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Original Research

Efficiency of Public and Private Universities in Bangladesh: A Comparative Approach Using Data Envelopment Analysis

M. Zakir Saadullah Khan* and Sharna Mazumder
Department of Economics, Comilla University, Kotbari, Comilla-3503, Bangladesh

Abstract

The aim of this study is to measure the efficiency of higher educational institutions and investigate the comparative efficiency of public and private higher education in Bangladesh. Using data envelopment analysis (DEA), technical efficiency of 15 public universities and 20 private universities of Bangladesh are evaluated over the period 2008-2018. The empirical results reveal that public universities on an average operate between 56.2 to 80.7 percent level of technical efficiency while the private universities between 49.1 to 77.6 percent level over the study period. That is, universities in Bangladesh, on an average, do not operate efficiently in terms of resource utilization. Over the years only 33% public universities and 25% private universities are found efficient. The inefficient universities can improve their efficiency by utilizing full capacity of the inputs or reducing the amount of inputs at the estimated inefficiency rate of the respective universities. Findings also show that the public universities have the scope of producing 1.24 to 1.78 times and private universities 1.28 to 2.04 times as much output from the same level of inputs. Special monitoring by the regulatory authorities is required for inefficient universities to enhance their efficiency level.

Keywords: *Efficiency, Data Envelopment Approach, Universities, Bangladesh*

* Corresponding Author.
zskbd@yahoo.com
https://orcid.org/0000-0001-7584-4951

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Introduction

At the independence in 1971 there were a few higher educational institutions in Bangladesh and this deficiency sustained for next decades despite huge cumulative demand for higher education. The scenario has changed in the last two decades while higher education has grown in an exponential rate, both from the perspectives of demand and supply. Government plan for establishing at least one public university in the headquarters of each greater district and private universities anywhere in the country in response to the increasing demands for access to higher education has given birth to 151 universities in Bangladesh by December 2019 (UGC Annual Report, 2019) which was only five immediate after the independence. To support the society towards self-sustained development, poverty alleviation and to survive in the global arena it is very much essential to produce accomplished and skilled graduate and higher education institutions hold one of the most important roles in this respect by providing quality teaching-learning. Higher education creates, applies, and spreads new ideas and technologies, as well as develops a skilled, productive, and flexible labour force and thus helps building a country's economy (Salmi, 2009). A strong system of higher education is crucial for a country's economic strength and social well-being, building competent workforce (Hanushek & Woessmann, 2010, 2012; Hanushek et al., 2015; Skaggs, 2014). As the key player of the system, efficient functioning of the institutions of higher education is very important to come up with optimum outcomes desired by society.

There is a long media discussion regarding the quality of education provided by universities in Bangladesh. Besides criticism is also there regarding how efficiently public funds and resources deployed to higher education sector, especially to public universities, are utilized. At the same time, there are questions regarding efficient and optimum utilization of the funds by private universities which are mostly collected from individual students at a higher rate. It is expected that investment, whether public or private, will be utilized in meeting the strategic goals of the society with maximum efficiency.

'Efficiency' refers to 'doing the things right' Drucker (1967) and 'quality' is (uncountable) level of excellence. The outcome of a service that is good worth and fit for the purpose is 'quality' which is traditionally more difficult to measure than

measure of 'efficiency'. Thus in the context of education efficient use of resources occurs when observed outputs from education are produced at the lowest level of resources (inputs) or more outputs are produced with the given level of resources (Johnes et al., 2017).

As enrolments in higher education continue to expand, public funding is becoming increasingly scarce and private institutions have to find more fund to meet increasing resource requirements. Despite this, universities vary in terms of productivity and efficiency. People, especially, the demander (students and guardians) show more concerns to the quality and efficiency of higher education. As special enterprises universities must pursue the maximum outputs under the restraints of resources. Moreover, public universities in Bangladesh are financed by the government and huge financing to some universities results in a polarization on the educational resource (input) allocation. Whereas, private universities are to depend mostly on students' fees putting pressure on individual students which further draws the public concern on comparative efficiency of public and private university issue, asking how worthy government huge funding to public universities is, while private universities absolute funded from private sources.

Policy-makers find it important to identity which universities have excess or redundant resources in producing current level of education output or which universities have their shortfalls in meeting the societal desired education output level (Emrouznejad & Cabanda, 2014). Both the public and private universities encounter problem of how to identify ways to improve their operations performance; that is, seeking ways with their available resources to maximise their outputs, or to minimize their resources without changing the volume of education output (Al-Amin & Gazar, 2020). Therefore, a comparison of efficiency among universities is important.

