Efficiency Estimation of Private Commercial Banks in Bangladesh: Application of DEA Approach Using Panel Data

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Abstract

Efficiency is one the major concerns in any business setting irrespective of the nature or type of industry which it belongs. So, any company wants to achieve greater outputs with lower inputs, or to use the available inputs to the maximum. In this paper, the use of Data Envelopment Analysis (DEA) technique is illustrated in measuring the operational efficiency of the banking sector in Bangladesh, which currently has 58 scheduled banks. Out of these, 38 private commercial banks are taken into this analysis, where state-owned banks and foreign commercial banks have not been considered. Five-year panel data (2013 to 2017), collected from the secondary sources, have been used to model the efficiency of different banks. DEA has provided several efficiency measures such as technical, allocative, cost, technical and scale efficiency that explain efficiency differentials of different banks in Bangladesh. The DEA results show that Islamic banks are slightly more efficient than conventional banks. While, among the conventional banks, public conventional banks are the least efficient. The returns to scale estimation show that both conventional and Islamic banks in Bangladesh have still scope of improvement in scale efficiency. Second stage regression results also indicate that Return on Asset (ROA) have significant contribution on efficiency level of the private commercial banks. It is also revealed that first-generation banks are efficient over second, third and fourth generation banks; while second generation banks are better than third and fourth generation banks.

Keywords: Data Envelopment Analysis, Conventional Banking, Islamic Banking, Allocative, Technical, Cost, Scale, Efficiency.

JEL Classification: G21; N25.

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1. Introduction

One of the major issues, raised in any economy especially in developing nations, is how to enhance their technical efficiency. This has led to the adoption of various economic systems and policy options throughout the history. The Bangladeshi economy in general and the banking sector is no way an exception to this phenomenon. This is more so when banks, like most other production entities are profit oriented. The efficient performance of banks can help them to compete and achieve higher rate of return relative to cost, and at the same time to participate in economic development. Inefficient performance of banks, on the other hand, will hinder economic activities in other sectors such as industry and services as banks are linked directly to the entire economy. Therefore, bank efficiency analysis is one of the vital tools for government, regulators, bank management, stock market, and investors.

Several models and approaches have been used to estimate banks' efficiency. One of them is Data Envelopment Analysis (herein after DEA) which has been used extensively to evaluate the efficiency of banking institutions, hospitals and other institutions. We execute our tests using 190 firm-year observations from 38 private commercial banks in Bangladesh for the years 2013 to 2017 by using the DEA technique. The study provides a deep understanding of the importance of maintaining the efficiency of the banking sector for sustained economic development. The paper also examines the stability of bank efficiencies over time for the studied period. The study contributes to the extant empirical literature on banking efficiency in developing countries, particularly in Bangladesh.

It will provide crucial information about Bangladeshi banks' financial conditions and management performance for the benefit to a number of interest groups and policymakers including the Bangladesh government, stock exchanges, banks managers, as well as people dealing with banks and bank stock investors. Moreover, the results of this study would provide explicit indications as to whether the Bangladeshi banks are efficient in the global financial conditions. Despite the vast number of studies that focus on the efficiency of the banking sector, to the researcher's best knowledge, only a few studies were carried out in developing countries. The majority were carried out in developed countries, with emphasis on the banking sector in the United States.

Despite the importance, there are very limited studies comparing the efficiency of Islamic and conventional banks within a country using parametric and nonparametric approach, especially in Bangladesh. Therefore, there should be a study that measures technical, allocative, cost, scale and profit efficiency of Islamic and conventional banks using modern approach in Bangladesh to provide comparison and to improve the robustness of

previous measurements. These measures could also be used as a guide for the concerned banks to recover their weakness, compete head to head with other Islamic and conventional banks, and to achieve the intended goals improving the market share.

The remainder of this study is organized as follows: section 1.1 presents the relevant literature, and section 2 is devoted to the data methodology and variable selection. Section 3 exhibits empirical results and analysis of the findings. Finally, Section 4 concludes the study with some recommendations.

1.1 Literature Review

The DEA is a non-parametric linear programming technique that measures the efficiency of decision-making units (DMUs) which use multiple inputs to produce multiple outputs and has been applied by various research communities across a wide range of industries. Concept of DEA starts by stating that Charnes (1978) in which he introduced "functional programming" in which ratios were playing very important role. That extended the single output-to-single input ratio measure of efficiency to multiple inputs and outputs without requiring recourse to a priori prescribed weights.

A good number of studies based on DEA have been found on efficiency estimation of commercial banks in different countries of across the world. For example, Zeitun & Benjelloun (2013) measured the relative efficiency of 12 Jordanian banks over the period 2005-2010 by using DEA. Constant Return to Scale (CRS) and Variable Return to Scale (VRS) were used in order to measure the relative efficiency. The result of the study showed that, on the technical efficiency scale only a few Jordanian banks were efficient in managing their financial resources and generating profit. Furthermore, few banks were found to be efficient on the scale of pure technical efficiency and only so in a few years. Most of Saudi banks had efficient financial resources by 86.17 percent and 93.97 per cent as per Charnes–Cooper–Rhodes (CCR) and Banker–Charnes–Cooper (BCR) approach respectively (Al Khathlan & Malik, 2010). Although most Syrian banks were inefficient on their operating level, they tend to be more efficient in their intermediation role (Khaddaj, 2010). Gordo (2013) estimated the 'best performing frontier' to compute for the relative efficiencies of different bank groups in the Philippines over the period 1999-2009 and found that Philippine banks have undergone technological progress, but this did not necessarily increase total factor productivity because of the decline in technical

efficiencies (TEs). Karimzadeh (2012) examined the efficiency of Indian commercial banks during 2000 – 2010 based on intermediation approach and it was revealed that Bank of India and ICICI bank are more efficient as compare to other banks in India and result confirmed that selected Public Sector Banks are more efficient than Private sectors during the study period in India. Using the DEA, Sufian and Kamarudin (2014) study the level of profit efficiency of banks in Bangladesh and found that this sector exhibits a decrease in efficiency in 2009 relative to 2004. Hence, the study suggested that the banks in Bangladesh need to improve their efficiency in order to maximize profit and shareholders' wealth. A number of later studies found the same scenario. For instance, profit efficiency of both the state-owned and the private commercial banks continue to show a decreasing trend for the post financial crisis years (e.g., Kamarudin et al. (2016)) although financial reform policies contributed in reducing banks' cost (Robin et al., 2018). Few previous studies of the efficiency of Bangladeshi Banks have been narrow in their focus. Rahman (2008) estimated branch-wise efficiency of Islami Bank Bangladesh Limited using different approaches including DEA, which was first attempt in the context of Bangladesh. Dilruba & Khandoker (2005) estimated relative economic and price efficiency of different banks in Bangladesh. This investigation estimates both technical and allocative efficiencies using different approaches for each firm in the sample, using different approaches, which covers a completely new study area to any previous study.

There are several efficiency estimation studies with special focus on the Islamic banking sub-sector across the world. For instance, Noor & Ahmad (2012) investigated the efficiency of the Islamic banking sector in 25 countries during the period 1992-2009 using data for 78 Islamic banks. The empirical findings suggest that the world Islamic banks have exhibited high pure technical efficiency. Pure technical inefficiency was found to have greater influence in determining the total technical inefficiency. Secondly, it is suggested that further analysis of the world Islamic banking sector's efficiency should consider specific factors relating to high-income countries' leading the efficiency over the years compared to banks operating in middle and low-income countries. The results showed a positive relationship between bank efficiency and size and profitability, while a negative relationship between bank efficiency and loans intensity and capitalization. A multivariate analysis based on the Tobit model reinforces these findings specifically for profitability. The return on equity had a positive but statistically insignificant relationship with bank efficiency. The finding implied that the higher the return on equity, the higher the bank productivity growth will be. Noor et al, (2011)

investigated the efficiency of the Islamic banking sectors in 4 Asian countries namely Bangladesh, Indonesia, Malaysia and Pakistan during the period of 2001-2006. The results indicated that during the period of study, although the Asian Islamic banking sectors have been operating at a relatively optimal scale of operations, they were relatively managerially inefficiency in controlling their operating costs and utilizing their resources to the fullest. Zainal & Ismail (2012) in their study examined the efficiency of Islamic banks in Malaysia in the year 2006 till 2010. The aims of the study were to calculate technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) of Islamic banks, and to compare the efficiency scores between local and foreign Islamic banks. The DEA was used to estimate the efficiency using input orientation. Inputs and outputs of this study were analyzed based on intermediation approach. The results showed that the average TE, PTE and SE were 0.79, 0.90 and 0.88 respectively. Next, local Islamic banks scored higher TE and SE compared to foreign Islamic banks. But foreign Islamic banks scored higher PTE than that of Islamic banks. Akhtar & Sadaqat (2011) investigated the impact of how the bank-specific factors of profitability affect the performance of Islamic banks of Pakistan from period 2006 to 2009. It was evident from both statistical multivariate regression models that the relationship of gearing ratio and capital adequacy ratio found to have a positive relation and are statistically significant at the 5 per cent significance level, whereas the asset management is statistically significant in model I and insignificant in model II with positive relation in both models. Size of the bank reported negative and insignificant relation in both models, which can be explained with the fact that most of the Islamic banks were facing losses in recent years. Moreover, capital adequacy found to have significant relation in both models, as prudential regulations tighten by the State bank of Pakistan.

