AN INVESTIGATION INTO THE DETERMINANTS OF COST EFFICIENCY IN THE JORDANIAN BANKS: AN APPLICATION STOCHASTIC FRONTIER METHOD

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ABSTRACT

This paper aims to measure and evaluate the cost efficiency for 17 Jordanian banks (2 large, 8 medium, 4 small and 3 foreign) for the period 1996-2007 covering the deregulation era, by employing a parametric estimation approach also known as a stochastic frontier analysis (SFA). In addition, this paper analyse the sources of the cost efficiency method developed by Papke and Wooldridge (1996). The empirical result for the cost efficiency are obtained by running an input-oriented SFA model using the computer program, FRONTIER Version 4.1., developed by Coelli (1996). The paper findings suggest that both the domestic and foreign banks have shown over the years of deregulation era slight improvements and this led to improvement in the efficiency of the Jordanian banking sector. In addition, this paper investigates whether ownership structure, size, number of branches and ATM, bad loan and age of the bank significantly affect the cost efficiency levels of Jordanian banks. Results show that differences in ownership structure significantly affect Jordanian banks' performance in terms of cost efficiency.

Keywords: Stochastic frontier analysis, Deregulation, Jordanian Banks, cost efficiency, second stage regression.

INTRODUCTION:

The measurement of efficiency and productivity of the banking industry is important for several reasons. First, the measures of efficiency and productivity are considered as crucial indicators of performance of individual banks and of the industry as a whole. Second, efficiency is a vital factor for the financial institutions wishing to maintain a successful business, given the increasing competition in financial markets. Third, in a rapidly changing and more globalised financial marketplace, governments, regulators, managers and investors are concerned about how efficiently banks transform their expensive inputs into various financial products and services. Finally, it may be noted that efficiency and productivity measures are critical aspects of banking industry that enable us to distinguish banks that will survive and prosper from those that will have problems with competitiveness.

The rest of the paper is organised as follows. A brief overview on financial liberalisation and the banking sector in Jordan in Section 2. Section 3 presents a brief overview of existing literature on the efficiency of the banking sector in Jordan. We discuss the concept of cost efficiency and its decomposition and provide details on the estimation of cost efficiency using SFA method and the variables employed in this paper to estimate the cost efficiency presented in section 4. Section 5 presents the results of the cost efficiency for all the 17 Jordanian banks for the period 1996-2007. Determinants of banks efficiency are presented in section 6 and section 7 concludes.

FINANCIAL REFORMS AND BANKING SECTOR IN JORDAN:

The Jordan banking system has undergone a number of developments since its creation in the second decade of the twentieth century. Before the 1980s the Jordanian banking sector was highly regulated, and economic policies were directed towards prevention of any foreign competition. The financial authorities put in place measures to limit foreign entry; as a result, domestic banks in Jordan operated in an oligopolistic environment, and interest rates on credits and deposits were determined in a monopolistic manner (Bdour and Al-khoury, 2008, p.163). In August 1989, Jordan experienced a crisis in its banking system following the collapse of Petra Bank and the financial difficulties of six other financial institutions linked to it. The crisis was a result of inadequate banking regulations, over-exposure of the banking system to the real estate market and imprudent speculations in foreign exchange (Canakci, 1995). To remedy the 1989 crisis, Jordanian government in close cooperation with International Monetary Fund (IMF) and the World initiated a reform program. At the same time the Central bank of Jordan (CBJ) used several monetary instruments, such as changing the rediscount rate and the reserve requirement ratio to influence the size, cost, and direction of credit facilities (Harrigan et al., 2006). The Jordanian government also took steps to enhance banking system efficiency and to create competition among Jordanian banks. For example, the government began the process of liberalising the banking system in 1993 and again in 1997 by establishing a western-type free market economy and competition. The liberalisation program aimed at removing restrictions on interest rates, reducing government direct lending, expanding product deregulation and reducing restrictions on foreign exchange transactions. In addition, the government adopted policies aimed at export promotion and structural reforms including the deregulation and liberalisation of financial markets (Maghyereh, 2004). Such reforms included the elimination of interest rate ceilings, reductions in both the reserve and liquidity requirements and reductions in taxes. These measures were taken to allow foreign banks to operate in Jordan and to reduce foreign exchange trading and capital movements.

The CBJ took steps to enhance the soundness and credibility of the overall banking industry. For example, in 1989 all licensed banks and financial companies were instructed to deposit 35% of their total deposits as a required reserve with the CBJ. In the following year, the CBJ liberalised the interest rates charged by banks and financial companies. In the second half of 1992, it instructed all commercial banks to restrict the maximum credit in local currency extended to non-residents to 5% of their total credit facilities. Later, in 1995, it increased the minimum paid-up capital for all domestic banks to JD 20 million, and foreign banks were asked to raise their capital to JD 10 million by the beginning of 1997. A milestone in the financial liberalisation process occurred when Jordan took two vital steps in 2000. First, Jordan came to an agreement with the WTO, which brought extensive legislative and regulatory reforms regarding customs and tariffs, patents, copyright and trademark legislation (Mahdi, 2001). Second, Jordan signed a Free Trade Area (FTA) agreement with the US to eliminate trade barriers within ten years. Towards the end of 2007, CBJ implemented a flexible monetary policy intended to maintain monetary stability and ensure the invulnerability and soundness of the banking system. This policy contributed to the achievement of economic growth of 6.0% and maintained inflation within

control despite unfavourable conditions such as the unprecedented rise in oil prices and the resultant rise in the price of basic commodities in the international market in 2007 (CBJ, Annual Report 2007).

LITERATURE REVIEW:

In the Jordanian literature of banking efficiency were found a small number of studied measuring efficiency in the banking sector. In my knowledge, so far the studies measured the level of efficiency of the Jordanian banking sector mostly used DEA technique, for example Maghyereh, A. (2004), Bdour and Al-khoury (2008), Jreisat & Paul 2010, Paul & Jreisat 2012, and Jreisat, A. (2012), only one study applied SFA technique to measure the efficiency for the Jordanian banks done by Ahmad (2000).

