CrossMark
click for updates

MEASURING EFFICIENCY IN BANKS: A BRIEF SURVEY ON NON – PARAMETRIC TECHNIQUE (DATA ENVELOPMENT ANALYSIS)

Khalad M. S. Alrafadi[1][†] --- **Mazila Md Yusuf**[2] --- **Badrul Hisham Kamaruddin**[3]

[1,2]*Arshad Ayub Graduate Business School, Universiti Teknologi MARA, Malaysia 40450 Shah Alam, Selangor, Malaysia*
[3]*Faculty of Business Management, Universiti Teknologi MARA, Malaysia 40450 Shah Alam, Selangor, Malaysia*

ABSTRACT

Objective: This paper provides a survey of efficiency in banks using Data Envelopment Analysis (DEA) in developed and developing countries. Methods: There are two ways were used; the first one is analyse previous reviews, and the other one is systemic search from ProQuest, Emerald, Scopus and Science Direct. The search conducted to identify efficiency in banks in developed and developing countries. Originality: This study contributes in the existing literature in measuring efficiency in banks using DEA as a non – parametric technique. Results: Studies that was survey showed that the score of allocative efficiency was more than technical and cost efficiencies. Also, Studies showed that the scores of cost efficiency were more than the scores of profit efficiency. Conclusion: This paper shows that most of these studies were conducted in developed countries context, Also many studies were in developing countries. But, very few studies were conducted in the context of banking industry in Arab countries.

Keywords: Efficiency, Banks, Data envelopment analysis, Developed countries, Developing countries.

Contribution/ Originality

This study contributes to fill the gap in literature for studies were conducted to measure the efficiency of banking industry. Also it contributes in the body of knowledge by understanding the status of efficiency in the banking industry using non – parametric approach.

1. INTRODUCTION

Efficiency is a general term in economics that describes how well a system is performing in the generation of maximum outputs for a given input. Efficiency is improved if more outputs are generated without changing inputs or if the same outputs are generated with fewer inputs. The efficiency of the banking system is one of the most important issues in the financial market because the efficiency of banks can affect the stability of the banking industry and thus the effectiveness of the whole monetary system.

Bank efficiency ratio is a measure of a bank's overhead as a percentage of its revenue. Bank efficiency is measured by different methods that estimate the frontier of production. These methods include non-parametric approach and parametric approach. In financial research, there is a huge body of literature that focuses on the efficiency of banking systems. This paper reviews Data Envelopment Analysis as a non-parametric and highlighted some empirical studies on bank efficiency that have been carried out in the past.

This study aimed to review the literature and find the gap on the literature in Arab Countries. The paper unfolds as follows section 2 provides types of efficiency. Section 3 provides a review on Data Envelopment Analysis, section 4 provides the methods for this study. And section 5 provides the results and discussion of this study.

2. TYPES OF EFFICIENCY

Efficiency is improved if more outputs are generated without changing inputs or if the same outputs are generated with fewer inputs. In today's turbulent financial environment, efficiency of the banking industry is regarded as an important area in the financial market because it can not only affect the stability of the banking system but also influence the effectiveness of the whole monetary system. Bank efficiency can be measured by many types of efficiencies. Many types of different efficiencies are presented below:

2.1. Technical, Allocative and Cost Efficiency

According to Bauer *et al*. (1998) technical efficiency (or X- efficiency) focuses on the physical relationship of levels of inputs relative to levels of outputs, so it requires only the input and output data without the prices.

According to Thanassoulis (2003) the allocative efficiency of a firm is the ratio of the minimum cost at which a firm could secure its outputs to the cost of its technical efficient input levels for its input mix (for given input prices).

According Cummins and Zi (1996) the cost efficiency is the act of saving money by making a product or performing an activity in a better way.

Farrell (1957) has proposed a method of measuring productive efficiency, which uses an "efficient isoquant" estimated as part of the convex hull of the observed points. Farrell proposes an assumption under which the production function is homothetic. A homothetic function is a monotonic transformation of a homogeneous function in which the marginal rate of technical substitution is constant along a ray drawn from the origin. For instance, let a production function $f(x1, x2)$ be homogeneous of the first degree in $x1$ and $x2$, and assume that the isoquant of this homogeneous production function is an efficient isoquant. An (increasing) monotonic transformation of a homogenous production function yields a homothetic production function in $F(X) = g [f(x1, x2)]$ where g is a strictly increasing monotonic transformation. A series of homothetic isoquants can be derived from the original (efficient) isoquant by appropriate scaling up. In other words, a proportional increase or decrease of all inputs should not affect the marginal rate of technical substitution along the isoquants. A comparison between the efficient isoquant and any other isoquant for given output would indicate departure from full efficiency (Clemhout, 1968).

The analysis of efficiency carried out by Farrell (1957) can be best illustrated, for the single output and two inputs case in the unit isoquant diagram (Figure 1).

Farrell (1957) initially assumes that constant returns to scale (CRS) depict the efficient production function or the frontier. The technological set is fully described by the unit isoquant YY' that captures the combination of the inputs (X1, X2) by which the firm can produce a certain output when it is perfectly efficient. In the other words, YY' shows minimum combinations of inputs needed to produce a unit of output. Thus, under this framework, every package of inputs along the unit isoquant is considered as technically efficient while any point above and to the right of it, such as point P, is defined as a technically inefficient producer since the input package that is being used is more than enough to produce a unit of output. Hence, the distance RP along the ray OP measures the technical inefficiency of a producer located at point P. This distance (RP) represents the amount by which all inputs can be reduced without decreasing the amount of output. Geometrically, the technical inefficiency level associated with package P can be expressed by the ratio **RP/OP** and, therefore, the technical efficiency (TE) of the producer under

analysis would be given by the ratio **OR/OP**, which takes a value between zero and one. A value of one implies that the firm is fully technically efficient.

Allocative efficiency (AE) involves the selection of an input mix that allocates factors to their highest value uses and introduces the opportunity cost of factor inputs to the measurement of productive efficiency. Allocative inefficiency can also be derived from the unit isoquant plotted in Figure (1) Given information on the market prices of inputs ($w1$, $w2$), the isocost line CC through P is associated with $w1\ x1 + w2\ x2 = k1$ and the slope of this line reflect the input price ratio. However, this cost can be further reduced by moving this line in parallel fashion until it is tangential to the isoquant at Q.

The coordinates of CC then give $w1\ x1^* + w2\ x2^* = k0$ achieving the minimal cost at the prescribed output level. Now we note that we can similarly determine the relative distances of S and R to obtain the ratio OS/OR. With respect to the least cost combination of inputs given by the point Q, the above ratio indicates the cost reduction that a producer would be able to achieve if it moved from a technically but not allocatively efficient input package (R) to both a technically and allocatively efficient one (Q). Therefore, the allocative efficiency that characterises the producer at point P is given by the ratio **OS/OR**.

There is another measure that is commonly referred to as cost efficiency or economic efficiency. It can be represented by the ratio of minimal cost (wx^*) to actual cost ($wx0$), that is, the ratio **$wx^*/wx0$ = OS/OP**. A cost efficient firm will choose its inputs and mixes according to their prices so as to minimize total cost. Cost inefficiency may arise from two different sources. One is deficiency in applying the technology (technical inefficiency) and another one is suboptimal allocation of resources (allocative inefficiency). Thus, total overall cost efficiency can be presented as the product of technical efficiency and allocative efficiency:

Overall cost efficiency = allocative efficiency × technical efficiency   = OS/OR ×OR/OP = OS/OP

2.2. Pure Technical and Scale Efficiency

Scale efficiency of scale occurs when the company's produces on the lowest point of its Long run average cost and therefore benefits fully from economies of scale (Sanchez, 2009). Also, scale efficiency measures a company's productivity at a given point with respect to what it could accomplish if it operated at the most productive scale size, where the average productivity reach a maximum level (Kounetas and Tsekouras, 2007).

