Technical Efficiency of Jordanian Banking Sector Based on DEA Approach

[1]Ammar Jreisat* and [1]Satya Paul
[1]School of Economics and Finance, University of Western Sydney,
Locked Bag 1797,Penrith NSW 2751, Australia.
*Corresponding e-mail: a.jreisat@uws.edu.au

Abstract

This study examines efficiency levels of the Jordanian banking sector (13 domestic and 3 foreign banks) over the period 1996 to 2007, by estimating a non-parametric approach (Data Envelopment Analysis). The study also investigates the trends in estimated efficiency scores. Results indicate that large banks appear to be more efficient than small banks and domestic banks appear to be more efficient than foreign banks. Arab Bank is found to be the most technically efficient among large banks and Capital Bank of Jordan is found to be on average more technically efficient among all the medium banks also among the entire sample.

Keywords: *Technical Efficiency, Data Envelopment Analysis, Jordanian Banking Sector*

1. INTRODUCTION

This paper analyses the technical efficiency of banks in Jordan using a non-parametric data envelopment analysis (DEA) approach. For a comprehensive analysis technical efficiency is decomposed into pure technical efficiency and scale efficiency. The empirical results are obtained by running an input-oriented DEA model using the software package, DEAP Version 2.1 (Coelli, T. 1996). The study uses data for 13 domestic commercial banks and 3 foreign banks operating in Jordan during the period, 1996-2007. The rest of the paper is organised as follows: Section 2 briefly describes the DEA methodology and the sources of data on inputs and outputs required for running the DEA model. Section 3 discusses the results of technical efficiency decomposed into the product of pure technical efficiency and scale efficiency. Conclusions are presented in Section 4.

2. METHODOLOGY, VARIABLES AND DATA SOURCES

The DEA approach that we use for examining the technical efficiency of Jordanian banks is a linear programming technique. The DEA does not impose any preconceived structure on the data in determining the efficient firms i.e. it does not assume a particular production technology or correspondence. It identifies the inefficiency of a particular firm by comparing it with similar firms regarded as efficient, rather than associating a firm's performance with statistical averages. A disadvantage of this approach is that it assumes no random errors. If there is a random error in an observation on the frontier, it will be mistakenly reflected in the measured efficiency of all firms that are measured to that part of the frontier. Despite this limitation, DEA is widely used to estimate the technical efficiency of banks in most countries of the world. Since the empirical results based on DEA often depend or are influenced by the choice and/ or number of inputs and outputs entering into the model, we discuss below the variables that are often used in deriving the efficiency results.

2.1 *Choice of variable for DEA model*
Until now there is no agreement on the choice of bank inputs and outputs. Four different approaches/ conceptualisations have been used in defining input-output relationship in financial institution behavior. These are: (1) The production approach, (2) The intermediation approach, (3) The value-added approach and (4) The user-cost approach. The production approach is one in which financial institutions are viewed as producers who use inputs of

labour and capital to generate outputs of deposits and loans. This approach is used, among others, by Sathey (2001) and Neal (2004). The production approach is preferable when one is interested in cost efficiency as this approach focuses on the operating costs of banking (Farrier and Lovell, 1990 and Fried et al, 1993). The intermediation approach views financial institutions as intermediaries that convert and transfer financial assets from surplus units to deficit units. The key inputs are usually labour, deposits, and capital costs.

Other inputs are operating and interest costs, with outputs denominated in loans and financial investments. In an earlier study of Jordanian banks for the period 1990-1996, Ahmad, (2000) conceptualizes banks as intermediaries' that uses two inputs, labour and deposits and two outputs, total loans and other investments. In an another conceptualization of the intermediate 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 the outputs. Under the value-added approach, high value creating activities such as making loans and taking deposits are classified as outputs measured in dollar terms, whereas labour, physical capital and purchased funds are classified as inputs (Wheelock and Wilson, 1995). The user-cost approach assigns an asset as an output if the financial returns are greater than the opportunity cost of funds. Similarly, a liability item is regarded as an output if the financial costs are less than the opportunity cost. If neither of these conditions is satisfied, the asset or the liability is classified as an input (Burger and Humphrey, 1992). The user costs can be calculated for all the assets and liabilities on the balance sheet. It is also worth noting that the assignment of assets and liability items as inputs or outputs may change with movements in interest rates and service charges.

The intermediation approach is quite popular in empirical research particularly based on cross-section data (Colwell and Davis, 1992; Favero and Papi, 1995). This is so because banks are considered as intermediate institutions. On the other hand, the production approach, though also used in empirical studies, is known to have one limitation mainly due to the exclusion of interest expenses which are considered to be a vital part of banking. There are other practical issues or reasoning that governs the selection of inputs and outputs. If one's aim is to estimate unit's production efficiency then production approach might be appropriate. However, if the interest of the researcher is in examining intermediation efficiency, then intermediary approach is appropriate. The choice of variables may also depend on the availability of required data.

Table 1: List of inputs and outputs

Input
Labour (X1)
Total deposits (X2)
Output
Total loans (Y1)
Other investments (Y2)

In the DEA approach, the number of inputs and outputs is always determined by the number of decision making units (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. As a rule of thumb, it is widely recognised that product of the number of inputs and outputs should not exceed the number of DMUs in the sample (Cooper et al. 2000). Dyson et al. (2001) suggest that product of total number of inputs and outputs should not exceed fifty percent of unit's number under investigation for the purpose of obtaining reasonable level of differentiation. On the other hand, Cinca et al. (2002) suggest that DMUs efficiency may be estimated through using alternative specification methods and should rely on the average estimated efficiency. In

examining banking efficiency based on DEA approach, the rule of thumb, as mentioned above, is the most popular strategy for selecting the number of inputs and outputs. We use the intermediation approach in which banks are viewed as financial intermediaries employing input such as total deposit and labour to produce outputs such as total loans and other investment. The variables are listed in Table 1.