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

The present paper has significant contribution in the Jordanian literature by covering the entire deregulation era, using the SFA technique. None of the past studies have covered the entire financial deregulation period in Jordan by using SFA technique. The present study overcomes this limitation by encompassing the entire financial liberalisation period, investigating the drivers of efficiency in Jordanian banks.

THE CONCEPT OF COST EFFICIENCY: DEFINITION AND MEASUREMENT:

This paper uses SFA approach for examining the cost efficiency of the Jordanian banks. According to Berger and Master (1997), "cost efficiency (CE) gives a measure of how close a bank's cost is to what a best-practice bank's cost would be for producing the same output bundle under the same condition". Cost efficiency is derived from a cost function in which variable costs depend on the input prices, quantities of the variable outputs and any fixed inputs or outputs, environmental factors, random error, and efficiency. Cost efficiency is then measured as the ratio of the minimum cost incurred by the firm (best-practice) and the observed costs for the same firm. For instance, a cost efficiency score of 0.75 for a firm would mean that the firm is using only 75% of its resources efficiently, or in other word, the firm wastes 25% of its costs relative to the best-practice firm.

SPECIFICATION FOR STOCHASTIC COST FRONTIER MODEL- THE BATTESE & COELLI MODEL:

This paper evaluated cost efficiency using SFA. Table 1 and 2 describe all variables used in SFA model and banks used in this paper. All the monetary variables are expressed in 2000 Jordanian Dinar (JD) using GDP deflators.

The specification model used in this paper following Battese and Coelli (1992)[1]. The translog stochastic cost frontier model takes the following form:

$$\ln(C/P_F) = \beta_0 + \beta_1 \ln(P_L/P_F) + \beta_2 0.5\ln(P_L/P_F)^2 + \beta_3 \ln(Y_1) + \beta_4 \ln(Y_2) \quad (1)$$
$$+ \beta_5 0.5\ln(Y_1)^2 + \beta_6 0.5\ln(Y_2)^2 + \beta_7 \ln(Y_1)\ln(Y_2) + \beta_8 \ln(Y_I)\ln(P_L/P_F)$$
$$+ \beta_9 \ln(Y_2)\ln(P_L/P_F) + U + V.$$

The corresponding estimating equation is:

[1] Battese and Coelli (1992) model specification of time-varying firm effects with truncated normal distribution, for more details see (Battese and Coelli, 1992, pp149-165) and (Coelli, T.J. 1996, *A Guide to FRONTIER version 4.1).*

$$\ln(C_{it}/P_{Fit}) = \beta_0 + \beta_1 \ln(P_{Lit}/P_{Fit}) + \beta_2 0.5\ln(P_{Lit}/P_{Fit})^2 + \beta_3 \ln(Y_{1it}) + \beta_4 \ln(Y_{2it}) \quad (2)$$
$$+ \beta_5 0.5\ln(Y_{1it})^2 + \beta_6 0.5\ln(Y_{2it})^2 + \beta_7 \ln(Y_{1it})\ln(Y_{2it}) + \beta_8 \ln(Y_{Iit})\ln(P_{Lit}/P_{Fit})$$
$$+ \beta_9 \ln(Y_{2it})\ln(P_{Lit}/P_{Fit}) + u_{it} + v_{it}$$

where $\ln(C_{it})$ is the natural log of *ith* total cost, $\ln y_i$ is the natural log of *ith* output, $\ln P_j$ is the natural log of price for the *jth* input, β is the parameter vector to be estimated, *V's* are assumed to be $v_{it} \sim (0, \sigma^2{}_v)$, $u_{it} \sim u_i \exp(-\eta(t-i))$. v_{it} and u_{it} are independent of each other[2]. η is an unknown scalar parameter (see Battese and Coelli, 1992, pp154). In the above cost function, u indicates how far the bank is operating above the cost frontier. The cost efficiency of the bank is defined as the ratio of the stochastic frontier total costs to observed total costs. The measure of cost efficiency is bounded between zero and one. A cost efficiency of one represents a fully cost efficient bank; 1 minus cost efficiency represents the amount by which the bank could reduce its costs and still produce at least the same amount of output. Moreover, in this paper model the linear homogeneity conditions were imposed on the estimating equation by normalizing total cost and the price of labour by the price of fund before the log transformation.

Table 1: Variables Definitions for the Jordanian banks

Variables	Description
Dependent variable	
C : Total Cost	: Interest expenses plus wages and benefit and expenses of the employee.
Independent variables	
Y_1 : Total loan	: Total customer loan.
Y_2 : Other investments	: Investments in bonds and securities, shares, treasury bills, and investment in affiliate and subsidiary companies.
P_L : Price of labour	: Wages and personal expenses and benefit of the banks staff divided by number of staff.
P_F : Price of fund	: Interest expense divided by total deposits

Table 2: Assets of Domestic and Foreign Banks during 2007

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

Source: The Association of Banks in Jordan (2007).

[2] The truncated normal frontier model is due to Stevenson (1980) while the gamma model is due to Greene (1990). The log-likelihood functions for these different models can be found in Kumbhakar and Lovell (2000).

THE ESTIMATION OF EFFICIENCY SCORES:

The SFA model for cost efficiency is simultaneously estimated by using the maximum likelihood function. The software package Frontier 4.1, developed by Coelli (1996) is used to estimate the cost efficiency levels of panel data of 17 banks for the period 1996-2007. In this model we use Battese and Coelli (1992) model specification[3]. The regressor variables are converted to their logarithm value in the model. SFA provides yearly efficiency scores over the period 1996-2007 based on the panel data for all the 17 banks (2 large, 8 medium, 4 small and 3 foreign). Similarly, the indices aggregated over the period are also weighted geometric means, where shares of yearly outputs in the total output for the period are used as weights. Table 3 presents the summary statistics for the dependent variable used in SFA model and explanatory variables used in the second stage regression for the Jordanian banks, which might be useful in understanding the broad structure of banking sector in Jordan.

