Salimi's (1998). In this study, DEA was used and an input oriented model was applied to 16 out of 18 commercial banks operating in Jordan in the period 1991–1994. The dataset for the study was obtained from the Amman Financial Market (1995). The empirical results revealed that the majority of banks investigated were fairly technically inefficient over the study period. Maghyereh (2004) investigated total factor productivity (TFP) in eight domestic Jordanian banks over 18 years from 1984 to 2001. The DEA model used three inputs (labour, capital, and deposits) and three outputs (earning assets, loans and liquid assets and investments). The results indicated that the mean of technical efficiency for all banks over the sample period was 91.8. The main source of technical inefficiency in the Jordanian banks was scale inefficiency, with an average rate of 93.1%, which means the inefficiency due to the divergence of the actual scale of operation for the most productive scale size is 6.9%. also, the average pure technical efficiency is 96%, which means that banks could produced the same amount of outputs with only 4% fewer inputs.

Importantly, the result indicated that the larger banks in the sample had lower scale efficiency and higher pure technical efficiency than small and medium banks.

Isik et al. (2004) analysed managerial[2] and scale efficiencies in the Jordanian banking sector (17 commercial, investment and Islamic banks) 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.

Bdour and Al–Khoury (2008) evaluated the technical 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. The average technical efficiency score during the period 1998-2004 were (53.09%, 96.36%, 98.77%, 98.38%, 99.03%, 89.42%, and 83.36%) respectively.

Recently, Paul & Jreisat (2012) investigated the level of cost efficiency in 17 Jordanian banks during the period 1996-2007 in which financial deregulation took place. However, this paper continues to Paul & Jreisat (2012) uses second stage, Cost efficiency scores are regressed on a set of potential explanatory variables in a logit model. Firstly, uses a DEA based approach, where input-oriented model is employed in order to examine cost efficiency in the Jordanian banking sector spanning the entire deregulated period: 1996-2007. I adopt two-stage approach, in which cost efficiency scores for the sample under study are estimated in the first stage. Further in the first stage, the cost efficiency scores were decomposed into the product of allocative and technical efficiency. Finally, in the second stage I study the potential determinants of cost efficiency.

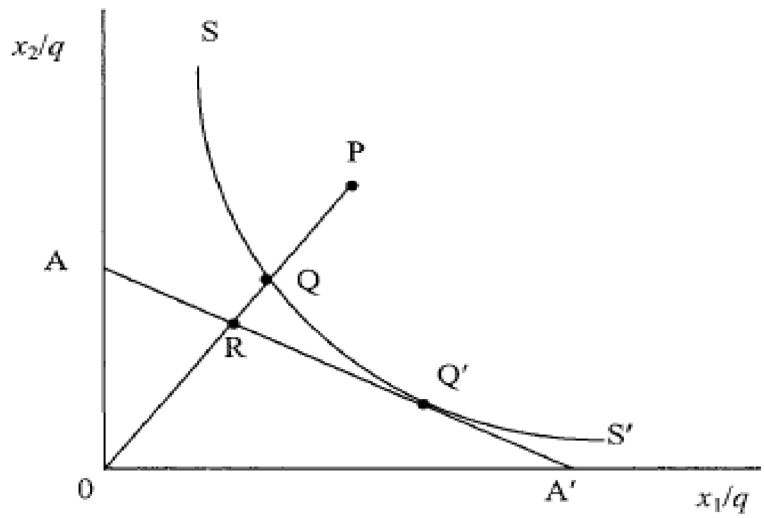
The paper is organised as follows. Section 2 discusses the concept of cost efficiency and its estimation based on DEA approach. Section 3 discusses the data as well as input and output variables. The results on banking cost efficiencies are discussed in Section 4. Determinants of banks efficiency and the related estimation results are presented in Section 5. Section 6 presents some conclusions.

[2]Managerial inefficiency consists of two mutually exclusive and exhaustive components, firstly, pure technical inefficiency.