In Figure (2), the use of the unit isoquant assumes constant returns to scale (CRS), but this assumption does not always hold. A firm using more of both inputs than the combination represented by R may exhibit variable returns to scale (VRS). Thus, in general, technical efficiency can be further decomposed into measures of pure technical efficiency (PTE) and scale efficiency (SE). In Figure (2), assume the simple case of one input X and one output Y, P represents an existing bank. OA represents the constant returns to scale frontier. Firms can either lie on, or below the frontier, but cannot be above it. Therefore, the ratio of GR/GP represents the measure of technical efficiency of bank P which corresponds to OR/OP in Figure (2)**.**

The concept of scale efficiency ascertains whether or not the firm operates at an optimum size. In order to measure scale efficiency, the assumption of variable returns to scale replaces that of constant returns to scale. In the above figure, FEBCD represents a variable returns to scale frontier. For the bank at point P, pure technical efficiency (PTE) equals the ratio of GE / GP. Scale efficiency is the ratio of GR / GE or equal to TE divided by PTE. The value of SE is unity when operating under constant returns to scale. Values of less than unity reflect scale inefficiency. Scale inefficiency could be caused by the firm having to operate under increasing returns to scale or decreasing returns to scale. In order to investigate this, the non-increasing returns to scale frontier is developed, represented by OBCD. If SE is not equal to unity and PTE is equal to GR/GP, decreasing returns to scale exists. If

PTE is not equal to GR/GP which is based on the frontier OBCD, then the scale inefficiency is due to increasing returns to scale.

3. DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis (DEA) can be defined as "a mathematical method using linear programming to measure the relative efficiency of a number of administrative units (decision-making units) through the identification of the optimal mix of inputs and outputs which are grouped based on their actual performance" Zhu (2003) and Manadhar and Tang (2002).

Also, Cullinane *et al.* (2006) define DEA as a non-parametric method of measuring the efficiency of a decision making unit with multiple inputs and outputs. And Jacobs (2001) defines DEA as the ratio of the weighted sum of outputs of a trust to its weighted sum of inputs (P. 106). Also efficiency is defined as the ratio of the actual quantity of output, relative to a maximal feasible quantity of output (Bryce, 1996).

"The relative efficiency of any decision-making unit (j_0) for a group of decision-making units is calculated by solving the following fractional linear programming model" (Charnes *et al.*, 1994):

$$Max\ u, v \qquad h_0 = \frac{\sum_{r=1}^{t} U_r\ Y_{rj_0}}{\sum_{i=1}^{m} V_i\ X_{ij_0}}$$

Subject to:

$$\frac{\sum_{r=1}^{t} U_r\ Y_{rj}}{\sum_{j=1}^{m} V_i\ X_{ij}} \leq 1 \qquad j = 1, 2, \ldots\ldots., \text{n}$$

$$U_r, V_i \geq\ \forall\ r\ \text{and}\ i \tag{1}$$

$$(r = 1,2,3, \ldots\ldots., t)\ ,\ (\ i = 1,2,3, \ldots\ldots., m)$$

Where:

Y_{rj} = Quantity of the output of the unit

U_r = Weight allocated to the output

X_{ij} = Quantity of input to the unit

V_i = Weight allocated to the input

t = Number of outputs

m = Number of inputs

In DEA normally as logical operational sequencing, there are some units regarded as efficient and, in turn, some of these are considered non-efficient. As a result, these units constitute a set of units with the high efficiency units enveloping all inefficient units. In order to conduct a DEA, the data is divided into two parts; "the front or surface section" contains the efficient units and "the internal section" contains the non-efficient units.

The fractional formula in Equation (1) can be converted to a linear formula and can deal with the traditional linear programming problem by rewriting the objective function by the equality above by one, thus becoming the following form:

$$\sum_{r=1}^{t} U_r\ Y_{rj_0}$$

Subject to:

$$\sum_{i=1}^{m} V_i\ X_{ij_0} = 1$$

$$\sum_{r=1}^{t} U_r\ Y_{rj}\ \leq\ V_i\ X_{ij} \qquad\qquad j = 1, 2, 3, \ldots\ldots., n$$

$$-V_i\ \leq\ -\varepsilon \qquad\qquad I = 1, 2, 3, \ldots\ldots., m$$

$$-U_r\ \leq\ -\varepsilon \qquad\qquad r = 1, 2, 3, \ldots\ldots., t \tag{2}$$

To obtain the efficiency of decision-making units it is very important to repeat the earlier Primary Model of each unit and to shorten the time required to achieve the results. The Dual Model can be used and be indicated as follows (Cooper *et al.*, 2003):

$$Min \, \lambda \, Z_0$$

Subject to:

$$X_{ij_0} Z_0 \geq \sum_{j=1}^{n} i \, X_{ij_0} \qquad\qquad i = 1, 2, 3, \ldots\ldots\ldots, m$$

$$\sum_{j=1}^{n} j \, Y_{rj_0} \geq Y_{rj_0} \qquad\qquad r = 1, 2, 3, \ldots\ldots\ldots, t$$

$$\lambda_j \geq 0 \qquad\qquad j = 1, 2, 3, \ldots\ldots\ldots\ldots, n \quad (3)$$

The CCR (Charnes, Cooper, & Rhodes) model and the BCC (Banker, Charnes, & Cooper) model are the most significant DEA models The CCR was the brainchild of Charnes *et al.* (1978). It evaluates efficiency and recognizes the source and level of inefficiency. The BCC model is credited to Banker, Charnes, and Cooper who based it on the CCR model. It provides an estimation of the technical efficiency based on the scale of operation in the unit required to render services to beneficiaries at the time of measurement, i.e., there is an association between efficiency and a specific operation size (Norman and Stoker, 1991).

3.1. CCR (Charnes, Cooper and Rhodes) Model

Charnes *et al.* (1978) introduced a measure of efficiency for each DMU that is obtained as the maximum of a ratio of weighted outputs to weighted inputs. So, the efficiency scores for DMUs are a function of the weights of inputs and outputs combinations, and they have to be less than or equal to unity.

Suppose that there are n DMUs to be assessed. Each DMU uses up varying quantities of m different inputs to attain s different outputs. For instance, DMUJ uses up amount x of input i and generates amount Y_{rj} of output r. The ratio of outputs to inputs provides the relative efficiency of the $DMU_j = DMU_0$ to calculate the ratios of all the j = 1, 2... n DMU_j. The efficiency scores for DMU_0 can be achieved by solving the following mathematical programming problem:

$$\max h_0 \, (u, v) = U_r \, Y_{r0}/VX_{i0} \qquad\qquad (4)$$

Subject to

$$\sum U_r \, Y_{rj} / \sum v_i \, x_{ij} \leq 1, \qquad j = 1, 2, ..., Jo, ..., n \qquad (5)$$

$$U_r \geq 0, \qquad\qquad r = 1, 2, ..., s \qquad (6)$$

$$v_i \geq 0, \qquad\qquad i = 1, 2, ..., m \qquad (7)$$

Where:

x_{ij} = the observed amount of input of the rth type of the jth DMU (x_i, > 0, i = 1, 2,...,m, j = 1,2,...,n).

Y_{rj} = the observed amount of output of the rth type for the jth DMU (Y_{rj} > 0, r = 1, 2, ...,s, j = 1,2,...,n).

U_r = the weight that determines output.

v_i = the weight that determines input.

r = indicates s different outputs.

i = denotes m different inputs.

j = indicates n different DMUs.

This problem produces an infinite number of solutions because if (u*, v*) is optimal, then (αu*, αv*) is optimal for positive α. Charnes and Cooper (1962) propose that for linear fractional programming a representative solution (u,v) should be selected for which:

$$v_i \, x_{i_0} = 1 \qquad\qquad (8)$$

The transformed linear programming problem can be expressed as:

$$\max Z_0 = \sum U_r \ Y_{r_0} \tag{9}$$

Subject to

$$\sum U_r \ Y_{r_j} - \sum V_i \ X_i \ \leq 0 \qquad j{=}1,2,...,n \tag{10}$$

$$\sum v_i \ x_{i_0} = 1 \tag{11}$$

$$U_r \geq 0, \qquad r{=}1,2,...,s \tag{12}$$

$$V_i \geq 0, \qquad i{=}1,2...,m \tag{13}$$

The linear programming dual problem can be expressed as:

$$\min z_0 = \ \theta_0 \tag{14}$$

Subject to:

$$\sum \lambda_i \ y_{r_j} \ \geq \ Y_{r_0} \qquad\qquad r{=}1,2,...,s \tag{15}$$

$$\theta_0 \ x_{i_0} - \sum \lambda_j \ x_{ij} \ \geq 0 \ , \qquad i{=}1,2,...,m \tag{16}$$

$$\lambda_j \geq 0, \qquad j = 1,2,...n \tag{17}$$

Where:

θ_0 = the technical efficiency of DMU_0.

λ_j = the weight of the jth DMU.

Both the primal and dual linear programming problems listed here yield an optimal solution for technical efficiency θ. The weight λ_j has a positive condition, so the problem obtains the CRS. Technical efficiency θ should be less than or equal to one. Furthermore, for a DMU with technical efficiency, $\theta_h < 1$ is considered as inefficient, and the efficiency $\theta_j = 1$ shows the efficient DMU placed on the efficiency frontier.