A number of studies compared efficiency of the Islamic and conventional banks in Bangladesh, but they fail to reach in a consensus on whether the former are more efficient than the latter (or vice-versa). For instance, Nabi et al. (2019) found that the Islamic commercial banks outperform the conventional banks in technical and pure technical efficiencies though fall short in scale efficiency. Similarly, Islam and Kassim (2015) found that the Islamic banks trump over conventional banks in pure technical efficiency but they are less efficient in technical and scale efficiencies. Islam & Kassim (2015) compared the efficiency between Islamic and conventional banks in Bangladesh using the Data Envelopment Analysis covering the period from 2009 to 2013.The study finds that the Islamic banks have been pure technically efficient, but their scale efficiency is not

satisfactory, suggesting that scale inefficiency is the main source of inefficiency of the Islamic banks. In contrast, the conventional banks are found to be pure technically inefficient, but their scale efficiency is satisfactory. Islamic banks have been found to completely outperform the conventional banks in other studies (e.g., Asmild et al., 2018; Mamun et al., 2018; Rasel et al., 2018). Islamic banks have also been found as less efficient and less financially stable in other studies (e.g., Hassan, 2006; Islam et al., 2019). Mohamad et. al. (2008) examined the cost and profit efficiency of conventional versus Islamic banks using the Stochastic Frontier Approach and found that there are no significant differences between the overall efficiency results of the conventional and Islamic banks. Public conventional banks were the most efficient banks followed by private conventional and private Islamic banks with an average bias of 10 per cent (Qayyum, 2012). Moreover, the results suggest that conventional banks were more efficient compared to Islamic banks. Viverita et. al. (2007) and Kamaruddin et. al. (2008) assessed the cost and profit efficiencies of Malaysian Islamic banks and conventional banks for the period 1998 to 2004. The results suggest that an Islamic banks wasted around 30.5 per cent of its inputs relative to the best-practice bank. The results also show that there existed about 30-37 percent inefficiencies in the operations of Islamic banks over the period of study. In contrast, in a study on banks from 21 countries including Bangladesh, Bader et al. (2008) found no significant difference in overall efficiency between the Islamic and conventional banks.

However, the above studies focusing on the relative efficiency of Bangladeshi banks are very limited, and there is scarcity of research in the Bangladesh. Therefore, this study will try to fill some of this gap in the literature. In addition, it will examine the impact of bank's size, capital adequacy and length of operation on the Bangladeshi banks' efficiency.

2. Methodology and Data

2.1 Data Envelopment Analysis (DEA)

DEA, measures efficiency by solving separate Linear Programming (LP) problem for each firm. Assuming that there are N firms which produce a single output using m different inputs and the ith firm unit produces yi units of output applying xki units of kth inputs, the variable returns to scale.

DEA model for Technical Efficiency of the branch:

$$\underset{\varphi_i \omega_i}{Max} \varphi_i \qquad (1)$$

$$\varphi_i y_i + \sum_j^n \omega_j y_j - so = 0$$

Subject to:

$$-x_{ki} + \sum_{j=1}^{n} \omega_j x_{kj} + s_{I,k} = 0$$

$$\left(k = 1,2,3,.....,m \ inputs\right)$$

$$\sum_{j=1}^{n} \omega_j = 1 \ \left(j = 1,2,3,.....,n \ \ farm\,unit\right)$$

$$\omega_j \geq 0; \ \ so \geq 0; \ s_{I,k} \geq 0$$

Where φ_i is the proportional increase in outputs that could be obtained by the ith firm unit given input vector x_i; so and $s_{I,k}$ are the output slack and the kth input slack; and ω_i is the weight of the jth firm unit, n and m are the number of firm units and inputs, respectively?

If constraint is removed a constant return to scale (CRS) output-oriented DEA results would be estimated. Then input saving efficiency measure and output increasing efficiency measure coincide and both coincide with scale efficiency in case of VRS. The frontier level of production for firm i, denoted by:

$$y^*_i = \sum_{j=1}^{n} \omega_j y_i = \varphi_i y_i$$

The output-oriented DEA frontier maximizes the proportional increase in the output vector while remaining within the envelopment space or efficient frontier. The proportional increase in output is obtained when output slack, s_o, equals zero. The ith firm unit is efficient and lies on the frontier if $\varphi_i = 1$, $\omega_i = 1$ and $\omega_i = 0$ for $i \neq j$ and

the firm unit is inefficient and lies outside the frontier if $\varphi_i \rangle 1$, $\omega_i = 0$ and $\omega_i \neq 0$ for $j \neq i$. The output oriented technical efficiency measure of each firm, τ_i^{DEA}, can be estimated by:

$$\tau_i^{DEA} = \frac{y_i}{y^*_i} = \frac{y_i}{\varphi_i y_i} = \frac{1}{\varphi_i}$$

The estimate of technical efficiency of each firm unit in the output-oriented VRS DEA $\left(\tau_i^{VRS}\right)$ will be higher than or equal to that in the output oriented CRS DEA $\left(\tau_i^{CRS}\right)$ as the VRS DEA is more flexible than the CRS DEA.

2.2 Allocative Efficiency and Cost Efficiency

If one has price information and is willing to consider a behavioral objective, such as cost minimization, then one can measure allocative efficiencies. The allocative efficiencies are estimated minimizing following DEA problem:

$$Min_{\lambda, X_i}, w_i^{'} x_i^{+}, \qquad (2)$$

Subject to:

$$-y_i + Y\lambda \geq 0,$$

$$x_i - X\lambda \geq 0,$$

$$N1^{'}\lambda = 1,$$

$$\lambda \geq 0,$$

where w_i is a vector of input prices for the ith DMU and x_i (which is calculated by the model) is the cost-minimizing vector of input quantities for the ith DMU, given the input prices w_i and the output levels y_i. The total cost efficiency (CE) of the ith firm is calculated as:

$$CE = w_i^{'} x_i^{+} / w_i^{'} x_i^{'}. \qquad (3)$$

That is, CE is the ratio of minimum cost and observed cost for the ith firm. One can then calculate allocative efficiency (AE) using $AE = CE / TE.$

2.3 Scale Efficiency

Many studies have decomposed the TE scores obtained from a CRS DEA into two components, one due to scale inefficiency and one due to pure technical inefficiency. This may be done by conducting both a CRS and a VRS DEA upon the same data. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency, and that the scale inefficiency can be calculated from the difference between the VRS TE score and the CRS TE score. The DEA models discussed so far have been variable returns to scale (VRS) DEA models. That is, they permit the constructed production frontier to have (local) increasing, constant or decreasing returns to scale properties. One can easily impose constant returns to scale (CRS) upon the DEA problem in problem (1) by deleting the convexity constraint $N1'\lambda = 1$. This allows calculation of the scale efficiency measure discussed below.

$$TE_{CRS} = AP_c / AP \tag{4}$$

$$TE_{VRS} = AP_v / AP \tag{5}$$

$$SE_{CRS} = AP_c / AP_V \tag{6}$$

where all of these measures are bounded by zero and one. Given this, it is clear that we can easily calculate scale efficiency (SE) as:

$$SE = TE_{CRS} / TE_{VRS} \tag{7}$$

That is, CRS technical efficiency measure is decomposed into pure technical efficiency and scale efficiency. One shortcoming of this measure of scale efficiency is that the value does not indicate whether the firm is operating in an area of increasing or decreasing returns to scale. This may be determined by running an additional DEA problem with non-increasing returns to scale (NIRS) imposed. This can be done by altering the DEA model in problem (1) by substituting the $N1'\lambda \leq 1$.

2.4 The Malmquist Productivity Index

In the presence of panel data, we can use DEA to calculate Malmquist index to measure productivity change and it can be decomposed in technological change and efficiency change. Caves et al. (1982) developed a productivity index and used the concept of distance functions in Malmquist's proportional scaling definition, without realizing the direct connection with Farrell efficiency measure.