Table 3: Summary Statistics for the Variables for the Jordanian Banks 1996-2007 (Values in Jordanian Dinar at constant 2000 prices using GDP Deflator)

		All Banks				Large				Medium				Small				Foreign				Domestic		
Variables	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
TotalCost	56.2	131	0.662	741.2	317	262	44	742	31	21	0.66	126	12	6	2.8	23	9.1	4.4	3.04	16.02	66.3	142.3	0.66	742
TA	1380	3233	19	16906	8035	6230	1210	16906	700	385	28	1607	256	129	53	507	257	122	19	492	1621	3517	28	16906
AGE	29.26	17.80	1	77	49.50	22.75	22	77	25.63	14.96	1	51	17	7.57	3	29	41.83	11.24	22	58	26.57	17.81	1	77
AGE2	1171.58	1303.75	1	5929	2946.17	2257.43	484	5929	878.17	810.56	1	2601	345.17	257.33	9	841	1872.83	894.21	484	3364	1021.31	1330.36	1	5929
Foreign	0.18	0.38	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
Bad loan	1.88	2.26	0	14.98	0.64	0.41	0.00	1.43	2.39	2.83	0	14.98	2.25	1.75	0	7.09	0.88	0.88	0.07	3.34	2.10	2.41	0	14.98
ATM	27.39	36.36	2	159	110.17	30.63	67	159	22.96	22.40	2	72	11.10	7.48	2	27	5.72	3.96	2	15	32.03	38.48	2	159
Branches	32.86	29.86	2	111	93.13	10.25	77	111	35.19	23.43	2	75	18.56	6.05	8	29	5.56	3.59	2	13	38.71	29.77	2	111
SFA-CE	0.48	0.16	0.27	0.95	0.39	0.02	0.36	0.41	0.44	0.21	0.27	0.95	0.53	0.08	0.45	0.65	0.56	0.07	0.46	0.61	0.46	0.17	0.27	0.95

Source: Data collected by author from individual bank Annual Report. Note: SD denotes standard deviation. SFA-CE denotes cost efficiency scores calculated using stochastic frontier model. The Value of total assets (TA) and Total Cost (C) divided by 1 Million (JD).

EMPIRICAL RESULTS OF THE COST EFFICIENCY BASED ON SFA:

This section evaluates the cost efficiency of 17 Jordanian banks over the period 1996 to 2007 of the financial liberalization. The stochastic translog cost efficiency frontier parameter estimated from the maximum likelihood model for the Jordanian banks and the statistics for noise (sigma-squared) and inefficiency component are given in Table 4.

Y_2^2 is significant at 1% level. Y_1 and $(P_L / P_F)^2$ are significant at 5% level. Furthermore, the results show that increase in the total loan, other investment and increase in $(P_L / P_F)^2$ will increase the cost for the banks. The inefficiency location parameter, μ, is significantly different from zero at the 1% level. The null hypothesis in this test is $\gamma = 0$ versus the alternative of $\gamma > 0$. If the null hypothesis is accepted, this could indicate that σ_u^2 is zero and hence that inefficiency effects in the cost function are not present, leaving a specification with parameters that can be appropriately estimated using ordinary least squares (OLS) (Coelli, 1996). However, if the null hypothesis is rejected, this could suggest that a standard mean response function is not an adequate representation of the data. Thus, the paper results the γ parameter corresponding to the estimated proportion of bank inefficiency in the composed total error term is significantly different from zero at the 1% level. This parameter shows high values (close to unity) in the model which account for heterogeneity, revealing that most of the variation in observed costs from the frontier are due to bank inefficiency, in other word, the gamma γ coefficient was found to be significant at 1% level indicated that cost efficiencies of banks were very much affected by inefficient usage of input. The hypothesis $\gamma = 0$, was rejected. This suggests that the stochastic frontier estimation procedure is more appropriate than OLS. In addition, the magnitude of the variance parameter σ^2 statistically significant at the 1% level suggests that both noise and inefficiency are significant, which indicates the noise component is also present that the stochastic frontier analysis model should be stochastic. I find that the log-likelihood value for present model is high and suggesting improves the fit significantly.

Now we will turn to discuss the results of one sided log-likelihood ratio (LR)[4] tests of the standard response

[3] Several studies apply this model. For instance, Resti (1997) applies this model for evaluating the cost efficiency of the Italian banks.

[4] Log-likelihood Ratio test: The likelihood ratio (LR) test is a very powerful and commonly used method for choosing models or validating assumptions.

function (OLS) versus the full frontier model. If the log-likelihood test statistic exceeds the appropriate critical value from the Chi-Square (X^2) tables, then the null hypothesis is rejected; that is, the imposed restrictions are invalid. The null hypothesis is accepted if the log-likelihood test statistic is less than the Chi-square critical value, meaning that the imposed restrictions are valid. Therefore, in the SFA model the null hypothesis $H_0 = \gamma = \mu = \eta = 0$ should be rejected at the 5% level of significance, if the *LR* test statistic exceeds the critical value from the (X^2) tables. In this case the value of the generalised log likelihood ratio (LR) statistics $(LR = 207)$ with degree of freedom (3) is compared with $x^2_{0.95}(3) = 7.81.$ Thus, the null hypothesis is rejected at the 5% level of significance (Coelli et al. 2005, p.258).

Table 4: The Maximum Likelihood Cost Frontier Parameter Estimates for Jordanian Banks 1996-2007

Parameter	Variable	Estimated value	Standard-error
β_0	Constant	-2.227**	1.000
β_1	P_L / P_F	-0.317	0.334
β_2	$(P_L / P_F)^2$	0.054**	0.026
β_3	Y_1	1.015**	0.459
β_4	Y_2	0.006	0.051
β_5	Y_1^2	0.676	0.530
β_6	Y_2^2	0.035*	0.020
β_7	$Y_1 \times Y_2$	-0.050	0.036
β_8	$Y_1 \times (P_L / P_F)$	0.018	0.023
β_9	$Y_2 \times (P_L / P_F)$	-0.018	0.017
σ^2		0.103***	0.024
γ		0.851***	0.036
μ		0.591***	0.151
η		0.001	0.005
Log likelihood function			80.593
LR test of the one-sided error			207.028
Total number of observation			204

*Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level. $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\gamma = \sigma_u^2 / \sigma^2$.