3.2. BCC (Banker, Charnes and Cooper) Model

Banker, Charnes and Cooper used an alternative assumption of CCR model in their DEA model (BCC model) which is the variable return to scale (VRS), the constraints for the weights should be added (X = 1). The DEA model in this case is called a BCC model that exhibits variable return to scale, and it can be written as:

$$\min z_0 = \ \theta_0 \tag{18}$$

Subject to:

$$\sum \lambda_i \ y_{r_j} \ \geq \ Y_{r_0}, \qquad\qquad r = 1,2,...,s \tag{19}$$

$$\theta_0 \ x_{i_0} - \sum \lambda_j \ x_{ij} \ \geq 0 \ , \qquad i = 1,2,...,m \tag{20}$$

$$\sum \lambda_j = 1 \tag{21}$$

$$\lambda_j \geq 0, \qquad\qquad j = 1,2,...n \tag{22}$$

The use of this model will provide the BCC efficiency scores (referred to as pure technical efficiency scores) for each DMU. Under Constant Return to Scale, we assume that outputs vary in direct proportion to the variance in inputs no matter the DMU size. The CRS may prove unsuitable for a group of DMUs with a large scale of operations. The Variable Return to Scale presupposes that modifying inputs fails to produce any proportional change in outputs. This means that as a DMU is enlarged, its average cost either falls or rises. VRS envelops the data more closely than CRS, and consequently calculates technical efficiency scores greater than or equal to CRS. The VRS approach is more appropriate, because the sample consists of very small to very large banks. Also, The VRS approach allows banks to deviate from the CRS line (viewed as optimal scale operation) because of factors like imperfect competition, regulatory requirements, credit and Loan restrictions, macro-economic effects, etc. Another preference for the VRS approach over the CRS is that the more developed the banking system is, the more likely it is that the banks face non-constant returns to scale (McAllister and McManus, 1993; Wheelock and Wilson, 1999).

Constant return to scale assumption (CCR model) is only appropriate when the operation of all DMUs is at an optimal scale. However, if there is imperfect competition, a DMU may not function at optimal scale (Casu and Molyneux, 2003). While technical efficiency derived from VRS will be greater than or equal to that measured by using CRS because VRS envelops the data points more tightly than the CRS. The VRS has proven to be more popular recently and it gives an enhanced reflection of the authentic observations found in the real world.

4. METHODS

A systemic review was conducted to recognize all available study about non – parametric methods to evaluate the efficiency in banking industry. There are two ways were used; the first one is analyse previous reviews (Berger and Humphrey, 1997) and the other one is systemic search from ProQuist, Emirald, Scopus and Science Direct. The search conducted to identify efficiency in banks in developed and developing countries. The search using several combinations of keywords: Efficiency, Data envelopment Analysis, Banks, Developed Countries and Developing Countries. No restrictions on dates were utilized during online database searches, only studies that targeted measuring efficiency in banks using DEA were included, non-English articles, books, thesis, non-published material were excluded from this search. From the search we found many studies counducted in efficiency in banks using DEA in developed and developing countries. Also, from the search we chose some studies counducted in developed and developing countries that show in tables 1 and 2.

5. RESULTS AND DISCUSSION

The results show around 70 studies measuring efficiency using DEA conducted in developed and developing countries during period 1985 – 2014. These results divided in two tables. Table (1) shows empirical studies on measuring banking efficiency in banks using DEA in developed countries, and Table (2) shows empirical studies on measuring banking efficiency in banks using DEA in developing countries

Table-1. Empirical Studies on Measuring Banking Efficiency in Banks Using DEA in Developed Countries

Year	Authors	Objective	Technique	Sample	Findings
1985	Sherman and Gold	Aimed to measure and evaluate operating efficiency for a saving bank in USA	DEA	Saving bank branch with 14 branch offices in USA for one year period was chosen for this study.	They found that DEA results provide meaningful insights not available from other techniques that focus on ways to improve productivity. Also, they suggested that DEA is a beneficial complement to other techniques for improving bank branch efficiency.
1993	Berg, et al.	Attempted to measure the efficiency of banking in Scandinavia	DEA	Their sample were from three countries Finland, Norway, and Sweden, and the data set consists of observations from 503 Finnish, 150 Norwegian, and 126 Swedish banks in 1990.	They found that the average efficiency was 0.58 for Finland, 0.78 for Norway, and 0.89 for Sweden. The Norwegian average bank has around 10per cent higher productivity than the Finnish within both the VRS and CRS specifications, and the Swedish average bank is also more productive than the Norwegian, the productivity gap ranging from 40 to 46 per cent.
1993	Fukuyama	Aimed to measure technical and scale efficiency of Japanese commercial banks.	DEA	The headquarters of Japanese commercial banks that located in Tokyo and Osaka metropolitan areas, at the end of fiscal 1991 were chosen.	He found that his study showed that the major cause of overall technical inefficiency was pure technical inefficiency, not scale inefficiency. The scale inefficiency for pooled data was found to mainly due to increasing returns to scale. The study found it is possible to identify more outputs by making different inputs - outputs specifications and it is important to examine the effects of technological change.
1995	Elyasiani and Mehdian	Measure the technical efficiency of US banks pre – and post – deregulation periods	DEA	US banking data for year 1997 and 1986, which are pre – and post – deregulation periods	They found that technical efficiency declined for large banks. Also showed by using a time-dependent ratio analysis that technology regressed over this eight-year span.
1995	Favero and Papi	Aimed to provide a measure of technical and scale efficiency in the Italian banking industry by using Data Envelopment Analysis.	DEA	174 Italian banks included in the Centrale de Bilanci taken in 1991 were chosen for this study.	They found the technical efficiency and productive specialization 53.3per cent and 78.3per cent, also they found the efficiency and size between 88.8per cent and 100per cent. These results were robust to modifications in the specification of inputs and outputs suggested by the intermediation approach and by Asset approach.

Table-1. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developed Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
1996	Miller and Noulas	Aimed to measure technical efficiency of large banks in USA	DEA	Large banks in USA that had assets in excess of $ 1 billion, a total of 201 banks over period 1984 – 1990 were chosen.	They found that the average inefficiency including both pure technical and scale, across all 201 banks is small at just over 5per cent. They though the difference may be due to the different sample of banks and the period covered.
1997	Resti	evaluated the cost efficiency of the Italian banking system by using to separate streams: econometric studies and Data Envelopment Analysis	DEA	The sample for her study from 270 Italian banks for five years from 1998 to 1992.	She found that the average values of the productive efficiency indexes (econometric model) between 69.4per cent in 1988 and 69.8per cent in 1992. Also he found the average values of the productive efficiency indexes (DEA models) for CRS model between 66.5per cent in 1988 and 69.2per cent in 1991. Also for VRS model between 73.4per cent in 1992 and 75.7 in 1989, from the results the efficiency of Italian banks did not increase over the period 1988 – 1992.
1997	Schaffnit, et al.	presented a best practice analysis the Ontario based branches of a la Canadian bank	DEA	sample consists of 291 branches located Ontario in Canada and they used annu data for the year 1993	They found that the results basic BCC and CCR models for both PT and PTM for production models we Average BCC Score 0.947 for PT and 0.969 for PT Average CCR score 0.914 for PT and 0.944 for PTM

Table-1. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developed Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
1998	Ashton	the efficiency characteristics of the British retail banking sector were investigated in this study	DEA	The sample has been constructed with data from the Annual Reports and Accounts of 12 UK retail banks from 1985 to 1997	A high level of efficiency dispersion is observed. Smaller retail banks appear to appreciate the highest levels of relative cost efficiency further supporting the estimates of diseconomies of scale for most British retail banks
1999	Avkiran	To demonstrate the application of data envelopment analysis (DEA) in examining the efficiency of bank branches relative to other branches.	DEA	Initially data on inputs and outputs were collected from 65 branches of a major trading bank.	Only one of the DMUs in the sample is 100 per cent efficient. The global leader for the model is branch 23
1999	Bikker	Applied the stochastic cost frontier approach and production approach to measure the X-efficiency of some European banks	DEA	Used the data of nine European banks over period 1989 – 1997.	He found that the less efficient banks were Spanish banks, followed by French and Italian banks. Banks in Germany, the Netherlands, and the U.K. were in the middle level of efficiency. However, the most efficient banks were in Luxemburg, followed by banks in Belgium and Switzerland.
1999	Golany and Storbeck	Evaluated the performance of large USA bank	DEA	They selected branches of a large US bank (that call big bank) over six quarters that started from 2nd quarter of 1992 to 3rd quarter of 1993. And they ran the DEA model for all 182 branches in all six quarters	They found that 92 branches were fully efficient in the 3rd quarter of 1993 and only five branches fell below 70per cent efficiency. Also, they found that branches with large loans were more efficient than branches with small loans.
1999	Zenios et al.	Had two objectives: to prove the efficiency of translation resources at work, and the establishment of environmental effects on the measurement of efficiency	DEA	His data was chosen from the Bank of Cyprus the major commercial bank of the country and has 144 branches, 83 branches in Urban areas, 41 branches located in Rural areas, and 20 branches operate near tourist resorts along the coast of the Island.	His analysis shown that tourist branches were on average more efficient than Urban branches during the peak tourist season, the DEA model was also used to benchmark seasonality effects.
2001	Cook, and Hababou,	To assess sales and services efficiency within a major Canadian Bank	DEA	They selected the data from 20 branches for major Canadian bank	They found the efficiency of sales (ES) and efficiency of services (ET) were between 5.73per cent in branch 7 and 100per cent in branches 5, 12, 13, 14, 15, and 16. And the average of ES was 62.41per cent and average of ET was 61.91per cent.

