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Impact of Yemeni Crisis on Efficiency of Yemeni Banks – Using (DEWA) Approach

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Abstract: The purpose of this study is to examine the efficiency level of Yemeni banks in pre and post Yemeni crisis. The banking intermediation approach was considered to choose the study inputs and outputs through unique panel data set of banking sector in Yemen over the period (2006-2015). It allows to study the variations in the efficiency of banks before and after Yemeni crisis. For the purpose of data analysis; nonparametric efficiency approach Data Envelopment Windows Analysis (DEWA) was applied. The average efficiency results before Yemeni crisis (2006-2010) reveal that Yemeni conventional banks are more efficient than Islamic banks in term of their inputs producing actual outputs. On the other hand, the average efficiency results in post Yemeni crisis (2011-2015) indicate that Islamic banks are more efficient after Yemeni crisis than conventional banks. It is recommended that banks managers should increase their banks' efficiency by improving resources utilization to produce optimal outputs.

Keywords: Efficiency, Data Envelopment Windows Analysis (DEWA), Yemeni crisis, Islamic & conventional banks.

1. Introduction

Developing economies during crisis provides an exceptional opportunity to examine the influence of these crises on the efficiency and performance of the banking sector (Qureshi & Shaikh, 2012).

Information on the bank's efficiency offers an additional significant dimension on the behavior of banks to managers, regulators, and shareholders of the bank (Fukuyama & Matousek, 2017). The banking sector in Yemen plays a magnificent role in efficient working of the different activities of the country.

The Yemeni banking sector has faced unprecedented challenges due to the ongoing crisis, which began in 2014 and has led to severe economic instability, currency depreciation, and disruptions in financial operations (World Bank, 2022). These conditions have significantly impaired bank performance, raising critical concerns about their operational efficiency and financial resilience. Evaluating bank efficiency during such turmoil is essential, as efficient banks are better equipped to withstand economic shocks, maintain liquidity, and support economic recovery (Berger & Humphrey, 1997).

The competitiveness between both Islamic conventional banks motivates the initiative to compare the efficiency between these two types of banking. Islamic banking has been operating in Yemen from the year 1995, while conventional since 1962.

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2. Literature Review

Tremendous research around the world has been carried out for examining the conventional and Islamic banking sector's efficiency. Majority of these studies have used standard DEA for examining bank's efficiency e.g. (Johnes et al., 2014; Sufian, 2011; Zimková, 2014). Johnes, Izzeldin & Pappas (2014) compared the "efficiency between Islamic and conventional banks during the period 2004–2009 using data envelopment analysis (DEA) and meta-frontier analysis (MFA)". The results of the study indicate that Islamic banks exhibit a similar level of gross efficiency to conventional banks. Further, the results show that Islamic bank have higher net efficiency, but it is significantly lower in terms of type efficiency than conventional banks.

Previous studies have examined bank efficiency using "Data Envelopment Analysis (DEA)" and "Stochastic Frontier Analysis (SFA)" under various economic conditions. For instance, Sufian (2007) applied DEA to assess Malaysian banks during the Asian financial crisis, finding that efficiency declined significantly due to macroeconomic instability. Similarly, Al-Muharrami (2008) analyzed GCC banks and highlighted that regulatory interventions played a crucial role in maintaining stability. However, few studies have focused on Yemeni banks, and none have employed Data Envelopment Window Analysis (DEWA) a dynamic approach that tracks efficiency trends over time (Asmild et al., 2004). This gap is particularly critical given Yemen's prolonged crisis, where traditional static efficiency models may fail to capture adaptive strategies.

The study conducted by Said (2012) is one of the comparative studies that investigated the efficiency of various banks around the world. This study concentrated on small conventional and Islamic banks efficiency change during financial crisis 2007-2009. The main aim of the present research is to introduce empirical evidence on the financial crisis, and to study the non-parametric DEA to examine efficiency. The study believed that the efficiency of small and large Islamic banks is significantly different in 2007. In the period from 2008 to 2009 the study found that the efficiency of large and small conventional banks is different. It was also found efficiency was significantly different among small Islamic and conventional banks over the three years. The findings confirmed that the efficiency of Islamic banks was suspended during those three years. The study emphasized DEA windows analysis. Among these studies there are number of research that have adopted efficiency analysis e.g. (Aggarwall & Schaffnit, 2004; F. Shawtari & Salem, 2018; Yang & Chang, 2009) (Kumar & Arora, 2012) (Kisielewskaa et al., 2007) (Sufian, 2011). Webb (2003) used DEA windows for five years data in order to analyze the level of efficiency of retail banks in UK for the period from 1982-1995. After adopting the intermediate approach, the study results indicated scale inefficiency is the cause of all inefficiencies while technical inefficiency is not an issue. It was also revealed that the larger the bank's size, the higher technical efficiency. Reisman et al. (2003) studied the level of efficiency in the banking sector in Tunisia using Data envelopment analysis windows approach. Study results showed that there was an improvement in the efficiency levels in the post crisis period. Furthermore, Public Banks were found to be technically more efficient than Private Banks. Sufian (2007) examined the banks efficiency of Singapore through the period 1993 - 2003 using DEA windows analysis. The findings reveal that the efficiency scores of Singaporean banks in the early period of the study were low and with time it started improving. Additionally, the findings indicated that large banks are lower in terms of all efficiency aspects than small banks. In the same context, Avkiran (2004) used a three-year window for analyzing the efficiency of some Australian banks. Results revealed the same outputs of Sufian (2007) in which efficiency was low in the early years and improved later in the period. The study believed that the main reason for low level of efficiency in Australian banks was purely attributed to technical inefficiency not scale efficiency. Gu and Yue (2011) followed the same approach for investigating efficiency. The study reported the efficiency estimation of listed Chinese listed companies. The study found that changes in pure technical efficiency and technical efficiency will affect stock return.