Malmquist productivity change (Fare et al., 1985)

$$M_0^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right]^{1/2} \tag{8}$$

This productivity index is the geometric mean of a pair of ratios of output distance function. The first ratio compares the performance of the data from period t to t+1 relative to production possibilities existing in period t, and the second compares the performance of the same data relative to production possibilities in period t+1.

The forgoing productivity index may be interpreted as an index of total factor productivity. It takes into account if firms are using the resources efficiency to produce goods and services, and if they are using the existing technology to produce goods and services. Values greater than one means increases in productivity, while values less than one indicate decreases in productivity over time.

Farrell et al. (1992) decomposed this index into sub-indexes measuring changes in efficiency and changes technology:

$$M_0^{t+1}\left(x^{t+1}, y^{t+1}, y^t\right) = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t}\left(x^t y^t\right)}\left[\frac{D_0^{t}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}\frac{D_0^{t+1}\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2} \quad (9)$$

The first term of the equation is the change in technical efficiency; and the second term is the change in technology. Values greater than one means increases in output technical efficiency, values less than one mean decrease and a value of one indicates no change. The second term is the technological change.

Farrell at al. (1994) further decomposed the Malmquist index by rewriting equation (2) as:

$$M_0^{t+1}\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \underbrace{\frac{\Delta_0^{t+1}\left(x^{t+1}, y^{t+1}\right) / D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{\Delta_0^{t}\left(x^t, y^t\right) / D_0^{t}\left(x^t, y^t\right)}}_{\Delta ScaleEfficiency}$$

$$\underbrace{\left[\frac{D_0^{t}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)} * \frac{D_0^{t}\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2}}_{\Delta PureTechnicalefficiency}$$

$$\underbrace{\left[\frac{\Delta_0^{t+1}\left(x^{t+1}, y^{t+1}\right) / D_0^{t}\left(x^{t+1} y^{t+1}\right)}{\Delta_0^{t+1}\left(x^{t+1}, y^{t+1}\right) / D_0^{t+1}\left(x^{t+1} y^{t+1}\right)} * \frac{\Delta_0^{t}\left(x^t, y^t\right) / D_0^{t}\left(x^t, y^t\right)}{\Delta_0^{t+1}\left(x^t, y^t\right) / D_0^{t+1}\left(x^t, y^t\right)}\right]^{1/2}}_{\Delta Techno\log y}$$

Where Pure Technical Efficiency * Scale Efficiency = Efficiency

Fare et al. refers the first term as a measure of change in scale efficiency and the second term as a measure of pure efficiency change. The last term is unchanged, and it gives a measure of change in technology.

Any change in scale efficiency may be caused either by i) change in the shape of the technology, ii) change in the location of the bank in the input/output space between t1 and t2, or a combination of i) and ii). Additionally, any change in the pure technical efficiency is caused by a movement of the bank relative to the existing technology. For each distance function is necessary to solve a DEA-VRS.

2.5 Determinants of Efficiency

In this study, to identify sources of inefficiency, sample banks' Return on Assets (ROA), Ratio of non-funded expense and non-funded income (NFE/NFI), generation of the banks based on year of establishment, Public or Private, Foreign or Domestic, Conventional or Islamic factors were regressed with the measured technical, Allocative and cost, scale and profit efficiency index. Second stage regression method was used to estimate the effects of those factors to the banks' efficiency.

Second stage regression

$$Y = f(X)$$

Dependent Variable:

i. Technical,
ii. Allocative,
iii. Cost, and
iv. Scale

Independent Variables:

i. Return on Assets (ROA),
ii. Ratio of non-funded expense & non-funded income (NFE/NFI),
iii. Generation of the Banks based on year of establishment,
iv. Conventional or Islamic

2.6 Sample Selection

The data needed for this empirical analysis have been taken from financial statements of conventional and Islamic banks in Bangladesh for the period 2013–2017. Out of 40 in total, 38 domestic private commercial banks are taken into this analysis. The Farmers Bank was excluded due to unavailability of data for the year 2017 and Shimanto Bank has also been excluded as it is in operation for less than five years. Public banks were dropped as objectives of the public banks are somehow different than those of private commercial banks. That is mainly profit is the objective of commercial banks while,

public banks in addition to profit earnings provide services for the people of the country on behalf of the government. Besides, recent years performances of all the public banks are poor so, considering them these efficiency analyses can influence the overall analysis and also can mislead the countries' banking efficiency performance.

Foreign banks were also dropped from the analysis as their operation in the country can be considered as a branch of international banks having main bank abroad also having branches across the world. The size, expertise and experience of these banks are much better than any domestic bank. Therefore, taking them into analysis can also hamper and mislead the performance of the domestic banks.

All 38 banks have been categorized into four: first generation (1980s), second generation (1990s), third generation (2000s) and fourth generation (2010s). Moreover, based on nature, all banks have been put into three types i.e., Islamic, conventional, and mixed (with partial Islamic banking operation through dedicated branch and window (Table 1). The complete list of the studied banks is given in the Appendix.

Table 1: Data of Studied Conventional and Islamic Banks

Generation of Bank	Type of Bank			
	Islamic	Conventional	Mixed	Total
First	2	4	3	9
Second	4	7	7	18
Third	1	1	1	3
Fourth	1	7	0	8
Total	8	19	11	38

Approach and Variables Defined

This study applied intermediation approach or asset approach developed by Sealey and Lindley (1977). Previous banking efficiency studies for Islamic and conventional banks that adopted this approach includes that of Kamaruddin et al. (2008), Bader et al. (2008), Abdul Majid et al. (2009), and Mohamed and Said (2013). The approach is also adopted due to lack of data required for implementing the production approach (Brissimis et al., 2008). In fact, the intermediation approach may be superior for assessing the profitability of financial institutions because it minimizes of total costs and not just the production costs which are an important precondition to maximize profits (Iqbal and Molyneux, 2005).

Accordingly, we assume two outputs of the private commercial banks like loan/investment (y_1) and other investment (y_2) with three inputs such as deposit (x_1), manpower (x_2), and fixed asset (x_3). The aggregate series of inputs and outputs of the banks included in this study can be read in Table 2 and Table 3.

Table-2: Mean Input and Output Variables Statistics (In Million Taka.)

Particular	2013	2014	2015	2016	2017
Manpower	2,305	2,483	2,552	2,657	2,825
Loan/Credit	86,010	100,951	117,678	138,845	167,325
Investment	27,270	31,323	33,768	34,680	34,940
Deposit	109,352	128,009	145,700	168,033	196,139
Fixed Asset	2,981	3,284	3,437	3,517	3,475
Funded Expenses	8,901	8,816	8,852	8,305	8,969
Non-Funded Expenses	3,093	3,552	3,961	4,560	5,082
Salary	1,605	1,873	2,089	2,438	2,736
Other Operating Expenses	1,488	1,679	1,873	2,122	2,346
Funded Income	11,952	12,433	12,700	12,989	14,313
Non-Funded Income	3,451	3,899	4,290	4,445	4,785

Table-3: Mean Input and Output Variables Statistics (In %)

Indicator	**2013**	**2014**	**2015**	**2016**	**2017**
Funded Expenses/Deposit	7.21	6.82	6.31	5.14	4.73
Salary/Manpower	666,758	778,502	850,552	923,500	974,713
Other Operating Expenses/Fixed Asset	76.98	84.24	91.26	101.55	112.61
Funded Expenditure/Funded Income	67.47	71.49	71.98	65.83	64.62
Non-Funded Expenses/Non-Investment Income	1,813.03	167.34	140.77	143.65	137.53
Return on Asset (ROA)	0.76	0.83	1.10	1.08	0.87

2.7 Determinants of Correlation and Regression Analysis

Bank level technical, allocative, cost, scale and profit efficiencies are ranked in descending order and a rank correlation matrix is produced. Spearman rank correlation coefficients have been estimated to examine the possible relationship among different efficiency measures.

In order to determine which factors can affect the efficiency scores, which examine some aspects of banks' structure is related to efficiency estimates. For this purpose, efficiency scores are regressed on a set of common explanatory variables like, ROA, NFE/NFI, bank type (Islamic, conventional, Mixed), and bank generation (First, Second, Third, Fourth).

In this study, to identify sources of inefficiency, sample banks' Return on Assets (ROA), Ratio of non-funded expense and non-funded income (NFE/NFI), generation of the banks based on year of establishment, conventional or Islamic factors were regressed with the measured technical, Allocative and cost, and scale efficiency index. Second stage regression method was used to estimate the effects of those factors to the banks' efficiency.