Institutions of higher education like a university that uses several inputs to produce several outputs; productivity is the rate at which composite[1] inputs are translated into composite outputs (Salerno, 2003). To identify the most (least) productive higher educational institution, efficiency is the index to rank the different productivity values. Based on the level of efficiency achieved, financing agency as well as operating institutions can plan for better allocation of resources to have improved output. A comparative study on the level of efficiency among different higher educational

institutions can be more motivating for them to set alternative targets by means of each input and output and increase efficiency to chase other. Therefore, the purpose of this study is to measure the efficiency of higher education and investigate the comparative efficiency of public and private universities in Bangladesh.

The paper is organized as follows: Section 2 presents the features of higher education system of Bangladesh. Section 3 presents the conceptual framework. Section 4 introduces methods and techniques used in measuring efficiency in education and also present data used for empirical study. Section 5 presents the results and discussion of the study, and finally section 6 make conclusion and recommendations.

Characteristics of Higher Education Sector in Bangladesh

Bangladesh is one of the world's fastest-growing economies over the past decade and to sustain this growth pace for long and ensure sustainable development and substantial development of human capital through quality higher education is a must. Higher education, also called tertiary level education in Bangladesh is generally used to comprehend the entire range and dynamics of post higher secondary education (completing twelve years of schooling). Higher education system of Bangladesh is a legacy of the British colonial education system, though several changes are evident in the last three decades. Structure of higher education in Bangladesh composed of five major types – i. General Education; ii. Science, Technology and Engineering Education; iii. Medical Education; iv. Agriculture Education; v. Madrasha Education. In addition, Vocational and Distance mode of education are also provided at higher education level. The general education at tertiary level in Bangladesh consists of a 3 year-pass-course or a 4 year-honours-course for the bachelor's degree, followed by a two year Master's course for pass graduates and a one-year Master's course for honours graduates. The duration of studies of other types varies from program to program. In addition, only public universities can award MPhil, PhD and other post graduate degrees.

According to the University Grants Commission of Bangladesh (UGC/Bangladesh) Annual Report 2019 there are 46 public universities - 15 general universities, 14 science and technology universities, 5 engineering universities, 7 agriculture universities, 4 specialized universities and 1 off campus universities in Bangladesh;

and there are 105 approved private universities in Bangladesh among those 98 are in academic operation. Among the public universities National University is the affiliating university for higher education providing colleges spread throughout the country, which enrols more than eighty percent students at tertiary level, and Bangladesh Open University provides distance mode of education. Medical education is provided by the medical universities and medical colleges, both public and private that are affiliated under a public university in the respective region. All the public universities are regulated under a government act for the respective university passed by Bangladesh Parliament and private universities are regulated by the Private University Act. Private University Act-1992 first approved establishment of private universities to supplement higher education besides public universities which is amended in 2010. The monitoring and regulatory authority of all universities is the UGC/Bangladesh. Bangladesh Madrash Education Board has regulating and monitoring authority for Madrash education spread all over Bangladesh.

In general higher education in Bangladesh is highly subsidized. Government budget subsidies are the primary funding source for the public higher educational institutions. Subsidies are assigned for education of full time students, salaries of academic and non-academic staff and facility maintenance. As per UGC reports it is found that on average 8% of government education budget is allocated for university education (Monem & Baniamin, 2010) and is allocated to universities by the UGC. In addition, medical education budget is allocated through Ministry of Health and Family Welfare and Madrash education through Bangladesh Madrash Education Board under Ministry of Education. The private universities are financed by the Board of Trustees of the respective universities and the tuition and other fees of their enrolees.

Conceptual Framework of Efficiency Measurement

Farrell (1957), who laid the foundation of the theory of efficiency, used three measures of efficiency - technical efficiency, allocative efficiency and economic efficiency. Combination of technical efficiency and allocative efficiency constitutes the economic efficiency (Coelli et al., 2002; Kosor, 2013; Mahmudi et al., 2014; Samsubar, 2000). Technical efficiency implies producing a maximum level of output from a given set of inputs and unchanged technology (Devine et al., 1985). A production unit is said to be technically efficient if it produces the maximum output

from the minimum quantity of inputs. The concept of technical efficiency is related to productive efficiency.

Allocative (or price) efficiency refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices, and is measured in terms of behavioural goal of the production unit (marginal product equals with marginal cost; MP = MC). Economic efficiency is related to the value (rather than the physical amounts) of all inputs used in producing a given output. The production of a given output is economically efficient if there are no other ways of producing the output using a smaller total value of inputs.

As an economic unit in producing graduates, higher educational institutions can improve their productive efficiency with improvements in technical efficiency together with technical progress and increasing returns to scale. Technical efficiency incorporates the value added in educational institutions as an output of the educational system (López-Matín & Gaviria, 2016). Therefore, technical efficiency, like many other studies (Figurek et al., 2019; Mahmudi et al., 2014; Nazarko & Saparauskas, 2014), is used in this study as a measure of efficiency of higher educational institutions in Bangladesh and comparing efficiency among them with an estimated efficiency score.