The summary statistics is presented in Table 5 relating to the estimated of cost efficiency scores for the panel of 17 Jordanian banks for the years 1996 through 2007. In the case of the SFA model, the average cost efficiency scores vary from 47.5% in 1996 to 48% in 2007. This results suggests that the average bank in the sample could have reduced its costs by approximately 52% to 52.5%, to achieve 'best practice' performance. Similarly, the minimal cost efficiency scores range from 26.7% in 1996 to 27.2% in 2007. The yearly average cost efficiency scores are plotted in Figure 1 for comparative purposes.

Figure 1 illustrates the trend of average cost efficiency changes over the sample period 1996 to 2007. It's clearly observed how the Jordanian banking sector shows an overall increase in efficiency which indicates that the reforms implemented by the liberalization program may have enhanced the performance of the Jordanian banks over this period. Interestingly, the results found to be consistent in term of cost efficiency improvements for the entire period 1996 till 2007 from SFA technique.

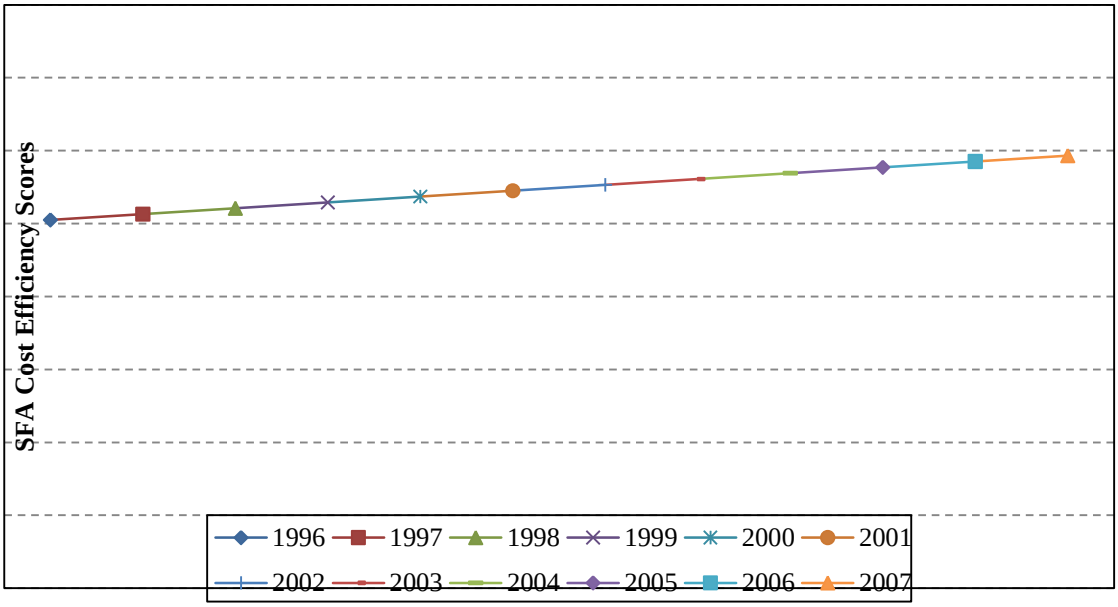
The likelihood ratio test is normally based on minus two times log-likelihood ratio and is giving by: LR = -2 ln λ = -2(ln *LR* –ln *LU*). (See Dong, 2009, p.274).

Table 5: Yearly SFA Estimates of cost efficiency 1996-2007

		Cost Efficiency		
Year	**Max**	**Min**	**Mean**	**St Dev.**
1996	0.950	0.267	0.475	0.170
1997	0.950	0.268	0.476	0.170
1998	0.950	0.268	0.476	0.170
1999	0.950	0.269	0.476	0.170
2000	0.950	0.269	0.477	0.169
2001	0.950	0.270	0.477	0.169
2002	0.950	0.270	0.478	0.169
2003	0.950	0.270	0.478	0.169
2004	0.950	0.271	0.478	0.169
2005	0.950	0.271	0.479	0.169
2006	0.950	0.272	0.479	0.169
2007	0.950	0.272	0.480	0.169

Source: Author's calculations.

Figure 1: Average Efficiency Over Time for SFA Model (1996-2007)



Source: Author's calculations.

The annual estimates of cost efficiency scores for each bank, presented in Table 6 show yearly fluctuations in cost efficiency for some banks over the deregulation era from 1996 until 2007. Both the large banks show cost efficiency improvements during the sample years, whereas in all other domestic banks cost efficiency has slight improved during the sample years. Besides, foreign banks show yearly slight improvements. Table 7 illustrates the changes of efficiency over the sub-periods of financial reforms, 1996-99, 1999-03 and 2003-07 which represent respectively the early, middle and later phases of financial liberalisation in Jordon. The results reveal that both the domestic and foreign banks have shown over the years of deregulation era slight improvement and this has led to improvement in the efficiency in the Jordanian banking sector. The highest mean cost efficiency has been shown by Capital Bank of Jordan on average 95% and lowest by the Cairo Amman Bank 27%. Figure 2 diagrammatically represents Table 8. Importantly, these results of cost efficiency scores for best and worst bank are consistent with Jreisat & Paul (2010) results on DEA findings for Jordanian banks for the same period.