3 Results and Discussion

The efficiency of conventional and Islamic banks in Bangladesh is measured by applying non-parametric DEA methods. To make a comparable measurement, conventional and Islamic banks are pooled together annually to form a common frontier. All banks for each year (2013 – 2017) are pooled to measure efficiency.

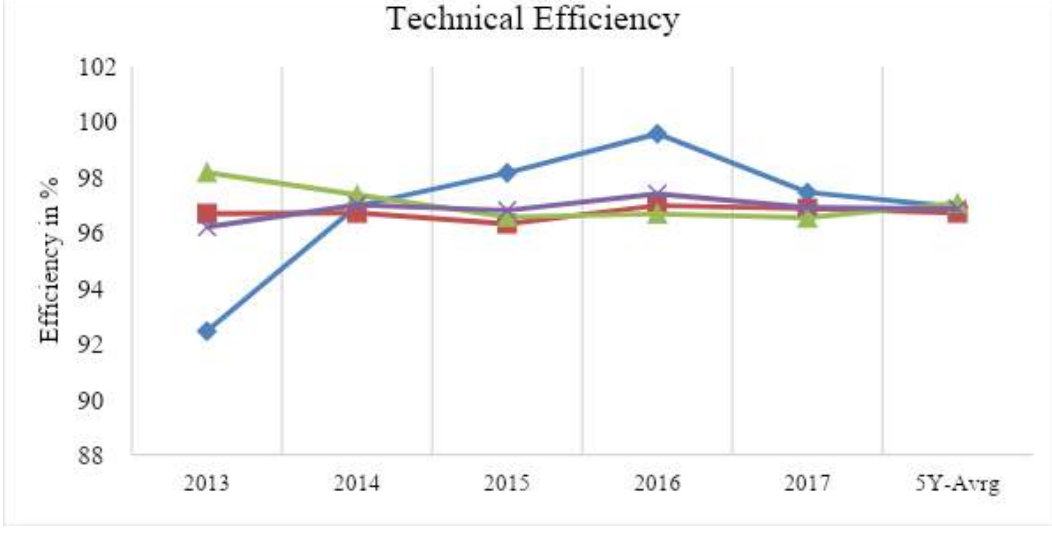
3.1 Efficiency Estimation using Different Models

Efficiency estimated different models are presented in the following sub-sections.

3.1.1 DEA Technical Efficiency

The mean technical efficiency, estimated using DEA approach, in Figure 3 shows that during the study period (2013-2017), the mixed banks turn out to be the most efficient (97.1) while Islamic (96.9) and conventional (96.7).

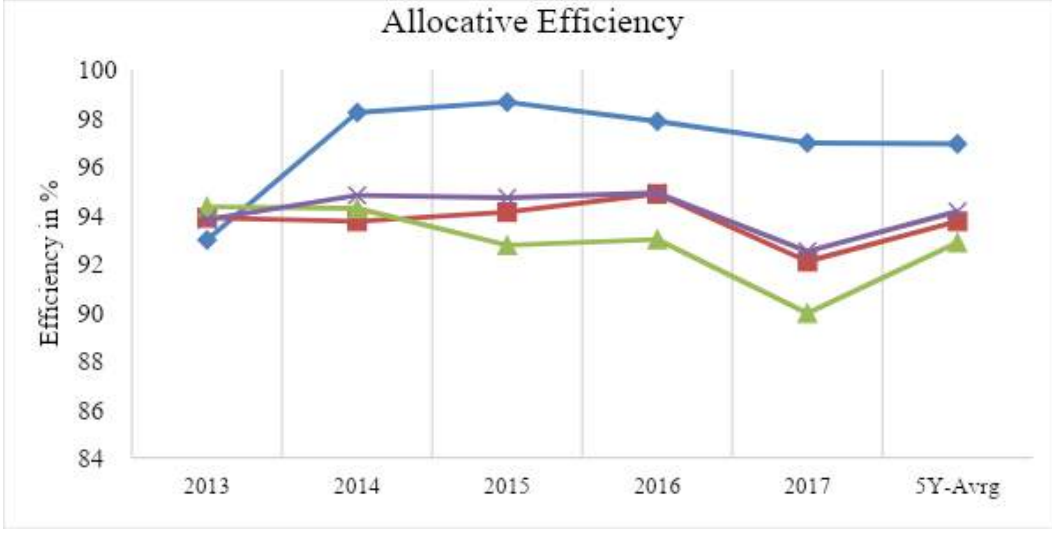
Figure 3: Technical Efficiency of Commercial Banks in Bangladesh (2013-17)



3.1.2 DEA Allocative Efficiency

The allocative efficiency estimation shows (Figure 4) that during the study period (2013-2017) on average Islamic banks have become more allocative efficient (96.9), followed by conventional banks (93.7), mixed banks (92.9) and all PCBs (94.1).

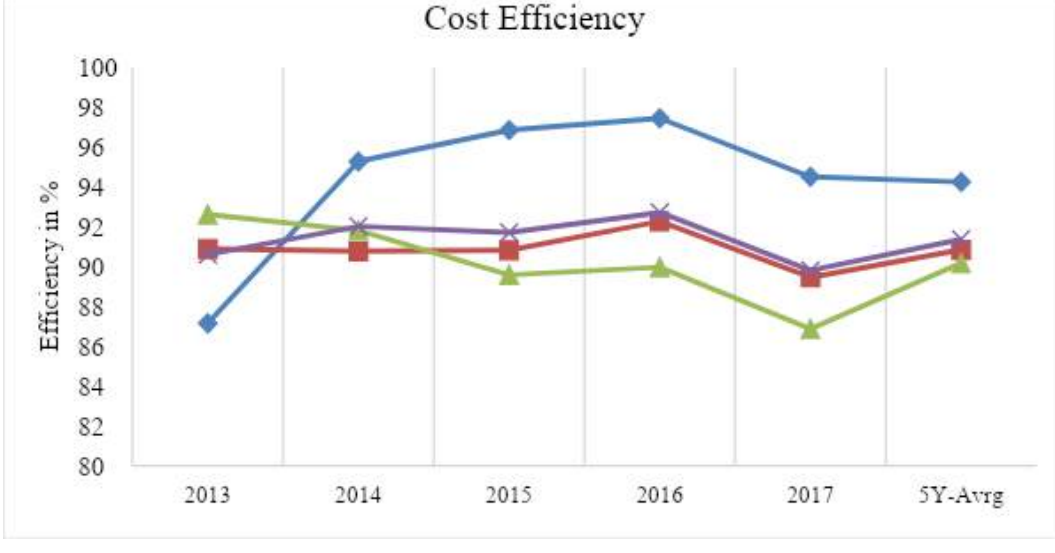
Figure 4: Allocative Efficiency of Commercial Banks in Bangladesh (2013-17)



3.1.3 DEA Cost Efficiency

The mean cost efficiency results show (Figure 5) that Islamic banks have been comparatively the most cost efficient private commercial banks (94.2) followed by conventional private commercial banks (90.8), mixed banks being the least cost efficient (90.2) and all PCBs (91.4).

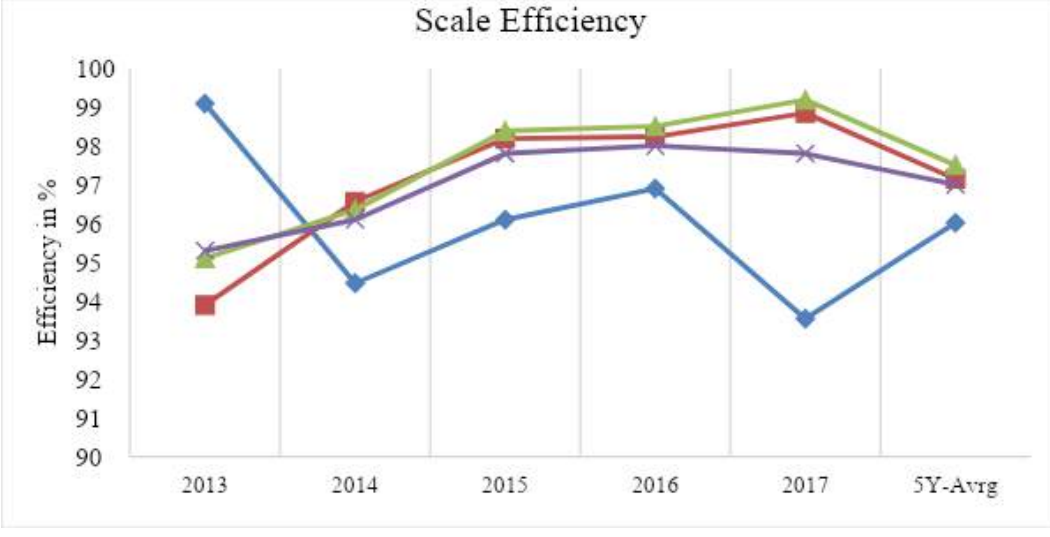
Figure 5: Cost Efficiency of Commercial Banks in Bangladesh (2013-17)



3.1.4 DEA Scale Efficiency

Group-wise mean scale efficiency results show (Figure 6) that mixed banks have become the most scale efficient (97.5) which was followed by conventional banks (97.1) and Islamic banks (96.0). The scale efficiency of all PCBs is (97.0).