2.2 Data sources

The non-availability of required data at the micro level is deemed as one of main reasons for the lack of adequate number of empirical analyses on banks in emerging markets in general and Jordanian market in particular. The Bankscope databases provide limited information on Jordanian banks. They do not cover all banks operating in Jordan particularly in the earlier years of data compilation. Second, the data reported in Bankscope are aggregate, not so detailed inhibiting a comprehensive analysis of institutions under study. Thirdly, samples compiled by BankScope suffer from an implicit selectivity bias in favour of large banks which may not be a good representation of the banking industry, and thus, may yield biased and inaccurate results (Ehrmann et al. 2001). Bhattacharya (2003) and Ehrmann et al. (2001) recommend the use of databases maintained by central banks, because such databases have more complete data and therefore produce more consistent, robust and stable results.

Table 2: Assets of domestic and foreign banks

Bank Category	Serial No.	Bank Name	Abbreviation Used	Assets Size in Jordan Dinar (Million)
Domestic Banks				
Large	1	Arab Bank	AB	6093
	2	The Housing Bank for Trade and Finance	HBTF	4132
Medium	3	Jordan Kuwait Bank	JKB	1752
	4	Jordan National Bank	AHLI	1548
	5	Bank of Jordan	BOJ	1276
	6	Cairo Amman Bank	CAB	1085
	7	Union Bank for Saving & Investment	UBJ	1056
	8	Capital Bank of Jordan	CBJ	896
	9	Jordan Investment & Finance Bank	JIFB	707
Small	10	Arab Banking Corporation /(Jordan)	ABC	574
	11	Jordan Commercial Bank	JCB	533
	12	Arab Jordan Investment Bank	AJIB	516
	13	Société Générale De Banque-Jordanie	SGBJ	222
Foreign Banks				
	14	HSBC bank	HSBC	587
	15	bank standard charter	BSC	483
	16	city bank	CB	241

Source: The Association of Banks in Jordan, 2007.

To ensure results reliability, comparability and consistency, the data used in this study covers (1996–2007) period and are taken from auditing annual report of individual banks and from the Central Bank of Jordan (CBJ). In addition, different libraries in Jordan and the data bases of Amman Stock Exchange (ASE) and the Association of Banks in Jordan were also consulted to gather some more or missing information. The annual data were collected from

16 banks -13 domestic banks and 3 foreign banks -operating in Jordan for the period 1996-2007 (See Table 2). A total of 192 Annual Report were consulted. The data collection process from the Annual reports was difficult and very time consuming. Such difficulty is deemed as one of the main limitations of the research on banking efficiency. The 13 domestic Jordanian commercial banks that we have selected for our study are those listed in Amman Stock Exchange (ASE). ASE does not list foreign banks. Currently there are eight foreign banks; we could collect data for three for the whole period from the libraries and the Association of Banks in Jordan, of the remaining five foreign banks, two refused to provide me the required data, the other three came into existence only in 2004.

Based on their assets size in 2007 measured in Jordanian dinar (JOD) millions, we have classified banks into four categories: (1) Large domestic banks (assets size ≥ JD 4000 million), (2) Medium domestic banks (700 ≤ Assets size < JD 4000 million), (3) Small domestic banks (assets size < JD 700 million) and (4) Foreign banks. All the foreign banks are small in terms of their assts size. The bank's assets have changed over the years but they have not crossed their categories, facilitating their comparison over the sample period. We may also mention, the exiting studies of banking efficiency in Jordan covered banks, the period from 1990 to 1996 and analysed 19 banks. Due to closure and merger over the years, we had to restrict to 16 banks. This study makes a significant contribution to the literature on banking efficiency in Jordan by covering the period not compassed in earlier studies.

The inputs and outputs used are defined as follows:
Inputs: Labour (X1) is defined as a number of full time worker, while total deposit (X2) is defined as customers' deposits.
Outputs: Total loan (Y1) is the total credit facilities as appear in the balance sheets of the banks. Other investments (Y2) are the investments in bonds and securities.
These variables were also used in an earlier study of banking efficiency in Jordan by Ahmad (2000). All variables are expressed in Jordanian dinar (JOD) millions at 1996 constant prices using GDP deflator. This adjustment does not apply to the labour input as this is measured by the number of employees (workers).

3. ANALYSIS OF TECHNICAL EFFICIENCY OF BANKS IN JORDAN

3.1 Summary statistics for bank inputs and outputs
Before we present our DEA results on technical efficiency levels of Jordanian banks, we present summary statistics for inputs and outputs which might be useful in understanding the broad structure of banking system in Jordan. The statistics presented in Table 3 reveal the heterogeneity of Jordanian banks as the mean size in our four variables vary considerably across banking groups. For instance, the number of workers in the large banks is four times the number of workers in the medium sized banks and almost six times the number of workers in small banks and 15 times of those in foreign banks. The number of workers for the domestic banks as a whole is four times larger than that of the foreign banks.

Another interesting observation is that the deposits in the large Jordanian banks are almost 10 times of the medium banks and 24 times of small banks, speculatively, this difference could be a product of variation in operational efficiency in respective banking sectors or simply could be an artifact of the banking services in the large banks more efficient and attractive for the customers than the small banks. This implies that the major source of funding in Jordan is collection, which is a typical characteristic of a traditional banking system. A similar trend is evident in terms of output variables as large banks with total loan 8 times bigger than medium banks and 25 times bigger than small banks, also the other investments variable (output) nearly 68 times larger than medium banks and 60 times larger than small banks. In addition, it appears that the total loan of the large Jordanian banks is half of their total deposit. This implies that Jordanian banks are facing risky business

environment, they may be reluctant to engage heavily in loan markets, as business credits are more costly to originate, maintain and monitor and thus more likely to default than investment securities.