However, there is no correlation between stock returns and scale efficiency. The study also found that pure technical efficiency and technical efficiency are more informative than return on equity. (Kisielewskaa et al., 2007) investigated the efficiency scores of the Polish banks during the period 1995 – 2003 using Data Envelopment Window Analysis. The Findings of the efficiency of the Polish banks indicate that the relative efficiency dispersion deteriorated with a general increase in overall cost efficiency performance between 1995 and 2003. Moreover, the efficiency remained unstable over the time period.

Subsequently, and based on the above studies, this study aims to fill this gap by evaluating Yemeni banks' efficiency from *2014 to 2023* using *DEWA*, which allows for a rolling-window assessment of productivity changes. By analyzing inputs (e.g., deposits, operating costs) and outputs (e.g., loans, profitability), the study will identify which banks (Islamic vs. conventional, public vs. private) have been most resilient. The findings will contribute to the limited literature on crisis-era banking efficiency (Fethi & Pasiouras, 2010) while offering policymakers actionable insights to stabilize Yemen's financial system.

3. Methodology

3.1 Sample of the Study

The research population 16 banks in Yemen. The study includes a panel of 9 banks (3 Islamic and 6 conventional), each observed over 10 years, resulting in 90 unique bank-year observations. When applying the DEWA approach with a three-year moving window across 8 windows, each bank-year is treated as a distinct Decision-Making Unit (DMU), yielding 9 x 3 x 8 = 216 DMUs in total.

The two microfinance banks were excluded one of Islamic banks (Alkuraimi Islamic microfinance bank) started its actual operations In January 2010 and one of conventional banks) Al-Amal Microfinance Bank) started its actual operations In January 2009 because of late establishment, the lack of data and the different nature of their work. Four foreign banks were also excluded because of the different nature of the capital structure and some of them were closed after 2011 because of the complicated situation in Yemen. Banks that were unable to obtain their financial statements for all years of study from 2006 to 2015 were also excluded.

3.2 Data Analysis Methods

3.2.1 Efficiency Analysis

Based on the data set that runs over the period 2006-2015 for both types of banks, and the section for estimating the efficiency levels of banks in Yemen, we use DEWA. This period allows the present study to evaluate the efficiency of both types of banks more appropriately in a comparative manner between both types of banks. Data used for the efficiency section was extracted from banks' annual reports, official web sites of the banks and the central banks of Yemen.

3.2.2 Efficiency estimation

Selection of variables.

Ahmed and Abdul Rahman (2012) state that input and output variable selection for designing of the efficiency model is well documented in prior studies. Further,(Fukuyama & Matousek, 2017) indicated that the selection of an appropriate model for efficiency has a background from the right theory of bank production. This theory provides a path and guidance for defining the inputs and outputs. Usually,

banks play an intermediate role by receiving money from depositors and lending them to borrowers. Webb (2003) suggests that the intermediate role played by banks combines deposits and capital yielding by loans and other investment or earnings assets and income. However, there is a difference in banking structure from Islamic to conventional banks. Based on this, the present study follows the intermediate approach to formulate the efficiency model. Further, consistent with prior research, the current study formulates conventional banks outputs to include (y1) which denotes operating income, and (y2) which refers to total loans, and Islamic banks outputs to comprise financing income (FI), and total financing (TF). Interest income or financing income includes those revenues from interest or income from loans or financing. Y2 and TF refer to the total loans of borrowers and the total financing respectively. Importantly, there should be some input to produce these outputs. The inputs for the efficiency model are (x1), (x2) and (x3) which are deposits, labor and capital respectively.

3.2.3 Efficiency estimation Models:

Data envelopment analysis (DEA) is a nonparametric tool which was initiated by Charnes et al. (1978). DEA functions as a linear programming tool to estimate the efficiency level of each bank. "Consider a set of n DMUs. For DMU k, let $Y_{rk}(r = 1, \dots . s)$ represent the level of the rth output, and $X_{ik}(i = 1, \dots . s)$the level of the ith input. To examine the efficiency of DMUs (Yang & Chang, 2009) retrieved from k, Charnes et al. (1978) presented the following" model: θ

min $\theta i \lambda_j \; \theta$

subject to $\sum_{j=i}^{n} \lambda_j \; x_{ij} \leq \theta \; x_{ik}, \; i = 1, \dots, m,$

$\sum_{j=i}^{n} \lambda_j \; y_{rj} \geq y_{rk}, \; r = 1, \dots, s,$

$\lambda_j \geq 0, \; j = 1, \dots, n, \quad \theta \geq 0.$

Where:

- n: number of DMUs (Decision Making Units)
- m: number of inputs
- s: number of outputs
- x_{ij} : input $i$for DMU j
- y_{rj}: output $r$for DMU j
- x_{ik}, y_{rk} : inputs and outputs of the DMU under evaluation (DMU k)
- λ_j: intensity variable (weight) for DMU j
- θ: efficiency score of DMU k

"The optimal θ, denoted by θ^*, satisfies $0 < \theta^* \leq 1$.If θ equals to unity, the DMU under estimation is considered to be technically efficient and lies in the efficiency limits that consisting of set of efficient" units.

3.3 Data Envelopment Window Analysis

A DEWA generalizes the view of moving averages during the study period to obtain DMU efficiency patterns. The reason for this is that every DMU in a window is considered to be a completely different one. This treatment makes it possible to compare the efficiency of a DMU in a given period with its behavior in other periods. It increases the number of DMUs in order to increase the discriminatory power when a limited number of DMUs are reached. As far as selecting a window width is concerned, Asmild et al. (2004) pointed out that minimizing the unfairness of comparison over time should be as small as possible, but still large enough to have a sufficient sample size.