Table-1. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developed Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2001	Sathye	Aimed to investigate the overall (economic), technical and allocative efficiency (also called X - efficiency).	DEA	He chose his sample of 29 Australian banks out of the total 32 locally incorporated banks has been used.	The results indicate that, as a source of overall inefficiency, the technical component was more important than the allocative component.
2002	Casu and Girardone	Used the data envelopment approach to study the efficiency of the Italian banking system. They compared banking groups and parent companies	DEA	They compared Italian banking groups and parent companies (the institutions leading the groups, taken individually)	They found that the banking groups had a lower mean efficiency level than parent companies and subsidiaries taken individually. They also found that there was no evidence of scale economies either in the sample of groups or in the one composed by the parent and subsidiaries taken individually
2003	Drake and Hall	wanted to utilize the non-parametric frontier approach, data envelopment analysis, to analyze the technical and scale efficiency in Japanese banking using a recent cross-section sample	DEA	The data for 149 Japanese banks for the financial year ending March 1997 were selected for their study	the results suggest that controlling for the exogenous impact of problem loans is important in Japanese banking, especially for the smaller regional banks
2006	Avkiran	Aimed to develop foreign bank technical, cost, and profit efficiency models grounded in finance and banking theories, which can bring comparability and direction to empirical productivity studies.	DEA	There are also certain policy implications of developing efficiency models through the process demonstrated in this study	Possible extensions of this study can explore ways to measure ethical and environmental dimensions of foreign bank performance with a view to identifying inputs and outputs that can be incorporated into new efficiency models.
2006	Havrylchyk	Wanted to estimate cost, allocative, technical, pure technical and scale efficiency	DEA	Used Polish banks from 1997 to 2001. The sample he used was the most comprehensive database on the Polish banking system compared to the other study because it covered approximately 95per cent of all banking assets.	He found that the average efficiency was 52.92 per cent for the domestic banks and 73.23per cent for the foreign banks. He also found that the efficiency in the banking system in Poland did not improve during the period of the study.

Table-1. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developed Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2006	Kirkwood and Nahm	Applied DEA to estimate the efficiency of producing revenue-generating banking services and the efficiency of producing profit in Australian banks.	DEA	They used a sample for 10 banks listed on the Australian Stock Exchange for the period of 1995 to 2002.	They found that the banking service and profit efficiency scores improved in the major banks because the banking service efficiency remained unchanged and the profit efficiency decreased for the regional banks. They also found that changes in profit efficiency were statistically significant in
2006	Wu et al.	Integrated Data Envelopment Analysis (DEA) and neural networks (NNS) to examine the relative branch efficiency of a big Canadian bank	DEA	They chose 142 branches in Toronto area from a big Canadian; the data were collected cover 3 months from October to December in 2001	This paper presented a DEA - NN study to the branches in a big Canadian bank. The results were comparable to the normal DEA results on the whole.
2008	Kyj and Isik	Aimed to X-efficiency and scale efficiency of commercial banks in the Ukraine	DEA	They chose the commercial banks in the Ukraine over the period from 1998 until 2003	They found that efficiency scores are significantly correlated between the common and separate frontier results. Their results also show that the average technical efficiency is only 47per cent and that the dominant source of inefficiency is driven by poor management decisions (pure technical efficiency) rather than there being any scale inefficiencies.
2008	Liu, and Tone	Proposed a three stage method to measure DEA efficiency while controlling for the impacts of both statistical noise and environmental factors.	DEA	They chose their sample from Japanese banks for five years from 1997 to 2001.	They found a stable upward trend in mean measured efficiency, indicating that, on average, the bankers were learning over the sample period.
2009	Brack and Jimborean	Aimed to addressed the issue of French banks efficiency, compared to their homologous from Europe and the United States	DEA	The analysis is realized on a sample formed by the ten biggest banks from France, Germany, Italy, Spain, the United Kingdom and the United States, over the period 1994-2006	The results show an improvement in cost efficiency of French and Spanish banks, while in the other countries a decline in cost efficiency is noted

Table-1. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developed Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2009	Drake et al.	examined the technical and allocative efficiency of the Japanese banking	DEA	They studied the Japanese banking system for eight years from 1995 to 2002 utilizing the slacks-based measure.	Mean efficiency scores; the dispersion of efficiency scores; and the ranking of banks and bank sectors.
2010	Banker et al.	Wanted to study the impact of banking System reforms during a crisis following a period of undisciplined lending.	DEA	They present evidence documenting the differential impact of regulatory reforms on Korean commercial bank productivity Over the period 1995–2005.	Average technical efficiency of banks decreased during the financial crisis of 1997 – 1998.it improved following the subsequent bank restructuring and continued to improve through
2010	Tecles and Tabak	Analyzed the cost and profit efficiencies of the Brazilian banking	DEA	Used Brazilian banking sector over the post-privatization period of 2000–2007	Their results showed that large banks are the most cost and profit efficient, supporting the concentration process observed in recent years. Foreign banks have achieved a good performance through both the establishment of new affiliates and the acquisition of local banks.
2011	Sufian	To critically examine the sources of inefficiency in the Korean banking sector.	DEA , and Value added approach	Used the annual bank level data of Korean commercial banks over the period 1992-2003.	"The empirical findings suggest that estimates of TE are consistently higher under an operating approach vis-a` -vis the intermediation and value-added approaches. On the other hand, banks are characterized by a relatively low level of TE".
2012	Barros et al.	attempted to analyze technical efficiency of the Japanese banks	DEA	They chose the Japanese banks from 2000 to 2007	The results indicate that NPLs (non- performing loans) remain a significant burden as for banks' performance.

Table-2. Empirical Studies on Measuring Banking Efficiency in Banks Using DEA in Developing Countries

Year	Authors	Objective	Technique	Sample	Findings
1993	Al- Faraj et al.	aimed to evaluate and measure the relative efficiency of bank branches is a major issue of great concern to bank administrators	DEA	The relative efficiencies for 15 branches of the bank in Saudi Arabia are evaluated.	The results of the evaluation helped to identify the inefficient branches and pinpoint the shortfall
1995	Zaim	Wanted to examine the effect of financial liberalisation on the technical efficiency of Turkish commercial banks	DEA	He chose the Turkish commercial banks over period 1981 – 1990.	Found that the technical efficiency of Turkish banks has improved by 10per cent, on average after the implementation of the liberalisation programme implemented by the Turkish Government and which aims to create a more competitive banking environment.
1998	Ayadi et al.	Attempted to determine the quality of bank management using data envelopment Analysis (DEA).	DEA	The data used in their study were the financial characteristics of ten commercial and merchant banks that are listed on the Nigerian Stock Exchange. The sample period was from 1991 through 1994.	the banks that are found to be relatively efficient in this study are those that have been in existence for a long period of time
1998	Al–Shammari and Salim	The objective of their study was to measure and compare the financial performance of banks in Jordan.	DEA	Their study used DEA methodology to model the comparative efficiency of banks in Jordan. Sample period was from 1991 through 1994.	The results obtained suggest that the majority of banks investigated are fairly inefficient over the period 1991-1994.
1998	Chu, and Lim	evaluate the relative cost and profit efficiencies	DEA	Six domestic banks in Singapore during the period 1992 – 1996	Average profit efficiency (83per cent) was found to be significantly lower than average cost efficiency (95per cent).
2000	Jackson and Fethi	The purpose of this paper was to investigate the performance of Turkish (TR) commercial banking sector. They evaluated the technical efficiency of individual TR banks using DEA.	DEA, and Tobit regression model	They chose Turkish commercial banks and they cover one year 1998.	We find that larger and profitable banks are more likely to operate at higher levels of technical efficiency. Also another finding reveals that the capital adequacy ratio has a statistically significant adverse impact on the performance of banks, which may reflect a risk-return trade off in the sector.
2002	Akhtar	Aimed to investigate and analyze X-efficiency of commercial banks in Pakistan.	DEA	40 commercial banks out of 46 banks in Pakistan were chosen for his study. Also, one year (1998) was covered in this study.	Private Banks in Pakistan emerged as efficient on both fronts i.e. technical efficiency and allocative efficiency, compared to their counterparts, the public and foreign banks. Result on the foreign banks is converse to expectations.