Table 3: Summary statistics of variable for Jordanian Banks, 1996-2007
(Values in Jordanian dinar at constant 1996 prices)

Variable	NoBs	Mean	SD	Minimum	Maximum
Large Banks					
Total Loan	2	2139170924	2786284807	556611418	9875128000
Other Investment	2	919685784	1438081946	121348325	4304121000
Labour	2	2047	380	1639	2894
Total Deposit	2	4318497841	5431493716	917595609	15378129000
Medium Banks					
Total Loan	7	254783304	213812544	10697277	1127481771
Other Investment	7	13403493	65264611	0	257506675
Labour	7	520	572	41	1565
Total Deposit	7	443874259	353682089	13336358	1534015930
Small Banks					
Total Loan	4	86240939	73182437	453431	294943837
Other Investment	4	15602189	37268398	316903	138106228
Labour	4	318	128	177	699
Total Deposit	4	176916003	117204820	33332733	462786678
ALL Domestic Banks					
Total Loan	13	319853465	1572648305	453431	9875128000
Other Investment	13	123373367	772498325	0	4304121000
Labour	13	528	720	41	2894
Total Deposit	13	688986020	3148857469	13336358	15378129000
ALL Foreign Banks					
Total Loan	3	76157076	55508037	15530746	253080285
Other Investment	3	2612176	5840844	0	21886001
Labour	3	140	93	54	393
Total Deposit	3	214551214	120106006	87685805	555200000
ALL Banks					
Total Loan	16	238584552	1437741625	453431	9875128000
Other Investment	16	66957139	705148200	0	4304121000
Labour	16	401	702	41	2894
Total Deposit	16	559488943	2874413534	13336358	15378129000

Source: Data collected by author from individual bank Annual Report.
Note: NoBs denotes number of banks and SD denotes standard deviation.

The total loan provided by domestic banks to their customers in Jordan is 4 times larger than the total loan provided by foreign banks. The other investments of domestic banks are 50 times larger than the investments of foreign banks. The Jordanian domestic banks have three times the total deposit of the foreign banks operating in Jordan. The contribution of individual (or category of) banks to total banking outputs has not remained stable or unchanged over the sample period. The share of large banks in total banking output has declined from 77% in 1996 to 69% in 2007. On the other hand, the shares of medium and small banks in total banking output have shown significant increase over the years. The output share of foreign banks shows a marginal decline over the sample period (see Table

4), the large banks have made a greater contribution to mean efficiency levels than the small and medium sized banks.

Table 4: Contribution of individual banks to total banking output (percentage), 1996-2007

Banks	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Large Banks												
AB	66.1	66.1	64.9	64.9	68.3	67.1	68.1	67.8	65.7	58.5	55.4	57.0
HBTF	10.3	9.5	9.3	8.9	7.4	8.1	7.9	8.2	9.6	11.4	12.3	12.2
Medium Banks												
JKB	2.0	2.1	1.9	2.0	2.2	2.4	2.5	3.0	3.4	4.7	5.9	5.6
AHLI	3.8	5.3	5.9	5.8	5.6	5.5	4.7	4.4	3.8	4.3	4.2	4.1
BOJ	3.3	2.8	3.4	3.4	2.9	3.1	3.3	3.7	3.4	3.8	3.9	3.8
CAB	4.1	4.0	4.0	3.9	3.3	2.6	3.1	2.7	2.9	3.8	3.4	3.1
UBJ	1.1	1.0	0.9	1.1	1.1	1.3	1.6	1.8	2.1	2.7	3.1	2.7
CBJ	0.1	0.4	0.6	0.9	1.2	1.4	1.5	1.9	1.9	2.7	2.8	2.7
JIFB	1.5	1.4	1.5	1.8	1.3	2.2	1.6	1.3	1.3	1.8	2.1	1.9
Small Banks												
ABC	1.3	1.3	1.3	1.3	1.1	1.3	1.2	1.2	1.2	1.4	1.6	1.5
JCB	1.5	1.2	1.4	1.6	1.8	1.9	1.0	0.6	0.8	1.4	1.6	1.5
AJIB	1.1	0.9	1.0	1.2	1.3	1.1	1.2	1.1	1.3	1.3	1.5	1.5
SGBJ	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.4	0.5	0.0	0.6
ALL Domestic Banks	96.7	96.5	96.7	97.0	97.8	98.2	98.1	98.0	97.9	98.1	97.8	98.2
Foreign Banks												
HSBC	1.6	1.7	1.6	1.3	1.0	0.9	1.0	1.1	1.0	1.0	1.1	0.4
BSC	1.3	1.3	1.3	1.3	0.9	0.5	0.5	0.6	0.7	0.8	0.9	1.1
CB	0.5	0.4	0.5	0.4	0.3	0.3	0.4	0.4	0.3	0.1	0.2	0.2
ALL Foreign Banks	3.3	3.5	3.3	3.0	2.2	1.8	1.9	2.0	2.1	1.9	2.2	1.8
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Author's calculations.

3.2 The estimates of technical efficiency

We now turn to results on technical efficiency of banks. The results are obtained by running the DEA model using the DEAP program to construct a grand frontier that envelopes all the input-output observations for all banks. More specifically, input-oriented DEA approach is applied to the panel data (192 observations) of all 16 banks to construct the grand efficient frontier against which the technical efficiency scores of all banking units are computed. The efficiency scores compare across banks and over the years, because the efficient frontier is made of best-practice observations from the whole data set. The approach provides the simplest and most direct way to compare and track down the efficiency level of a bank. The approach assumes that technology is constant over the sample period.

The technical efficiency scores lie between 0 and 1, where 1 indicates full efficiency and 0 means fully inefficient. Thus, DEA reveals how efficient a decision making unit (DMU) is relative to the others. The efficiency score translates into how well a bank converts its inputs into outputs. For instance, if a bank has a technical efficiency score of 75%, then it means that it would have to reduce its inputs by 25% to become as efficient as its reference set, that is, those banks with 100% scores. Technical efficiency can be decomposed into the product of 'pure technical' and 'scale' efficiencies. This requires the estimation of two DEA models-one with constant returns to scale (CRS) and the other with variable returns to scale (VRS). If there is a difference in the two technical efficiency scores for a particular bank, then this indicates that the bank has scale inefficiency. This process is illustrated in Figure 1 for the one input (x) and one output (y) case. The constant returns and variable returns to scale

DEA frontiers are represented by CRS and VRS, respectively. Under CRS, the input-oriented technical inefficiency of the point P is the distance PP_c, while under VRS the technical inefficiency would only be PP_v. The difference between these two, P_cP_v, is put down to scale inefficiency. This can all be expressed in ratio efficiency measures:

$$TE_{CRS} = AP_C/AP \qquad \text{(Technical Efficiency)} \qquad (1)$$
$$TE_{VRS} = AP_V/AP \qquad \text{(Pure Technical Efficiency)} \qquad (2)$$
$$SE = AP_C/AP_V \qquad \text{(Scale Efficiency)} \qquad (3)$$

