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An Assessment of Financial Efficiency using Data Evolvement Analysis (DEA)-Multistage Approach: A Case Study of Banks in Bangladesh

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Abstract
Paper*: Research paper*
Purpose*:This study is identifying financial efficiency level of Financial institutions especially Banks in Bangladesh over the period from 2011 to 2015*
Methodology:*This research study consider 24 private commercial banks out of 30 who are listed in capital market. Technical efficiency is determined using Data Envelopment Analysis (DEA) considering both input and output orientation measures.*
Findings:*Study result revealed that at firm level about 62% banks preforming efficiently under Constant Returns to Scale (CRS) and 75% banks under Variable Returns to Scale (VRS) in both input and output orientation.While assessing technical efficiency level as a whole banking industry does not performing efficiency, it shows a decreasing returns to scale over the period from 2011-2015.*
Keywords:Technical efficiency, Data evolvement analysis, ROA, CRS, VRS

I. Introduction

Financial system consist of financial markets, banks, non-bank financial institutions, leasing organization, micro finance institution. All the actors in the financial system put significant contribution in economic growth process, among those Banks, over the period, draw considerable attention among investors, researchers and regulatory authority due prime sources of fund mobilization from deficit units to surplus units in the economy. Banks are integrated component in the financial system such as nervous system in human body, so it need to perform with efficiently so as to entire financial system can perform efficiently. Bank efficiency is very important and crucial issue especially in transition economies, where the banking sector faced a considerable change in ownership structure as a result of privatization, foreign banks entry and competition, liberalization, change in legislative environment and institutional rules. All these factors exerted some influence on the bank performance and efficiency. In addition, the technological changes and knowledge, transferred normally with the increase in foreign ownership in the transition economies, altered significantly the operational environment for the banking institutions and the technology of banks production, which in its turn changed the bank efficiency.Efficiency can be simply defined as the ratio of output to input. More output per unit of input reflects relatively greater efficiency. If the greatest possible output per unit of input is achieved, a state of *absolute* or *optimum efficiency* has been achieved and it is not possible to become more efficient without new technology or other changes in the production process. We go for this study by considering the hypothesis is that ***"over the period efficiency level of private commercial banks in Bangladesh is increasing"***

There is a vast amount of literature concerning the modeling of banking efficiency and performance using a variety of approaches. Non parametric model like Data envlovemetn analysis, **Nenovsky et al**(2008) , **Noreen**(2014), **Barbullushi**(2016), **Ahmad et al** (2015), **Morita &Avkiran**(2015), **Eken &**Kale, (2011), sufain, (2010), **Micajkov & Klimentin**(2013),**Yang**(2009) &**Paradi et al.,**(2015) on Branch Operatinoal efficiency of Canadeian Bank, **Eriki &Osagie**(2014)on Nigeria Banking industry, **M. Radojicic et al.**,(2015) on banking industry of Sebria, **Karimzadeh**(2012),**Sreeaarthi et al**., (2013)**Singh & Kumar**(2014)&**Jayaraman & Srinivasan** (2014), **Kumar & Shree** (2015), **Mahendru & Bhatia**2015) on Indian banking indutry, **Nitol**(2010) on Romanian Banking System, **Tahir et al.**,(2009)&**Rossazana Ab Rahim**(2015) on Malaysain Banking industry as well as **Haron** (2008) apply SFA to assess technical efficiency of Malaysain Commercial Banks,**Staub et al.,**(2009) on Brazelian Banking industry,**Hassan et al**.,(2011) , **Ayse Altıok Yılmaz**(2013) and**Kutlar et al.,**(2015) on Turkish Banking Syestem, **Muvingi &Hotera**(2015) on Zimbabwe commercials banks, **Miencha et al.,**(2015) on Private and Public Sector Banks in Kenya,**Coert & Makina**(2014) on south africaian Banking Industry,**Analysis et al.,**(2013) examine efficinecy of commercial banks in Pakistan,**Liu & Li** (2012),**Xiping &Yuesheng**(2010),***Kai Ji et al.,*** (2012)&**Sok-Gee**(2011) on Chines listed commercial Banks, **Benites et al.,** (2010) assess efficiency level on bank, woking in Brazilian market, **Pratheepan&Thayaparan**(2014) apply DEA-Malmquist Index on Sri Lankan banks, **Soetanto & Ricky**(2011) used DEA (Two stage model) on Indonesian commercial banks to analysis technical efficinecy, **Lung et al.,**(2014)Malmquist Indexes advance model in DEA Commercial Banks in Taiwan.Morover exclusive dependecny on DEA, researchers consider both non-parametice and parametice method for efficiency analyis like **Herrmann et al.**,(2006) study on German universal banks and analyze their level of efficiency basis on both efficiency model.