60

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2002	Isik and Hassan	Aimed to investigate input and output efficiency in the Turkish banking industry to understand the impact of size, international variables, ownership, control and governance on profit, cost, allocative, technical, pure technical and scale efficiency measures	DEA	Turkish banks over the 1988–1996 periods were chosen for this study.	The results suggested that the heterogeneous characteristics of banks have significant impact on their efficiency. Moreover, cost and profit efficiencies of the Turkish banks have exacerbated over time. Results also indicate that the dominant source of inefficiency in Turkish banking is due to technical inefficiency rather than allocative inefficiency, which is mainly attributed to diseconomies in scale.
2002	Mukherjee et al.	aimed to measure performance for Indian banks	DEA	Their data were collected for 68 Indian banks over the period 1996 -1999.	Almost of banks were overstaffed, with high per centage of nonperforming assets capital adequacy ratio less than norm and high cost of
2002	Yildirim	aimed to analyze the efficiency performance of the Turkish banking sector	DEA	His data was collected from balanced sheet and income statements from Bank in Turkey between 1998 and 1999	The empirical results showed that over the sample period both pure technical and scale efficiency measures show a great variation and the sector did not achieve sustained efficiency gains.
2003	Sathye	The objective of this paper is to measure the productive efficiency of banks in India. Using tow models A, and B.	DEA	"For this study there were 27 public sector commercial banks, 34 private sector commercial banks and 42 foreign banks in India as a sample. In the year 1997 – 1998.	The mean efficiency score of Indian banks was 0.83 as per Model A and 0.62 as per Model B of the study. And The study shows that the mean efficiency score of Indian banks compares well with the world mean efficiency score and the efficiency of private sector commercial banks as a group is, paradoxically lower than that of public sector banks and foreign banks in India.
2004	Ataullah et al.	provide a comparative analysis of the evolution of the efficiency of commercial banks in India and Pakistan	DEA	commercial banks in India and Pakistan covering the period from 1988 until 1998	They found that the overall technical efficiency of both Indian and Pakistani banks has improved gradually over the sample period.
2004	Hassan et al	used non-parametric data envelopment analysis to quantifiably benchmark the productive efficiency of Bahrain banks	DEA	31 Bahrain banks in 1998 and 2000 were chosen for this study	The results show that larger bank size and greater profitability are associated with higher efficiency.

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2004	Ho and Zhu	presented a study which used an innovative two stages data envelopment analysis model that separates efficiency and effectiveness to evaluate the performance of Taiwan's commercial banks	DEA	They used CCR model to evaluate the performance of 41 commercial banks in Taiwan for year 2001.	The empirical result of this paper is that a company with better efficiency does not always mean that it has better effectiveness. There is no apparent correlation between these two indicators.
2004	Shanmugam and Das	Analyzed the technical efficiency of 94 banks in four different ownership groups in India	DEA	They applied the stochastic frontier function methodology, using panel data for the period between 1992 and 1999 of 94 banks in India.	Their empirical results pointed out that the technical efficiency of raising interest margins varied widely across sample banks and was time-invariant. The results also noted that the banking sector in India showed an improvement in its efficiency level during the period of study due the increase of non-interest income, investments, and credits.
2005	Chen et al.	Wanted to examine the cost, technical and allocative efficiency of Chinese banks.	DEA	43 Chinese banks were chosen over period 1993 to 2000	The large state – owned banks and smaller banks are more efficient than medium sized Chinese banks.
2005	Demir et al.	In this paper we identify key factors determining the technical efficiency differentials among Turkish commercial banks in the pre- and post-liberalization periods, using the technical inefficiency effects model.	DEA and technical inefficiency effects model	The sample for the pre-liberalization period included 23 commercial banks for the years between 1981 and 1984. A consistent set of panel data was available for 43 commercial banks for the years 1991–98. The financial sector faced serious crisis in 1999.	They found that loan quality, size, ownership of the banks, and profitability has a positive and significant impact on the technical efficiencies of banks. The results warrant implementation of effective regulatory measures to improve the quality of the earning assets of commercial banks.
2006	Hassan	wanted to investigate relative efficiency of the Islamic banking industry in the world by analyzing a panel of banks	DEA	Islamic banking industry in the world was chosen during the period from 1995 to 2001.	The results indicate that, on average; the Islamic banking industry is relatively less efficient compared to their conventional counterparts in other parts of the world.

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2006	Shahooth et al.	Aimed to use DEA in measuring and analyzing the relative cost efficiency of Islamic banking institutions	DEA	They chose 24 Islamic banking institutions over period 1999 – 2001	This study showed that most Islamic banking institutions which were the sample of this study were efficient and the rest is on the way of improving their efficiencies.
2007	Fu and Heffernan	aimed to investigate the cost X-efficiency in China's banking sector	DEA	They chose Chinese banks over period 1985 – 2002.	The results showed that banks are operating 40–60per cent below the X-efficiency frontier. On average, the joint-stock banks are found to be more X-efficient than the state-owned commercial banks
2007	Mostafa	The major aim of this research is to measure the relative efficiency of the top 100 Arab banks. The sensitivity of the results is also investigated.	DEA	Top 100 Arab banks over period 2005 – 2006 were chosen for this study.	The results indicate that the performance of several banks is sub-optimal, suggesting the potential for significant improvements. Separate benchmarks were derived for possible reductions in resources used, and significant savings are possible on this account.
2007a	Sufian	To examine the relative efficiency between the domestic and foreign banks Islamic banking operations in Malaysia.	DEA	11 domestic Islamic banks and four foreign Islamic banks in Malaysia over period 2001 – 2004 were chosen for this study.	The domestic Islamic banks were more efficient compared to the foreign Islamic banks albeit marginally. The results from the correlation coefficients have further confirmed the dominance of scale in determining the technical efficiency of Malaysian Islamic banks. The results also suggest that profitability is significantly and positively correlated to all efficiency measures.
2007b	Sufian	To examine the long – term trend in the efficiency of the Singapore banking sector	DEA window analysis approach	Sample in this study consists of six Singapore incorporated (full licence) banks over period 1993 – 2003.	Singapore banking groups have exhibited mean overall or technical efficiency of 88.4 per cent.

61

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2008	Ariff and Can	Aimed to investigate the cost and profit efficiency of Chinese commercial banks.	DEA	28 Chinese commercial banks over period 1995 – 2004 were chosen for this study.	The profit efficiency levels are well below those Of cost efficiency. The results suggest the need for speedier reforms to open the banking market, improving risk management, minimizing the government's capital subsidy and diversifying Ownership of Chinese banks.
2008	Chansam	To examine the relative efficiency of Thai commercial banks during 2003 – 2006 by utilizing DEA	DEA	He chose 13 commercial banks in Thailand for four years from 2003 to 2006.	"The efficiency of Thai commercial banks via operation approach is very high and stable while the efficiency via intermediation approach is moderately High and somewhat volatile".
2008	Erdem and Erdem	Aimed to estimate the technical, allocative, and economic efficiency levels of the commercial banks in Turkey	DEA	They chose the commercial banks in Turkey during the period between 1998 and 2004.	Results showed that six banks appeared to be Technically efficient at least once during the period of study
2008	Mokhtar et al.	This study aimed to empirically investigate the efficiency of the fully fledged Islamic banks as well as Islamic windows in Malaysia.	DEA	The study used 288 panel data from the banks' financial statement of 20 Islamic Windows, 2 full-fledged Islamic banks and 20 conventional banks from 1997 to 2003.	The findings show that, on average, the efficiency of the overall Islamic banking industry has increased during the period of study. The study also revealed that, although the fully fledged Islamic banks were more efficient than the Islamic windows, they were still less efficient than the conventional banks. Finally, Islamic windows of the foreign banks were found to be more efficient than Islamic windows of the domestic banks.
2009	Aydin, Yalama, and Sayim	Aimed to assess the efficiency of the banks operating in Turkish Banking Sector	DEA	They chose the banks operating in Turkish Banking Sector for the period December 2002 to March 2006, consisted of 14 quarterly periods	Empirical results showed that the most efficient banks in Turkey are state-owned, foreign-owned, development-investment and private-owned banks respectively. The efficiency rates in Turkish Banking Sector had been increased for the covered period substantially.