"Following (Yang & Chang, 2009) who consider N DMUs $(n = 1, \dots, N)$ that all r inputs are used to produce s outputs and are observed in $T \; (n = 1, \dots, N)$ periods. Let DMU_n^t indicates an observation

n in period t with input" vector $X_n^t = \begin{pmatrix} x_n^{1t} \\ \vdots \\ x_n^{rt} \end{pmatrix}$ and output vector$Y_n^t = \begin{pmatrix} y_n^{1t} \\ \vdots \\ y_n^{st} \end{pmatrix}$. If the window begins at time $k(1 \le k \le T$ with width$w(1 \le w \le T - k)$ accordingly, thematrices of inputs and outputs are expressed as follows:

$$X_{kw} = \begin{pmatrix} x_1^k & x_2^k & \cdots & x_N^k \\ x_1^{k+1} & x_2^{k+1} & \cdots & x_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ x_1^{k+w} & x_2^{k+w} & \cdots & x_N^{k+w} \end{pmatrix}, \; Y_{kw} = \begin{pmatrix} y_1^k & y_2^k & \cdots & y_N^k \\ y_1^{k+1} & y_2^{k+1} & \cdots & y_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ y_1^{k+w} & y_2^{k+w} & \cdots & y_N^{k+w} \end{pmatrix}$$

Replacing inputs and outputs of DMU_n^t into the model will produce the results of DEWA Data envelopment window analysis.

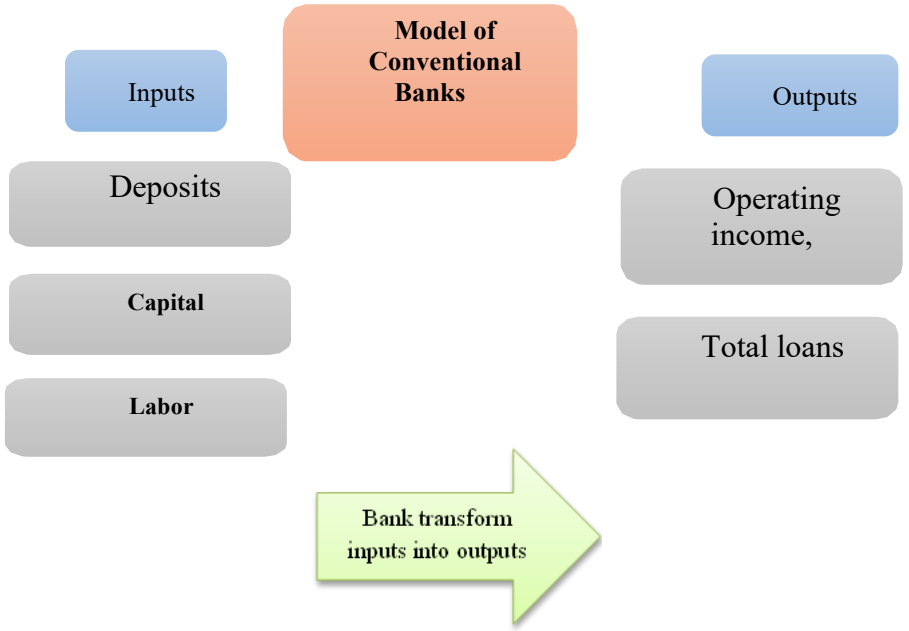

Fig. 1 Model of Conventional Banks.

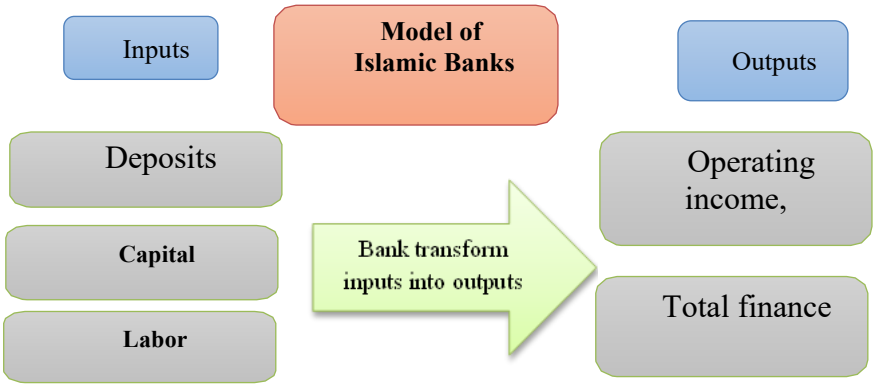

Fig. 2 Model of Islamic Banks.

4. Data Analysis and Results

4.1. Descriptive Statistics Analysis:

The descriptive statistics present the output and input variables used to build the DEWA model. The study adopts mean, median and standard Div., for the purpose of comparing between Islamic and conventional banks In Yemen in table 1 while table 2 for comparing between pre and post Yemeni crisis.