Figure 6: Scale Efficiency of Commercial Banks in Bangladesh (2013-17)

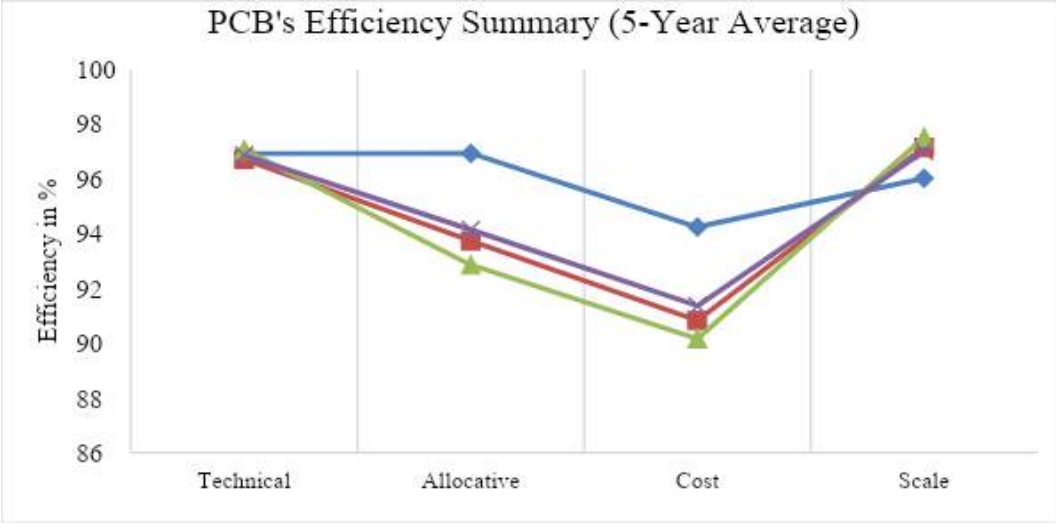


3.1.5 Summary of DEA Efficiency of Different Banks

The study shows that all Bangladeshi banks are relative less cost efficient. Islamic banks are comparatively better cost and allocative efficient than conventional counterpart. The average technical and scale efficiency of all banks is almost similar, while likewise technical efficiency scale efficiency of the all banks are almost similar. This means that the dominant source of inefficiency all banks are due to allocative inefficiency and cost inefficiency rather than technical inefficiency. Similar results are observed for conventional banks as well.

Figure 7: Summary of Efficiency of Private Commercial Banks in Bangladesh (2013-17)

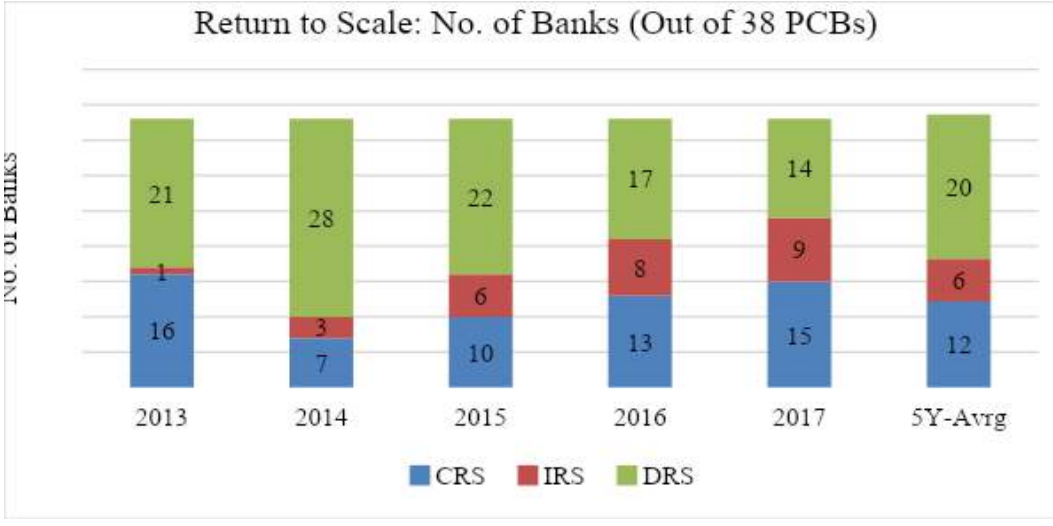
3.2 Return to Scale of Private Commercial Banks in Bangladesh



The scale efficiency of banks can be viewed from the trend of the return to scale (RTS) measured by DEA. Scale efficient banks exhibit constant return to scale (CRS). Banks experiencing economies of scale exhibit increasing return to scale (IRS), which means that the bank operates at a wrong scale of operation. Banks experiencing diseconomies of scale exhibit decreasing return to scale (DRS).

Figure 8 shows that most of the PCBs (on average 20) in Bangladesh are operating at diseconomies of scale (DRS), 12 banks on CRS and 6 banks on IRS during the study period. However, more and more banks are heading toward CRS and IRS.

Figure 8: Return to Scale of Commercial Banks in Bangladesh (2013-17)



Five out of 8 Islamic Banks are running at DRS, 2 at CRS and one 1 at IRS. Out of 19 conventional banks 10 banks are operating at DRS, 6 at CRS and 3 at IRS. On the other hand, 5 at DRS, 4 at CRS and 1 at IRS among 11 mixed banks (Table 4).

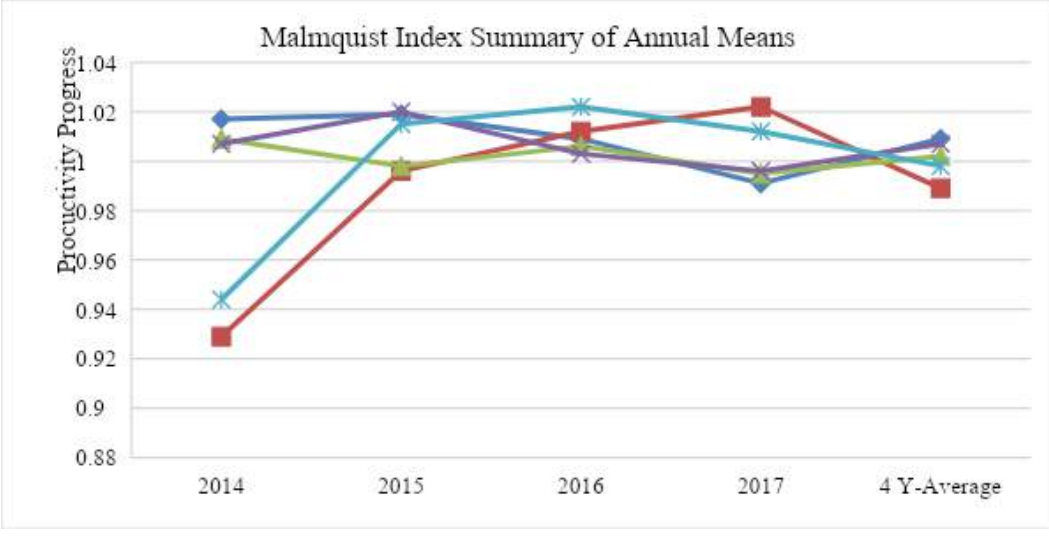
Table 4: Return to Scale: Commercial Banks of Bangladesh

Return to Scale (No. of banks)																		
Scale	Islamic Banks (8)						Conventional Banks (19)						Mixed Banks (11)					
	'13	'14	'15	'16	'17	5Y-Avrg	'13	'14	'15	'16	'17	5Y-Avrg	'13	'14	'15	'16	'17	5Y-Avrg
CRS	5	1	0	2	1	2	6	3	5	8	7	6	5	3	5	3	7	4
IRS	1	1	3	2	1	1	0	2	3	4	6	3	0	0	0	2	2	1
DRS	2	6	5	4	6	5	13	14	11	7	6	10	6	8	6	6	2	5

3.3 Productivity Progress

The chart below reports results from measuring productivity progress of different banks (Figure 9 and Figure 10). The results indicate that the studied banks have experienced only 2.2 per cent productivity growth over the sample period. It is worth mentioning that productivity changes reflect the product of changes in technical and technological efficiency. According to the study findings, banks in Bangladesh have been able to achieve such productivity improvement from becoming more technologically advanced than from being more technically efficient.