All of these efficiency measures are bounded by zero and one. It may be noted that
$$TE_{CRS} = TE_{VRS} \times SE. \qquad (4)$$

That is, the CRS technical efficiency measure is the product of pure technical efficiency and scale efficiency. The scale efficiency measure does not indicate whether a bank is operating at increasing returns to scale (IRS) or decreasing returns to scale (DRS). This may be determined by imposing non-increasing returns to scale (NIRS) to the DEA problem. The NIRS DEA frontier is also plotted in Figure 1. The nature of the scale inefficiencies (due to increasing or decreasing returns to scale) for a particular bank can be determined by noting whether the NIRS technical efficiency score is equal to the VRS technical efficiency score. If they are unequal (as is the case at P) then increasing returns to scale exist for that bank. If they are equal (as is the case at Q) then decreasing returns to scale apply (Coelli 1996, p. 18).

Figure 1: Calculation of scale economies in DEA
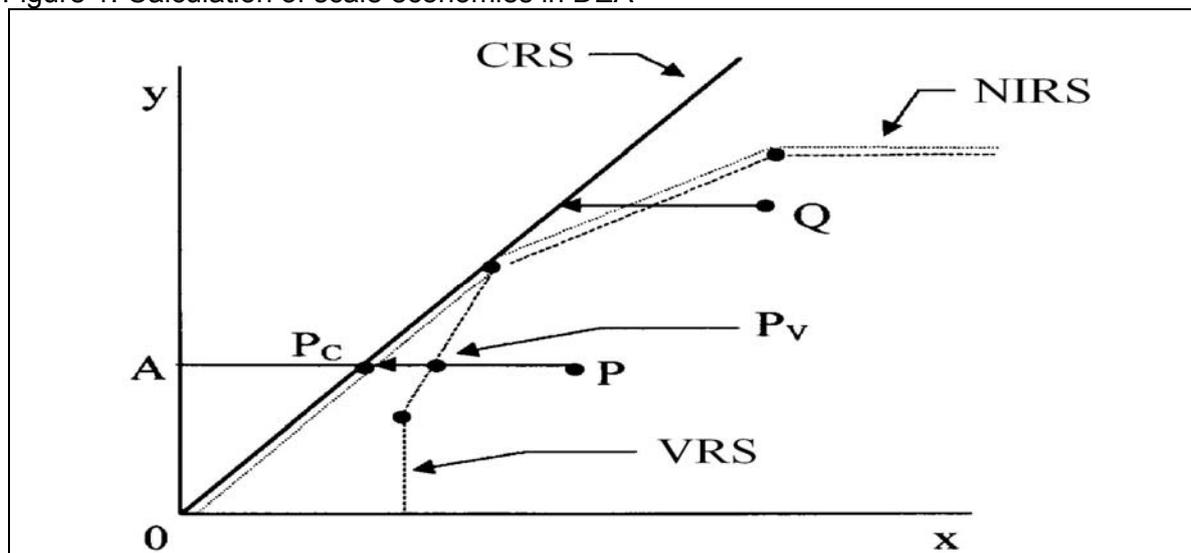
Source: Coelli (1996).

An advantage of DEA is that it does not impose any preconceived structure on the data in determining the efficient firms. That is, it does not assume a particular production technology or correspondence. It identifies the inefficiency of a particular firm by comparing it with similar firms regarded as efficient, rather than associating a firm's performance with statistical averages. The disadvantage of this approach is that it assumes no random errors. If there is random error in an observation on the frontier, it will be mistakenly reflected in the measured efficiency of all firms that are measured to that part of the frontier. Despite this limitation, DEA is widely used to estimate the technical efficiency of banks in many countries. The results for DEA technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) for all banking groups and units are detailed and presented in Table 5 Following Paul and Kourouche (2008), the aggregated estimates of technical efficiency for

the entire banking sector is obtained as the weighted geometric mean of individual bank's scores using the share of each bank in total output as weight. The same procedure is used to calculate the efficiency scores of each group of banks. The aggregate efficiency scores so calculated are more accurate than the simple arithmetic or geometric average of banks specific scores. This is so because each bank differs in term of its contribution to aggregate output. The results presented in Table 5 indicates that Arab Bank is found to be the most technically efficient with an average score of 84% and fully technically efficient in 2004 and 2007 when it was also operating at the most productive scale size (MPSS) or optimal scale for six years (See Table 5). Banks at MPSS maximised their outputs for inputs expended. To be more specific, Arab Bank's technical efficiency was 71.5% in 1996 which increased during the sample period to reach fully efficiency (100%) in 2007. The Housing Bank for Trade and Finance (HBTF) achieved strong improvement in pure technical efficiency in 2006 (99.2%). However, it consistently operated at decreasing returns to scale (DRS) throughout the study period and showed a relatively strong deterioration in scale efficiency over time (see Table 5). At DRS, increase in inputs is accompanied with less than proportionate rise in outputs. Banks operating at DRS could increase their efficiency levels by downsizing their scale of operations. Over the sample period, the HBTF Bank achieved little improvement in technical efficiency on an average of 60.8%; however, it was found the least efficient of the large banks group.

Among the category of medium sized banks group, Capital Bank of Jordan (CBJ) was found to be the most efficient bank (95.3%). It was also the most scale efficient bank (95.7%) because it had consistently performed optimal scale in years (1998, 2002, 2005, 2006 and 2007), when increasing returns to scale (IRS) set in (see Table 5.5 and 5.6). At IRS, increase in inputs leads to more than proportionate rise in outputs. Banks operating at IRS could increase their efficiency by enlarging their scale of operations. The CBJ dominated in pure technical efficiency (mean 99.6%) by being fully pure technically efficient in 8 years out of 12 years (see Table 5). There is an increase in banks efficiency in all years except 2003. However, a decrease in bank efficiency was evident for some banks in the sample. This result is accordance with Bdour and Al-Koury (2008) findings Jordanian banks efficiency over the period (1998-2004) except in 2003 and 2004. Nevertheless, the efficiency scores increased between 1999 and 2002, dropped again in 2003, this can be attributed to the worldwide recession and the political situation in the area, second Gulf War in particular, which seriously affected Jordan's economy in terms of income declinations, inflation unemployment and poverty increment. The third Gulf war American–British war on Iraq (2003) adversely affected Jordan economy in general which in its turn reflected negatively on Jordanian banks performance in particular.