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2009	Lin et al.	Wanted to evaluate the operating performance of business units of a certain bank in Taiwan.	DEA	The sample for this study was chosen from 117 branches of a certain bank in Taiwan in 2006.	The average overall technical efficiency of branches is 54.8per cent and the average pure technical efficiency of branches is 67per cent, which is probably because of lower loan-to-deposit ratio, leading to excessive input waste.
2009	Meepadung et al.	Aimed to explore the impact of IT – based retail banking services on branch efficiency.	DEA	They chose 165 full – service branches in Bangkok's metropolitan area.	IT-based transactions at the branch level have a significant impact on profit efficiency, and therefore have a significant role to play in profit maximization.
2009	Sufian	This study investigated for the first time the efficiency of Malaysian banking sector around the Asian financial crisis 1997	DEA	They used annual bank level and macroeconomic data of all Malaysian commercial banks over the period 1995–1999.	The results suggested that the decline in technical efficiency is more abrupt under the intermediation approach relative to the value added approach and operating approach.
2010	AlKhathlan and Abdul Malik	They used basic DEA models i.e. CCR and BCR to evaluate the relative efficiency of Saudi Banks	DEA	They used annual data of Saudi banks from 2003 through 2008	The results showed that, on a relative scale, Saudi banks were efficient in the management of their financial resources. In addition, the results would provide crucial information about Saudi banks' financial conditions and management performance for the benefit of bank regulators, managers and bank stock investors.
2010	Kumar, and Gulati	The purpose of this paper is to appraise the efficiency, effectiveness, and performance of 27 public sector banks (PSBs) operating in India by using a two-stage performance evaluation model.	DEA	Public banks sector in India over period 2006 – 2007 were chosen for this study.	The overall technical inefficiency stems primarily from managerial inefficiency rather than scale inefficiency.
2010	Tecles and Tabak	Wanted to analyze the efficiency of the Brazilian banking sector.	DEA	The Brazilian banking sector over the post-privatization period of 2000–2007 was chosen for this study.	That large banks are the most cost and profit efficient, supporting the concentration process observed in recent years. Foreign banks have achieved a good performance through both the establishment of new affiliates and the acquisition of local banks.

Table-2. Empirical Studies on Measuring Efficiency Using DEA in Banks in Developing Countries (Continue)

Year	Authors	Objective	Technique	Sample	Findings
2011	Avkiran	Wanted to investigate to what extent bank DEA super-efficiency estimates are associated with key financial ratios.	DEA	Chinese banking sector in 2007 were chosen for this study.	A low correlation may present an opportunity to address inefficiencies that were not obvious in financial ratio analysis, thus enabling an update of inferences drawn from ratios
2011	EL Moussawi and Obeid	The purpose of this paper is to propose a method of evaluating the productive performance of Islamic banks operating in the GCC.	DEA	They chose the Islamic banks operating in the GCC region over the period 2005-2008.	The technical inefficiency and allocation inefficiency increased bank costs, on average, by about 14per cent and 29per cent, respectively.
2012	Qureshi and Shaikh	The purpose of this paper is to analyze comparative efficiency of banking system in Pakistan comprising of Islamic banks (IB), conventional banks with Islamic banking division (IBD) and conventional banks (CB).	DEA	Islamic banks in Pakistan over period 2003 – 2008 were chosen for this study.	They found that Islamic bank is more cost efficient and less revenue efficient.
2012	Shyu and Chiang	Explored the true managerial efficiencies of the branches of a case bank in Taiwan.	DEA	This study used the data of first six months of 2007 and 2008 for the 123 branches of the case bank.	The findings based on business scope and deposit amount suggest that a branch operating both wealth management service and loan business have higher efficiency values than those that operate wealth management service only.
2012	Sufian and Habibullah	Attempted to provide new empirical evidence on the efficiency of the Malaysian banking sector around the Asian financial crisis of 1997.	DEA	Data of banks operating in Malaysia during the period 1995–2008 was used in this study.	The results indicate that the foreign banks have exhibited higher technical efficiency compared to their domestic bank counterparts.
2014	Alrafadi, Kamaruddin and Yusuf	provides a comparative analysis regarding the performance of Libyan banks	DEA	They chose 17 Libyan banks over the period 2004 to 2007	The results showed that the specialized banks have exhibited higher mean technical efficiency relative to commercial and private banks. The results of efficiency determinants showed positive relationship between bank efficiency, and ROA; size of operation; capital adequacy; and government linked banks (government ownership)

The main aim of this paper is to highlight the existing body of literature on efficiency in banks. To achieve this objective several definitions of efficiency were explored. In addition, some other important issues regarding banking efficiency were identified. Survey of methods to assess efficiency were presented .Finally, the gaps of the study was identified and the proposed model of the study present.

In the previous mentioned studies we noted that most of the studies compared between allocative, technical, and cost efficiencies. And there are some studies compared the efficiency of banks between countries such as Sathye (2001) and Brack and Jimborean (2009). Also, some studies compared efficiency between types of banks such as Sathye (2001). The previous studies also showed that the score of allocative efficiency was more than technical and cost efficiencies.

Also, in the empirical studies in section 3, we noted that there are studies compared between cost efficiency and profit efficiency and showed that the scores of cost efficiency were more than the scores of profit efficiency such as Chu and Lim (1998); Isik and Hassan (2002); Chen *et al.* (2005) and Ariff and Can (2008). Also, there are studies compared between large, medium, and small banks such as Hassan *et al.* (2004) in Bahrain and Tecles and Tabak (2010) in Brazil, and they found that large banks were more efficient than medium and small banks. And there are some studies conducted to measure the cost efficiency of Islamic banks such as Hassan (2006); Shahooth *et al.* (2006); Mokhtar *et al.* (2008) and Qureshi and Shaikh (2012) and they found that the Islamic banks were more cost efficient while Hassan (2006) found that the Islamic banks were less cost efficient.

As a conclusion, from the above previous studies in developed and developing countries the gap in the literature has been determined as follows:

- Most of these studies were conducted in developed countries context. Also many studies were in developing countries.
- Very few studies were conducted in the context of banking industry in Arab countries.

REFERENCES

Ariff, M. and L. Can, 2008. Cost and profit efficiency of Chinese banks: A non − parametric analysis. China Economic Review, 19(2): 260 − 273.

Bauer, P.W., A.N. Berger, G.D. Ferrier and D.B. Humphrey, 1998. Consistency conditions for regulatory analysis of financial institutions: A comparison of frontier efficiency methods. Journal of Economics and Business, 50(8): 85 − 114.

Berger, A.N. and D.B. Humphrey, 1997. Efficiency of financial institutions: International survey and directions for future research. European Journal of Operational Research, Elsevier, 98(2): 175-212.

Brack, E. and R. Jimborean, 2009. Cost efficiency of French banks: 1- 30. Available from http://mpra.ub.uni-muenchen.de/23471/ [Accessed 25 August 2012].

Bryce, C.L., 1996. Alternative approaches to estimating the efficiency of health maintenance organizations. ProQuest Dissertations & Theses: The Sciences and Engineering Collection.

Casu, B. and P. Molyneux, 2003. A comparative study of efficiency in European banking. Applied Economics, 35(17): 1865-1876.

Charnes, A., W. Cooper, A. Lewin and L. Seiford, 1994. Data envelopment analysis- theory, methodology and applications. Massachusetts, USA: Kluwer Academic Publisher Group.

Charnes, A. and W.W. Cooper, 1962. Programming with linear fractional functionals. Naval Research Logistic Quarterly, 9(3 − 4): 181 − 186.

Charnes, A., W.W. Cooper and E. Rhodes, 1978. Measuring the efficiency of decision making units. European Journal of Operational Research, 6(2): 429 -444. DOI 10.1016/0377-2217 (78)90138-8.

Chen, X., M. Skully and K. Brown, 2005. Banking efficiency in China: Application of DEA to pre − and post − deregulation eras: 1993 − 2000. China Economic Review, 16(3): 229 − 245.

Chu, S.F. and G.H. Lim, 1998. Share performance and profit efficiency of banks in an oligopolistic market: Evidence from Singapore. Journal of Multinational Financial Management, 8(2 − 3): 155 −168.