Figure 9: Malmquist Index Summary of Annual Means (Output Oriented Malmquist DEA)



Tfpch = change in total factor productivity (Malmquist index of productivity); effch = Change in technical efficiency; techch = Change in Technology; pech = Change in Pure technical efficiency; sech = Change in Scale Efficiency

3.4 Spearman rank order correlation coefficients

Cardinal comparisons are probably not possible given the different assumptions of various methodologies. Therefore, Bank level technical, allocative, cost, scale and profit efficiencies are ranked in descending order and a rank correlation matrix is produced. Spearman rank correlation coefficients were estimated to examine the possible relationship among different efficiency measures is reported in Table 5. The null hypothesis is that correlation coefficient between two variables is zero. As the results indicate, the Spearman correlation coefficients are all significantly different to zero, indicating that there is a strong association amongst efficiencies. Most of the rank correlations are positive and significant. Results on a bivariate basis turn out to be high enough to conclude that the ranking of banks across different frontier approaches remains largely unchanged.

Table 5: Spearman rank order (s) correlation coefficients among efficiency estimates and proxy-measured of performance

Efficiency	Technical	Allocative	Cost	Scale
Technical	1.000	.543**	.767**	.157*
Allocative	.543**	1.000	.938**	.142
Cost	.767**	.938**	1.000	.154*
Scale	.157*	.142	.154*	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

3.5 Second-Stage Regression

Table 6 reports the results of the regression estimation. It is important to note that dependent variables are the DEA efficiency scores. The results suggest that the positive sign of the ROA and NFE/NFI coefficients signals that higher efficiency is correlated with higher profitability. Second stage regression results also indicate that ROA, FE/FI and NFE/NFI have significant positive relation on the efficiency of the banks. Results also show that first generation banks are generally slightly better than all other three generation banks, though second-generation banks are also doing well. Islamic banks overall efficiency levels are comparatively better than conventional banks though not significant.

Table 6: Second-Stage Regression Results

Reference	Variable	TE	AE	CE	SE
	R Square	0.505	0.659	0.624	0.622
	Constant	.912 (.000)	.762 (.000)	.705 (.000)	.976 (.000)
	Funded Expenditure/Funded Income	.173 (.032)	.604 (.000)	.486 (.000)	-.052 (.475)
	Non-Funded Expenditure/Non-Funded Income	.196 (.008)	.180 (.005)	.211 (.002)	-.016 (.806)
	Return on Assets	.626 (.000)	.591 (000)	.639 (.000)	.122 (.173)
First Generation	Second Generation	-.211 (.016)	-.258 (.001)	-.274 (.001)	.319 (.000)

	Third Generation	-.128 (.085)	-.100 (.122)	-.139 (.038)	.063 (.348)
	Fourth Generation	-.021 (.818)	-.007 (.929)	-.007 (.935)	.235 (.006)
Islamic	Conventional	-.157 (.177)	-.057 (.575)	-136 (.196)	.040 (.707)
	Mixed	-.005 (.964)	-.117 (.225)	-.120 (.233)	.130 (.198)

Note: TE: Technical Efficiency, AE: Allocative Efficiency CE: Cost Efficiency, SE: Scale Efficiency, ROA is return on assets (Net income/Total assets) and NFE/NFI is the ratio of non-funded expenditure and non-funded income.

*** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.10 level

4 Conclusion

The paper investigates the relative efficiency of the Private Commercial Banks (PCBs) under subgroups of Islamic, conventional, and mixed in Bangladesh employing a panel data during 2013 to 2017. Out of the 58 banks of the country only 38 banks are taken into analysis, dropping the public and foreign banks working in the country. Non-parametric DEA technique is used to examine efficiency of these banks. The study shows that overall cost efficiency (CE) estimates of all PCBs are relatively less cost efficient. Islamic banks are also relatively less efficient in containing cost, though comparatively better cost efficient than conventional counterpart. Islamic banks are relatively efficient in allocating resources. The average technical and scale efficiency of all these banks is almost similar. This means that the dominant source of inefficiency all banks are due to allocative inefficiency and cost inefficiency rather than technical inefficiency. Similar results are observed for conventional banks as well.

Overall, using non-parametric DEA method, Islamic private banks are slightly more efficient than conventional banks in two measures (allocative and cost efficiencies) during the period of study, while technical and scale efficiencies are very similar for all banks. This can be attributed, among others, to efficient financing activities.

Productivity progress analysis indicates that there has been moderate increase in productivity growth over the years. Productivity increase in banking industry is mainly driven by technological change (opening and penetrating in other markets) not technical efficiency change, i.e., efforts of inefficient banks to catch up with the efficient ones).

Second stage regression results indicate that Return on Assets (ROA) of the banks have significant contribution on banks efficiencies. Though not significant but Islamic banks

are still have been performing better than their conventional counterparts. Islamic and Conventional banks show a convergence in the characteristics of inputs and outputs, where income has become the most efficient element, while labor or human resource should be given top priority for improvements. Income from banking services have come from sophisticated diverse banking services provided by conventional and Islamic banks, such as e-banking, internet-banking, online banking, phone-banking, sms-banking, and so on. Conversely, labour has always been inefficient part of conventional and Islamic banks. This could be attributed to the nature of service industry where the most important capital is skilled and experienced human capital. Moreover, in Islamic banking, the supply of human resource is always lagging the demand of this still fast-growing industry.

The findings of this study are expected to contribute to the existing knowledge on the operating performance of the commercial banking industry in Bangladesh. The study has also provided further insight to bank specific management as well as the policymakers about attaining optimal utilization of capacities, improvement in managerial expertise, efficient allocation of scarce resources and most productive scale of operation of the PCBs. This may also facilitate directions for sustainable competitiveness of future banking operations in Bangladesh.

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Appendices

Appendix A: Scale Efficiency of PCBs

Bank	Type	Generation	2013	2014	2015	2016	2017	5Y-Avrg	Rank
Al-Arafah Islami Bank Ltd	Islamic	Second	0.995	0.996	0.994	0.948	0.973	0.981	20
EXIM Bank Ltd	Islamic	Second	1	1	0.992	1	0.955	0.989	16
First Security Islami Bank Ltd	Islamic	Second	1	0.993	0.952	0.949	0.946	0.968	27
ICB Islamic Bank Ltd	Islamic	First	0.982	0.645	0.857	0.93	0.656	0.814	38
Islami Bank Bangladesh Ltd	Islamic	First	0.95	0.931	0.905	0.942	0.961	0.938	34
Shahjalal Islami Bank Ltd	Islamic	Third	1	0.995	0.999	0.999	1	0.999	4
Social Islami Bank Ltd	Islamic	Second	1	0.998	0.999	0.984	0.998	0.996	10
Union Bank Ltd	Islamic	Fourth	1	0.999	0.99	1	0.995	0.997	8
AB Bank Ltd	Mixed	First	1	1	1	1	1	1.000	1
BD Commerce	Conventional	Second	0.894	0.951	1	1	1	0.969	25
Bank Asia Ltd	Mixed	Second	0.997	0.976	1	1	1	0.995	11
BRAC Bank Ltd	Conventional	Third	0.949	0.919	0.974	0.988	0.968	0.960	30
Dhaka Bank Ltd	Mixed	Second	1	0.994	0.998	0.996	1	0.998	7
Dutch-Bangla Bank Ltd	Conventional	Second	0.896	0.916	0.968	0.982	1	0.952	33
Eastern Bank Ltd	Conventional	Second	0.909	0.99	0.981	0.992	1	0.974	24
IFIC Bank Ltd	Conventional	First	0.909	0.954	0.988	0.993	0.999	0.969	26
Jamuna Bank Ltd	Mixed	Third	0.832	0.838	0.95	0.989	0.999	0.922	36
Meghna Bank Ltd	Conventional	Fourth	1	1	1	0.977	0.943	0.984	18
Mercantile Bank Ltd	Conventional	Second	0.963	0.979	0.981	1	1	0.985	17
Midland Bank Ltd	Conventional	Fourth	0.966	1	1	1	1	0.993	12
Modhumoti Bank Ltd	Conventional	Fourth	1	1	1	1	0.996	0.999	3
Mutual Trust Bank Ltd	Conventional	Second	0.924	0.982	0.984	0.99	0.999	0.976	23
National Bank Ltd	Conventional	First	0.93	0.981	0.997	1	1	0.982	19
National Credit & Commerce Bank Ltd	Conventional	Second	1	0.985	1	1	0.999	0.997	8
NRB Bank Ltd	Conventional	Fourth	1	0.986	0.992	1	0.97	0.990	15
NRB Commercial Bank Ltd	Conventional	Fourth	0.95	0.959	0.996	0.992	1	0.979	22
NRB Global Bank Ltd	Conventional	Fourth	1	0.998	0.994	0.974	0.999	0.993	13
One Bank Ltd	Conventional	Second	1	0.999	0.999	1	0.995	0.999	4
Premier Bank Ltd	Mixed	Second	0.923	0.955	0.99	0.987	0.984	0.968	28