2 The Cost Efficiency: 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 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. The allocative efficiency (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. Cost efficiency is defined as the ratio of minimum (optimum) cost to the observed cost for producing a level of output by a firm. If the cost efficiency 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 cost efficiency can be conceptualised and measured using input-oriented framework. Following the lead of Farrell (1957), I consider a simple example of a bank 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 minimising input vector at Q' respectively. Thus, cost efficiency can be defined as the ratio of input costs associated with input vectors x and x^* associated with points P and Q′.

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



Source: Coelli et al. (2005)
Figure 1: Cost, Technical and Allocative Efficiencies

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:

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

$$TE = \frac{w'\hat{x}}{w'x} = \frac{OQ}{OP} \tag{3}$$

Thus, if the firm sets its inputs at the point Q on the unit 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:

$$TE \times AE = (OQ/OP) \times (OR/OQ) = (OR/OP) = CE. \tag{4}$$

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 often called economic efficiency or overall efficiency. The details of linear programming required to estimate cost efficiency is provided in Coelli et al. (2005, p.184) and hence is not repeated here.

3 The Data and Variables

There is no agreement among economists on the choice of bank inputs and outputs required for estimating DEA model; in fact, the choice of input and output variables for the banking sector remains controversial. In the literature, I come across three distinct approaches for selecting inputs and outputs: the production approach, the intermediation approach, and the value-added approach. The first approach views financial institutions as producers who use inputs of labour and capital to generate outputs of deposits and loans. This approach is used by Sathye (2001), Neal (2004) and many others. 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 and Wilson, 1995).

The intermediation approach is quite popular in empirical research particularly that based on cross-sectional data (Colwell and Davis, 1992; Favero and Papi, 1995). The production approach is known to have a limitation in that 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 lies in examining intermediation efficiency, then the intermediary approach is more appropriate. The choice of variables may also depend on the availability of data.

Following intermediation approach, I choose two inputs, labour (x_1) and total deposits (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 GDP deflator. Ideally an investment price deflator should have been used to express other investments at constant prices. Since information on investment deflators is not available, I 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, out of these 14 are domestic and 3 are foreign banks. The data for domestic banks (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 I 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 (measured in Jordanian Dinar) in 2007: (i) Large domestic banks (Assets size $\geq$ JD 4000 million), (ii) Medium domestic banks (700 $\leq$ Assets size $<$ JD 4000 million), and (iii) Small domestic banks (Assets size $<$ JD 700 million). The banks' assets have changed over the years but this has not changed their classification, facilitating their comparison over the sample period. The banks are listed in Table 1.

Table 1: Assets of Domestic and Foreign Banks, 2007

Bank Category	Bank Name	Short Name	Total Assets (JD millions)
Domestic			
Large	Arab Bank	AB	6093
	The Housing Bank for Trade and Finance	HBTF	4132.6
Medium	Jordan Kuwait Bank	JKB	1752
	Jordan Islamic Bank For Finance and Investment	JIBF	1596.83
	Jordan National Bank	JNB	1548.58
	Bank of Jordan	BOJ	1276
	Cairo Amman Bank	CAB	1085.36
	Union Bank for Saving and Investment	UBJ	1056.3
	Capital Bank	CPB	896.82
	Jordan Investment and Finance Bank	JIFB	707.37
Small	Arab Banking Corporation	ABC	574
	Jordan Commercial Bank	JCB	533.92
	Arab Jordan Investment Bank	AJIB	516
	Societe Generale De Banque-Jordanie	SGBJ	222.58
Foreign			
	HSBC BanK	HSBC	587.07
	Bank Standard Charter	BSC	483.89
	Citi Bank	CB	241.8

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

A summary of statistics on outputs, inputs and input prices for different categories of banks is provided in Table 2. A few interesting points emerge from the table. First, the number of employees in large banks is almost three times the number in medium sized banks, six times the number in small banks and twelve times the number in foreign banks. The number of employees within the domestic banks as a whole is five times that of the number within foreign banks. Also, the deposits in the large Jordanian banks are almost eleven times of those held by medium banks, and thirty two times of those of small banks.