Clemhout, S., 1968. The class of homothetic isoquant production functions. Review of Economic Studies, 35(1): 91-104.

Cooper, W.W., L.M. Seiford and K. Tone, 2003. Data envelopment analysis: A comprehensive text with models, applications, references, and DEA solver software. Massachusetts, USA: Kluwer Academic Publisher Group.

Cooper, W.W., L.M. Seiford and K. Tone, 2007. Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software. 2nd Edn., New York: Springer.

Cullinane, K., T.F. Wang, D.W. Song and P. Ji, 2006. The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis. Transportation Research Part A: Policy and Practice, 40(4): 354 − 374.

Cummins, J.D. and H. Zi, 1996. Measuring cost efficiency in the US life insurance industry: Econometric and mathematical programming approaches. Working paper. Available from http://fic.wharton.upenn.edu/fic/papers/97/9703.pdf [Accessed 1 Feb. 2012].

Farrell, M.J., 1957. The measurement of productive efficiency. Journal of the Roya Statistical Society, Series A, 120(3): 253−281.

Hassan, M.K., 2006. X − efficiency in islamic banks. Islamic Economics Studies, 13(2): 49 − 78.

Hassan, M.K., A. Al-Sharkas and A. Samad, 2004. An empirical study of relative efficiency of the banking industry in Bahrain. Studies in Economics and Finance, 22(2): 40-69.

Isik, I. and M.K. Hassan, 2002. Technical, scale and allocative efficiencies of Turkish banking industry. Journal of Banking and Finance, 26(4): 719-766.

Jacobs, R., 2001. Alternative methods to examine hospital efficiency: Data envelopment analysis and stochastic frontier analysis. Health Care Management Science, 4(2): 103 − 115.

Kounetas, K. and K. Tsekouras, 2007. Measuring scale efficiency change using a translog distance function. International Journal of Business and Economics, 6(1): 63 − 69.

Manadhar, R. and J. Tang, 2002. The evaluation of bank branch performance using data envelopment analysis: A framework. Journal of High Technology Management Research, 13(1): 1−17.

McAllister, P.H. and D. McManus, 1993. Resolving the scale efficiency puzzle in banking. Journal of Banking and Finance, 17(213): 389-405.

Mokhtar, H.S.A., N. Abdullah and M.S. Al − Habashi, 2008. Efficiency and competitions of islamic banking in Malaysia. Humanomics, 24(1): 28 − 48.

Norman, M. and B. Stoker, 1991. Data envelopment analysis: The assessment of performance. England: John Wiley & Sons Ltd.

Qureshi, M.A. and M. Shaikh, 2012. Efficiency of islamic and conventional banks in Pakistan: A non-parametric approach. International Journal of Business and Management, 7(7): 40 − 50.

Sanchez, I., 2009. Technical and scale efficiency in Spanish urban transport: Estimating with data envelopment analysis. Available from http://www.hindawi.com/journals/aor/2009/721279 [Accessed 1 Feb 2012].

Sathye, M., 2001. X − efficiency in Australian banking: An empirical investigation. Journal of Banking & Finance, 25(3): 613 − 630.

Shahooth, K., A.H. Battall, K. Al − Delaimi and Al − Ani, 2006. Using data envelopment analysis to measure cost efficiency with an application on islamic banks. Scientific Journal Administrative Development, 4: 134 −156.

Tecles, P.L. and B.M. Tabak, 2010. Determinants of bank efficiency: The case of Brazil. European Journal of Operational Research, 207(3): 1587−1598.

Thanassoulis, E., 2003. Introduction to the theory and application of data envelopment analysis. Text Book, Library of Congress Control Number: 2001034441.

Wheelock, D.C. and P.W. Wilson, 1999. Technical progress, inefficiency and productivity changes in US banking 1984-1993. Journal of Money, Credit and Banking, 31(2): 212 - 234.

Zhu, J., 2003. Quantitative models for performance evaluation and benchmarking: Data envelopment analysis with spreadsheets and DEA excel solver. Massachusetts, USA: Worcester Polytechnic Institute.

BIBLIOGRAPHY

Akhtar, M.H., 2002. X-Efficiency analysis of commercial banks in Pakistan: A preliminary investigation. The Pakistan Development Review, 41(4 Part II): 567 − 580.

Al-Faraj, T., A. Alidi and K. Bu-Bshait, 1993. Evaluation of bank branches by means of data envelopment analysis. International Journal of Operations & Production Management, 13(9): 45-52.

Al − Shammari, M. and A. Salimi, 1998. Modeling the operating efficiency of banks: A nonparametric methodology. Logistics Information Management, 11(1): 5 −17.

AlKhathlan, K. and S. Abdul Malik, 2010. Are Saudi banks efficient? Evidence using data envelopment analysis (DEA). International Journal of Economics and Finance, 2(2): 53 − 58.

Alrafadi, K.M.S., B.H. Kamaruddin and M.M. Yusuf, 2014. Efficiency and determinants in Libyan banking. International Journal of Business and Social Science, 5(5): 156 − 168.

Ashton, J., 1998. Cost efficiency, economies of scale and economies of scope in the British retail banking sector. School of Finance & Law Working Paper Series, No. 13.

Ataullah, A., T. Cockerill and H. Le, 2004. Financial liberalization and bank efficiency: A comparative analysis of India and Pakistan. Applied Economics, 36(17): 1915−1924.

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

Avkiran, N.K., 2006. Developing foreign bank efficiency models for DEA grounded in finance theory. Socio − Economic Planning Sciences, 40(4): 275 − 296.

Avkiran, N.K., 2011. Association of DEA super-efficiency estimates with financial ratios: Investigating the case for Chinese banks. Omega, 39(3): 323 − 334.

Ayadi, F., A.O. Adebayo and E. Omolehinwa, 1998. Bank performance measurement in a developing economy: An application of data envelopment analysis. Managerial Finance, 24(7): 5-16.

Aydin, N., A. Yalama and M. Sayim, 2009. Banking efficiency in developing economy: Empirical evidence from Turkey. Journal of Money, Investment and Banking, 4(8): 49 − 70.

Banker, R.D., H. Chang and S. Lee, 2010. Differential impact of Korean banking system reforms on bank productivity. Journal of Banking & Finance, 34(7): 1450 − 1460.

Barros, C.P., S. Managi and R. Matousek, 2012. Technical efficiency of the Japanese banks: Non-radial directional performance measurement with undesirable output. Omega, 40(1): 1 −8.

Berg, S.A., F. Forsund, L. Hjalmarsson and M. Suominen, 1993. Banking efficiency in the Nordic countries. Journal of Banking and Finance, 17(2-3): 371 − 388.

Bikker, J.A., 1999. Efficiency in the European banking industry: An exploratory analysis to rank countries. De Nederlandsche bank. Research Series Supervision No. 18.

Casu, B. and C. Girardone, 2002. A comparative study of the cost efficiency of Italian banking conglomerates. Managerial Finance, 28(9): 3 − 23.

Chansarn, S., 2008. Relative efficiency of commercial banks in Thailand: DEA approach. International Research Journal of Finance and Economics, 18(3): 53 − 68.

Cook, W.D. and M. Hababou, 2001. Sales performance measurement in bank branche. Omega, 29(4): 299 − 307.

Demir, N., S.F. Mahmud and S. Babuscu, 2005. Technical inefficiency effects of Turkish banks after financial liberalization. The Developing Economics, 43(3): 396 − 411.

Drake, L. and M.J.B. Hall, 2003. Efficiency in Japanese banking: An empirical analysis. Journal of Banking and Finance, 27(5): 891-917.

Drake, L., M.J.B. Hall and R. Simper, 2009. Bank modelling methodologies: A comparative non-parametric analysis of efficiency in the Japanese banking sector. Journal of International Financial Markets, 19(1): 1 − 15.

EL Moussawi, C. and H. Obeid, 2011. Evaluating the productive efficiency of islamic banking in GCC: A non- parametric approach. International Management Review, 7(1): 10 − 21.

Elyasiani, E. and S.M. Mehdian, 1995. Comparative efficieney performance of small and large US cornmercial banks in the pre- and post-deregulation eras. AppIied Economics, 27(4): 1069 — 1079.

Erdem, C. and M. Erdem, 2008. Turkish banking efficiency and its relation to stock performance. Applied Economics Letters, 15(3): 207 − 211.

Favero, C.A. and L. Papi, 1995. Technical efficiency and scale efficiency in the Italian banking sector: A non-parametric approach. Applied Economics, 27(4): 385-395.