In 2004, banks efficiency increased in most banks (13 banks out of 16). The other medium size bank such as Union Bank for saving and Investment (UBJ) has great improvement in technical efficiency from 1996 until 2005 to reach efficient score amounting 80.5%. HSBC as a outperforming foreign bank operating in Jordan had the highest mean scale efficiency among the medium banks (97.7%) and the second highest banks among all banks in the sample, it was also operating at the MPSS or optimal scale in years 2000 and 2001 (See Table 5). Jordan Ahli Bank (AHLI) and Bank of Jordan (BOJ) are found to be less efficient as Jordan Kuwait Bank (JKB) and Jordan Investment and Finance Bank (JIFB), respectively. It is clear that the improvement in technical efficiency can be attributed to gains made in both pure technical and scale efficiencies over time. Among the group of small sized domestic banks, Jordan Commercial Bank (JCB) had the highset efficiency score (70%) and operated at DRS over the sample period (see Table 5). On the other hand, Arab Jordan Investment Bank (AJIB) had the lowest efficiency (mean 45.6%). All the three foreign banks had low efficiency scores as compared to domestic banks. Their efficiency scores were even less than half of the large banks. The HSBC operated at MPSS in the years 2000 and 2001.

Table 6 indicates the nature of scale returns of banks. Eight banks operated at DRS over the sample period, which indicates they need to decrease their sizes. Four banks (AB, CBJ, HSBC and BSC) managed to achieve MPSS in the study period. CB operated at IRS over the time which indicates the need for more inputs or increases the size.

Table 5: DEA estimates of efficiency for domestic and foreign banks, 1996-2007

Banks	Eff	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Large														
AB	TE	0.715	0.744	0.735	0.696	0.813	0.847	0.925	0.837	1.000	0.922	0.919	1.000	0.840
	PTE	0.716	0.744	0.737	0.697	0.818	0.851	0.925	0.838	1.000	0.935	0.949	1.000	0.844
	SE	1.000	0.999	0.998	0.999	0.993	0.995	1.000	1.000	1.000	0.986	0.968	1.000	0.995
HBTF	TE	0.685	0.646	0.615	0.499	0.479	0.632	0.607	0.529	0.618	0.646	0.695	0.692	0.608
	PTE	0.718	0.678	0.677	0.648	0.671	0.903	0.870	0.760	0.915	0.947	0.992	0.914	0.799
	SE	0.954	0.953	0.909	0.771	0.714	0.699	0.698	0.696	0.675	0.682	0.701	0.757	0.761
Medium														
JKB	TE	0.554	0.559	0.519	0.499	0.457	0.572	0.570	0.611	0.700	0.765	0.976	0.853	0.620
	PTE	0.570	0.576	0.534	0.514	0.479	0.593	0.590	0.626	0.715	0.778	1.000	0.959	0.644
	SE	0.972	0.972	0.971	0.971	0.954	0.964	0.967	0.976	0.980	0.984	0.976	0.889	0.964
AHLI	TE	0.703	0.588	0.740	0.652	0.564	0.525	0.431	0.401	0.338	0.426	0.462	0.485	0.513
	PTE	0.727	0.618	0.769	0.677	0.594	0.551	0.457	0.419	0.380	0.499	0.581	0.576	0.559
	SE	0.967	0.952	0.962	0.962	0.951	0.952	0.944	0.956	0.888	0.855	0.796	0.842	0.917
BOJ	TE	0.452	0.449	0.526	0.531	0.515	0.541	0.497	0.486	0.484	0.532	0.576	0.617	0.515
	PTE	0.467	0.464	0.550	0.551	0.533	0.560	0.522	0.516	0.541	0.558	0.598	0.643	0.540
	SE	0.968	0.968	0.956	0.964	0.966	0.965	0.953	0.941	0.896	0.953	0.963	0.959	0.954
CAB	TE	0.410	0.390	0.408	0.412	0.375	0.399	0.367	0.368	0.397	0.507	0.523	0.505	0.419
	PTE	0.424	0.404	0.425	0.428	0.397	0.413	0.408	0.383	0.422	0.681	0.627	0.664	0.462
	SE	0.967	0.965	0.962	0.961	0.945	0.966	0.900	0.961	0.940	0.744	0.834	0.761	0.905
UBJ	TE	0.367	0.420	0.440	0.450	0.473	0.568	0.498	0.538	0.658	0.805	0.760	0.703	0.541
	PTE	0.388	0.428	0.446	0.459	0.483	0.581	0.522	0.554	0.769	0.906	0.821	0.752	0.570
	SE	0.947	0.980	0.985	0.981	0.979	0.978	0.953	0.970	0.856	0.889	0.926	0.935	0.947
CBJ	TE	0.778	0.900	1.000	0.936	0.911	0.978	1.000	0.978	0.987	0.994	1.000	1.000	0.953
	PTE	1.000	0.966	1.000	1.000	1.000	0.998	1.000	1.000	0.990	0.994	1.000	1.000	0.996
	SE	0.778	0.932	1.000	0.936	0.911	0.980	1.000	0.978	0.997	1.000	1.000	1.000	0.957
JIFB	TE	0.497	0.442	0.510	0.616	0.463	0.893	0.708	0.586	0.746	0.755	0.914	0.743	0.638
	PTE	0.594	0.520	0.532	0.624	0.517	0.929	0.724	0.586	0.825	0.803	1.000	0.790	0.686
	SE	0.835	0.850	0.957	0.987	0.896	0.961	0.977	0.999	0.905	0.940	0.914	0.940	0.929
Small														
ABC	TE	0.576	0.537	0.514	0.476	0.482	0.507	0.513	0.555	0.585	0.702	0.686	0.625	0.559
	PTE	0.589	0.550	0.527	0.487	0.491	0.522	0.532	0.571	0.599	0.713	0.708	0.663	0.575
	SE	0.979	0.977	0.977	0.977	0.981	0.971	0.964	0.973	0.975	0.984	0.969	0.942	0.972
JCB	TE	0.684	0.643	0.675	0.640	0.832	0.881	0.580	0.699	0.638	0.733	0.683	0.737	0.698
	PTE	0.700	0.658	0.694	0.658	0.859	0.910	0.596	0.711	0.654	0.759	0.696	0.760	0.716
	SE	0.976	0.977	0.973	0.972	0.968	0.967	0.973	0.984	0.976	0.966	0.981	0.969	0.973
AJIB	TE	0.334	0.298	0.316	0.333	0.565	0.462	0.579	0.438	0.551	0.537	0.615	0.635	0.456
	PTE	0.339	0.302	0.323	0.349	0.568	0.466	0.596	0.440	0.562	0.579	0.710	0.749	0.477
	SE	0.986	0.987	0.977	0.953	0.995	0.992	0.972	0.995	0.980	0.927	0.865	0.847	0.955
SGBJ	TE	0.773	0.672	0.727	0.528	0.447	0.644	0.702	0.716	0.903	0.692	0.011	0.840	0.484
	PTE	0.787	0.691	0.751	0.561	0.490	0.700	0.728	0.741	0.914	0.707	0.193	0.863	0.638
	SE	0.983	0.972	0.968	0.941	0.911	0.919	0.964	0.967	0.988	0.980	0.058	0.973	0.760
Foreign														
HSBC	TE	0.592	0.617	0.560	0.460	0.402	0.363	0.347	0.357	0.358	0.377	0.410	0.153	0.395
	PTE	0.598	0.623	0.563	0.460	0.402	0.363	0.350	0.368	0.370	0.384	0.434	0.170	0.404
	SE	0.991	0.991	0.995	0.999	1.000	0.999	0.991	0.969	0.967	0.980	0.946	0.904	0.977