Apart from DEA application on financial instirutions, several researchers go for application in other sectors as well, **Adeyinka**(2015) on European Financial Cooperative Sector in addition that **Fotios Pasiouras et al.,(**2007) used DEA to access cost efficiency of Greek Cooperative Banks. **Tahir &Tahrim**(2013) on Microfinance Institutions in ASEAN,

Peggy & Review (2005) to assess Reputation and Organizational Efficiency, Basso & Funari (2010) on ethical Mutual fund**, Cullmann &Hirschhausen**(2008)studied level of efficiency by employing DEA in German Public Transport Companies.Emparical research outcome on analyzing efficiency of banking industry in Bangladesh are as follows in order to determne potential research gap for further analysis.

Authors	Year	Data period	Methodology
Hossain et al.,	2016	2014	DEA under VRS
Rahman	2012	2008	DEA – two stage
Hoque & Rayhan	2013	2009	DER under CRS
Nghiem &Khanam	2005	2003-2005	ANOVA analysis
Samad	2009	2000	SFA

It is prominent that DEA has a strong appeal among researchers for assessing level of efficinency wether for it finanical institutiona or other business area. Considering emparical *research**Table – 1*** using DEA in Banking industry of Bangladesh that a few research were conducted by reaearchers but having no comprehensive study for evaluation of efficiency level. Though financial instituaions contribute sigficantlly on economic progress especially Banks in bangladesh but no such comprehensive research was conducted to evaluationg operational efficiency level in banking industry. This research gap intice us to go for conduct such reaearch appliying widely used non-perametic model known as Data Envlovement Anallysis (DEA).

The paper is organized as follows: Section II presents in details the methodology used in bank efficiency estimations and analyses, Section IIIdiscusses the results, obtained by using DEA approaches. Section IV Findings

II. Methodology of the study

As sample, study consider 24 banks out of 30 private commercial banks in Bangladesh on the basis of their commencement of operation. Banks selected for study who established in before 2009. All the input and output variables were collected from financial statement of respective banks from 2011 to 2015 as research period. For efficiency analysis we apply DEA.Data Envelopment Analysis (DEA) is a very powerful service management and benchmarking technique originally developed by ***Chames, Cooper and Rhodes (1978)*** to evaluate nonprofit and public sector organizations.DEA is a specific methodology for analysis of the relative efficiency for multiple inputs and outputs by evaluation of all decision-making units (DMUs) and measurement of their performance in respect to the best practice banks, which determine the so-called efficient frontier. The most important advantage of DEA is that it does not require in advance assumptions about the production function's analytical form. At the same time like the rest of the models, DEA also has some disadvantages. First, it is sensitive to extreme observations, and second, it does not decompose the banks deviation from the efficient production frontier into inefficiency and random error components.