Table 6: SFA Estimates of Cost Efficiency for Domestic and Foreign Banks, 1996-2007

Bank	Cost Efficiency	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
Large														
AB	CE	0.361	0.362	0.362	0.362	0.363	0.363	0.364	0.364	0.364	0.365	0.365	0.365	0.363
HBTF	CE	0.409	0.409	0.409	0.410	0.410	0.411	0.411	0.412	0.412	0.413	0.413	0.413	0.411
Medium														
JKB	CE	0.429	0.430	0.430	0.431	0.431	0.431	0.432	0.432	0.433	0.433	0.434	0.434	0.432
JIBF	CE	0.283	0.284	0.284	0.285	0.285	0.286	0.286	0.286	0.287	0.287	0.288	0.288	0.286
AHLI	CE	0.292	0.293	0.293	0.294	0.294	0.294	0.295	0.295	0.296	0.296	0.297	0.297	0.295
BOJ	CE	0.291	0.291	0.292	0.292	0.293	0.293	0.294	0.294	0.294	0.295	0.295	0.296	0.293
CAB	CE	0.267	0.268	0.268	0.269	0.269	0.270	0.270	0.270	0.271	0.271	0.272	0.272	0.270
UBJ	CE	0.510	0.510	0.511	0.511	0.511	0.512	0.512	0.513	0.513	0.514	0.514	0.514	0.512
CBJ	CE	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
JIFB	CE	0.501	0.501	0.502	0.502	0.503	0.503	0.504	0.504	0.504	0.505	0.505	0.506	0.503
Small														
ABC	CE	0.543	0.543	0.544	0.544	0.545	0.545	0.546	0.546	0.546	0.547	0.547	0.548	0.545
JCB	CE	0.481	0.481	0.482	0.482	0.483	0.483	0.484	0.484	0.484	0.485	0.485	0.486	0.483
AJIB	CE	0.451	0.452	0.452	0.452	0.453	0.453	0.454	0.454	0.455	0.455	0.456	0.456	0.454
SGBJ	CE	0.649	0.649	0.649	0.650	0.650	0.650	0.651	0.651	0.651	0.652	0.652	0.652	0.651
Foreign														
HSBC	CE	0.460	0.461	0.461	0.462	0.462	0.462	0.463	0.463	0.464	0.464	0.465	0.465	0.463
BSC	CE	0.594	0.594	0.594	0.595	0.595	0.596	0.596	0.596	0.597	0.597	0.598	0.598	0.596
CB	CE	0.608	0.609	0.609	0.610	0.610	0.610	0.611	0.611	0.611	0.612	0.612	0.613	0.610

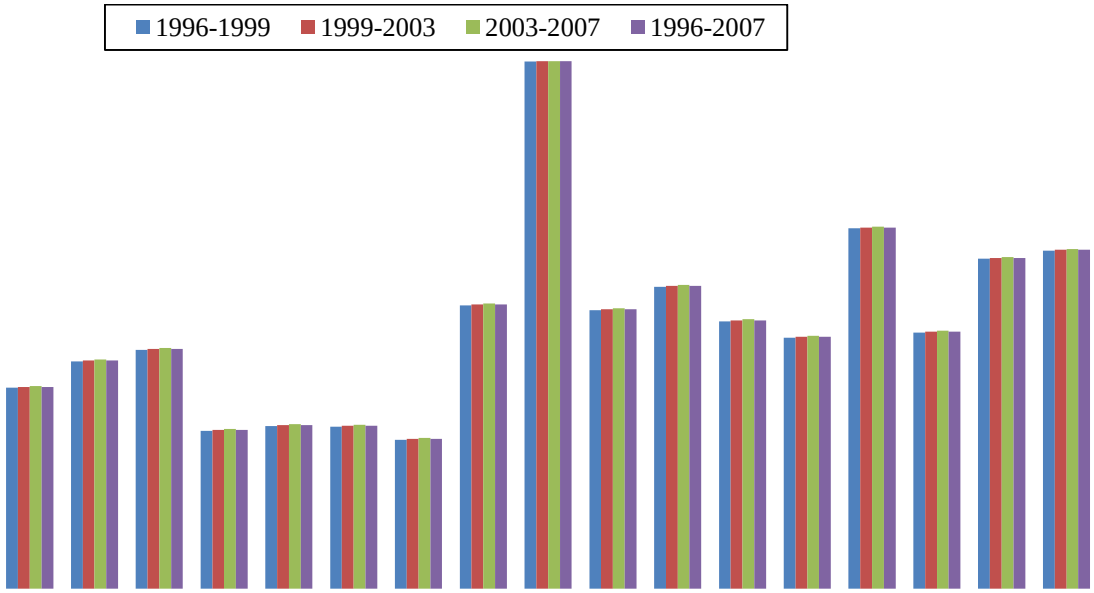
Source: Author's calculations. *Notes:* CE denotes cost efficiency.

Table 7: SFA Estimates of Cost Efficiency average of Banks, over the period (1996-2007) and Sub-period

Bank Type	1996-1999	1999-2003	2003-2007	1996-2007
Large				
AB	0.362	0.363	0.365	0.363
HBTF	0.409	0.411	0.413	0.411
Medium				
JKB	0.430	0.432	0.434	0.432
JIBF	0.284	0.286	0.288	0.286
AHLI	0.293	0.295	0.296	0.295
BOJ	0.292	0.293	0.295	0.293
CAB	0.268	0.270	0.272	0.270
UBJ	0.510	0.512	0.514	0.512
CBJ	0.950	0.950	0.950	0.950
JIFB	0.502	0.503	0.505	0.503
Small				
ABC	0.544	0.545	0.547	0.545
JCB	0.482	0.483	0.485	0.483
AJIB	0.452	0.454	0.455	0.454
SGBJ	0.649	0.651	0.652	0.651
Foreign				
HSBC	0.461	0.463	0.464	0.463
BSC	0.594	0.596	0.597	0.596
CB	0.609	0.610	0.612	0.610

Source: Author's calculations. *Notes:* The cost efficiency estimates for each bank for each period and sub-period are the weighted average means of bank specific cost efficiencies.

Figure 2: SFA Estimates of Cost Efficiency average of Banks, over the period (1996-2007) and Sub-period



Source: Author's calculations.

Further analyse done to the cost efficiency levels of Jordanian banks in more details with particular emphasis on the categories of banks and ownership. The average cost efficiencies from the SFA model for the three different categories of domestic banks (large, medium and small) and ownership (domestic and foreign) are presented in Table 8 and in time profile in Figures 3 and 4. The aggregated estimates of cost efficiency for the entire banking sector and of each group of banks are obtained as the weighted average mean of individual bank's scores using the share of each bank in total output as weight. On the other hand, to check how efficiency has changed over the sub-periods of financial reforms, we present in Table 10, the mean of cost estimates for broad categories of banks for three sub-periods, 1996-99, 1999-03 and 2003-07 which represent respectively the early, middle and later phases of financial liberalisation in Jordon.