Table 1 Descriptive Statistics of the Input and the Output for efficiency (In millions YR) comparing between Islamic and conventional banks

	Variables	Types	Mean	Median	Std. Dev.	Obs.
Output	OPERATING INCOME	Conventional	3796.163	2604.64	3387.234	60
		Islamic	2965.194	1892.62	2211.069	30
		Overall	3519.173	2464.175	3058.446	90
	INVESTMENT	Conventional	12233.34	9960.1	7001.569	60
		Islamic	25674.38	8624.08	36997.24	30
		Overall	16713.68	9719.79	22783.94	90
Input	LABOR	Conventional	99641.38	75254.9	80998.84	60
		Islamic	79821.8	50525.37	95194.47	30
		Overall	93034.86	62999.66	85967.19	90
	DEPOSITS	Conventional	133550.1	106351.3	95029.39	60
		Islamic	56176.14	44510.89	42675.62	30
		Overall	107758.8	85401.17	89024.3	90
	CAPITAL	Conventional	8706.601	5981.165	6782.617	60
		Islamic	5664.589	5171.16	4154.79	30
		Overall	7692.597	5771.635	6180.717	90

This table "reports descriptive statistics for inputs and outputs variables adopted in examining the efficiency of Islamic and conventional banks on a sample of 9 banks for 10 years using the (DEWA) data envelopment windows analysis. It is presented in three sub-sections. The first sub-section presents descriptive statistics of Islamic Banks while the second sub-section presents Conventional banks. Finally, the last sub-section presents the overall values of Islamic and conventional banks in Yemen for the period 2006 to 2015. Two types of variables were adopted. The first type is" (inputs)

namely; deposits, capital and labor, while the second type is (outputs) namely investments and operating income".

The results of descriptive analysis in table 1 shows that the mean value of the Islamic banks inputs (deposits, labor and capital) are 56176, 79821 and 5664, respectively, while the conventional banks inputs (deposits, labor and capital) are 133550,99641 and 8706 respectively, which indicate that conventional banks are having higher input values than Islamic banks. It is also found that the mean value of outputs (operating income and investments) of Islamic banks are 2965 and 25674, respectively, while the conventional banks outputs (operating income and investments) are 3796 and12233, respectively, which indicates that Conventional banks are more efficient than Islamic banks.

Furthermore, the standard deviation result shows that there is a greater variation in the inputs and outputs of conventional banks as compared to the results of Islamic banks.

Table 2 Descriptive Statistics of the Input and the Output for efficiency (In millions YR) comparing between pre and post Yemeni crisis

Variables	Period	Mean	Median	Std. Dev.	Obs.
OPERATING INCOME	pre-crisis	2531.606	1803.63	2032.476	45
	post-crisis	4506.74	3545.69	3576.997	45
	Overall	3519.173	2464.175	3058.446	90
INVESTMENT	pre-crisis	14283.65	7495.96	28095.82	45
	post-crisis	19143.72	14226.74	15765.79	45
	Overall	16713.68	9719.79	22783.94	90
LABOR	pre-crisis	54843.13	47251.21	40198.46	45
	post-crisis	131226.6	94968.07	101731.2	45
	Overall	93034.86	62999.66	85967.19	90
DEPOSITS	pre-crisis	75875.36	69591.96	53613.72	45
	post-crisis	139642.1	108271.2	105247.5	45
	Overall	107758.8	85401.17	89024.3	90
CAPITAL	pre-crisis	5502.236	4994.36	3243.378	45
	post-crisis	9882.957	6517.25	7545.714	45
	Overall	7692.597	5771.635	6180.717	90

This table reports descriptive statistics results for comparing the inputs and outputs variables between "two periods' namely pre-Yemeni crisis (2006-2010) and post Yemeni crisis (2011-2015). It is presented in three sub-sections. The first sub-section presents descriptive statistics of pre-crisis while the second sub-section presents post crisis. Finally, the last sub-section presents the overall values of Islamic and conventional banks in Yemen for the period "2006 to 2015.

Table 2 shows the results of descriptive analysis for pre and post Yemeni crisis. The mean values of the inputs (deposits, labor and capital) in the first period (2006-2010) pre crisis are 75875, 54843 and 5502, respectively, while the mean values of the inputs (deposits, labor and capital) in the second period (2011-2015) post Yemeni crisis are 139642,131226 and 9882 respectively, which indicates that the period of the post Yemeni crisis are having two times input values than pre crisis. It is also found that the mean value of outputs (operating income and investments) in pre-crisis is 2531 and 14283, respectively, while the outputs (operating income and investments) in post-crisis are 4506 and19143, respectively, which indicates that the efficiency of banking sector of Yemen in pre-crisis are more efficient than post crisis.

4.2 Empirical results

4.2.1 Efficiency Analysis (Data Envelopment Window Analysis)

Data Envelopment Analysis is "a flexible method that, in a multiple input–output framework, is reduced to a virtual unit-input–output structure" (Pulina et al., 2010).

Charnels et al. (1985a),(Ramanathan, 2003)described DEWA data envelopment windows analysis as a moving average pattern of analysis. Let us consider the performance of nine banks, A, B, C, D, E, F, G, H and I, over a ten-year time period. Then, A three-year 'Window' (the analog of 'moving average' are selected in traditional time series econometric analysis). We analyze the firms for the first three years. In total, we will have 9 * 10 = 90 DMUs since Bank A in Year 1 is treated as a different DMU as compared to Bank A in Year 2. The following table shows the results of DEWA for each Yemeni bank.

Table 3 Efficiency analysis of conventional banks DEA windows

CAC	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
w1	100%	100%	100%								100%
W2		100%	100%	100%							100%
w3			100%	100%	100%						100%
w4				100%	100%	100%					100%
w5					100%	100%	100%				100%
w6						100%	90%	86%			68%
w7							100%	100%	5%		68%
w8								100%	14%	14%	43%
Average	100%	100%	100%	100%	100%	100%	97%	95%	10%	14%	**85%**
YKCB	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average**
w1	68%	75%	64%								69%
W2		68%	66%	84%							73%
w3			100%	93%	93%						95%
w4				100%	92%	100%					97%
w5					100%	100%	100%				100%
w6						100%	88%	100%			64%
w7							100%	75%	16%		64%
w8								100%	26%	20%	48%
Average	68%	72%	77%	92%	95%	100%	96%	92%	21%	20%	**76%**
YBRD	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average**
w1	100%	100%	73%								91%
W2		100%	70%	86%							85%
w3			83%	100%	100%						94%
w4				100%	100%	100%					100%
w5					90%	100%	100%				97%
w6						91%	95%	95%			67%
w7							100%	100%	2%		67%
w8								100%	45%	29%	58%
Average	100%	100%	75%	95%	97%	97%	98%	98%	24%	29%	**82%**
IYCB	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average**
w1	80%	76%	53%								70%
W2		80%	52%	61%							64%
w3			56%	66%	66%						63%
w4				68%	68%	62%					66%
w5					68%	64%	68%				66%
w6						61%	63%	63%			60%
w7							78%	76%	24%		60%
w8								80%	23%	16%	40%