There are various models of DEA. We choose to apply the most frequently used ones – CCR-model and BCC-model. CCR-model was developed by Charnes, Cooper and Rhodes **(Charnes et al. (1978)).** Its specific assumption is that the DMU operates under constant returns to scale (CRS). BCC-model was defined by **Banker, Charnes and Cooper (Banker et al. (1984)).** It estimates the efficiency under the assumption of variable returns to scale (VRS).Efficiency may be defined as an effort to obtain the highest output possible bypreferring the method that uses the input composition in the most productive way.Assuminga decision making unit (DMU) generates the outputs $y_i = (i = 1,2,3,,4 \dots \dots \dots n)$from the inputs $x_k = (k = 1,2,3,,4 \dots \dots \dots m)$ the equation can be expressed in the following way by help of the appropriateweights $(v_i = 1,2\ ,3\ ,4 \dots \dots . n)$ and $(w_k = 1,2\ ,3\ ,4 \dots \dots . m)$ on the variables, considering all variables, output and input ratio can be as follows;

$$\sum_{i=1}^{n}(y_i v_1) / \sum_{k=1}^{m}(x_k w_k) \qquad Eq(1)$$

In DEA, weights are determined pertaining to DMUs for each variable.DEA takes the inputsx_k and outputs y_i in the equation given above and selects weight for maximize performance of DMUs "p" related to the performance of other unites, Equation (1), can be rewrite as follows;

$Max v_i k_i (\frac{\sum_{i=1}^{n} y_{ip} v_1}{\sum_{k=1}^{m} x_k w_{kp}})$ Eq (2)

Here efficiency score of "Z" number DMUs under the ≤ 1 is constraint as follows,

$$0 \leq \sum_{i=1}^{n}(y_i v_{ic}) / \sum_{k=1}^{m}(x_k w_{kc}) \leq 1 \qquad Eq(3)$$

In the model, "v"and "w" constituteweighton the inputs and output variables respectively in theequation. Solution of the model gives an efficiency value of "p" DMU and a set of necessary weights to reach this value. Solution of non-parametric efficiencymeasurement model in the form of fractional programming form was converted to the linearprogramming model easier to solve. (**Charnes et al**., 1978, 1979; **Banker et al**., 1984)

Constant return to scale (CRS)

First, we use constant returns to scale (CRS) DEA model introduced by *Charnes et al.,(1978)* to measure the bank's technical efficiency. The efficiency score in the presenceof multiple input and output factors can be express as:

$$Efficiency = \sum \frac{Weighted sum output}{weighted sum input} Eq(4)$$

Consider a set of n DMUs (in this study $n = 4$), with each DMU k ($k = 1, 2, \dots, n$), using p inputs x_{ik}($i = 1, \dots, p$) and generating q outputs y_{jk}($j = 1, \dots, q$). The relative efficiency score of a DMU$k$can be express as the ratio of weighted output to weighted input.

$$Efficiency = \sum_{j} \frac{\bar{u}_j y_{jk}}{\bar{v}_i x_{ik}} Eq(5)$$

So the technical efficiency of DMU can be obtained using following equation:

$$max = \frac{\sum_{j=1}^{q} \bar{u}_j y_{jk}}{\sum_{i=1}^{p} \bar{v}_i x_{ik}} Eq(6)$$

$$std = \sum_{j=1}^{q} \bar{u}_j y_{jk} - \sum_{i=1}^{p} \bar{v}_i x_{ik} \leq 0 \qquad Eq(7)$$

$$u_j, v_i \geq \varepsilon$$

Input oriented approach

The model discussed above (equation 6) involving the ratio of outputs to inputs is referred to as the input-oriented approach in the (CRS) DEA model. And by duality, equation 4 is equivalent to the linear programming, which is the input-oriented approach we use in this study following **Yao, Han and Feng's (2008)** framework

$$Min = \theta_k - \varepsilon \left(\sum_{j=1}^{q} s_j^+ + \sum_{i=1}^{p} s_i^- \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots Eq(8)$$

$$s.t., \sum_{k-1}^{n} \gamma_k x_{ik} + s_{i=}^- \theta_k x_{iki=1\dots\dots\dots p}$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} - s_i^+ \leq x y_{jkj=1\dots\dots\dots p}$$

$$\gamma_k, s_i^-, s_i^+ \geq 0$$

We also use the output-oriented approach in (CRS) DEA model to measure the technical efficiency following Seiford and Zhu's (1999) framework. The linear programming function of the output-oriented approach is given as:

$$Max == \theta_k + \varepsilon \left(\sum_{j=1}^{q} s_j^- + \sum_{i=1}^{p} s_i^+ \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots Eq(9)$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} + s_{i=}^- \theta_k x_{iki=1\dots\dots\dots p}$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} - s_i^+ \leq x y_{jkj=1\dots\dots\dots p}$$

$$\gamma_k, s_i^-, s_i^+ \geq 0, \forall k$$

The derivation of the fractional programming function and the linear programming model are similar to the input-oriented approach and all the variables are similarly defined as in equation (8) in both approaches.