BSC	TE	0.444	0.523	0.509	0.470	0.371	0.305	0.297	0.346	0.423	0.455	0.455	0.629	0.426
	PTE	0.447	0.528	0.511	0.470	0.420	0.532	0.418	0.467	0.483	0.512	0.483	0.631	0.489
	SE	0.992	0.991	0.997	1.000	0.884	0.573	0.712	0.742	0.876	0.889	0.942	0.998	0.872
CB	TE	0.387	0.364	0.390	0.403	0.254	0.305	0.406	0.320	0.292	0.143	0.222	0.424	0.313
	PTE	0.764	0.636	0.722	0.821	0.707	0.828	0.823	0.795	0.898	0.817	0.812	0.729	0.776
	SE	0.506	0.572	0.540	0.491	0.360	0.368	0.493	0.403	0.325	0.175	0.273	0.581	0.403

Source: Author's calculations.
Note: Mean levels are geometric means. Eff denotes Efficiency, TE Technical Efficiency, PTE Pure Technical Efficiency and SE Scale Efficiency.

Each year, only one bank was operating at MPSS exceptions are 2002 and 2007 when two banks operated at MPSS. In contrast, the number of banks operating at IRS has increased from four banks in 1996 to seven banks in 2000, but it declined to 3 banks in 2007.

Table 6: DEA estimates of nature of return to scale, 1996-2007 for domestic banks and foreign banks

Banks	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Large Banks												
AB	MPSS	MPSS	IRS	IRS	IRS	IRS	MPSS	MPSS	MPSS	DRS	DRS	MPSS
HBTF	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
Medium Banks												
JKB	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
AHLI	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
BOJ	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
CAB	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
UBJ	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
CBJ	IRS	IRS	MPSS	IRS	IRS	DRS	MPSS	DRS	IRS	MPSS	MPSS	MPSS
JIFB	IRS	IRS	IRS	IRS	IRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
Small Banks												
ABC	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
JCB	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS	DRS
AJIB	DRS	DRS	DRS	DRS	IRS	IRS	DRS	IRS	DRS	DRS	DRS	DRS
SGBJ	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	DRS	DRS	IRS	DRS
Foreign Banks												
HSBC	DRS	DRS	DRS	DRS	MPSS	MPSS	IRS	IRS	IRS	IRS	IRS	IRS
BSC	DRS	DRS	DRS	MPSS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS
CB	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS	IRS

Source: Author's calculations. Notes: MPSS denotes Most Productive Scale Size, DRS denotes Decreasing Return to Scale and IRS denotes Increasing Return to Scale.

In order to understand how pure technical and scale efficiencies have contributed to overtime changes in technical efficiency, we make use of the relationship that PTE ×SE = TE. The growth rate of technical efficiency is the sum of the growth rate of pure technical efficiency and scale efficiency.

$$\ln\left(TE_{CRS(t)}\Big/TE_{CRS(t-1)}\right) = \ln\left(TE_{VRS(t)}\Big/TE_{VRS(t-1)}\right) + \ln\left(SE_{(t)}\Big/SE_{(t-1)}\right)$$

(5)

Table 8 presents the growth rates for technical efficiency for each group of banks for three sub-periods, 1996-1999, 1999-2003, 2003-2007 and for the entire period 1996-2007. We

also present estimates of technical efficiency and its decomposition for each group in Table 7. Several points emerge from tables 7, 8 and figures 3, 4 and 5.

First, the group of large sized banks has the highest technical efficiency (81.1% on average) during the study period. Their efficiency level has increased at the rate of 2.59% per year due to 2.89% increase in pure technical efficiency per year. Scale efficiency of these banks shows a mild decline. Second, medium banks have the lowest technical efficiency (57.8%) amongst the group of domestic banks. Their efficiency had declined at the rate of 1.50% per year during 1999-2003, due to falls in both pure technical and scale efficiencies. In addition, their scale efficiency score had declined at the rate of 0.05% per year during 1999-2003. Third, the efficiency performance of small banks was somewhat better than medium sized banks. In contrast, foreign banks showed the worst performance in term of TE, SE and PTE (See Table 7). Fourth, the pure technical inefficiency is the primary source of technical inefficiency change in Jordanian banks. Over the study period, improvements have been made in pure technical efficiency (2.71% per year) while scale efficiency has deteriorated (0.41% per year).