Prime Bank Ltd	Mixed	Second	0.942	0.935	0.94	0.974	1	0.958	31
Pubali Bank Ltd	Mixed	First	0.876	0.93	0.963	0.935	0.936	0.928	35
South Bangla Agriculture	Conventional	Fourth	0.93	0.996	0.995	0.988	0.994	0.981	21
Southeast Bank Ltd	Mixed	Second	1	1	1	0.972	0.991	0.993	14
Standard Bank Ltd	Mixed	Second	1	0.993	1	0.997	1	0.998	6
The City Bank Ltd	Mixed	First	0.892	0.978	0.981	0.985	1	0.967	29
Trust Bank Limited	Mixed	Second	1	1	1	1	1	1.000	1
United Commercial Bank Ltd	Conventional	First	0.945	0.964	0.965	0.924	0.987	0.957	32
Uttara Bank Ltd	Conventional	First	0.677	0.788	0.841	0.864	0.931	0.820	37
38 PCBs			**0.953**	**0.961**	**0.978**	**0.98**	**0.978**	**0.970**	

Appendix B: Technical Efficiency of PCBs

Bank	Type	Generation	2013	2014	2015	2016	2017	5Y-Avrg	Rank
Al-Arafah Islami Bank Ltd	Islamic	Second	1	0.952	1	1	0.935	0.977	17
EXIM Bank Ltd	Islamic	Second	1	1	0.978	1	0.999	0.995	11
First Security Islami Bank Ltd	Islamic	Second	0.897	0.937	0.974	1	1	0.962	25
ICB Islamic Bank Ltd	Islamic	First	0.65	1	1	1	1	0.930	35
Islami Bank Bangladesh Ltd	Islamic	First	1	1	1	1	1	1.000	1
Shahjalal Islami Bank Ltd	Islamic	Third	0.931	0.97	0.961	0.965	0.972	0.960	26
Social Islami Bank Ltd	Islamic	Second	0.918	0.938	0.972	1	0.941	0.954	28
Union Bank Ltd	Islamic	Fourth	1	0.96	0.967	1	0.949	0.975	18
AB Bank Ltd	Mixed	First	1	1	1	1	1	1.000	1
BD Commerce Bank	Conventional	Second	0.875	0.996	1	1	1	0.974	19
Bank Asia Ltd	Mixed	Second	0.978	0.994	1	1	1	0.994	13
BRAC Bank Ltd	Conventional	Third	0.942	0.983	0.971	0.959	1	0.971	20
Dhaka Bank Ltd	Mixed	Second	1	0.904	0.933	0.923	0.906	0.933	33
Dutch-Bangla Bank Ltd	Conventional	Second	0.858	0.873	0.863	0.852	0.856	0.860	38
Eastern Bank Ltd	Conventional	Second	0.973	0.973	0.952	0.948	0.948	0.959	27
IFIC Bank Ltd	Conventional	First	0.978	0.945	0.925	0.923	0.96	0.946	30
Jamuna Bank Ltd	Mixed	Third	0.954	1	0.929	0.936	0.917	0.947	29
Meghna Bank Ltd	Conventional	Fourth	1	1	1	1	1	1.000	1
Mercantile Bank Ltd	Conventional	Second	0.97	0.98	0.996	1	1	0.989	15
Midland Bank Ltd	Conventional	Fourth	0.979	1	1	1	1	0.996	10

Modhumoti Bank Ltd	Conventional	Fourth	1	1	1	1	0.994	0.999	8
Mutual Trust Bank Ltd	Conventional	Second	0.882	0.892	0.903	0.903	0.912	0.898	37
National Bank Ltd	Conventional	First	1	1	1	1	1	1.000	1
National Credit & Commerce	Conventional	Second	1	1	1	1	0.974	0.995	12
NRB Bank Ltd	Conventional	Fourth	1	1	1	1	1	1.000	1
NRB Commercial Bank Ltd	Conventional	Fourth	1	0.975	0.963	1	1	0.988	16
NRB Global Bank Ltd	Conventional	Fourth	1	0.893	0.903	0.931	0.905	0.926	36
One Bank Ltd	Conventional	Second	0.989	1	0.949	0.951	0.954	0.969	22
Premier Bank Ltd	Mixed	Second	0.914	0.924	0.919	0.962	0.939	0.932	34
Prime Bank Ltd	Mixed	Second	1	1	1	0.976	0.979	0.991	14
Pubali Bank Ltd	Mixed	First	0.957	0.957	0.919	0.994	1	0.965	23
South Bangla Agriculture	Conventional	Fourth	0.965	0.923	0.911	0.958	0.959	0.943	31
Southeast Bank Ltd	Mixed	Second	1	1	1	1	1	1.000	1
Standard Bank Ltd	Mixed	Second	1	0.931	0.941	0.909	0.934	0.943	32
The City Bank Ltd	Mixed	First	0.995	1	0.981	0.934	0.944	0.971	21
Trust Bank Limited	Mixed	Second	1	1	1	1	1	1.000	1
United Commercial Bank Ltd	Conventional	First	0.959	0.949	0.964	1	0.942	0.963	24
Uttara Bank Ltd	Conventional	First	1	0.993	1	1	1	0.999	9
38 PCBs			**0.962**	**0.97**	**0.968**	**0.974**	**0.969**	**0.969**	

Appendix C: Allocative Efficiency of PCBs

Bank	Type	Generation	2013	2014	2015	2016	2017	5Y-Avrg	Rank
Al-Arafah Islami Bank Ltd	Islamic	Second	0.999	0.989	1	0.975	0.979	0.988	8
EXIM Bank Ltd	Islamic	Second	1	1	0.978	0.967	0.919	0.973	11
First Security Islami Bank Ltd	Islamic	Second	0.993	0.988	0.959	0.947	0.974	0.972	12
ICB Islamic Bank Ltd	Islamic	First	0.629	1	1	1	1	0.926	25
Islami Bank Bangladesh Ltd	Islamic	First	1	1	1	1	1	1.000	1
Shahjalal Islami Bank Ltd	Islamic	Third	0.963	0.944	0.966	0.96	0.947	0.956	20
Social Islami Bank Ltd	Islamic	Second	0.945	0.958	0.999	0.979	0.957	0.968	15
Union Bank Ltd	Islamic	Fourth	0.908	0.978	0.989	1	0.981	0.971	13
AB Bank Ltd	Mixed	First	0.97	0.974	1	0.939	0.932	0.963	16
Bangladesh Commerce Bank Ltd	Conventional	Second	0.999	0.962	1	1	1	0.992	6
Bank Asia Ltd	Mixed	Second	0.906	0.882	0.896	0.878	0.829	0.878	35

