
*International Review of Accounting, Banking and Finance*

**Vol 4, No.2, Summer 2012 Pages 28~60**

**IRABF**

© 2012

# The Efficiency of Banks and Financial Crisis in a Developing Economy: The Case of Jordan

**Rami Zeitun,** [a] **Hicham Benjelloun** [b]

a, b Department of Finance and Economics, College of Business and Economics, Qatar University

---

**ABSTRACT:** This paper measures and evaluates the relative efficiency of Jordanian banks over the period 2005-2010. The measurement of efficiency is estimated using Data Envelopment Analysis (DEA). Our sample contains 12 banks; three of them are Islamic banks. Constant returns to scale (CRS) and variable retursn to scale (VRS) were used in order to measure the relative efficiency of the Jordanian banks, using annual data from 2005 through 2010. The results show that, on the technical efficiency scale only a few Jordanian banks were efficient in managing their financial resources and generating profit. Furthermore, only a few banks were found to be efficient on the scale of pure technical efficiency and in few years. The financial crisis was found to have a significant impact on banks' efficiency. These findings can be used by regulators, policy makers and bank management to further investigate the reasons behind the inefficient DMUs.

**JEL: D22, D24, D61; G21; G34**

**Keywords:** Bank efficiency, DEA analysis, Technical Efficiency, Scale Efficiency, Jordan,

## 1. Introduction

Bank efficiency analysis is vital for government, regulators, banks management, stock market, and investors. Government regulations could affect banks' efficiency in transferring their inputs into outputs (see Berger, Hunter and Timme, 1993). The efficient performance of banks is essential to maintain trust, confidence and soundness in the banking system that helps them to survive and compete. Without this trust and soundness, banks will be exposed to risk and will have a higher likelihood of failure and default that could lead to bankruptcy. Also, the results of bank failure would hinder economic activities in other sectors such as industry and services as banks are linked directly to the entire economy. Hence, efficient banks can compete and achieve higher rate of return relative to cost, and at the same time participate in economic development. Inefficient banks, on the other hand, cannot compete efficiently with their fewer chances to survive.

According to the World Bank (2003), Jordan is considered as a bank-based financial system where banks play a major role in financing the economic activities. During the 1980s, the government introduced greater regulation of bank activity to counterbalance fluctuations in stock values and the rapid expansion of banking. Since 1989, the Central Bank of Jordan (CBJ) has initiated a number of reforms to make the banking system more secure and more competitive. Such reforms included increasing the paid-up capital and removing the restrictions on the flow of trade in foreign currency in 1997 (JIB, 2005). More reforms were also undertaken to enhance the sector during the period 1999-2002.

The Jordanian economy was affected by several internal and external shocks, crises and regional risk such as the 1989 crisis, the first Gulf War in 1990-1991 and the second Gulf War, which had a negative impact on tourism and investment in

Jordan, in 2003. Recently, the regional political changes that started in the Arab world in 2011 (e.g. Egypt, Libya, Tunisia and Syria), was added to the risk. These crises led to more cooperation between the Jordanian government and international financial institutions, such as the World Bank and IMF, in order to develop its economic and financial system. Developing and reforming the financial system by freeing the economy was the main priority for the Jordanian government to adopt trade liberalisation policies aiming at supporting exports and increasing economic growth (Maghyereh, 2004; CBJ, 2005). Prior to 1990, the Jordanian economy used to be dominated by the public sector, but recently, Jordan has liberated its economy and deregulated the banking system (Zeitun, 2006; Hassan et al., 2004). For example, in 1999, the government sold its equity investment in a large number of banks (Housing Bank, Cairo Amman Bank, Export & Finance Bank) (Zeitun, 2006). Therefore, assessing Jordanian banks' efficiency after the deregulations of the banking system is crucial. Despite the vast number of studies that focus on the efficiency of the banking sector, only a few studies were carried out in the developing countries. The majority were carried out in the developed countries, with particular emphasis on the banking sector in the United States. However, studies on bank efficiency in the Middle East countries were very limited, and there is scarcity of research in the Arab countries, especially Jordan.

The objective of this paper is to evaluate the relative efficiency of 12 Jordanian banks over the period 2005-2010, which is the period after bank deregulation. No foreign banks were used in this study. The measurement of efficiency used in this study is the Data Envelopment Analysis (DEA) approach. It was used to examine the technical efficiency of the Jordanian banks. The technical efficiency (TE) is decomposed into the product of pure technical efficiency (PTE) and scale efficiency

(SE), which allows deep investigation into the sources of inefficiencies. We also investigate whether banks are operating at the most productive scale size (MPSS), increasing returns to scale (IRS), or decreasing returns to scale (DRS). Furthermore, it provides a deep understanding of the importance of maintaining the efficiency of the banking sector for sustained economic development. The research will also examine the stability of bank efficiencies over time for the studied period.

Our study will contribute to the growing existing empirical literature on banking efficiency in the developing countries, particularly in the Middle East. The study is also important as it covers all the local commercial and Islamic banks in Jordan during the period of study. Furthermore, it has another significant contribution as it may reflect the effect of deregulation in the banking sector, which was not really covered by previous studies. This investigation is likely to be useful to a number of public interest groups and policy-makers including the Jordanian government, the Central Bank of Jordan (CBJ), Amman Stock Exchange (ASE), commercial banking authorities, Islamic banking authorities, and society, as well as people dealing with banks.

The rest of the paper is organized as follows: Section 2 presents an overview of the Jordanian banking sector. Section 3 provides a brief review of the literature. Section 4 outlines the DEA approach, and Section 5 presents the empirical results. Section 6 provides concluding remarks.

## 1. Banking Sector and Deregulation in Jordan

Jordan is considered as a bank-based financial system where banks play a major role in financing the economy's activities (World Bank, 2003). The banking

system in Jordan is unique as Jordan has two banking systems; the conventional banking system (commercial banks) and the Islamic banking system. Islamic banks offer banking financing and services in accordance with the Shari'a or Islamic laws. Three Islamic banks are operating in Jordan; the Jordan Islamic Bank for Finance and Investment, Jordan Dubai Islamic Bank, and the Islamic International Arab Bank PLC. The main principle of the Islamic bank is the prohibition of Riba or interest rate.

The Central Bank of Jordan controls the banking sector (Conventional and Islamic). The Central Bank of Jordan was established in 1964 as an independent institution (authority) which acts as a fiscal agent for the government. It regulates the banking sector and sponsors the creation of new financial institutions (Khamis, 2003). The financial sector in Jordan is well developed compared to MENA countries. For example, Jordan was the only Arab country in which the value of bank assets exceeded GDP in 1980.

Jordan has adopted the model of a free economy, with reduced government involvement in the economy, thus encouraging the private sector to lead the economy. During the 1980s, the government introduced greater regulation of bank activity to counterbalance fluctuations in stock values and the rapid expansion of banking. Such regulations included: increasing the minimum capital requirement to US $7.1 million, requiring banks to invest 8% of their deposits in government bills and bonds, investing at least 15% of the banks' capital in public and mixed sector corporate equity, setting binding interest rate ceilings on both loans and deposits, and fixing the Jordanian dinar exchange rate by the CBJ (Zeitun, 2006).