Table 7: DEA estimates of efficiency by category of banks, 1996-2007

Banks	Eff	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Large														
	TE	0.711	0.732	0.720	0.672	0.781	0.824	0.892	0.804	0.951	0.877	0.878	0.946	0.811
	PTE	0.716	0.736	0.729	0.691	0.804	0.857	0.919	0.830	0.989	0.937	0.957	0.985	0.839
	SE	0.994	0.993	0.987	0.971	0.966	0.963	0.969	0.967	0.959	0.936	0.919	0.957	0.965
Medium														
	TE	0.515	0.500	0.580	0.563	0.517	0.597	0.529	0.530	0.568	0.654	0.739	0.698	0.578
	PTE	0.542	0.526	0.601	0.584	0.547	0.619	0.553	0.549	0.612	0.717	0.796	0.773	0.612
	SE	0.952	0.953	0.964	0.965	0.948	0.963	0.950	0.964	0.922	0.905	0.916	0.897	0.941
Small														
	TE	0.577	0.529	0.540	0.499	0.647	0.662	0.566	0.553	0.618	0.663	0.661	0.685	0.597
	PTE	0.590	0.541	0.555	0.516	0.664	0.682	0.584	0.564	0.631	0.688	0.704	0.740	0.618
	SE	0.980	0.979	0.975	0.966	0.976	0.972	0.969	0.982	0.978	0.962	0.938	0.925	0.967
ALL Domestic Banks														
	TE	0.673	0.683	0.686	0.643	0.727	0.774	0.812	0.743	0.865	0.813	0.832	0.872	0.756
	PTE	0.682	0.691	0.698	0.662	0.751	0.804	0.838	0.767	0.903	0.872	0.903	0.920	0.786
	SE	0.986	0.985	0.982	0.970	0.963	0.963	0.965	0.967	0.952	0.930	0.920	0.941	0.960
ALL Foreign Banks														
	TE	0.506	0.549	0.517	0.456	0.370	0.334	0.347	0.347	0.371	0.391	0.414	0.492	0.418
	PTE	0.562	0.617	0.565	0.516	0.449	0.507	0.474	0.472	0.489	0.467	0.485	0.538	0.510
	SE	0.924	0.938	0.933	0.927	0.819	0.742	0.804	1.000	0.839	0.884	0.890	0.922	0.882
ALL Banks														
	TE	0.667	0.678	0.680	0.638	0.719	0.766	0.803	0.735	0.854	0.805	0.823	0.865	0.749
	PTE	0.678	0.687	0.693	0.658	0.744	0.799	0.831	0.761	0.894	0.865	0.894	0.914	0.780
	SE	0.984	0.984	0.980	0.969	0.961	0.960	0.962	0.964	0.950	0.929	0.919	0.941	0.958

Source: Author's calculations. Notes: Eff denotes Efficiency, TE Technical Efficiency, PTE Pure Technical Efficiency and SE Scale Efficiency. The efficiency estimates for each bank category are the weighted geometric means of bank specific efficiencies, where the weights are their shares in the aggregate output of the bank category they belong too. The weights vary from year to year and were outlined in Table 4.

Fifth, the average technical efficiency for all banks is 74.9%. This suggests that inputs could be reduced by 35.1% on average, relative to the best-practice banks during the period 1996-2007. Technical efficiency ranged from 66.7% in 1996 to 86.5% in 2007, it had increased over the entire period at the rate of 2.36% per year due to pure technical efficiency improvements for the large, medium and small sized banks. However, during 1996-1999 technical efficiency in all banks had declined at the rate of 1.51% per year due to fall in both pure technical and scale efficiencies. The decline in pure technical efficiency can be attributed to the large, small and foreign banks; also the decline in scale efficiency can be attributed solely to the group of large and small banks. Later on, during 1999-2003, technical efficiency marginally improved at a rate of 3.56% per year due to pure technical efficiency.

The improvement in pure technical efficiency can be attributed solely to the large and small banks. During 2003-2007, technical efficiency had improved at a higher rate of 4.07% per year due to pure technical efficiency improvements from the large, medium and small sized banks.Sixth, the domestic banks are more efficient than foreign banks, as may be noted that technical efficiency and pure technical efficiency for domestic banks increased over the sample period while TE and PTE for foreign banks declined. Thus, the difference in efficiency levels of domestic and foreign banks had widened over the period (1996-2007).

Table 8: Average annual growth rates of efficiency (percentage)

Banks	Period	Growth of TE	Growth of PTE	Growth of SE
Large Banks				
	1996-99	-1.87	-1.19	-0.76
	1999-03	4.47	4.57	-0.11
	2003-07	4.06	4.29	-0.26
	1996-2007	2.59	2.89	-0.34
Medium Banks				
	1996-99	2.96	2.46	0.45
	1999-03	-1.50	-1.54	-0.05
	2003-07	6.88	8.56	-1.79
	1996-2007	2.76	3.22	-0.55
Small Banks				
	1996-99	-4.84	-4.46	-0.48
	1999-03	2.55	2.24	0.42
	2003-07	5.35	6.77	-1.50
	1996-2007	1.55	2.06	-0.53
ALL Domestic Banks				
	1996-99	-1.49	-0.97	-0.56
	1999-03	3.61	3.67	-0.07
	2003-07	3.99	4.56	-0.69
	1996-2007	2.36	2.73	-0.43
ALL Foreign Banks				
	1996-99	-3.44	-2.87	0.10
	1999-03	-6.82	-2.22	1.89
	2003-07	8.74	3.25	-2.04
	1996-2007	-0.24	-0.41	-0.02
ALL Banks				
	1996-99	-1.51	-1.00	-0.53
	1999-03	3.56	3.64	-0.13
	2003-07	4.07	4.57	-0.61
	1996-2007	2.36	2.71	-0.41

Source: Author's calculations.
Note: TE Technical Efficiency, PTE Pure Technical Efficiency and SE Scale Efficiency.

4. CONCLUSIONS

We employed a non-parametric approach (DEA) to examine technical efficiency in the domestic and foreign banks in Jordan during the period 1996-2007. The results were obtained by running an input-oriented DEA model to construct a grand frontier that envelopes all of the input-output observations for all banks. The estimates of technical efficiency were decomposed into the product of pure technical efficiency and scale

efficiency. Study provides the estimates of both domestic and foreign banks for the period not covered by earlier studies.