Numerous interesting points emerge from these Tables 8 and 9. Firstly, on cost efficiency; among the domestic banks the small bank on average are the most efficient (50.6%), followed by large and medium banks with cost efficiency on average (36.9% and 35.3%, respectively). Relatively speaking, however, we find that the foreign banks revealed to be the greatest efficiency and medium banks have perform with least efficiency in most years.

Secondly, the SFA cost efficiency levels of both domestic and foreign banks have significantly improved over the deregulation period from (36.1%, 52.8%) 1996 to (38.4%, 53.6%) in 2007, respectively. These results suggest that liberalisation program reformed and enhanced their cost efficiency over this period (See Table 8 and Figures 3, 4).

Thirdly, in the first, second and third phase of three sub-periods, 1996-99, 1999-03 and 2003-07 of deregulation era shows that the cost efficiency for the domestic banks increased on average 36.2% 37% 38.1%, respectively. This implies that the Jordanian banks responded positively to the financial liberalisation policies initiated by the Jordanian government (See Table 9). Berger and Humphrey (1997) have outlined results of 130 studies of efficiency measurements covering 21 countries using five different frontier approaches. They state that the deregulation of financial institutions may improve or worsen efficiency depending upon the earlier conditions for the industry to deregulation.

Fourthly, the average cost efficiency for all banks is 38.7%. This suggests that the banks waste 61.3% from their cost relative to the best-practice banks during the period 1996-2007. Cost efficiency ranges from 36.5% in 1996 to 38.7% in 2007, suggesting an increase over the deregulation period.

Fifth, the domestic banks are less cost efficient than foreign banks, as may be noted that the difference in efficiency levels of domestic and foreign banks has widened over the period 1996 to 2007.

As the results in the present paper based on SFA, cost efficiency scores suggests that liberalisation program reformed may enhance the cost efficiency for the Jordanian banking sector over the period 1996-2007.

Table 8: SFA Estimates of Cost Efficiency by Category of Banks and ownership, 1996-2007

Banks	Cost Efficiency	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Large	CE	0.367	0.367	0.368	0.368	0.367	0.368	0.368	0.369	0.370	0.372	0.373	0.373
Medium	CE	0.317	0.321	0.323	0.330	0.343	0.357	0.359	0.367	0.373	0.381	0.390	0.389
Small	CE	0.509	0.510	0.506	0.502	0.496	0.499	0.502	0.507	0.508	0.510	0.508	0.511
Foreign	CE	0.528	0.527	0.534	0.544	0.533	0.529	0.528	0.528	0.531	0.526	0.529	0.536
Domestic	CE	0.361	0.361	0.362	0.363	0.367	0.371	0.370	0.372	0.375	0.380	0.384	0.384
All Banks	CE	0.365	0.365	0.366	0.368	0.370	0.373	0.373	0.375	0.378	0.382	0.387	0.387

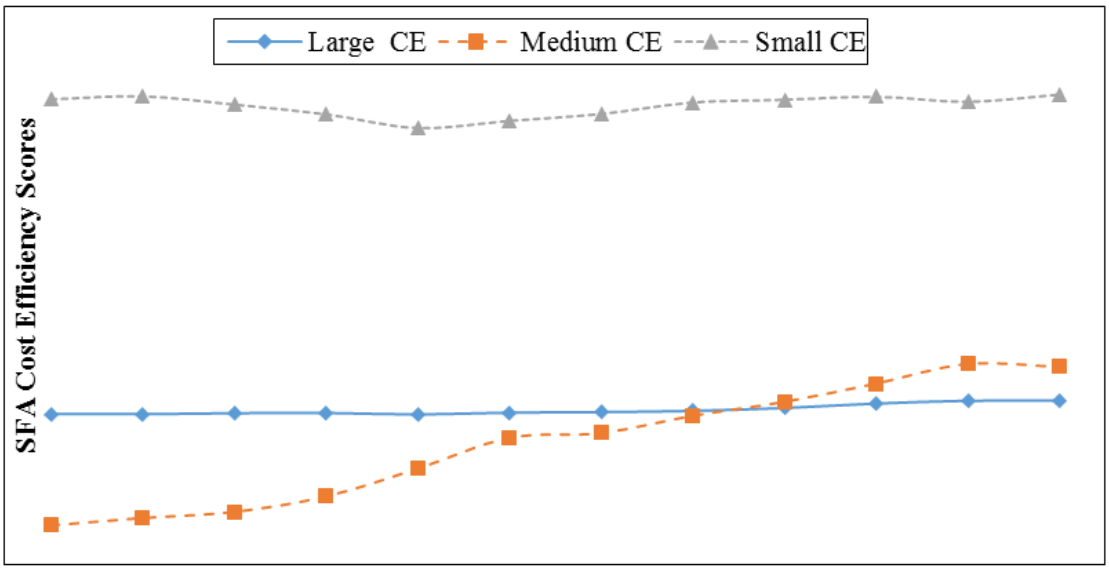
Source: Author's calculations. *Notes:* CE denotes cost efficiency. The cost efficiency estimates for each bank category are the weighted average means of bank specific efficiencies, where the weights are their shares in the aggregate output of the bank category they belong to. The weights vary from year to year.