Since 1989, the CBJ has initiated a number of reforms to make the banking system more secure and competitive: local Jordanian banks paid-up capital increased to US$ 28.25 million, foreign banks paid-up capital increased to USD 14.12 million, 80% of required reserves must be held at the CBJ, no restrictions on the inter-bank

foreign exchange market, restrictions on the flow of trade in foreign currency were removed during 1997, and the main restrictions on foreign capital were removed during 1997 (JIB, 2005; Zeitun, 2006). Furthermore, more reforms were undertaken to enhance the sector, such as the new banking law, new securities law, new auditing profession law, among others during the period 1999-2002 (Khamis, 2003; Zeitun 2006). In 1999, for example, the government sold its equity in a large number of banks (The Housing Bank, Cairo Amman Bank, Export & Finance Bank) (Zeitun 2006). Furthermore, the Privatisation Law No. 25 of the year 2000 was promulgated (National Portfolio Securities, 2001). One of the objectives of privatisation under article 3 of the Law (National Portfolio Securities, 2001) was boosting efficiency, competitiveness and productivity.

The total assets of the licenced banks increased dramatically. For instance, the total assets grew by $53,137.82 million USD in 2011 compared to 9,520.6 million USD in 1993 (see Table 1). Total deposits and credit facilities of licensed banks also increased intensely, reflecting the growth of commercial banks in Jordan and the increasing importance of the banking sector in the economic development. Table 1 also shows that the total deposits in Jordanian banks grew by 6,964.55 million USD in 1993 compared to 3,4372.84 million USD in 2011. Furthermore, the outstanding balance of credit facilities increased from 3,865.233 million USD in 1993 to 22,350.19 million USD in 2011. Increasing the availability of credit for different economic sectors participating provides stability, and decreases the consequences of the financial crisis.

The numbers of banks operating in Jordan had risen to twenty five by the end of 2010, thirteen of which are commercial with 521 branches and 52 representative offices, three Islamic banks with 94 branches and 12 representative offices, and nine foreign banks with 48 branches and 7 representative offices (CBJ, Annual Report

2010). In addition to that, there are three specialized credit institutions in Jordan (such as the agricultural Credit Corporation) with 37 branches. Thus, the population branch index of operating banks at the end of 2010 was nearly 9.9 thousand citizens per branch, compared with 11.9 thousand citizens per branch in 2004. Moreover, the number of branches of Jordanian banks operating abroad reached 153 branches and 13 representative offices in 2010, compared with 124 branches and 10 representative offices in 2004 (CBJ, 2010, 2004).

The branches of foreign banks operating in Jordan include HSBC Bank, Middle East LTD, Citibank, Rafidain Bank, Egyptian Arab Land Bank, Standard Chartered Bank, National Bank of Kuwait, Banque Audi SAL/ Saradar Audi Group, BLOM Bank and National Bank of Abu Dhabi.

The banking system in Jordan is highly concentrated in terms of total assets. The three largest banks account for 66.5% of the total assets of the banking sector, out of which the Arab Bank dominated with 48% of all assets in 2011. The Arab Bank plc and Housing Bank were the two largest banks in Jordan, with total assets of US $ 32,844 million and US $ 9,408 million, respectively in 2011 and 2010. The Housing Bank is the second largest, with the most extensive branch network, followed by the Jordan Islamic Bank for Finance and Investment (Zeitun, 2006: Creane, Goyal, Mobarak and Sab, 2003).

**Table 1: Licensed Banks Assets, Deposits and Credit Facilities**

| Year | Assets (Millions USD) | Total Deposits (Millions USD) | Credit Facilities (Millions USD) |
|---|---|---|---|
| 1993 | 9520.602 | 6964.554 | 3865.233 |
| 1994 | 10614.2 | 7602.015 | 4580.244 |
| 1995 | 11886.86 | 8160.375 | 5225.037 |
| 1996 | 12489.36 | 8444.208 | 5527.623 |
| 1997 | 13647.67 | 9006.939 | 5611.377 |
| 1998 | 14748.88 | 9604.074 | 6042.273 |
| 1999 | 16287.19 | 10578.38 | 6297.06 |
| 2000 | 18208.04 | 11596.55 | 6410.565 |
| 2001 | ------- | 12297.03 | 6977.949 |
| 2002 | 21318.21 | 13208.46 | 7233.3 |
| 2003 | 22139.12 | 14056.85 | 7419.984 |
| 2004 | 25127.75 | 16305.38 | 8726.772 |
| 2005 | 29731.97 | 18498.21 | 10919.46 |
| 2006 | 34175.02 | 20574.58 | 13764.28 |
| 2007 | 37810 | 22543.22 | 15926.8 |
| 2008 | 42013.21 | 25524.67 | 18392.46 |
| 2009 | 45059.23 | 28620.74 | 18777.25 |
| 2010 | 49312.07 | 31731.77 | 20376.47 |
| 2011 | 53137.82 | 34372.84 | 22350.19 |

Sources: Central Bank of Jordan (CBJ)

## 2. Literature Review

Several approaches have been used to estimate banks' efficiency. One of these approaches is Data Envelopment Analysis (DEA) which has been used extensively to evaluate the efficiency of banking institutions, hospitals and other institutions. DEA is a non-parametric linear programming technique introduced by Charnes et al. (1978) and extended by many researchers (e.g., Banker et al. 1984, Charnes et al., 1994; and Kleine, 2004, Faraj et al., 2006, AlKhathlan and Abdul Malik, 2010, among others). It is a linear programming procedure for frontier analysis of multiple inputs and multiple

outputs. The literature examining the efficiency of banking with nonparametric frontier techniques has increased precipitously during the last 15 years. According to Emrouznejad et al. (2008) DEA is widely used to assess efficiency in public and private sectors alike. In their international literature survey, Berger and Humphrey (1997) stated that more than 130 studies used DEA in banking industry in 21 countries.

The vast majority of the literature focuses on the banking sectors of well-developed countries, with particular emphasis on the banking sector in the United States. Miller and Noulas (1996) examined the efficiency of large banks in the United States. They found that technical efficiency (TE) is about 97%. They also found that pure technical efficient is positively related to the bank's profit and size. Seiford and Zhu (1999) provide further evidence from US banks. They used a two-stage DEA approach to examine the top fifty five US banks performance. They found that large banks' performance was better than small banks', while smaller banks performed better with marketability.

Alirezaee et al. (1998) provided evidence from Canada. They examined the efficiency for 1282 branches, using numerical experiments relating to DEA results. They found that the average branch efficiency score varied positively with the number of inputs and outputs, but inversely with the number of branches. Yildirim (2002) examined the efficiency of Turkish banks, using the DEA over the period 1988-1999. He found that pure technical (PE) and scale efficiency (SE) measures showed a great variation over the study period. Furthermore, the Turkish banks' efficiency is not sustained over the period 1988-1999. Krishnasamy (2003) assessed the efficiency of Malaysian banks over the period 2000-2001, using the DEA and Malmquist productivity index. He found that growth in Malaysian banks' productivity is attached

more to the changes in technology than technical efficiency.

Al-Faraj et al. (1993) used eight inputs and seven outputs to evaluate the efficiency of fifteen branches of one of the largest banks in Saudi Arabia, using the DEA. They found that twelve of the fifteenth braches were efficient. Another study conducted by Al-Faraj et al. (2006), using DEA to compare the technical efficiency of Saudi banks with world mean for the year 2002, found that Saudi banks' efficiency was very good compared with the world efficiency scores. A recent study by AlKhathlan and Abdul Malik (2010) evaluates the relative efficiency of 10 Saudi banks over the period 2003-2008, using two DEA models, CCR model and BCC. Their findings revealed that Saudi banks are efficient in managing their financial resources, confirming the findings of previous studies such as Al-Faraj et al. (2006).