Average	80%	78%	54%	65%	67%	62%	70%	73%	23%	16%	**61%**
CCB	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average**
w1	78%	73%	74%								75%
W2		78%	72%	95%							82%
w3			74%	100%	98%						91%
w4				100%	100%	83%					94%
w5					91%	83%	82%				85%
w6						61%	65%	72%			55%
w7							67%	73%	26%		55%
w8								78%	19%	17%	38%
Average	78%	75%	74%	98%	97%	76%	71%	74%	22%	17%	**72%**
NYCB	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average**
w1	91%	100%	56%								82%
W2		100%	100%	80%							93%
w3			62%	100%	88%						83%
w4				89%	100%	80%					89%
w5					92%	94%	100%				95%
w6						100%	97%	100%			70%
w7							100%	100%	9%		70%
w8								90%	9%	1%	33%
Average	91%	100%	73%	90%	93%	91%	99%	97%	9%	1%	**77%**

Table 4 Efficiency analysis of Islamic banks DEA windows

TIB	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
w1	100%	95%	100%								98%
W2		100%	69%	100%							90%
w3			100%	100%	100%						100%
w4				100%	100%	100%					100%
w5					84%	100%	100%				95%
w6						72%	82%	100%			73%
w7							81%	95%	42%		73%
w8								100%	11%	33%	48%
Average	100%	98%	90%	100%	95%	91%	88%	98%	27%	33%	85%
SIB	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
w1	62%	64%	44%								57%
W2		62%	43%	53%							53%
w3			43%	56%	56%						52%
w4				53%	53%	60%					53%
w5					52%	60%	69%				61%
w6						58%	67%	71%			54%
w7							60%	64%	38%		54%
w8								62%	41%	41%	48%
Average	62%	63%	43%	54%	54%	60%	65%	66%	40%	41%	54%
YBIB	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
w1	100%	100%	100%								100%
W2		100%	45%	69%							71%
w3			45%	71%	71%						62%
w4				100%	100%	100%					100%
w5					100%	78%	100%				93%
w6						66%	81%	87%			75%
w7							100%	100%	24%		75%
w8								100%	18%	33%	51%
Average	100%	100%	63%	80%	90%	81%	94%	96%	21%	33%	78%

4.2.2 The DEWA findings

Table 3 and 4 present TE results for 10 years (2006–2015) for Islamic and conventional banks. For window analysis, the basic concept is to view each bank as a different bank in each of the periods listed at the top of the table to obtain the scores specified in the window columns. The lift side stub denotes the size of the window and the dates covered. The first row, for example, stretches from 2006 to 2008 for a three-year period window span which is reflected in the first row. The next row begins in 2007 and extends for another window to 2009, and so on. Following prior studies; (Yang & Chang, 2009) and Cooper, Seiford, and Tone (2007), the formula that can be utilized in this regard to estimate the number of data pints is k = number of periods = 10, n = number of firms = 9, p = length of window = 3, w = number of windows, where w = k - p + 1 . Based on these formulas, the following formula is considered: number of windows = 10- 3+1 =8, the total number of banks = n × p × w = 9×3×8 = 216. Hence, 216 different data points are considered to which the DEWA is functioned to get the scores of the banks' efficiency.

The rows are used to estimate windows trends, and the columns are utilized to assess the performance stability (Yang & Chang, 2009; Cooper et al., 2007). The results of the rows show high values in some windows while low in other windows. The trends are instable, because the continuation of Yemeni crisis. Further, the figures in the columns appear instable performances. In addition, the averages of rows (windows) and columns (years) are presented in the right and at the bottom of the tables which can be can be seen as indicative of these performances. The magnificent average of each bank is provided in the lower right edge. The average efficiency score for both types of banks are shown in table 4.18 and figure 4.1 below**.**