The group of large sized banks is seen as the best performer with an average technical efficiency score of 81.1%, pure technical and scale efficiencies of 83.9% and 96.5% respectively, followed by the small banks 59.7%, 61.8% and 96.7% respectively. The medium banks are found to be the worst performers on average with a technical efficiency score of 57.8% and pure technical and scale efficiencies of 61.2% and 94.1%, respectively. Within the Jordanian banking system, domestic banks on average had better technical efficiency than the foreign banks. Nevertheless, scale efficiency levels for the domestic banks have declined over time from 98.6% in 1996 to 92% in 2006. However, scale efficiency levels solely improved in 2007 to reach 94.1%. Technical efficiency for the foreign banks over the entire period had declined at the rate of 0.24% per year. However during 2003-2007 technical efficiency had improved at a rate of 8.74% per year due to improvement in pure technical efficiency at rate 3.25%. Scale efficiency for the foreign banks declined during 2003- 2007 at a rate of 2.04% per year. For the banking sector as whole, mean technical efficiency over the period 1996-2007 is found to be 86.5% with pure technical inefficiency observed as the primary source of technical inefficiency. However, the annual estimates reveal that technical efficiency has improved at the rate of 2.36% per year over the study period. This improvement is the outcome of improvement in pure technical efficiency of 2.71% per year and a decline of 0.41% in scale efficiency per year.

The nature of returns to scale provides some further intriguing observations. It is shown that the large banks HBTF operated at DRS over the entire period; it indicates that the large banks must reduce the size of their operations to achieve efficiency improvements. On the other hand, the medium sized banks initially operated at DRS and some of them operated at IRS. The Capital Bank of Jordan operated five times at MPSS. On the other hand, the small sized banks operated at IRS over the sample period. This indicates that the small banks must increase the size of their operations to reach the optimal scale efficiency.

References

Ahmad, T. (2000). *The efficiency of the banking system in Jordan* (Unpublished Ph.D thesis). Colorado State University, USA.

Annual Report (various issues).Published for Each Bank for each year separately.

Annual Report (2007). Association of Banks in Jordan.

Annual Report (various issues). Published by Central Bank of Jordan.

Avkiran (1999). The evidence on efficiency gains: The role of mergers and the benefits to the public. *Journal of Banking & Finance,* 23 (7), 991-1013.

Berger, A., & Humphrey, D. B. (1992). Megamergers in banking and the use of cost efficiency as an antitrust defense. *Antitrust Bulletin,* 37, 541-600.

Bhattacharya, K. (2003). *How good is the bank scope database? A cross-validation exercise with correction factors for market concentration measures* (BIS Working Paper 133). Basel: Bank for International Settlements.

Casu, B., & Molyneux, P. (2003). A comparative study of efficiency in European banking. *Applied Economics,* 35, 1865-1876.

Cinca, C. S., Molinero, C. M., & Garcia, F. C. (2004). Behind DEA efficiency in financial institutions's. *Discussion Papers in Accounting & Finance AF02.* University of Southampton.

Coelli, T. (1996). *A guide to deep version 2.1: A data envelopment analysis (computer) program* (CEPA Working Paper 96/08). Australia: Department of Economics, University of New England.

Cooper, W., Seiford, L., & Kaoru, T. (2000). *Data envelopment analysis; A comprehensive text with models, application, references and DEA-solver software*. Boston: Kluwer Academic Publishers.

Colwell, R. J., & Davis, E. P. (1992). Output and productivity in banking. *Scandinavian Journal of Economics*, 94, 111-129.

Dyson R. G., Allen R., Camanho A. S., Podinovski V. V., Sarrico C. S., & Shale E. A. (2001). Pitfalls and protocols in DEA. *European Journal of* Operational Research, 59, 132-245.

Ehrmann, M., Gambacorta, L., & Martinez-Pages, J. (2001). Financial systems and the role of banks in monetary policy transmission in the euro area. *Discussion Paper 432*. Italy: Bank of Italy.

Favero, C. A., & Papi, L. (1995). Technical efficiency and scale efficiency in the Italian banking sector: A non-parametric approach. *Applied Economics*, 27, 385-395.

Ferrier, G. D., & Lovell, C. A. K. (1990). Measuring cost efficiency in banking: Econometric and linear programming evidence. *Journal of Econometrics*, 46, 229-245.

Fried, H. O., Lovell, C. A. K., & Eechaut, P. V. (1993). Evaluating the performance of U.S credit unions. *Journal of Banking & Finance,* 17, 251-265.

Jamal I., Bdour, Abeer F., & Al-Khoury. (2008). Predicting change in bank efficiency in Jordan: A data envelopment analysis. J*ournal of Accounting & Organization Change,* 4, 162-181.

Kourouche, K. (2008). *Measuring Efficiency and productivity in the australian banking sector* (Unpublished Ph.D thesis). University of Western Sydney, Australia.

Leong, W. H., Dollery, B., & Coelli, T. (2002). *Measuring the technical efficiency of banks in Singapore for the period 1993 to 1999: An application and extension of the Bauer et al., (1997) technique* (Paper Series in Economics 10). University of New England, 1-28.

Maghyereh, A. (2004). *The effect of financial liberalization on the efficiency of financial institutions: the case of Jordanian commercial banks* (Working Paper Series). Retrieved from http://ssrn.com/abstract=436420.

Paul, S., & Kourouche, K., (2008). Regulatory policy and the efficiency of the banking sector in Australia. *Australian Economic Review*, 41, 260-271.

Sathye, M. (2001). X-efficiency in Australian banking: An empirical investigation. *Journal of Banking & Finance,* 25, 613-30.

Isik, I., Gunduz, L., & Omran, M. (2008). *Managerial and scale efficiency in the MENA banking: A panel study of the Jordanian banking sector* (Working Paper Series). Retrieved from http://ssrn.com/abstract=494224.

Wheelock, D. C., & Wilson, P. W. (1995). Evaluating the efficiency of commercial banks: Does our view of what banks do matter? *Review*, 77, 39-52.

Worthington, A. C. (2001). Efficiency in pre-merger and post-merger non-bank financial institutions. *Managerial and Decision Economics*, 22(8), 439-52.