A Study by Al-Shammari and Salimi (1998) used DEA to evaluate the operating efficiency of the Jordanian banks for the period 1991-1994. They found that the majority of the Jordanian banks relatively performed inefficiently. Ramathan (2007) used the DEA and Malmquist productivity index (MPI) to evaluate the performance efficiency of 55 banks from the Gulf Cooperation Council (GCC) over the period 2000-2004. His findings revealed that only 15 banks out of the 55 banks were found to be efficient under CRS. Bahraini banks were also found to have the highest productivity improvements during the study period 2000-2004, while the highest reductions in productivity was registered by Qatari banks. Another study from GCC was conducted by Al-Muharrami (2007). He investigated the productivity changes for 55 banks in the GCC countries using the Malmquist DEA method over the period 1993-2001. He found that there was a negative change in efficiency for 52 banks in GCC over the study period.

Sufian et al. (2009) study provides a comparative analysis of the Islamic banking sector performance in 16 MENA and Asian countries, using DEA. They

found that Islamic banks in MENA are more efficient than Islamic banks in Asia. They also found that banks with small market share are more efficient. Johnes et al, (2009) investigated the efficiency of Islamic and conventional banks in the GCC countries, using DEA and financial ratios. They found that Islamic banks are more profit efficient but less cost efficient. Noor et at. (2011) investigated the efficiency of 78 Islamic banks from 25 countries over the period 1992-2009. They found that Islamic banks have high pure technical efficiency. Also, they reported a positive correlation between banks' profitability and technical efficiency.

## 3. Methodology

### 3.1. Data Envelopment Analysis (DEA)

DEA is a linear programming procedure for frontier analysis of multiple inputs and multiple outputs. It was introduced by Charnes et al (1978) and extended by many researchers (e.g., Banker et al. 1984, Charnes et al., 1994; and Kleine, 2004). The purpose of DEA is to measure the relative efficiency and productivity of decision-making units (DMUs) among similar banks with similar resources (inputs) to achieve gain or similar (outputs) (Perez et al., 1988). However, the mathematics underlying the DEA approach will not be repeated here as it was outlined in several studies such as Charnes, Cooper and Rhodes (1978), Banker, Charnes and Cooper (1984), Coelli (1996a, 1996b), Kleine (2004), Kumar and Gulati (2008) and AlKhathlan and Abdul Malik (2010), among others.

DEA results will classify the decision-making units into efficient and inefficient DMUs. The efficient DMUs are the best practice banks with assigned score of 100%, while other banks are given scores between 0-100 percent. A bank is considered to be technically inefficient if it scores less than100% relative to the

efficient bank. Using technical efficiency (TE), a bank's score reflects how well a bank can convert its inputs into output. For example, if the TE for a bank is 90%, it means that the bank should reduce its inputs by 10% to be efficient. Technical efficiency is decomposed into pure technical and 'scale' efficiencies. DEA will be estimated using two DEA models; one with constant returns to scale (CRS) proposed by Charnes, Cooper and Rhodes (1978), and the other with variable returns to scale (VRS) proposed by Baker, Charnes and Cooper (1984). A bank has a scale inefficacy if there is a difference between technical efficiency for the same bank. If there is a difference in the two technical efficiency scores for a particular bank, then this indicates that the bank has scale inefficiency. In order to determine whether a bank is operating at increasing return to scale (IRS) or decreasing return to scale (DRS), non-increasing return to scale should be imposed for the DEA problem (Paul and Kourouche (2008) and Kourouche (2008), Kumar and Gulati, (2008).

DEA approach has several advantages. According to Seiford and Thrall (1990) DEA does not require any assumptions about the functional form relating inputs to outputs. The efficiency of the DMU is measured relative to all other DMUs with the simple restriction that all decision making units fall at or below the efficient frontier. According to Golany and Roll (1989), DEA results provide precious information, such as ranking of the DMUs (banks) by their efficiency scores, the identification of the sources and values of relative inefficiency in each of the tested DMUs, and managerial interpretation for the DEA outcomes, among other advantages. More details about the advantages and limitations of the DEA can be found in Paul and Kourouche (2008), Alshare et al. (2006), Rousseau and Semple (1995), Anderson and Petersen (1993) and Charnes et al. (1996), among others. However, regardless of the limitations of the DEA, this approach is widely applied and used in estimating banks' efficiency as a powerful approach for estimating and assessing efficiency for public

and private institutions (Emrouznejad et al., 2008).

### 4.2. Data and Model Used

Data on banks' inputs and outputs is required to estimate bank efficiency using DEA approach. According to the literature, there are three approaches that can be used in defining and selecting banks' inputs and outputs. These are: the production approach, the intermediation approach, and the value-added approach. According to the Production approach a bank is viewed as a producer using inputs such as capital and labour to produce loans and deposits (see e.g. Sathye (2001), among others). The intermediation approach defines a bank as an intermediary that transfers assets from the surplus units to deficit units.

The second approach was widely used by previous studies using various conceptualizations in defining banks' inputs and output (see. AlKhathlan and Abdul Malik (2010), Paul and Kourouche (2008), Kourouche (2008), Avkiran (1999), Miller and Noulas (1996), Charnes, Cooper, Huang and Sun (1990), among others). Following the intermediation approach, Model A is used. In this model three inputs were used: deposits (X1), equity capital (X2) and other assets (X3), in addition to one output which is net income before tax (Y1). Another two models were used. Model B defines three inputs: deposits (X1), equity (X2) and fixed assets (X3), in addition to two outputs which are net income (Y1) and loans (Y2). Model C defines four inputs: deposits (X1), equity (X2), other assets (X3) and fixed assets (X4), in addition to two outputs which are net interest (Y1) and other earning assets (Y2).)

The sample used in the study contains a panel of 12 Jordanian banks over the period of 2005 to 2010. The data on inputs and outputs used in this study were collected from the Bankscope and from the individual bank annual reports. Our

sample included only the national banks (conventional and Islamic banks). Foreign banks were not used in this study as no data is available on the branches of foreign banks operated in Jordan. It's also too difficult to collect the foreign banks' data due to the fact that they are wholly owned by foreigners. According to the Central Bank of Jordan in 2010, the total number of national banks operating in Jordan was 13 commercial banks and 3 Islamic banks. There were also 9 foreign banks and 3 specialized credit institutions owned by the public (CBJ, 2010).

Table 2 listed the banks used in terms of assets, country rank, number of branches and mini branches. Arab Bank is ranked as number 1 with total assets of $32,844 million USD and with 80 branches, followed by Housing Bank for Trade and Finance with total assets of $9,408 million USD, 104 branches and 5 mini branches. The Jordan Investment Bank is ranked 14 with total assets of $939 million USD and 9 branches. In terms of Islamic banks, Jordan Islamic Bank is ranked third with total assets of $3,667 million USD, 60 branches and 12 mini branches. On the other hand, Islamic International Arab Bank was ranked tenth with total assets of $1,596 million USD and 27 branches.