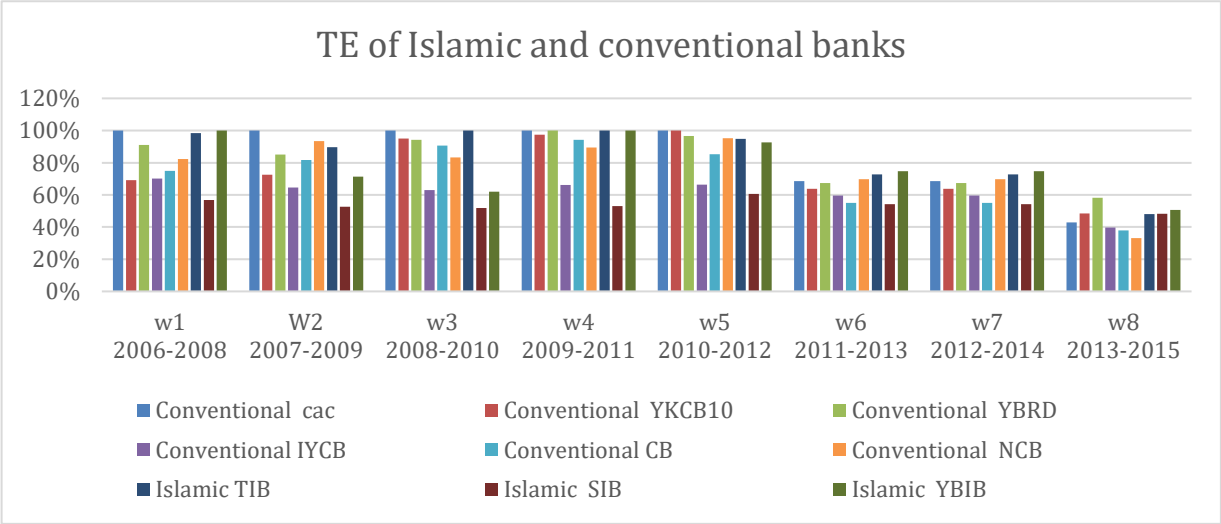

Figure 31 Comparing the TE of Islamic and conventional banks using DEWA

4.2.3 The Comparing the efficiency of Islamic and conventional banks in Yemen using

The purpose of this section is to compare the efficiency of Islamic and conventional banks in Yemen using DEWA, The average efficiency score of both types of Yemeni banks based on three years moving average windows started in 2006. As earlier detailed, eight windows were built for the study period (2006-2015).

Table 5 the average of TE score for each window of Islamic and conventional banks in Yemen

Type	DMUs	w1 2006-2008	w2 2007-2009	w3 2008-2010	w4 2009-2011	w5 2010-2012	w6 2011-2013	w7 2012-2014	w8 2013-2015	Average
Conventional	CAC	100 %	100 %	100 %	100 %	100 %	68%	68%	43%	85%
	YKCB	69%	73%	95%	97%	100 %	64%	64%	48%	76%
	YBRD	91%	85%	94%	100 %	97%	67%	67%	58%	82%
	IYCB	70%	64%	63%	66%	66%	60%	60%	40%	61%
	CB	75%	82%	91%	94%	85%	55%	55%	38%	72%
	NCB	82%	93%	83%	89%	95%	70%	70%	33%	77%
Islamic	TIB	98%	90%	100 %	100 %	95%	73%	73%	48%	85%
	YBIB	57%	53%	52%	53%	61%	54%	54%	48%	54%
	SIB	100 %	71%	62%	100 %	93%	75%	75%	51%	78%
Average		83%	79%	82%	89%	88%	65%	65%	45%	75%

Table 5 displays that the Yemeni Islamic and conventional banks efficiency scores were in the range of 85 and 54 per cent across all windows. The estimated results of overall efficiency levels indicate that the Yemeni banking sector has experienced a low efficiency level which hits 33%. These results offer indications that some of the Yemeni Banks were suffring, having low performance and powerless to to successfully carry out their main activities in an efficient manner. In the intermediation performance, the banking sector in Yemen faced difficulties in transforming deposits into loans, causing banks to waste an average input of about 15% to 46%. This is because the obstacles that Yemeni banks were faced in investment decisions making because of Yemeni crisis, poor socioeconomic conditions exacerbated by continuing of warmed conflict, which may have contributed towards the low level financial performance of Islamic and conventional banks (F. A. Shawtari et al., 2015). Gernerally, the results in table 4.19 shows that efficiency trends of Yemeni banks are stable with high growth rates before yemeni crisis in the line with descriptive analysis, which indicates a declining trend after yemeni crisis since 2011. The average of technical efficiency score (TE) in window 1(2006-2008) is 83%, in the next window (2007-2009) the technical efficiency decreased to 79% due to global financial crisis in 2008. The average of (TE) trends started to increase in window 3 (2008-2010) to reach 83%. Furthermore, the highest TE score are in windows 4 and 5 (2009-2011 and 2010- 2012) i.e 89% and 88%, respectively. On the other hand, the efficiency trends immediately apparent that there was a steady decline in windows 6 and 7 in the average efficiency levels of 65% and decreased to lowest level in window 8 to reach 45%. As revealed in Table 4.19, the highest efficient bank was Tadhamon Islamic Bank (TIB) and CAC conventional banks with average efficiency of 85 %. While Shamil Bank of Yemen and Bahrain (YBIB), an Islamic bank, was the less efficient bank with average efficiency of 54%. Further clarification on other banks ranking according to the level of efficiency in the table 4.21 and figure 4.3 are given below

Table 6 banks ranking according to efficiency level

Type	DMUs	TE	Stability	Rank
Conventional	CAC	85%	82%	1
	YKCB	76%	70%	5
	YBRD	82%	81%	2
	IYCB	61%	59%	7
	CB	72%	68%	6
	NCB	77%	72%	4
Islamic	TIB	85%	82%	1
	YBIB	54%	55%	8
	SIB	78%	76%	3

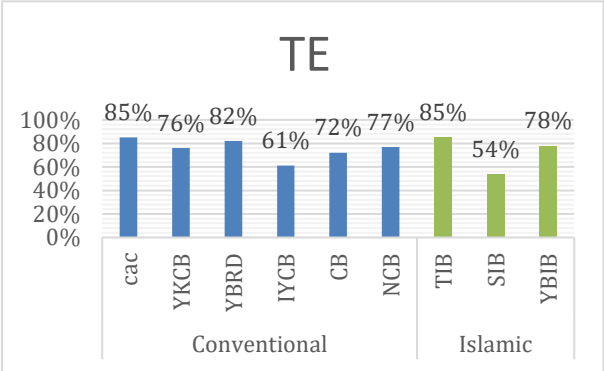

Figure 5 banks Efficiency

Table 6 and Figure 5 shows the efficiency trends of banking sector in Yemen in between 85%and 54%. One of Islamic (TIB) and one of conventional (CAC) banks have the same highest-level average of technical efficiency score 85% over the periods of the study while YBIB has the lowest level of efficiency score 54%. To study each bank's trend performance and stability, the data in the table 4.16 and 4.17 can be used to study the efficiency score for each bank's over one year period and simultaneously, plot each type together, to get a good awareness into their efficiency trends.