We also used the variable returns to scale (VRS) DEA model, introduced by Banker, Charnes and Cooper (1984) to examine the scale efficiency.

$$Max \frac{\sum_{j=1}^{q} u_j y_{jk} - u_k}{\sum_{i=1}^{p} v_i x_{ik}} Eq(10)$$

$$s.t., \quad \sum_{j=1}^{q} u_j y_{jk} - u_k - \sum_{i=1}^{p} v_i x_{ik} \leq 0, \forall k$$

All the variables in the VRS model have the same definition as in the CRS model

The linear programming of equation (7) is given as follows:

$$Max \sum_{j=1}^{q} u_j y_{jk} - u_k \, Eq(11)$$

$$s.t., \quad \sum_{i=1}^{p} v_i x_{ik} = 1$$

$$\sum_{j=1}^{q} u_j y_{jk} - u_k - \sum_{i=1}^{p} v_i x_{ik} \leq 0, \forall k$$

Equations (10) and (11) are referred to as the input-oriented approach in the (VRS) DEAmodel. And by duality, equation (11) is equivalent to the linear programming of thefollowing equation:

$$Min == \theta_k - \varepsilon\left(\sum_{j=1}^{q} s_j^+ + \sum_{i=1}^{p} s_i^-\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots Eq(12)$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} + s_{i=}^- \theta_k x_{iki=1\dots\dots\dots p}$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} - s_i^+ \leq xy_{jkj=1\dots\dots\dots p}$$

$$\sum_{k=1}^{n} \theta_k = 1$$

$$\gamma_k, s_i^-, s_i^+ \geq 0, \forall k$$

The value from the input-oriented (VRS) DEA model represents the pure technical efficiency under the variable returns to scale and the only difference between the input-oriented approach in the CRS and VRS model is the extra convexity constraint

$$\sum_{k=1}^{n} \theta_k = 1$$

similarly, we also use the output-oriented approach in VRS DEA model to measure the pure technical efficiency of the four state-owned banks. The only difference between the output-oriented approach in the CRS and VRS model is the extra convexity constraint

$$\sum_{k=1}^{n} \theta_k = 1$$

$$Max == \theta_k + \varepsilon\left(\sum_{j=1}^{q} s_j^- + \sum_{i=1}^{p} s_i^+\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots Eq(13)$$

$$s.t., \sum_{k-1}^{n} \gamma_k x_{ik} + s_{i=}^- x_{iki=1\dots\dots\dots p}$$

$$\sum_{k-1}^{n} \gamma_k x_{ik} - s_i^+ = \theta_k y_{jkj=1\dots\dots\dots p}$$

$$\sum_{k=1}^{n} \theta_k = 1$$

$$\gamma_k, s_i^-, s_i^+ \geq 0, \forall k$$

We chose a sample of 24 private commercial banks in Bangladesh out of 30 which is listed in Dhaka stock exchange (DSE), the reason of excluding other listed from study sample that we only consider those banks who are established prior in the year of 2009. Data for research variables are collected from annual reports of respective banks. Basically for study purpose we select five inputs and three outputs by the consideration of empirical researchers study on similar case.