According to Dyson et al. (1998) a sample size needs to be greater than the inputs and outputs in order to discriminate between efficient and inefficient banks. However, some researchers such as Avkiran (1999b) argue that the sample size should be three times the sum of inputs and outputs. There are others such as Evanoff and Israilevich (1991) who argue that DEA can be used even with small sample sizes. There are many previous empirical studies that used small sample (e.g. Paul and Kourouche (2008), Sherman and Gold (1985), among others).

**Table 2: Sampled Banks by Asset Size**

| | Bank Name | Abbreviation used | Assets Millions USD | Branches | Mini Braches | Latest Accounts Date | Country rank by assets, roll |
|---|---|---|---|---|---|---|---|
| 1 | Arab Bank Plc | ABBI | 32,844 | 80 | - | Jun-11 | 1 |
| 2 | Housing Bank for Trade & Finance (The) | THBI | 9,408 | 104 | 5 | Dec-10 | 2 |
| 3 | Jordan Islamic Bank | JIBI | 3,667 | 60 | 12 | Mar-11 | 3 |
| 4 | Jordan Ahli Bank Plc | JNBI | 3,549 | 46 | 3 | Dec-10 | 4 |
| 5 | Jordan Kuwait Bank | JKBI | 2,935 | 42 | 9 | Dec-10 | 5 |
| 6 | Bank of Jordan Plc | BOJI | 2,773 | 65 | 13 | Dec-10 | 6 |
| 7 | Cairo Amman Bank | CABI | 2,596 | 62 | 6 | Dec-10 | 7 |
| 8 | Bank al Etihad | UBSI | 2,168 | 20 | 2 | Dec-10 | 8 |
| 9 | Capital Bank of Jordan | | 1,697 | 17 | 1 | Dec-10 | 9 |
| 10 | Islamic International Arab Bank | IIAI | 1,596 | 27 | - | Dec-10 | 10 |
| 11 | Arab Jordan Investment Bank | AJII | 1,227 | 10 | 10 | Dec-10 | 11 |
| 12 | Jordan Commercial Bank | | 1,074 | 25 | 3 | Dec-10 | 12 |
| 13 | Arab Banking Corporation (Jordan) | ABCI | 981 | 25 | - | Dec-10 | 13 |
| 14 | Investment Bank | JIFI | 939 | 9 | - | Dec-09 | 14 |
| 15 | Egyptian Arab Land Bank | | 515 | | | Dec-10 | 15 |
| 16 | Société générale de Banque-Jordanie | | 483 | 16 | - | Dec-10 | 16 |
| 17 | Jordan Dubai Islamic Bank | | 378 | 7 | - | Jun-11 | 17 |
| 18 | Philadelphia Investment Bank | | 247 | | | Dec-01 | |
| 19 | National Microfinance Bank Company | | 16 | | | Dec-08 | |

Source: Central Bank of Jordan and Bank scope and Banks Annual Reports

## 4. Empirical Findings

The study sample is composed of twelve local banks in Jordan. It includes the commercial, investment, and Islamic banks only over the period 2005-2010. Our sample does not include any foreign or public banks. Table 3 presents the descriptive statistics of the selected variables for the period 2005-2010.

In this study three models were used. Model A defines three inputs: deposits (X1), equity (X2), and other assets (X3), in addition to one outputs, which is net income (Y1). Model B defines three inputs: deposits (X1), equity (X2), fixed assets (X3), in addition to two outputs which are net income (Y1) and loans (Y2). Model C defines four inputs: deposits (X1), equity (X2), other assets (X3), fixed assets (X4), in addition to two outputs which are net interest (Y1) and other earning assets (Y2). DEA efficiencies for all banks were calculated on a scale from 0% to 100%, under the constant returns to scale (CRS) and variable returns-to-scale (VRS) assumptions for all models. The three models have been used in this study to show how efficiency scores differ when inputs and outputs used are changed.

**Table 3: Descriptive Statistics for the Period 2005-2010 (Measured in USD Millions)**

| Variable | Maximum | Minimum | Mean | Standard Deviation |
|---|---|---|---|---|
| Deposits | 26328.87 | 2.112676 | 3558.373 | 6321.392 |
| Equity | 5353.803 | 59.50199 | 652.7683 | 1261.011 |
| Other assets | 13774.3 | 22 | 1591.102 | 3270.679 |
| Net Income | 507.8819 | -4.92958 | 62.94085 | 100.9962 |
| Fixed Assets | 310.8451 | 2.527025 | 53.77464 | 70.09989 |
| Net Income | 507.8819 | -4.92958 | 62.94085 | 100.9962 |
| Loan | 15283.97 | 69.15493 | 1985.243 | 3457.39 |
| Net Interest | 825.2728 | 0 | 122.0737 | 194.6603 |

Table 4 shows some descriptive statistics about the banks in the sample for each model. The mean efficiency score of Jordanian banks was 54% as per model A, using CSR, while it was 67% using VRS. The maximum value for Model A was 1, while the minimum efficiency score was 10% for Model A, followed by 21% for Model C. Model C got the highest average 89% using VSR.

**Table 4: Summary Statistics for the Three Models**

| Models | No. of DMUs | Mean | Standard Deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| Model A CRS | 71 | 0.54 | 0.23 | 1 | 0.10 |
| Model A VRS | 71 | 0.67 | 0.25 | 1 | 0.11 |
| Model B CRS | 72 | 0.68 | 0.20 | 1 | 0.36 |
| Model B VRS | 72 | 0.80 | 0.19 | 1 | 0.36 |
| Model C CRS | 72 | 0.82 | 0.15 | 1 | 0.21 |
| Model C VRS | 72 | 0.89 | 0.15 | 1 | 0.22 |

The estimates of cost efficiency for banks used in this study are obtained by running an output-oriented DEA model. The output-oriented efficiency scores obtained from the CRS and VRS models have been discussed in this section. The output-oriented efficiency analysis provides information on how much the bank should increase the levels of outputs (outcomes) of an inefficient bank to become DEA-efficient whilst keeping current input levels (sources). Table 5 presents the year-wise average estimates of technical efficiency (CRS) and variable returns-to-scale (VRS). Table 5 shows that the technical efficiency (CRS) for Model A initially declined from 72% in 2005 to 42% in 2009. It then rose to 45% in 2010. Similarly, VRS fell down from 83% in 2005 to 68 % in 2007. It then increased to 69% in 2008, and then decreased to 57% in 2010. For Model B, CRS ranges from 78% in 2005 to 64% in 2010, while VRS ranges from 90% in 2005 to 77% in 2010.

Furthermore, for Model C, CRS ranges from 75% in 2010 to 87% in 2005, while VRS ranges from 95% in 2005 to 82% in 2010. The efficiency score for Jordanian banks is within the range of the scores in other studies around the world for the three models. However, the mean efficiency is lower than the world mean, which means that Jordanian banks need to improve their efficiency (e.g. Berger and Humphrey ( 1997), among others).

Table 5 also shows that the average technical efficiency (CRS) in the Jordanian banks during the study period (2005-2010) ranges from 42% in 2009 to 72% in 2005 for Model A. This suggests that the average bank in the sample could have increased the level of output for inefficient banks by approximately 58% to 28% respectively to achieve efficiency or 'best practice' performance. Similarly, the average VRS over the period of study (2005-2010) ranges from 57% in 2009 to 83% in 2005 for Model A. Model C shows the best results in terms of the average technical efficiency for both VRS and CRS. For example, Model C using CRS ranges from 75% in 2010 to 87% in 2005, while the VRS ranges from 82% in 2009 to 95% in 2005.