Second, the total loans extended to the customers by Jordanian banks of all sizes are about half of that total deposits. In light of this, it can be inferred that Jordanian banks are facing a risky business environment and so they may be reluctant to engage heavily in loan markets, as business credits are more costly to originate, maintain and monitor. The total loans provided by domestic banks to customers are seven times larger than those provided by foreign banks. Other investments of domestic banks are twenty six times larger than those of foreign banks,

Third, all input and output variables are more volatile for large banks compared the medium and small banks. The standard deviations of all variables for the large banks are larger than the medium and small banks, and the large banks have the smallest minimum and largest maximum.

4 Empirical Results on Cost Efficiency

The cost efficiency scores of banks are obtained by running an input-oriented DEA model using the software package, DEAP Version 2.1 (Coelli, 1996). While the bank specific yearly scores are presented in Appendix Table A1, Table 4 presents 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 cost efficiency score was low (55.4%) in the beginning of the sample period. The efficiency scores show a declining trend with some fluctuations up to 2003 and an improvement thereafter, showing the highest cost efficiency score of 66.5% in the final year (2007) of the sample period. The estimates of allocative efficiency are higher than the technical efficiency in each year, see Fig. 1.

Table 2: Summary Statistics for the Variables for the Jordanian Banks 1996–2007

Variable	Mean	SD	Minimum	Maximum
Large Banks				
Total Loans	3163.35	2491.00	556.61	7867.51
Other Investments	1444.36	1310.84	129.18	4019.06
Labour	2079	380	1639	2894
Total Deposits	6871.50	5439.22	976.81	13845.15
Price of Labour	32557	21368	5519	63685
Price of Fund	0.0384	0.0152	0.0120	0.0589
Medium Banks				
Total Loans	292.18	173.88	11.39	898.26
Other Investments	86.13	51.58	3.19	205.16
Labour	861	573	41	1611
Total Deposits	597.96	354.63	14.20	1381.49
Price of Labour	10573	4331	4849	24493
Price of Fund	0.0430	0.0198	0.0118	0.0860
Small Banks				
Total Loans	106.97	59.42	21.03	234.98
Other Investments	29.95	32.10	0.31	113.54
Labour	338	128	177	699
Total Deposits	210.62	106.56	36.36	387.01
Price of Labour	10184	3652	4526	25304
Price of Fund	0.0478	0.0193	0.0165	0.0888
Foreign Banks				
Total Loans	92.46	52.29	14.17	203.04
Other Investments	10.08	6.47	0.20	30.95
Labour	168	93	54	393
Total Deposits	236.66	97.32	93.34	442.33
Price of Labour	17945	6305	9213	39297
Price of Fund	0.0309	0.0164	0.0053	0.0562

Note: SD: standard deviation. Total loans, total deposits and other investments are expressed in Jordanian Dinar (millions) at constant 2000 prices and labour is the number of employees.

Table 3: Estimates of Cost, Allocative and Technical Efficiencies, Jordanian Banking Sector, 1996–2007

Year	CE	AE	TE
1996	0.564	0.839	0.675
1997	0.549	0.871	0.634
1998	0.572	0.866	0.659
1999	0.564	0.895	0.633
2000	0.509	0.878	0.584
2001	0.553	0.861	0.644
2002	0.525	0.850	0.617
2003	0.487	0.833	0.588
2004	0.543	0.818	0.664
2005	0.599	0.850	0.703
2006	0.663	0.891	0.742
2007	0.665	0.914	0.723