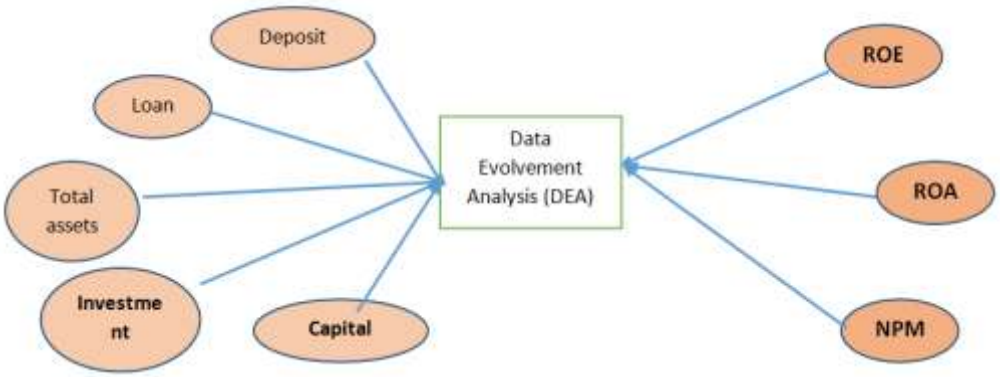

Figure - 1: Financial efficiency Model for Banks

III. Data analysis and interpretation:

For analyzing this information the models that were used are- non paramedic technique to determine level of efficiency widely known as Data Envelopment Analysis (DEA).

Table 01: DEA result – Input orientation

firm	CRSTE	VRSTE	Scale efficiency	
1	**1.000**	**1.000**	1.000	crs
2	**1.000**	**1.000**	1.000	crs
3	**1.000**	**1.000**	1.000	crs
4	**1.000**	**1.000**	1.000	crs
5	0.923	**1.000**	0.923	irs
6	**1.000**	**1.000**	1.000	crs
7	**1.000**	**1.000**	1.000	crs
8	**1.000**	**1.000**	1.000	crs
9	**1.000**	**1.000**	1.000	crs
10	0.852	**1.000**	0.852	drs
11	0.909	0.957	0.950	irs
12	**1.000**	**1.000**	1.000	crs
13	**1.000**	**1.000**	1.000	crs
14	0.992	0.993	0.999	**drs**
15	**1.000**	**1.000**	1.000	crs
16	0.902	0.907	0.995	irs
17	**1.000**	**1.000**	1.000	crs
18	**1.000**	**1.000**	1.000	crs
19	0.669	0.962	0.695	irs
20	0.597	0.719	0.831	irs
21	**1.000**	**1.000**	1.000	crs
22	0.898	0.916	0.980	irs
23	0.587	**1.000**	0.587	irs
24	**1.000**	**1.000**	1.000	crs
mean	0.930	0.977	0.951	

Note: crste = technical efficiency from CRS DEA
vrste = technical efficiency from VRS DEA
scale = scale efficiency = crste/vrste

It is obvious that Banks 1, 2, 3, 4, 6, 7, 8, 9,12,13,15,17,18,21 and 24 are the only efficient banks when CSR method is applied and Banks 1,2,3,4,5,6,7,8,9,10,12,13,15,17,18,21,23 and 24 when VRS is applied. Among all banks 5 registerdecreasing returns to scale and 7 registered for increasing return to scale and 12 banks are efficient.

Difference efficiency values are observed in efficiency table - : in both CRS and VRS for Banks 11, 14,16,19,20 are inefficient in both CSR and VSR.

Table – 2: Summary of Input orientation efficient Banks

Method	No of firm efficient		No of firm inefficient	
CSR	15	62.5%	9	37.5%
VRS	19	75%	5	25%

Table –03: DEA result – output orientation

firm	CRSTE	VRSTE	scale	
1	1.000	1.000	1.000	crs
2	1.000	1.000	1.000	crs
3	1.000	1.000	1.000	crs
4	1.000	1.000	1.000	crs
5	0.923	1.000	0.923	irs
6	1.000	1.000	1.000	crs
7	1.000	1.000	1.000	crs
8	1.000	1.000	1.000	crs
9	1.000	1.000	1.000	crs
10	0.852	1.000	0.852	drs
11	0.909	0.910	0.999	irs
12	1.000	1.000	1.000	crs
13	1.000	1.000	1.000	crs
14	0.992	0.994	0.999	drs
15	1.000	1.000	1.000	crs
16	0.902	0.932	0.968	drs
17	1.000	1.000	1.000	crs
18	1.000	1.000	1.000	crs
19	0.669	0.674	0.993	irs
20	0.597	0.629	0.950	drs
21	1.000	1.000	1.000	crs
22	0.898	0.902	0.996	irs
23	0.587	1.000	0.587	irs
24	1.000	1.000	1.000	crs
mean	0.930	0.960	0.969	