The variable returns to scale efficiency (VRS) for banks is quite high, using the three models compared with CRS. These results could reveal that there have been some improvement made in inputs and outputs used, which reflects the VRS that allows efficiency to vary with bank size. The results also show that most of the technical efficiency is in the form of scale inefficiency. The average cost efficiency shows a declining trend with some fluctuations from 2005 thereafter. The initial results also show that in all models used, the Jordanian efficiency was the highest in 2005. The reason could be the Gulf War II in 2005, which brought more refugees from Iraq and increased banks' investment opportunities. Furthermore, banks' efficiency decreased in 2008. This could be as a consequence of the financial crisis that affected

banks' efficiency.

**Table 5: Decomposition Of Mean Technical Efficiency CRS and Variable Returns-to-Scale VRS**

| | Model A | | Model B | | Model C | |
|---|---|---|---|---|---|---|
| | CRS | VRS | CRS | VRS | CRS | VRS |
| 2005 | 0.72 | 0.83 | 0.78 | 0.90 | 0.87 | 0.95 |
| 2006 | 0.57 | 0.68 | 0.66 | 0.78 | 0.87 | 0.92 |
| 2007 | 0.56 | 0.68 | 0.67 | 0.77 | 0.87 | 0.92 |
| 2008 | 0.53 | 0.69 | 0.67 | 0.79 | 0.83 | 0.89 |
| 2009 | 0.42 | 0.57 | 0.67 | 0.77 | 0.75 | 0.82 |
| 2010 | 0.45 | 0.57 | 0.64 | 0.77 | 0.75 | 0.84 |

The average estimates of CRS and VRS for individual banks over the study period are presented in Table 6. These estimates reveal that the Jordan Kuwait Bank (JKB) ranked first in terms of all three models, using CRS and VRS efficiencies. The JKB bank was found to be the most efficient in terms of CRS (0.98, 100 and 0.99 using model A, B and C respectively) and VRS (100% using model A, B and C). The second most efficient bank was Dubai Islamic Bank (DIB), using CRS and VRS. For example, the average of efficiency for DIB was 0.97 for both model A and model B, using VRS. The Arab Bank (ABB), which is the largest bank, and JIF banks were found to be the lowest efficient, using CRS in model A and B. On the other hand, Islamic International Arab Bank (IIA) and Jordan Investment and Finance Bank (JIF) were found to be the lowest efficient, using VRS in model A and B.

**Table 6: Mean DEA Estimates Efficiency of CRS and VRS, 2005–2010**

| | | CRS | | | VRS | | |
|---|---|---|---|---|---|---|---|
| Bank Name | Bank Abb | Model A | Model B | Model C | Model A | Model B | Model C |
| Arab Bank | ABB | 0.34 | 0.55 | 0.83 | 0.83 | 0.96 | 1.00 |
| The Housing Bank | THB | 0.48 | 0.52 | 0.72 | 0.86 | 0.89 | 0.97 |
| Jordan Islamic Bank for Finance & Investment | JIB | 0.61 | 0.87 | 0.82 | 0.72 | 0.93 | 0.82 |
| Jordan National (Ahi ) Bank | JNB | 0.36 | 0.58 | 0.87 | 0.44 | 0.69 | 0.96 |
| Jordan Kuwait Bank | JKB | 0.98 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| Bank of Jordan | BOJ | 0.59 | 0.66 | 0.91 | 0.69 | 0.76 | 0.93 |
| Cairo Amman Bank | CAB | 0.58 | 0.62 | 0.91 | 0.67 | 0.71 | 0.93 |
| Union Bank for Savings & Investment | UBS | 0.46 | 0.62 | 0.66 | 0.5 | 0.65 | 0.69 |
| Islamic International Arab Bank | IIA | 0.36 | 0.79 | 0.64 | 0.39 | 0.87 | 0.68 |
| Jordan Investment & Finance Bank | JIF | 0.41 | 0.46 | 0.84 | 0.44 | 0.5 | 0.87 |
| Arab Banking Corporation | ABC | 0.57 | 0.62 | 0.76 | 0.59 | 0.65 | 0.82 |
| Dubai Islamic Bank | DIB | 0.77 | 0.89 | 0.95 | 0.97 | 0.95 | 0.97 |

Table 7 presents the DEA efficiency scores for Model A and Model B based on constant return to scale (CRS) and variable return to scale (VRS) for each year, while Table 8 shows the DEA efficiency scores for Model C based on constant return to scale (CRS) and variable return to scale (VRS) for each year. Table 7 shows that as per Model A based on CRS, out of 12 banks only two banks, Jordan Kuwait Bank (JKB) and Dubai Islamic Bank (DIB) were on the frontier. JKB bank was on the frontier in years 2005, 2006, 2008 and 2009. DIB, however, was efficient only in 2005 and 2007. As per Model A based on VRS, out of 12 banks used in the study only JKB bank was efficient over the period of study. In 2005, the Housing Bank (THB), Jordan Kuwait Bank (JKB), Union Bank (UBS), Arab Bank Corporation (ABC) and Dubai Islamic Bank (DIB) were the only efficient banks, about 42%, while only one bank, Jordan Kuwait bank (JKB) was efficient in 2010. Jordan Islamic Bank (JIB), Jordan

National Bank (JNB), Bank of Jordan (BOJ), Cairo Amman Bank (CAB), International Islamic Arab Bank (IIA) and Jordan Investment and Finance Bank (JIF) did not show any sign of efficiency, using Model A based on VRS. Model B shows similar results, but slightly better than Model A. For example, JKB bank was on the frontier in years 2005, 2006, 2008, 2009 and 2010, while DIB was efficient only in 2005, 2007 and 2009 based on CRS.

ABB, THB, JNB and ABC banks did not show any sign of efficiency as per Models A, B and C based on CRS (see Table 7 and Table 8). Arab bank (ABB) and Housing Bank (THB) are the largest banks in terms of assets. This shows that bank efficiency based on CRS is not necessary affected by bank's size. It could also reveal that large banks are not efficient in using their inputs to generate output. On the other hand, JIB, JNB, BOJ, CAB, IIA and JIF did not show any sign of efficiency as per Model A based on CRS. Jordan National Bank (JNB), Bank of Jordan (BOJ), Cairo Amman Bank (CAB) and Jordan Investment and Finance Bank (JIF) as per model B did not show any sign of efficiency, and UBS and ABC did not show any sign of efficiency as per Model C. The banks that were on the efficiency frontier under the three models based on VRS in 2005 included Housing Bank (THB), Jordan Kuwait Bank (JKB) and Dubai Islamic Bank (DIB).

The scores computed using Model A, B and Model C need some explanation. As discussed earlier, DEA technique produces different efficiency scores for banks used in the study based on the inputs and outputs used in the estimation. In Model A, three inputs (deposits, equity, other assets) were used and one outputs (net income), while in Model B three inputs (deposits, equity, fixed asset) were used and two outputs (net income and loans). Model C, four inputs (deposits, equity, other assets, fixed assets), and two outputs (net interest and other earning assets). Jordanian banks appear to be more efficient users of more input quantities (deposits, equity, other

assets, fixed assets) to produce more outputs (net interest and other earning assets). This means that there are inefficiencies in the use of three inputs (deposits, equity, other assets) and one outputs (net income). On the other hand, Jordanian banks need to focus on deposits, equity, fixed asset, other assets of their inputs and outputs (loans, net income, interest earning assets and other earning assets) to achieve a higher level of efficiencies. The finding could reveal that these banks may have used higher amount of fixed assets than they should to generate income.