4.2.4 Comparing the stability of the efficiency in Islamic and conventional between pre and post Yemeni crisis using

The aim of this section is to study the stability performance of banking sector by comparing the overall average efficiency of each type of Yemeni banks, based on the study period (2006-2015). Furthermore, to check the different impact of Yemeni crisis on the banks' efficiency.

Table 7 comparing the efficiency score between pre and post Yemeni crisis

Type	DMUs	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
Conventional	CAC	100%	100%	100%	100%	100%	100%	97%	95%	10%	14%	82%
	YKCB	68%	72%	67%	89%	95%	98%	85%	81%	21%	20%	70%
	YBRD	100%	100%	75%	95%	97%	97%	98%	98%	24%	29%	81%

	IYCB	80%	78%	54%	65%	67%	62%	70%	73%	23%	16%	59%
Islamic	CB	78%	75%	74%	98%	97%	76%	71%	74%	22%	17%	68%
	NCB	91%	95%	59%	86%	90%	91%	99%	97%	9%	1%	72%
	TIB	100%	98%	90%	100%	95%	91%	88%	98%	27%	33%	82%
	YBIB	62%	63%	43%	54%	54%	60%	65%	66%	40%	41%	55%
	SIB	100%	100%	63%	80%	90%	81%	94%	96%	21%	33%	76%
	Average	87%	87%	69%	85%	87%	84%	85%	87%	22%	23%	72%

Table 7 shows the results of Average TE during the study period (2006-2015). Through the average efficiency results it could be concluded that there are different levels of efficiency and performance during 2006-2015. Furthermore, it is noticed that the last two years 2014 and 2015 are the lowest efficiency level for each bank. The average efficiency level in the last year are between the worst 1% for The National Bank of Yemen (NCB) and the best 41% for Shamil Bank of Yemen & Bahrain (YBIB).

For more clarification Yemeni banks can be categorized into three groups based on the average of trends efficiency in windows and the stability of the efficiency. The first group includes the most stable and highest efficient banks in Yemen. This group comprises two Islamic banks namely, Tadhamon international islamic bank (TIB), and Saba'a Islamic Banks (SABA'A) and two conventional banks namely, Coop. and Agricultural Credit Bank (CACB) and Yemen Bank for Reconstruction and Development (YRDB). Banks under this group can be described as the highest performers and hence keeping valuable efficiency and stability level. Moreover, these banks should make a good consideration to enhance the performance in the gloabilzation era and as such bank's competition is also beneficial.

The second group contains the banks with acceptable efficiency level but low stability. Under this group, three conventional banks were categorized as being efficient, but there is varaibility in their performance. These banks are National bank of Yemen (NCB), the Commercial Bank of Yemen (CBY), and Yemen Kuwait Bank for Investment (YKCB). The banks managers should attempt to find ways for keeping the stability, while trying to improv the efficiency level even more. Causes for their efficiency's variability need to be investigated and solutions need to be provided so as to improve their stability and maintain their high performance. The last group consist of one Islamic bank(Bank of Yemen and Bahrain (YBIB)),and one conventional bank (International Bank of Yemen (IYCB)) with low average efficiency level and low stability. The efficiency of this group is very low and the variability is very high which means very important solutions must be taken by the banks' managements to improve the efficiency levels.

Table 8 comparing the total average efficiency of Islamic and conventional banks

Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
CB	0.86	0.88	0.75	0.90	0.91	0.88	0.89	0.88	0.18	0.16	0.73
IB	0.87	0.87	0.65	0.78	0.80	0.77	0.82	0.87	0.29	0.36	0.71
OVER ALL	0.87	0.87	0.70	0.84	0.86	0.82	0.85	0.87	0.24	0.26	0.72

Efficiency from a competitive point of view, since, Islamic banks entrance in 1996, the banking sector in Yemen affected the competition positively and enhance levels of efficiency. However, the results were dissimilar to some such expectations. In fact, the efficiency levels have increased over time following the entrance of Islamic banking in Yemen. In the view of the academicians and researchers, the rise in efficiency indicators continued to be stable for two years 2006 and 2007 in the average efficiency score 87% for both types of banks. In 2008 during the global financial crisis the efficiency trends were decreased to reach 75% for conventianal and 65% for Islamic with overall average is 70% and arised again in 2009 and 2010.