Table 9: SFA Estimates of Cost Efficiency average by Category of Banks and ownership, over the period (1996-2007) and Sub-period

Banks	CE	1996-1999	1999-2003	2003-2007	1996-2007
Large	CE	0.368	0.368	0.372	0.369
Medium	CE	0.323	0.356	0.383	0.353
Small	CE	0.507	0.501	0.509	0.506
Foreign	CE	0.533	0.530	0.530	0.531
Domestic	CE	0.362	0.370	0.381	0.371
All Banks	CE	0.366	0.373	0.383	0.374

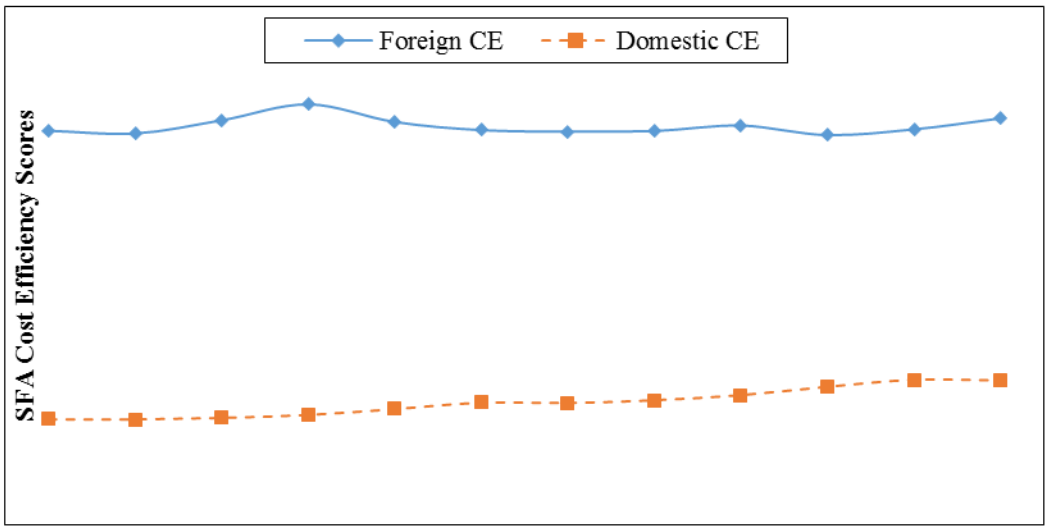
Source: Author's calculations. Notes: CE denotes cost efficiency. The cost efficiency estimates by category of banks and ownership for each period and sub-period are the weighted average means of bank specific cost efficiencies. The cost efficiency estimates for each bank category are the weighted average means of bank specific efficiencies, where the weights are their shares in the aggregate output of the bank category they belong to. The weights vary from year to year.

Figure 3: SFA Estimates of Cost Efficiency by Category of Banks, 1996-2007



Source: Author's calculations.

Figure 4: SFA Estimates of Cost Efficiency by ownership of Banks, 1996-2007



Source: Author's calculations.

DETERMINANTS OF BANKS EFFICIENCY:

This section relates to the efficiency estimates derived to investigate the determinations of banking efficiency. The present paper adopt two-stage approach, in which cost efficiency are estimated in the first stage using SFA approach, and estimated efficiencies are regressed against a vector of explanatory variables in the second stage, and these variables may potentially affect the efficiency scores.

we examine the effects of other factors on cost efficiency levels in order to provide some explanations for variations in efficiency scores and to offer insights for the improvement of bank management and regulatory policies. The results are obtained by using method developed by Papke and Wooldridge (1996).

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

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

$$l_{it}(\beta) \equiv y_{it} \log[G(x_{it}\beta)] + (1 - y_{it}) \log[1 - G(x_{it}\beta)] \qquad (3)$$

where 0< G (.) <1 is a logit function. In this paper application y_i corresponds to cost efficiency and the vector $x = (Age, Age2, TA, Branches, ATM, BD, DF)$. The estimates[5] for the parameter β are obtained by maximizing the log- likelihood for the entire sample of 17 Jordanian banks to cover the deregulation period 1996-2007. In other word, the maximization problem can be written as:

$$\max_{\beta} \sum_{t=1}^{12} \sum_{i=1}^{17} l_{it}(\beta) \qquad (4)$$

The definitions of the explanatory variables are as per Table 10 below.

Table 10: Explanatory Variables Definition

Variables	Description
Age	The number of year the bank exited
Age^2	The square of Age
TA	Total assets in logarithm
Branches	The number of branches for each bank
ATM	Number of Automatic Telling Machines
BD	Bad loan
DF	Dummy variable for foreign banks

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

where:
Age the number of years a bank existed.This variable is included in this analysis to distinguish between the new banks and the established ones. It is expected that this variable will be positively related to the efficiency, as costs in banking are very significantly affected by the risk of doing business with the client. Age is determined by the information the bank has about each customers' credit worthiness, banking need, banking habits and performance etc. The accumulation of such information, however, is costly and most often requires repeated dealing with new clients over many years. In term with the management of the bank, the more age the bank the more experience to deal with the clients and to deal with the problems the bank may face. It is argued that established banks should have good customer base and have a good operative strategies to achieve a higher level of efficiency following the concept of learning by doing. Berger and Master (1997) and Ahmad (2000) find that more age the bank the more cost efficient the bank.

Age^2: The square of AGE and it is employed to account for the nonlinear effect.

TA: Total assets. This variable is included in this analysis as a control for the size of the banks and its impact on efficiency. Following Dong (2009) we use the logarithm of total assets as a proxy for bank size. This variable captures the effects of scale on cost efficiency while avoiding potential misspecification by using inappropriate break points for dividing our range of banks into different size groups.
Branches: Number of branches for each bank. The high network density (number of branches) leads to higher structural overheads and therefore, lower cost efficiency. This also will enables the banks to use their extensive branch network as a barrier against the entry of completion, thus, it leads to higher profit. It is expected that this variable will be positively or negatively related to efficiency, depending on how the banks attract the customer for giving them a good services.
ATM: Number of ATM machine for each bank. This variable is included in this analysis to find out the demand for the bank services. It is expected that this variable will be positively related to efficiency.
BD: Bad loan. This variable defined as the ratio of the prevision loans or *nonperforming loan* to total loan. This variable is related to the bank risk, and is employed to control the differences in efficiency across banks due to differences in credit risk. The coefficient of this variable is expected to be negative. Some studies include bad loans (e.g., Hughes and Mester, 1993; Master, 1996, 1997) and find inverse relationship between efficiency and problem loans[6].
DF: Dummy variable for foreign banks.