**Table 7: Estimation of CRS and VRS in Jordanian banks 2005-2010 for Model A and B**

| **Model A** | | | | | **CRS** | | | | | | **VRS** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bank Name | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| ABB | 40% | 36% | 40% | 42% | 28% | 16% | 97% | 87% | 100% | 100% | 69% | 41% |
| THB | 72% | 51% | 55% | 47% | 29% | 36% | 100% | 100% | 100% | 89% | 56% | 70% |
| JIB | | 50% | 64% | 80% | 58% | 55% | 76% | 52% | 70% | 95% | 71% | 69% |
| JNB | 53% | 38% | 20% | 32% | 35% | 39% | 63% | 45% | 25% | 40% | 41% | 48% |
| JKB | 100% | 100% | 98% | 100% | 100% | 93% | 100% | 100% | 100% | 100% | 100% | 100% |
| BOJ | 70% | 67% | 56% | 64% | 44% | 51% | 75% | 76% | 66% | 79% | 56% | 66% |
| CAB | 78% | 53% | 54% | 49% | 53% | 63% | 85% | 57% | 60% | 57% | 65% | 78% |
| UBS | 99% | 46% | 29% | 32% | 30% | 37% | 100% | 46% | 37% | 39% | 34% | 44% |
| IIA | 28% | 47% | 71% | 36% | 10% | 26% | 31% | 53% | 72% | 36% | 11% | 30% |
| JIF | 59% | 46% | 26% | 41% | 36% | 37% | 71% | 48% | 27% | 43% | 37% | 39% |
| ABC | 90% | 68% | 54% | 48% | 40% | 41% | 100% | 71% | 55% | 48% | 40% | 41% |
| DIB | 100% | 81% | 100% | 60% | 43% | 77% | 100% | 84% | 100% | 100% | 100% | 97% |
| **Model B** | | | | | **CRS** | | | | | | **VRS** | |
| Bank Name | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| ABB | 58% | 50% | 57% | 61% | 53% | 50% | 100% | 89% | 100% | 100% | 93% | 93% |
| THB | 72% | 53% | 55% | 51% | 39% | 41% | 100% | 100% | 100% | 90% | 71% | 71% |
| JIB | 100% | 76% | 82% | 87% | 88% | 91% | 100% | 77% | 86% | 100% | 96% | 100% |
| JNB | 53% | 45% | 54% | 64% | 66% | 68% | 63% | 53% | 63% | 75% | 79% | 83% |
| JKB | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| BOJ | 70% | 70% | 68% | 65% | 59% | 60% | 75% | 78% | 76% | 79% | 71% | 75% |
| CAB | 78% | 56% | 55% | 62% | 61% | 63% | 85% | 60% | 62% | 68% | 71% | 79% |
| UBS | 100% | 66% | 50% | 58% | 50% | 49% | 100% | 68% | 50% | 58% | 57% | 58% |
| IIA | 54% | 66% | 84% | 72% | 99% | 100% | 78% | 84% | 84% | 78% | 100% | 100% |
| JIF | 59% | 53% | 36% | 46% | 41% | 42% | 76% | 60% | 36% | 46% | 41% | 42% |
| ABC | 90% | 68% | 57% | 54% | 50% | 49% | 100% | 75% | 61% | 55% | 51% | 49% |
| DIB | 100% | 95% | 100% | 87% | 100% | 51% | 100% | 99% | 100% | 100% | 100% | 71% |

**Table 8: Estimation of CRS and VRS in Jordanian banks 2005-2010 for Model C**

| Model C | CRS | | | | | | VRS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bank Name | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| ABB | 83% | 94% | 94% | 81% | 77% | 67% | 100% | 100% | 100% | 100% | 100% | 98% |
| THB | 79% | 82% | 70% | 73% | 65% | 63% | 100% | 100% | 97% | 100% | 94% | 91% |
| JIB | 99% | 78% | 79% | 77% | 72% | 85% | 100% | 80% | 79% | 77% | 73% | 86% |
| JNB | 95% | 87% | 87% | 84% | 77% | 90% | 100% | 100% | 100% | 90% | 86% | 100% |
| JKB | 100% | 96% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| BOJ | 91% | 100% | 90% | 93% | 83% | 88% | 92% | 100% | 92% | 93% | 90% | 94% |
| CAB | 80% | 91% | 91% | 96% | 88% | 100% | 87% | 91% | 91% | 99% | 93% | 100% |
| UBS | 61% | 67% | 79% | 65% | 62% | 63% | 63% | 68% | 80% | 68% | 65% | 72% |
| IIA | 86% | 75% | 100% | 77% | 26% | 21% | 100% | 77% | 100% | 81% | 27% | 22% |
| JIF | 100% | 100% | 81% | 69% | 75% | 80% | 100% | 100% | 86% | 74% | 80% | 85% |
| ABC | 70% | 78% | 76% | 81% | 74% | 78% | 95% | 84% | 78% | 82% | 74% | 79% |
| DIB | 98% | 100% | 100% | 100% | 100% | 70% | 100% | 100% | 100% | 100% | 100% | 84% |

Table 9 shows the total number of efficient banks using the three models (Model A, B and C) over the study period 2005-2010. According to Table 9 Model C shows the best results followed by Model B and Model A. For example, in 2005 eight banks were efficient as per Model C based on VRS, while seven banks were found on the frontier in the same year using Model B. Interestingly, the results reveal that the total number of efficient banks is decreasing using Model C, but fluctuating over the study period 2005-2010 using Model A and Model B.

**Table 9: Total efficient banks for the three Models used over the period 2005-2010**

| CRS | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total efficient banks |
|---|---|---|---|---|---|---|---|
| Model A | 2 | 1 | 1 | 1 | 1 | 0 | 6 |
| Model B | 1 | 1 | 2 | 1 | 2 | 2 | 9 |
| Model C | 2 | 3 | 2 | 2 | 2 | 2 | 13 |
| VRS | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total efficient banks |
| Model A | 5 | 2 | 4 | 3 | 2 | 1 | 17 |
| Model B | 7 | 2 | 4 | 4 | 3 | 3 | 23 |
| Model C | 8 | 7 | 5 | 4 | 3 | 3 | 30 |

Table 10 provides further information on returns to scale at the bank level (individual level). Interestingly, there were only two banks consistently operating at IRS over the sample period (2005-2010), that is, Islamic International Arab Bank (IIA) and Arab Jordan Investment and Finance Bank (JIF), using only Model B. However, these two banks were not consistently technically efficient over the sample period using Model A, Model B and Model C, while IIA bank was found to be technically efficient using Model B in 2009 and 2010. The number of banks operating at IRS over the period (2005-2010) decreased from three banks in 2005 to zero in 2009 and 2010 using Model A and Model C. On the other hand, the total number of banks operating under IRS, using Model B, increased to five banks in 2006 then decreased to three banks over the period 2007-2009, and then increased again to four banks in 2010.