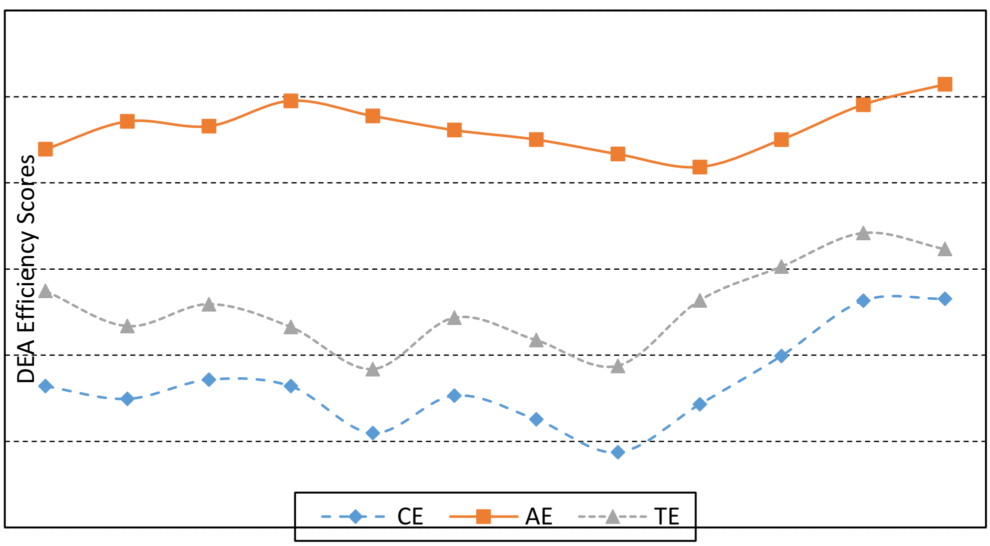


Figure 2: Technical, Allocative and Cost Efficiency Scores, 1996–2007

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 4. The cost efficiency score of banks is 0.74, which implies that the banking sector could have reduced the cost of production by 26 percent without affecting the level of output. In other words, banks have wasted 26 percent of resources in producing their levels of output. The allocative efficiency is quite high (90%). This is consistent with the estimates reported for banks in most of the countries. The group of large banks is found to be most efficient in terms of cost efficiency as well as in terms of allocative and technical efficiencies. The group of small banks ranks second in terms of their efficiency. The cost efficiency of foreign banks is found to be the lowest (46%). The time series estimates of the cost efficiency by bank categories presented in Table 5 also reveal that the group of domestic banks has performed better than foreign banks in terms of CE and TE in each year of the sample period. The gap in their efficiency levels has widened, especially from 2000 onwards. The allocative efficiency of foreign banks is higher than the domestic banks. This implies that in terms of input use in response to input prices, the foreign banks are more efficient than their domestic counterparts. The group of large banks has outperformed all other bank categories in terms of cost efficiency in almost all the sample years.

Table 4: Sample Period Mean Estimates of Cost, Allocative and Technical Efficiencies

Bank categories	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

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

Table 5: 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

Note: CE: cost efficiency; AE: allocative efficiency; TE: technical 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, I 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 represent the early, medium and later phases of financial deregulation/ reform in Jordanian 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 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 has 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 has increased at the rate of 1.55% per annum. The allocative efficiency has contributed about 60% of this increase.

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 6: Average Annual Growth Rates of Cost Efficiency by Bank Category in Sub Periods

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.

5 Determinants of Cost Efficiency

So far, I analysed cost efficiency decomposed into technical and allocative efficiencies at aggregated level. What is equally important is to know what explains the differences in the cost efficiency scores between banks in Jordan. The annual estimates of cost efficiency for each bank presented in Appendix Table A1 show a vast variation ranging from 0.24 to 1.00. In this section, I identify a set of variables that may affect the efficiency level of a bank. The potential variables of interest are drawn from a number of recent international studies on banking efficiency (eg, Cavallo and Rossi (2002), Hermes and Nhung (2010), Pasiouras et al. (2009), Casu and Girardone (2004) and Vu and Turnell (2011)).