Fu, X. and S. Heffernan, 2007. Cost X − efficiency in Chin's banking sector. China Economic Review, 18(1): 35 − 53.

Fukuyama, H., 1993. Technical and scale efficiency of Japanese commercial banks: A non − parametric approach. Applied Economics, 25(8): 1101 − 1112.

Golany, B. and J. Storbeck, 1999. A data envelopment analysis of the operational efficiency of bank branches. Interfaces, 29(3): 14 − 26.

Havrylchyk, O., 2006. Efficiency of the polish banking industry: Foreign versus domestic banks. Journal of Banking and Finance, 30(7): 1975 − 1996.

Ho, C.T. and D.S. Zhu, 2004. Performance measurement of Taiwan's commercial banks. International Journal of Productivity and Performance Management, 53(5): 425 − 434.

Jackson, P.M. and M.D. Fethi, 2000. Evaluating the technical efficiency of Turkish commercial banks: An application of DEA and tobit analysis. The International DEA Symposium, University of Queensland, Australia.

Kirkwood, J. and D. Nahm, 2006. Australian banking efficiency and its relation to stock return. Economic Record, 82(258): 253 − 267.

Kumar, S. and R. Gulati, 2010. Assessing the effect of ownership on the efficiency of Indian domestic banks. Journal of Bank Management, 9(3): 76 − 104.

Kyj, L. and I. Isik, 2008. Bank X-efficiency in Ukraine: An analysis of service characteristics and ownership. Journal of Economics and Business, 60(4): 369 − 393.

Lin, X., Y. Zhang and N. Zhu, 2009. Does bank ownership increase firm value? Evidence from China. Journal of International Money and Finance, 28(4): 720-737.

Liu, J. and K. Tone, 2008. A multistage method to measure efficiency and its application to Japanese banking industry. Socio - Economic Planning Sciences, 42(2): 75 - 91.

Meepadung, N., J.C.S. Tang and D.B. Khang, 2009. IT − based banking services: Evaluating operating and profit efficiency and bank branches. Journal of High Technology Management Research, 20(2): 145 − 152.

Miller, S.M. and A.G. Noulas, 1996. The technical efficiency of large bank production. Journal of Banking & Finance, 20(3): 495 − 509.

Mostafa, M., 2007. Benchmarking top Arab banks efficiency through efficient frontier analysis. Industrial Management and Data Systems, 107(6): 802 − 823.

Mukherjee, A., P. Nath and M.N. Pal, 2002. Performance benchmarking and strategic homogeneity of Indian banks. International Journal of Bank Marketing, 20(3): 122 − 139.

Resti, A., 1997. Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joint application of parametric and nonparametric techniques. Journal of Banking and Finance, 21(2): 221-250.

Sathye, M., 2003. Efficiency of banks in a developing economy: The case of India. European Journal of Operational Research, 148(3): 662 − 671.

Schaffnit, C., D. Rosen and J.C. Paradi, 1997. Best practice analysis of bank branches: An application of DEA in a large Canadian bank. European Journal of Operational Research, 98(2): 269-289.

Shanmugam, K.R. and A. Das, 2004. Efficiency of Indian commercial banks during the reform period. Journal of Applied Financial Economics, 14(9): 681− 686.

Sherman, H.D. and F. Gold, 1985. Bank branch operating efficiency: Evaluation with data envelopment analysis. Journal of Banking and Finance, 9(2): 297-315.

Shyu, J. and T. Chiang, 2012. Measuring the true managerial efficiency of bank branches in Taiwan: A three-stage DEA analysis. Expert Systems with Applications, 39(13): 11494 − 11502.

Sufian, F., 2007a. Efficiency of islamic banking industry in Malaysia: Foreign vs domestic banks. Humanomics, 23(3): 174 − 192.

Sufian, F., 2007b. Trends in the efficiency of Singapore's commercial banking groups: A non-stochastic frontier DEA window analysis approach. Int. J. Prod Perform Manage, 56(2): 99-136.

Sufian, F., 2009. Determinants of bank efficiency during unstable macroeconomic environment: Empirical evidence from Malaysia. Research in International Business and Finance, 23(1): 54 − 77.

Sufian, F., 2011. Benchmarking the efficiency of the Korean banking sector: A DEA approach. Benchmarking: An International Journal, 8(1): 107 − 127.

Sufian, F. and M.S. Habibullah, 2012. Developments in the efficiency of the Malaysian banking sector: The impacts of financial disruptions and exchange rate regimes. Progress in Development Studies, 12(1): 19 − 46.

Wu, D., Z. Yang and L. Liang, 2006. Efficiency analysis of cross-region bank branches using fuzzy data envelopment analysis. Applied Mathematics and Computation, 181(1): 271−281.

Yildirim, C., 2002. Evolution of banking efficiency within an unstable macroeconomic environment: The case of Turkish commercial banks. Applied Economics, 34(18): 2289-2301.

Zaim, O., 1995. Effect of financial liberalization on the efficiency of Turkish commercial banks. Applied Financial Economics, 5(4): 257-264.

Zenios, C., S. Zenios, K. Agathocleous and A. Soteriou, 1999. Benchmarks of the efficiency of bank branches. Interfaces, 29(3): 37 − 51.
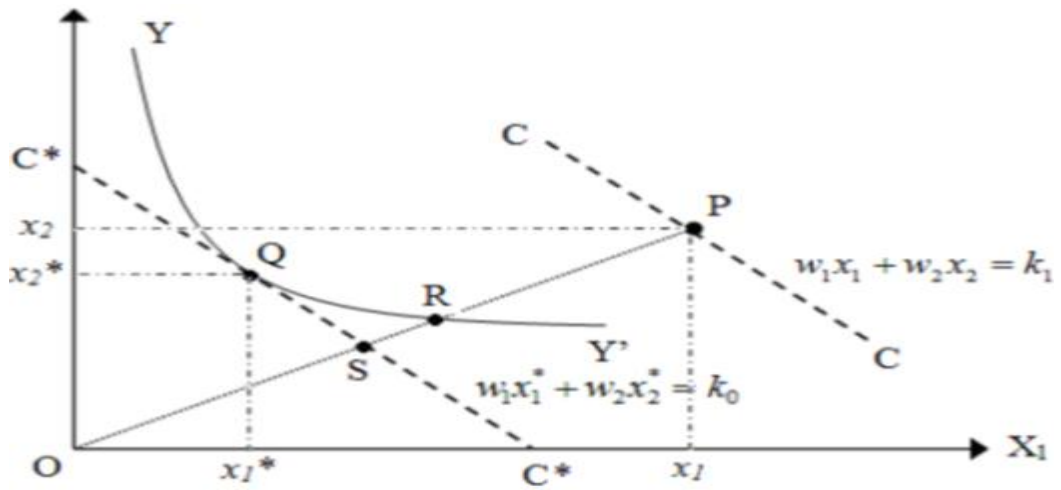
Figure-1. Technical, Allocative and Cost Efficiency
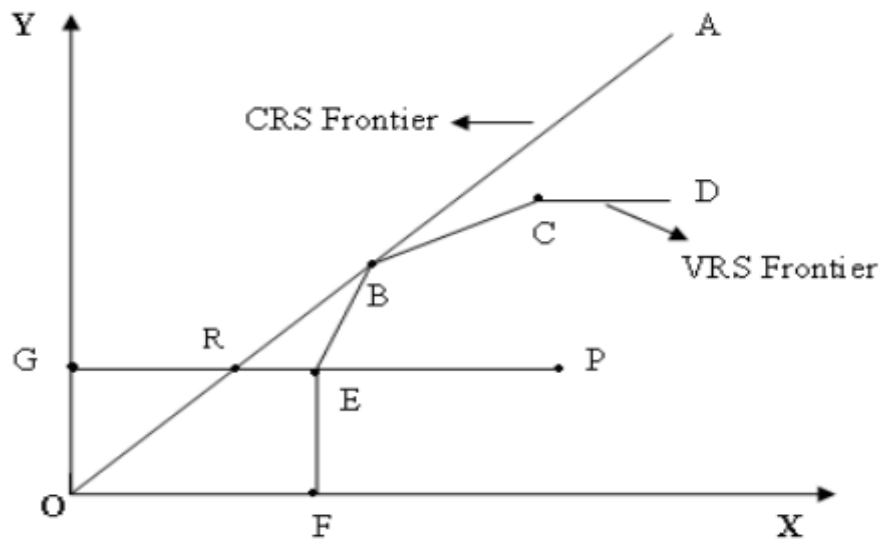
Source: Cooper *et al.* (2007)

Figure-2. Pure Technical and Scale Efficiency

Source: Hassan *et al.* (2004)