BRAC Bank Ltd	Conventional	Third	0.95	0.898	0.787	0.751	0.836	0.844	36
Dhaka Bank Ltd	Mixed	Second	0.92	0.934	0.913	0.892	0.876	0.907	32
Dutch-Bangla Bank Ltd	Conventional	Second	0.791	0.877	0.775	0.7	0.628	0.754	38
Eastern Bank Ltd	Conventional	Second	0.898	0.871	0.903	0.891	0.861	0.885	34
IFIC Bank Ltd	Conventional	First	0.939	0.924	0.939	0.926	0.877	0.921	27
Jamuna Bank Ltd	Mixed	Third	0.972	1	0.954	0.956	0.92	0.960	17
Meghna Bank Ltd	Conventional	Fourth	1	1	1	1	0.958	0.992	7
Mercantile Bank Ltd	Conventional	Second	0.942	0.939	0.929	0.964	0.943	0.943	23
Midland Bank Ltd	Conventional	Fourth	0.927	0.993	1	1	1	0.984	10
Modhumoti Bank Ltd	Conventional	Fourth	1	1	1	1	0.996	0.999	4
Mutual Trust Bank Ltd	Conventional	Second	0.923	0.925	0.909	0.92	0.873	0.910	31
National Bank Ltd	Conventional	First	1	1	1	1	1	1.000	1
National Credit & Commerce	Conventional	Second	1	0.967	1	1	0.957	0.985	9
NRB Bank Ltd	Conventional	Fourth	0.951	0.9	0.939	1	0.834	0.925	26
NRB Commercial Bank Ltd	Conventional	Fourth	0.867	0.954	0.942	0.964	0.994	0.944	22
NRB Global Bank Ltd	Conventional	Fourth	1	0.851	0.935	0.968	0.978	0.946	21
One Bank Ltd	Conventional	Second	0.991	0.92	0.966	0.981	0.934	0.958	18
Premier Bank Ltd	Mixed	Second	0.929	0.901	0.876	0.907	0.846	0.892	33
Prime Bank Ltd	Mixed	Second	0.923	1	0.951	0.861	0.829	0.913	30
Pubali Bank Ltd	Mixed	First	0.943	0.958	0.946	0.996	1	0.969	14
South Bangla Agriculture & Commerce	Conventional	Fourth	0.732	0.956	0.957	0.959	0.968	0.914	29
Southeast Bank Ltd	Mixed	Second	0.991	0.937	0.865	1	0.877	0.934	24
Standard Bank Ltd	Mixed	Second	1	0.969	0.952	0.937	0.929	0.957	19
The City Bank Ltd	Mixed	First	0.822	0.814	0.849	0.862	0.856	0.841	37
Trust Bank Limited	Mixed	Second	1	1	1	1	1	1.000	1
United Commercial Bank Ltd	Conventional	First	0.926	0.903	0.9	1	0.859	0.918	28
Uttara Bank Ltd	Conventional	First	1	0.969	1	1	1	0.994	5
38 Banks			**0.938**	**0.948**	**0.947**	**0.949**	**0.925**	**0.941**	

Appendix D: Cost Efficiency of PCBs

Bank	Type	Generation	2013	2014	2015	2016	2017	5Y-Avrg	Rank
Al-Arafah Islami Bank Ltd	Islamic	Second	0.999	0.941	1	0.975	0.915	0.966	11
EXIM Bank Ltd	Islamic	Second	1	1	0.957	0.967	0.918	0.968	9
First Security Islami Bank Ltd	Islamic	Second	0.891	0.926	0.934	0.947	0.974	0.934	15
ICB Islamic Bank Ltd	Islamic	First	0.409	1	1	1	1	0.882	27
Islami Bank Bangladesh Ltd	Islamic	First	1	1	1	1	1	1.000	1
Shahjalal Islami Bank Ltd	Islamic	Third	0.897	0.916	0.928	0.926	0.92	0.917	22
Social Islami Bank Ltd	Islamic	Second	0.868	0.899	0.972	0.979	0.901	0.924	21
Union Bank Ltd	Islamic	Fourth	0.908	0.939	0.956	1	0.931	0.947	13
AB Bank Ltd	Mixed	First	0.97	0.974	1	0.939	0.932	0.963	12
Bangladesh Commerce Bank Ltd	Conventional	Second	0.874	0.957	1	1	1	0.966	10
Bank Asia Ltd	Mixed	Second	0.886	0.877	0.896	0.878	0.829	0.873	29
BRAC Bank Ltd	Conventional	Third	0.894	0.883	0.765	0.72	0.836	0.820	35
Dhaka Bank Ltd	Mixed	Second	0.92	0.844	0.852	0.824	0.794	0.847	33
Dutch-Bangla Bank Ltd	Conventional	Second	0.679	0.765	0.669	0.597	0.538	0.650	38
Eastern Bank Ltd	Conventional	Second	0.874	0.848	0.86	0.845	0.816	0.849	32
IFIC Bank Ltd	Conventional	First	0.918	0.873	0.869	0.854	0.843	0.871	30
Jamuna Bank Ltd	Mixed	Third	0.927	1	0.886	0.895	0.843	0.910	23
Meghna Bank Ltd	Conventional	Fourth	1	1	1	1	0.958	0.992	6
Mercantile Bank Ltd	Conventional	Second	0.913	0.921	0.925	0.964	0.943	0.933	17
Midland Bank Ltd	Conventional	Fourth	0.907	0.993	1	1	1	0.980	7
Modhumoti Bank Ltd	Conventional	Fourth	1	1	1	1	0.99	0.998	4
Mutual Trust Bank Ltd	Conventional	Second	0.814	0.824	0.82	0.831	0.796	0.817	36
National Bank Ltd	Conventional	First	1	1	1	1	1	1.000	1
National Credit & Commerce	Conventional	Second	1	0.967	1	1	0.932	0.980	8
NRB Bank Ltd	Conventional	Fourth	0.951	0.9	0.939	1	0.834	0.925	20
NRB Commercial Bank Ltd	Conventional	Fourth	0.867	0.931	0.907	0.964	0.994	0.933	18
NRB Global Bank Ltd	Conventional	Fourth	1	0.76	0.844	0.902	0.886	0.878	28
One Bank Ltd	Conventional	Second	0.98	0.92	0.917	0.933	0.891	0.928	19
Premier Bank Ltd	Mixed	Second	0.848	0.833	0.805	0.872	0.795	0.831	34
Prime Bank Ltd	Mixed	Second	0.923	1	0.951	0.84	0.812	0.905	24
Pubali Bank Ltd	Mixed	First	0.903	0.917	0.87	0.99	1	0.936	14
South Bangla Agriculture &	Conventional	Fourth	0.706	0.883	0.872	0.918	0.929	0.862	31

Commerce Bank									
Southeast Bank Ltd	Mixed	Second	0.991	0.937	0.865	1	0.877	0.934	16
Standard Bank Ltd	Mixed	Second	1	0.902	0.896	0.852	0.867	0.903	25
The City Bank Ltd	Mixed	First	0.818	0.814	0.832	0.805	0.807	0.815	37
Trust Bank Limited	Mixed	Second	1	1	1	1	1	1.000	1
United Commercial Bank Ltd	Conventional	First	0.889	0.857	0.867	1	0.809	0.884	26
Uttara Bank Ltd	Conventional	First	1	0.962	1	1	1	0.992	5
38 PCBs			0.906	0.92	0.917	0.927	0.898	0.914	

Appendix E: Malmquist Productivity Index of PCBs

Bank	Type	Generation	effch	techch	pech	sech	tfpch
Al-Arafah Islami Bank Ltd	Islamic	Second	0.978	1.025	0.985	0.993	1.003
EXIM Bank Ltd	Islamic	Second	0.989	1.028	1	0.989	1.016
First Security Islami Bank Ltd	Islamic	Second	1.013	1.027	1.024	0.989	1.041
ICB Islamic Bank Ltd	Islamic	First	1.007	1.105	1.116	0.902	1.112
Islami Bank Bangladesh Ltd	Islamic	First	1.003	1.006	1	1.003	1.009
Shahjalal Islami Bank Ltd	Islamic	Third	1.011	1.009	1.011	1	1.02
Social Islami Bank Ltd	Islamic	Second	1.006	1.026	1.008	0.998	1.032
Union Bank Ltd	Islamic	Fourth	0.986	1	0.987	0.999	0.986
AB Bank Ltd	Mixed	First	1	1.06	1	1	1.06
Bangladesh Commerce Bank Ltd	Conventional	Second	1.064	1.011	1.031	1.032	1.076
Bank Asia Ltd	Mixed	Second	1.006	1.014	1.006	1.001	1.02
BRAC Bank Ltd	Conventional	Third	1.02	0.987	1.013	1.007	1.007
Dhaka Bank Ltd	Mixed	Second	0.975	1.026	0.976	1	1.001
Dutch-Bangla Bank Ltd	Conventional	Second	1.027	0.984	0.999	1.028	1.011
Eastern Bank Ltd	Conventional	Second	1.017	1.005	0.993	1.024	1.023
IFIC Bank Ltd	Conventional	First	1.019	1.001	0.995	1.024	1.02
Jamuna Bank Ltd	Mixed	Third	1.036	0.984	0.989	1.048	1.019
Meghna Bank Ltd	Conventional	Fourth	0.985	0.902	1	0.985	0.889
Mercantile Bank Ltd	Conventional	Second	1.017	1.022	1.008	1.01	1.04
Midland Bank Ltd	Conventional	Fourth	1.014	0.916	1.004	1.01	0.928
Modhumoti Bank Ltd	Conventional	Fourth	0.998	0.764	0.999	0.999	0.762
Mutual Trust Bank Ltd	Conventional	Second	1.028	1.002	1.007	1.021	1.031
National Bank Ltd	Conventional	First	1.018	1.009	1	1.018	1.028