5.1 Explanatory Variables

I briefly discuss potential effects of various variables on the cost efficiency of the banks below:

LTA: Following Dong (2009) I use the logarithm of total assets as a proxy for bank size. This variable captures the effects of scale on cost efficiency.

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 & Turnell (2011) found a positive and statistically significant relationship between LTD and cost efficiency.

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

ROE: It is the return on equity. The higher the ROE, the more cost efficient the bank is.

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 more efficient the bank is.

BRANCH: Number of branches for each bank refers to network density. A high network density leads to higher structural overheads and thus may lower cost efficiency. 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 Moudos et al. (2002) find a negative and significant relationship between number of branches and cost efficiency. At the same time, for all other bank categories, they find that the number of branches does not have any significant effect on cost efficiency.

5.2 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 cost efficiency be represented by *CE*,the fractional variable of interest, $0 \le CE \le 1$, 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*:

$$E(CE / x) = x\beta \quad (6)$$

However, given that the dependant 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

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

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

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

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[3] 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:

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[3]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.

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

where 0 < G(.) < 1 is a logit function. The estimates[4] for the parameter β can be obtained by maximizing the log-likelihood for the entire sample of 17 Jordanian 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 $\hat{A} = (N \times T)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{g}_{it}^{2} x_{it}^{'} x_{it} [\hat{G}_{it}(1 - \hat{G}_{it})]^{-1}$ 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 $u_{it} = CE_{it} - \hat{CE}_{it}$.

5.3 Results

Now, the regression estimates obtained using method developed by Papke and Wooldridge (1996). Presented in Table 7 are the regression coefficients obtained from OLS and quasi-maximum likelihood estimator (QMLE) based on equation (9).

The coefficient of LTA is estimated to be positive and significant, indicating that larger banks are more cost efficient than smaller ones. The positive and statistically significant coefficient of LTD suggests that banks which have a higher ability of transforming loans into deposit are more cost efficient than others. This result is quite intuitive in that as higher loans to deposit ratio suggest that the inputs are used productively, leading to a reduction in cost.

The negative and significant coefficient of NIETA implies that higher administrative cost leads to a decrease in cost efficiency. The negative and significant sign of ROE suggests that banks which are more profitable are less cost efficient. At the first instance this result may seem counter-intuitive. ROE indicates how well bank management is using the investors' capital. However, it turns out, that a bank cannot grow earnings faster than its current ROE without raising additional cash. That is, a bank that now has a 5% ROE cannot increase its earnings faster than 5% annually without borrowing funds or selling more shares. But raising funds comes at a cost: servicing additional debt cuts into net income and selling more shares shrinks earnings per share by increasing the total number of shares outstanding.

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

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[4]The Stata command for this estimator can be downloaded from the following link: https://www.msu.edu/~ec/faculty/papke/flogitinstructions.pdf .

Branches suggests banks with a bigger network of branches are relatively cost inefficient possibly due to higher structural overloads.

Table 7: Estimates of Regression Model

Variables	Coefficient (OLS)	Coefficient (QMLE)
Constant	-1.822107***	-10.8136***
	(.3427982)	(1.63704)
LTA	0.1097059***	0.510878***
	(.0178162)	(0.0840933)
LTD	.6990829***	3.254273***
	(.0587814)	(0.3205346)
NIETA	-2.831957***	-13.15337***
	(.9186541)	(4.339031)
ROE	-.0020495**	-0.0099465**
	(.0009791)	(0.0045267)
NIM	2.311214***	10.91649***
	(.7389316)	(3.890463)
BRANCHES	-0.0033514***	0.0158394***
	(.0006622)	(0.003026)
No of observation	204	204
R^2	0.4835	
Log pseudo-likelihood		-90.40307049

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Asymptotic standard errors in parentheses.