Note: crste = technical efficiency from CRS DEA
vrste = technical efficiency from VRS DEA
scale = scale efficiency = crste/vrste

Table 4: Summary of Output orientation efficient Banks

Method	No of firm efficient		No of firm inefficient	
CSR	15	62.5%	9	37.5%
VRS	18	75%	6	25%

It can be deduce from above summery that while analyzing level of efficiency on the basis of Constant Return to Scale (CRS)

Table 5: DEA Multistage – Input Output Orientation

	Input orientation			Output orientation		
	CRSTE	VRSTE	scale	CRSTE	VRSTE	scale
Mean	0.930	0.977	0.951	0.930	0.960	0.969

Table – 5: centralizes the data obtain in the two case: input orientation, using inputs and outputs of 24 private commercial banks in Bangladesh all over five year periods (2011-2015). The firstcolumn indicates the results obtained after having applied the scale constant returnmethod (CRS), the second column presents the results obtained after having appliedthe scale variable return method and the last column centralizes the scale efficiencydata. The efficiency mean, using CRS, is 0.930, the scale efficiency mean is 0.951 andthe efficiency mean, using VRS differs a little bit between the two orientations, amounting to 0.930, respectively 0.969.

Table 6:DEA Multistage by years –input and output Orientation

Model	year	Output	Input
Constant Returns to Scale	2011	**0.930****	**0.930****
	2012	0.521	0.521
	2013	0.899	0.899
	2014	0.853	0.853
	2015	0.812	0.812
Variable Returns to Scale	2011	**0.960****	***0.977****
	2012	0.641	0.592
	2013	0.928	0.907
	2014	0.913	0.948
	2015	0.880	0.848
Scale Efficiency	2011	**0.969****	**0.951****
	2012	0.779	0.861
	2013	**0.969****	0.943
	2014	0.931	0.933
	2015	0.899	0.938

In table 6:depicts technical efficiency level and scale efficiency level under assumption of input and output orientation. It is apparent that in CRS assumption efficiency level of Banks is decreasing from 0.93 to 0.812 over the research period from 2011 to 2015 under both input and output orientation model, maximum efficiency level shows in year 2011 having 0.930 for both $\mathbf{CRS_{input}}$ and $\mathbf{CRS_{output}}$. Considering VRS approach, under both assumptions show decreasing technical efficiency level, maximum efficiency level shows in the year of 2011 in both input and output orientation as $\mathbf{VA_{input} = 0.960}$ and $\mathbf{VAR_{output} = 0.977}$ respectively. But we observed mixed scale efficiency under assumption of input orientation and output orientation.

IV. Conclusion

This study measure level of efficiency of financial institution especially private commercial banks in Bangladesh. We use standard indicators for bank efficiency, namely return on assets (ROA), return on equity (ROE) and net profit margin. In order to check the robustness of the obtained results we use the DEA approach to bank efficiency scores' measurement which is widely used Data Involvement Analysis considering both input and output orientation methods under VRS and CRS mode for each year over last five years from 2011 to 2015. Study results revealed that during five years period banking industry as a whole does not perform efficiently, efficiency score shows from 2011 to 2015 that overall technical efficiency level is decreasing under both assumptions CRS and VRS. Under CRS assumption having same efficiency score regardless of orientation range from 0.930 to 0.812 but we experienced mixed efficiency score under input-VRS and output-VRS assumption having efficiency score 0.960 to 0.880 and 0.977 to 0.848 respectively. But the most key out is that, at firm level significant no of banks perform efficiently in both CRS and VRS assumption. So, those banks do not performing efficiently need to look over their operational procedure by taking experience from those who are performing efficiently.

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