Jordan Kuwait Bank (JKB) was the only bank found to operate at MPSS over the sample period using the three models. However, Dubai Islamic Bank (DIB), Union Bank for Saving and Investment (UBS), Arab Bank (ABB), Jordan Investment and Finance Bank (JIF) were the only banks operating at MPSS, and only in 2005. However, there are few banks operating at MPSS in some years, such as THB and DIB, using Model A and Model B, while ABB, JNB, THB using Model C. As a general observation, it can be seen that only three banks were operating at DRS:

Jordan Ahli Bank (JNB), Bank of Jordan (BOJ) and Cairo Amman Bank (CAB). In terms of size these banks are ranked 4, 6 and 7 respectively. The explanation could be the conservative investment and credit policy followed by these three banks

**Table 10: Estimation of Return to Scale at the Individual Bank Level in Jordanian banks 2005-2010**

| Model A | | | | | | | Model B | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bank Name | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| ABB | DRS | DRS | DRS | MPSS | DRS | DRS | MPSS | DRS | DRS | MPSS | DRS | DRS |
| THB | MPSS | MPSS | MPSS | DR | DRS | DRS | MPSS | MPSS | MPSS | DRS | DRS | DRS |
| JIB | IRS | DRS | DRS | DRS | DRS | DRS | MPSS | DRS | DRS | DRS | DRS | MPSS |
| JNB | DRS | DRS | DRS | DRS | DRS | DRS | DRS | DRS | DRS | DRS | DRS | DRS |
| JKB | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS | MPSS |
| 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 |
| UBS | MPSS | DRS | DRS | DRS | DRS | DRS | MPSS | IRS | CRS | CRS | DRS | DRS |
| IIA | IRS | IRS | DRS | DRS | DRS | DRS | IRS | IRS | IRS | IRS | IRS | CRS |
| JIF | IRS | IRS | DRS | DRS | DRS | DRS | IRS | IRS | IRS | IRS | IRS | IRS |
| ABC | MPSS | IRS | IRS | DRS | DRS | DRS | MPSS | IRS | IRS | IRS | IRS | IRS |
| DIB | MPSS | DRS | MPSS | MPSS | MPSS | - | MPSS | IRS | MPSS | MPSS | MPS | CRS |

| Model C | | | | | | |
|---|---|---|---|---|---|---|
| Bank Name | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| ABB | MPSS | MPSS | MPSS | MPSS | DRS | DRS |
| THB | MPSS | MPSS | DRS | MPSS | DRS | DRS |
| JIB | MPSS | IRS | CRS | CRS | CRS | CRS |
| JNB | MPSS | MPSS | MPSS | DRS | DRS | MPSS |
| JKB | MPSS | MPSS | DRS | MPSS | MPSS | MPSS |
| BOJ | IRS | MPSS | DRS | DRS | DRS | DRS |
| CAB | DRS | CRS | IRS | CRS | CRS | MPSS |
| UBS | CRS | DRS | DRS | DRS | DRS | DRS |
| IIA | MPSS | IRS | MPSS | DRS | CRS | CRS |
| JIF | MPSS | MPSS | DRS | DRS | DRS | DRS |
| ABC | IRS | IRS | IRS | IRS | CRS | DRS |
| DIB | IRS | CRS | CRS | CRS | CRS | MPSS |

IRS: Increasing Returns to Scale, DRS: Decreasing Returns to Scale, CRS: Constant Return to Scale, MPSS: Most Productive Scale Size

We further investigated the effect of the financial crisis on Jordanian banks' efficiency using ANOVA. Table 11 shows the results of Kruskal-Wallis Test. It is clear that there is a significant difference in bank performance (rank) before, during and after the global financial crisis. The global financial crisis seems to have a significant impact on bank performance (rank).

**Table 11: the results of Kruskal-Wallis Test for Bank Performance (rank) Before, During and After the Global Financial Crisis 2008.**

| Year | | N | Mean Rank | Chi-Square | df | Asymp. Sig. |
|---|---|---|---|---|---|---|
| VRS Output | Before | 24 | 44.31 | 8.208 | 2 | 0.017 |
| | During | 24 | 37.9 | | | |
| | After | 24 | 27.29 | | | |
| | Total | 72 | | | | |
| VRS Input | Before | 24 | 47.6 | 14.484 | 2 | 0.001 |
| | During | 24 | 37.1 | | | |
| | After | 24 | 24.79 | | | |
| | Total | 72 | | | | |

## 5. Conclusion

DEA is widely used for measuring and analyzing the relative efficiency and managerial performance of banks that have similar inputs and outputs. This paper used technical efficiency that decomposes into pure technical efficiency and scale efficiency to measure the relative efficiency of the Jordanian banks over the period 2005-2010. Our sample contains 12 banks three of which are Islamic banks.

The empirical results in this paper confirmed that the majority of the Jordanian banks are inefficient in managing their inputs (financial resources). Jordan Kuwait Bank was the most efficient bank followed by Dubai Islamic Bank, using the three models. Model C got the highest average of efficiency 89% using VS, followed by Model B, which reflects the importance of the variables used in this model. The VRS

for banks is quite high using the three models, compared with CRS. These results could reveal that there have been some improvement made in inputs and outputs used, which reflects the VRS. Furthermore, the efficiency of Jordanian banks is below the world mean efficiency. Therefore, an action needs to be taken on bank level to increase efficiency. The Financial Crisis was also found to have a significant impact on banks' efficiency

The empirical results are very important to the policy maker and bank management to pay more attention to the banking activities and sources of major inputs. In addition to that, the finding that the current study contributes to the existing literature by providing evidence from developing countries may help future studies. However, the main limitation of this study is that the availability of data for some input and output variables was limited, which prevents us from doing extra analysis. Another limitation is that the study used cross sectional data, while time series could provide better results. An area of future research would be to use DEA window analysis to track efficiency of banks over time and to use monthly data. Furthermore, the contribution of the variables used to the banks' performance needs further investigation besides macroeconomic factors.

## References

Al-Faraj, T., Alidi, A., and Bu-Bshait, K. (1993). Evaluation of bank branches by means of data envelopment analysis. *International Journal of Operations and Production Management*, 13, 45–52.

Al-Faraj, T., Bu-Bshait, K., and Al-Muhammad, W. (2006). Evaluating the efficiency of Saudi commercial banks using data envelopment analysis. *International Journal of Financial Services Management*, 1(4), 466-477.

Alirezaee, M., Howland, M., and van de Panne, C. (1998). Sampling size and

efficiency bias in data envelopment analysis. *Journal of Applied Mathematics and Decision Sciences*, 2, 51-64.

AlKhathlan, K., Abdul Malik, S. (2010). Are Saudi Banks Efficient? Evidence Using Data Envelopment Analysis (DEA). *International Journal of Economics and Finance*. 2(2); May 2010

Al-Muharrami, S. (2007). The Causes of Productivity Change in GCC Banking Industry. *International Journal of Productivity and Performance Management*, 56, 731–743.

Al-Shammari, M. and Salimi, A. (1998). Modeling the operating efficiency of banks: A nonparametric methodology. *Logistics Information Management*, 11, 5–12.

Alshare, K. and Chowdhury, M. (2006). Data Envelopment Analysis (DEA): A review of Concepts and Applications. *International Journal of Business and Public Administration*, 3(2), 1-14.