6 Conclusions

In this paper, I adopt two-stage approach, in which efficiency scores are estimated in the first stage using input oriented DEA, and in the second stage I study the potential determinants of cost efficiency. I estimate the level of cost efficiency in 17 Jordanian banks using annual data for 1996-2007. 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. The results obtained seem to justify Jordanian government's policy to deregulate the banking sector. In the short term after the banking sector was deregulated the cost efficiency deteriorated as the banks were re-organizing in order to manage this abrupt transition. During the transition period the banks were able re-allocate (AE) their inputs as well as improve their operating techniques (TE), thus in the process they were able to reduce their overall cost. Hence, in the final phase it observe large improvements in cost efficiency.

In the second stage I further analyse the factors playing a critical role in shaping the cost efficiency of Jordanian banks. i find that loans to deposit ratio, administrative cost, net interest margins and bank size are the main determinants cost efficiencies of Jordanian banks. Thus, the policy implications for the banking sector to improve cost efficiency 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.; and (c) to ensure that the available liquid funds are managed properly.

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Appendix

Table A1: DEA Estimates of Cost Efficiency for Domestic and Foreign Banks, 1996–

2007

Bank	1996	1997	1998	1999	2000	2001	2002
Large							
AB	0.827	0.861	0.840	0.799	0.854	0.878	0.953
HBTF	0.637	0.608	0.637	0.641	0.625	0.758	0.662
Medium							
JKB	0.522	0.530	0.474	0.446	0.437	0.491	0.488
JIBF	0.712	0.684	0.595	0.564	0.371	0.350	0.249
JNB	0.563	0.558	0.681	0.602	0.458	0.428	0.359
BOJ	0.260	0.392	0.238	0.461	0.394	0.399	0.385
CAB	0.428	0.359	0.422	0.373	0.343	0.332	0.319
UBJ	0.460	0.503	0.444	0.438	0.439	0.516	0.534
CPB	1.000	0.697	1.000	1.000	0.927	0.927	1.000
JIFB	0.532	0.513	0.613	0.735	0.517	0.964	0.800
Small							
ABC	0.572	0.538	0.514	0.477	0.475	0.481	0.474
JCB	0.557	0.534	0.577	0.573	0.663	0.657	0.422
AJIB	0.334	0.307	0.373	0.407	0.595	0.485	0.576
SGBJ	0.725	0.628	0.681	0.526	0.409	0.527	0.505
Foreign							
HSBC	0.510	0.641	0.563	0.466	0.411	0.366	0.357
BSC	0.453	0.536	0.588	0.571	0.378	0.407	0.381
CB	0.495	0.447	0.476	0.507	0.365	0.436	0.467

Bank	2003	2004	2005	2006	2007	Mean
Large						
AB	0.877	1.000	0.947	0.942	1.000	0.896
HBTF	0.527	0.603	0.693	0.826	0.815	0.664
Medium						
JKB	0.519	0.592	0.826	1.000	0.912	0.579
JIBF	0.246	0.265	0.335	0.369	0.408	0.401
JNB	0.361	0.329	0.387	0.451	0.477	0.460
BOJ	0.359	0.353	0.418	0.494	0.464	0.377
CAB	0.261	0.266	0.422	0.454	0.438	0.362
UBJ	0.526	0.710	0.859	0.828	0.765	0.567
CPB	0.893	0.947	0.995	0.974	1.000	0.942
JIFB	0.649	0.861	0.828	1.000	0.814	0.717
Small						
ABC	0.430	0.472	0.583	0.664	0.650	0.523
JCB	0.482	0.396	0.531	0.608	0.617	0.545
AJIB	0.423	0.512	0.555	0.684	0.725	0.481
SGBJ	0.465	0.511	0.505	0.649	0.696	0.56
Foreign						
HSBC	0.384	0.369	0.398	0.446	0.458	0.440
BSC	0.426	0.487	0.520	0.485	0.602	0.480
CB	0.453	0.556	0.383	0.400	0.439	0.449