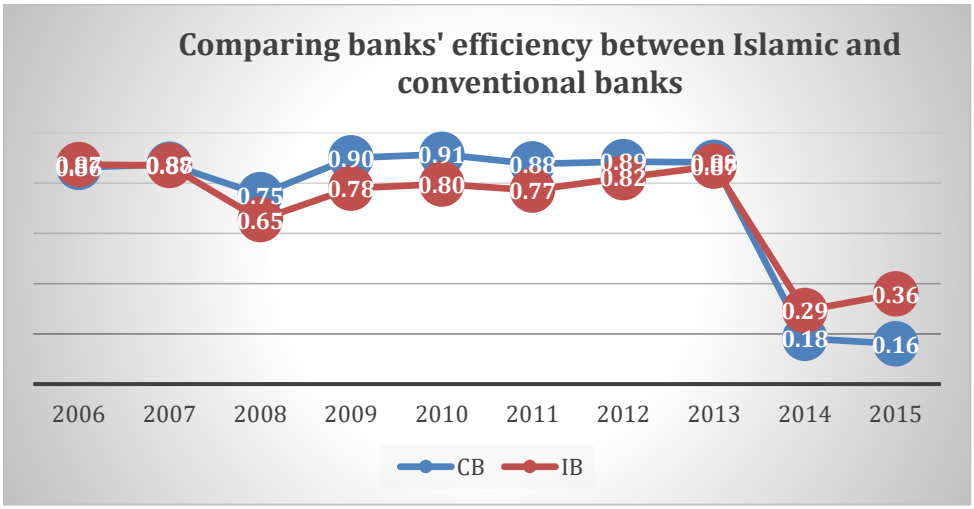

Figure 6 Comparing banks' efficiency between Islamic and conventional banks

Additionally, Yemeni crisis began in 2011 and as aresult of the crisis the efficiency trends declined slightly as shown in Figures no 4.3 to reach 88% in conventional and 77% in Islamic. The rise in efficiency indicators continued until the Yemeni crisis in 2011 and then the trends highly declined to reach 16% in Conventional and 36% in Islamic in 2015. In general, the overall results of the average efficiency of Islamic and conventional banks are 71% and 73%, which indicates that there is no high difference in the overall efficiency level between Islamic and conventional banks in Yemen during the period 2006-2015. Furthermore, the average efficiency for banking sector is 72 per cent.

4.2.5 Comparing the efficiency of Islamic and conventional banks between pre and post Yemeni crisis

Table 9 Efficiency score pre and post Yemeni crisis

Type/crisis	pre	post	Overall
Conventional	0.86	0.60	0.73
Islamic	0.79	0.62	0.71
Overall	0.83	0.61	0.72

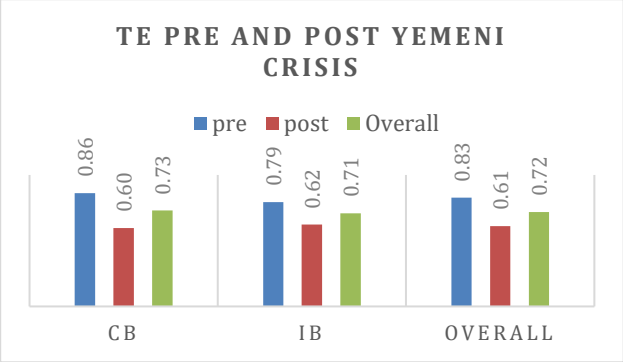

Figure 7 comparing the efficiency between pre and post Crisis

It is noticeable in table 9 and figur 7 that the average efficincy in pre crisis are 86% of conventinaland 79% of Islamic banks, which indicate that conventional banks are more efficient before Yemeni crisis than Islamic banks.On the other hand the average efficincy in post Yemeni crisis are 60% of conventinal and 62% of Islamic banks, which indicate that Islamic banks are more efficient after Yemeni crisis than conventional banks, this result is consistent with findings of previous studies, such as Alsarhan (2009), Hussein (2004) and Al-Jarrah and Molyneux (2003). Generaly, the overall average efficincy score of both types in pre crisis is 83%, while in post Yemeni crisis it is 61%, which indicates that there is a significant impact of financial crisis on the efficiency of both bank types (Islamic and conventinal banks) in Yemen.

The marked decline in efficiency after 2011 aligns with key crisis developments in Yemen, such as the fragmentation of the central bank into competing branches in Sana'a and Aden, severe liquidity shortages, and the rapid depreciation of the Yemeni Rial. These factors disrupted interbank operations, increased credit risk, and limited the ability of banks to transform deposits into profitable assets, directly impacting their efficiency scores.

Conclusion

The objective of this study is to compare the efficiency levels between Islamic and conventional banks as well as to compare the efficiency levels between pre and post Yemeni crisis using data envelopment windows analysis (DEWA), a non-parametric approach, for the period from 2006 to 2016.

DEA is a more robust technique to measure the efficiency level as stated by (MOHD, FAIZAL, 2016) because it studies the efficiency level of each bank based on the efficiency frontier that is built from the real data.

The variables used in DEA model are chosen based on the intermediation approach, which has been used by in previous researches such as (Akhtar, 2013; Azad et al., 2017; Sufian, 2011). The inputs under this approach are deposits, capital and labor for creating the outputs which are total loans and operating income.

This research presents three research aspects. Firstly, comparing the average score of the efficiency level between Islamic and conventional banks in Yemen during the period of study. Secondly, studying the impact Yemeni crisis by comparing the average score of the efficiency level between pre and post Yemeni crisis of Islamic and conventional banks in Yemen. Finally, studying the efficiency level of the banking sector in Yemen totally.

A. The analysis of the efficiency (DEWA)

1. The mean values of the efficiency (inputs and outputs) indicate that Conventional banks are more efficient than Islamic banks.

2. The standard deviation result shows that there is a greater variation in the inputs and outputs of conventional banks as compared to the results of Islamic banks.
3. The results of descriptive analysis for pre and post indicate that the efficiency of banking sector of Yemen in pre-crisis are more efficient than post crisis.
4. The efficiency score of Islamic and conventional banks in Yemen was between 85 and 54 per cent throughout all windows.
5. There are significant differences between Islamic and conventional banks in terms of the technical efficiency.
6. Conventional banks are more efficient before Yemeni crisis than Islamic banks.
7. Islamic banks are more efficient after Yemeni crisis than Conventional banks.
8. The overall average technical efficiency (TE) for all banks over the sample period is 75%.

Policy implications drawn from the findings include:

1. Support for Islamic banking models, which showed greater resilience post-crisis, possibly due to their asset-based and risk-sharing nature.
2. Re-centralization of monetary authority to improve regulatory clarity and rebuild interbank trust.
3. Digital transformation of financial supervision to ensure continued monitoring, transparency, and access to banking data during crisis disruptions.
4. Strengthening deposit insurance and liquidity backstops to bolster depositor confidence and maintain input stability for banks.

These steps may enhance banking sector efficiency, promote financial stability, and support recovery in prolonged crisis environments like Yemen.

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