Andersen, P. and Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39(10), 1261-1264.

Avkiran, N. K. (1999a). An application reference for Data Envelopment Analysis in branch banking: Helping the novice researcher. *International Journal of Bank Marketing*, 17 (5), 206-220.

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

Banker, R. D. (1984). Estimating most productive scale size using Data Envelopment Analysis, *European Journal of Operational Research*, 17, 35-44.

Banker, R., Charnes, A. and Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30, 1078–1092.

Berger A. N., and Humphrey D. B. (1997). Efficiency of financial institutions: international survey and directions for future research. *European Journal of Operational Research,* 98, 175–212.

Berger, A.N., Hunter, W. C., and Timme, S. G. (1993). The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present, and Future. *Journal of Banking and Finance*, 17 (April 1993), 221-49.

Central Bank of Jordan. (2004). Annual Report, (Amman, Jordan).

Central Bank of Jordan. (2004). Annual Report , (Amman, Jordan).

Central Bank of Jordan. (2010). Annual Report, (Amman, Jordan).

Charnes, A., Cooper W. W., Huang, Z. M., and Sun, D.B. (1990). Polyhedral Cone-Ratio DEA Models with an Illustrative Application to Large Commercial Banks. Journal of Econometrics, 46, 73-91.

Charnes A., Cooper, W., Lewin, A., and Seiford, L. (1994). *Data Envelopment Analysis: Theory, methodology, and applications,* Kluwer Academic Publishers,

Charnes, A., Cooper, W. W. and Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2, 429–444.

Charnes, A., Rousseau, J. and Semple, J. (1996). Sensitivity and stability of classifications in Data Envelopment Analysis. *The Journal of Productivity Analysis,* 7, 5-18.

Coelli, T. J. (1996a). A guide to DEAP version 2.1: A data envelopment analysis (computer) program (CEPA Working Paper No. 8/96). Armidale, Australia: Department of Econometrics, University of New England.

Coelli, T. J. (1996b). A guide to Frontier version 4.1: A computer program for stochastic frontier production and cost function estimation (CEPA Working Paper 96/07). Armidale, Australia: Department of Econometrics, University of New England.

Creane, Susan, Rishi Goyal, A Mushfiq Mobarak, and Randa Sab. (2003). Financial Development in the Middle East and North Africa, Working Paper No.33, (International Monetary Fund).

Dyson, R.G., Thanassoulis, E., and Boussofiane, A. (1998). Data envelopment analysis, Warwick Business School, http://www.csv.warwick.

ac.uk/[similar]bsrlu/dea/deat/deat1.htm

Emrouznejad, A., and Anouze, A. B. (2010). Data envelopment analysis with classification and regression tree – a case of banking efficiency, Expert Systems, 27 (4), 231-246.

Emrouzenjad A., Parker, B., and G. Tavares, G. (2008). Evaluation of research in efficiency and productivity: a survey and analysis of the first 30 years of scholarly literature in DEA. *Socio-Economic Planning Sciences*, 42, 151–157.

Evanoff, D. D., and Israilevich, P. R. (1991), Productive efficiency in banking. *Economic Perspectives*, 15 (4), 11-32.

Golany, B. and Roll, Y. (1989). An application procedure for DEA. *Omega*, 17, 237-250.

Hassan, M., Al-Sharkas, A., and Samad, A. (2004). An Empirical Study of Relative Efficiency of the Banking Industry in Bahrain. *Studies in Economics and Finance*, 22, 40–69.

Johnes, J., Izzeldin, M., and Pappas, V. (2009). The efficiency of Islamic and conventional banks in the Gulf corporation Council (GCC) countries: An analysis using financial ratios and data envelopment analysis. Lancaster University Management School, WP 2009/23.

Jordan Investment Bank (JIB), 2005, Finance and Banking, [online], (http://www.jordaninvestment.com/2c.htm, retrieved on 9/19/2005).

Khamis, M. (2003). Financial Sector Reforms and Issues in Jordan, Central Bank of Jordan, Paper Presented to the Euro-Med Regional Economic Dialogue, Rome.

Kleine, A. (2004). A general model framework for DEA. *Omega*, 32 (1).

Kourouche, K. (2008). Measuring Efficiency and Productivity in the Australian Banking Sector, PhD Thesis, University of Western Sydney, NSW, Australia.

Krishnasamy, G. (2003). Malaysian post-merger banks' productivity: application of Malmquist productivity index. *Managerial Finance*, 30, 63-74.

Kumar, S., and Gulati, R. (2008). An Examination of Technical, Pure Technical, and

Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis. *Eurasian Journal of Business and Economics*, 1 (2), 33-69.

Maghyereh, A. (2004). The Effect of Financial Liberalization on the Efficiency of Financial Institutions: The Case of Jordanian Commercial Banks. *Journal of Transnational Management Development, 9(2-3), 71-106.*

Miller, S. M., and Noulas, A. G. (1996). The Technical Efficiency of Large Bank Production. *Journal of Banking and Finance* 20: 3, 495–509

National Portfolio Securities (NPS), 2001, [online], (www.mahfaza.com.jo).

Noor, M., Akbar, M., and Nor Hayati, A. (2011). The profitability and determinants of efficiency of world Islamic banks. *Journal of Islamic banking and finance*, 28 (2). 57-87.

Paul, S & Kourouche, K. ( 2008). Regulatory Policy and the Efficiency of the Banking Sector in Australia. *Australian Economic Review*, 41, 260–271.

Perez, G., Coskunoglu, O., and Moore, A. (1988). Data Envelopment Analysis as a tool to Evaluate Efficiency of Army Real Property Management Activities (RPMA) Spending. *US Army Corps of Engineers Construction Engineering Research Laboratory,* pp. 1-41.

Ramanathan, R. (2007). Performance of banks in countries of the Gulf Cooperation Council. *International Journal of Productivity and Performance Management*, 56 (2), 137-154

Rousseau, J. J., and Semple, J. H. (1995). Twoperson ratio efficiency games. Management Science, 41(3), 435-441.

Sathye, M. (2005). Privatization, Performance, and Efficiency: A study of Indian Banks. *Vikalpa*, 30(1), 7-16.

Seiford, L. M., and Thrall. R. M. (1990). Recent developments in DEA: the mathematical programming approach to frontier analysis. *Journal of Econometrics*, 46, 7-38.

Seiford, L. and Zhu, J. (1999). Profitability and marketability of the top 55 US commercial banks, *Management Science*, 45, 1270-88.

Sherman, D., and Gold, F. (1985). Branch Operating Efficiency. Evaluation with Data Envelopment Analysis. *Journal of Banking and Finance*, 9, 297-315.

Sufian, F., Akbar, M., and Noor, N. (2009). The determinants of Islamic banks' efficiency changes: Empirical evidence from the MENA and Asian banking sectors, *International Journal of Islamic and Middle Eastern Finance and Management*, 2 (2), 120-128.

World Bank, (2003). The Hashemite Kingdom of Jordan Country Assistance Evaluation, Report No.26875-JO.

Yildirim, C. (2002). Evolution of banking efficiency within an unstable macroeconomic environment: the case of Turkish commercial banks. *Applied Economics*, 34, 2289-301.

Zeitun, R, 2006, Firm Performance and Default Risk for Publicly Listed Companies in Emerging Markets: A Case Study of Jordan, PhD Thesis, University of Western Sydney, Australia.