RESULTS OF THE SECOND STAGE REGRESSION:

Now we turn to present the results from the analysis of the second stage regression using method developed by Papke and Wooldridge (1996) in which the relationship between the efficiency score computed using SFA in the first stage and set of explanatory variables in order to investigate whether these variables significantly affect the cost efficiency levels of Jordanian banks. Table 11 contains the estimated results from equation (9). Table 11 shows that the variables Age, Age^2, number of branches, number of ATM, bad loan and the dummy variable are all statistically significant.
The estimate for Age and Age^2 are highly statistically significant with negative and positive sign, respectively. This implies that the cost efficiency for the Jordanian banks is negatively correlated with age. Age^2 is found to be positively correlated indicating the nonlinear effect on the cost efficiency which means the cost efficiency positively correlated with the age of the bank. Secondly, cost efficiency is negatively correlated with size of the bank but statistically insignificant. Girardone et al., (2004) and Dacanay, (2007) also find negative relationship between bank size and efficiency.
Thirdly, branches are expected to be positively or negatively related to cost efficiency, depending on how the banks attract the customer for giving them good services. The coefficient estimate for number of branches is highly statistically significant with negative sign, and this indicates that greater the number of branches the less cost efficient is the bank. Research finding is consistent with Moudos, J. et al. (2002), who state that the bank with higher network density (more branches) are less cost efficient. Ahmad (2000) found number of branches per total deposit is negatively related to the Jordanian banks during the period 1990 to 1996, and this variable also account for the overhead expenses.
Fourthly, the number of ATM is included in this paper analysis to find out the demand for the bank services. To the best of my knowledge, no study has included this variable to investigate the effect of ATM on the cost

[6] For more details see Berger and Humphrey (1997).

efficiency for the banks. The results show as expected that this variable is statistically significant with positive impact on efficiency in Jordanian banks.

Fifthly, bad loan is generally defined as the ratio of nonperforming loan to total loan and this indicates the credit risk or loan quality of the bank (Mester 1996, Das and Ghosh, 2006). Ariff and Can (2008) state negative relationship between this variables and efficiency for the Chinese banks and results conclude that the higher loan-loss provisions the higher credit risk and the least cost efficient banks. Our results show that the coefficient of this variable is negative as expected.

Finally, it is important to investigate the effect of ownership on efficiency. The coefficient estimate of the dummy variable of foreign banks is found highly statistically significant with positive sign which indicates that the foreign banks are more cost efficient than the domestic banks, Dong (2009) find that both state-owned and foreign banks are more efficient than domestic private banks.

Table 11: Results of the Second Stage Regression for the Jordanian Banks

Variables	Parameter	Coefficient	Std. Error	P>|z|
Constant	β_0	-2.405075*	1.316987	0.068
Age	β_1	-.0767983***	.0078963	0.000
Age^2	β_2	.0007839***	.0000864	0.000
TA	β_3	-.0508597	.072338	0.482
Branches	β_4	-.0099173***	.0020716	0.000
ATM	β_5	.0054125***	.0013401	0.000
BD	β_6	-.0450889***	.0125394	0.000
DF	β_7	.60968***	.0995184	0.000
No of observation		204		
Log pseudo-likelihood		-89.56651719		

Source: Author's calculations. *Notes:* CE denotes cost efficiency, AE denotes allocative efficiency and TE denotes technical efficiency. The quantities in (*) estimates are the standard errors. Notes: 1. ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. 2. Asymptotic standard errors in parentheses.

CONCLUSION:

This paper investigates the cost efficiency levels of Jordanian banks during the reform period from 1996 to 2007. The efficiency scores are obtained from the SFA technique. Results from SFA model indicate that the average cost efficiency scores vary from 47.5% in 1996 to 48% in 2007. The results show that the average cost efficiency increased over this period. This improvement in cost efficiency may indicate the reforms implemented by the liberalization program have enhanced the performance of the Jordanian banks over the deregulation period.

The paper findings suggest that both the domestic and foreign banks have shown over the years of deregulation era slight improvements and this led to improvement in the efficiency of the Jordanian banking sector. The highest mean cost efficiency has been shown by Capital Bank of Jordan on average 95% and lowest by the Cairo Amman Bank 27%. (Also See Figure 6.2). The paper findings show that among the domestic banks, the small bank on average are the most efficient (50.6%), followed by large and medium banks with cost efficiency on average (36.9% and 35.3%, respectively).

In addition, the average cost efficiency for all banks is 38.7%. This implies that the Jordanian banks waste 61.3% from their cost relative to the best-practice banks during the period 1996-2007. Importantly, cost efficiency has increased over the deregulation period which ranged between 36.5% in 1996 to 38.7% in 2007. In addition, the domestic banks are less cost efficient than foreign banks.

Finally, this paper investigates whether ownership structure, size, number of branches and ATM, bad loan and age of the bank significantly affect the cost efficiency levels of Jordanian banks. The results show that foreign banks

are more efficient than domestic private banks. Thus, the findings show that differences in ownership structure significantly affect Jordanian banks' performance in terms of cost efficiency. With respect to bank size, we find that size of the bank is statistically insignificant with negative sign on impact on the cost efficiency. Also, we conclude that the cost efficiency for the Jordanian banks is negatively correlated with age. AGE2 is found to be positively correlated indicating the nonlinear effect on the efficiency. Moreover, the coefficient estimate for number of branches is highly statistically significant with negative sign, and this indicates the greater the number of branches the less cost efficient is the bank and this can be explain with more branches opening lead to high overhead expenses to the bank. Interestingly, as expected in this paper finding on the effect of number of ATM on the cost efficiency is a statistically significant with positive impact on cost efficiency in Jordanian banks. In addition, the results reveal that the relationship between bad loan (credit risk) and cost efficiency seems to be very strong, in which bad loan is significantly negatively related to cost efficiency. Overall, the results for the determinants of cost efficiency seem to be consistent to the other banking efficiency studies.

To sum up, the findings from SFA techniques show that the institutional and structural changes in the Jordanian banking sector as a result of deregulation and liberalisation have significantly affected the efficiency and performance of Jordanian banks.

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