There are two general types of techniques to empirically estimate the efficiency – parametric, or regression based estimators and nonparametric or mathematically programming estimators. The parametric methods involve the estimation of an economic function such as production function, cost function, or profit function and the derivation of efficiency scores from either the residuals or dummy variables. That is, in parametric frontier analysis the technology of a Decision Making Unit (DMU) is specified by a particular functional form that links the DMU's output to input factors. The most widely applied technique is the stochastic frontier approach (SFA). The nonparametric methods involve solving linear programs, in which an objective function envelops the observed data; then efficiency scores are derived by measuring how far an observation is positioned from the "envelope" or frontier. The widely used nonparametric approach to efficiency measurement is the Data Envelopment Analysis (DEA) developed by Charnes et al. (1978).

An important drawback of the parametric approaches is that they impose a particular functional form (hence all its associated behavioural assumptions), which predetermines the shape of the frontier. If the functional form is unspecified, the estimated efficiency may be confounded with significant bias. Therefore, as the most appropriate efficiency measurement method for higher education, this study employs non-parametric method and applied DEA technique to get efficiency scores, following Begum et al. (2011), Krasachat (2002), Islam (2015), Hoque and Rayhan (2012). The Data Envelopment Analysis (DEA) approach constructs an optimization algorithm based on mathematical programming to characterize the set of efficient producers and then derives estimates of efficiency for inefficient observations based on how far they deviate from the most efficient ones (Salerno, 2003).

With DEA method, it is possible to generate a relationship between output and input in order to characterize the efficiency of education (Figurick et al., 2019). DEA has the ability to measure the efficiency of multiple-input and multiple-output DMUs without assigning prior weight to the input and output, no need to explicitly specify any assumption about functional form, proven to be useful in uncovering relationship that remain hidden for other methodologies, capable of being used with any input-output measurement, the source of inefficiency can be analysed and quantified for every evaluated unit.

Since outcomes of DEA may provide valuable information supporting higher educational institution (HEI) management, it is applied in measuring efficiency in higher education sector (Nazarko & Šaparauskas, 2014). This method occupies an important place in the comparative efficiency studies in different sectors worldwide (Chalos & Cherian, 1995; Odeck 2007), which goes much with our objective of comparing efficiency of public and private universities in Bangladesh.

Methods and Materials

The estimation of efficiency using DEA depends on the extent to which institutions studied have the control to inputs or outputs they produce. The orientations include input and output orientation. The output oriented is used when the DMUs have control over output as compared to the inputs. In public and private universities it is easy to control the input resources which include assets, personnel, capital and operating expenses incurred. The output in HEIs is a function of many factors some of which are

beyond the control of the institutions. This study, therefore, adopt the input oriented efficiency estimation to evaluate the extent to which public and private institutions use the input resources in the production of outputs.

This study relies on the idea of technical (or productive) efficiency, meaning the ability of a university to transform inputs into outputs. Efficient universities are those for which the ratio between outputs and inputs is highest: in other words, they produce the maximum level of output given the available inputs. Efficient universities are then used as a 'benchmark' to compare with other universities; the latter are defined as 'inefficient' and the degree of inefficiency is calculated as a distance from 'best-practice' institutions.

The Model

There are two major DEA approaches used for estimation of efficiency of decision making units (DMUs) are the Charnes et al. (CCR) model and the BCC model propounded by Banker et al. (1984). The first model takes constant return to scale (CRS) into account by composing technical efficiency into pure technical efficiency and scale efficiency, and the later model, the variable returns to scale (VRS) efficiency score represents pure technical efficiency, that is, a measure of efficiency without scale efficiency (Singh & Fida, 2015). This study uses CCR model to evaluate the technical efficiency of universities of Bangladesh. There are two versions (dual problem) of CCR model in estimating technical efficiency - the Input-oriented approach that aims to minimize inputs while satisfying at least the given output levels, and the Output-oriented approach maximizes output levels at a given input level. The Input-oriented technical efficiency focuses on the possibility of reducing inputs to produce given output levels and the output-oriented TE considers the possible expansion in outputs for a given set of input quantities. Under CRS assumption the input-oriented and output-oriented measures always produce the same relative efficiency scores, provided all the inputs are controllable.

Under DEA approach, the CCR model aims to maximize the relative efficiency (hk) of the k-th DMU which is defined as the ratio of the weighted sum of the outputs to the weighted sum of the inputs of the DMU (here, university) of the study. The objective function, defined by hk for k-th entity (university) under study, is maximized subject to the constraint that any other entity (university) in the sample cannot exceed

unit efficiency by using the same weights. Hence, the objective function the selected entity k is:

$$\text{Maximize } h_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \quad (1)$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_i}{\sum_{i=1}^{m} v_i x_i} \leq 1, \; j = 1, 2, \ldots, j\,k, \ldots n \quad (2)$$

$$u_r \geq \varepsilon, \; r = 1, 2, \ldots, s \quad (3)$$

$$v_i \geq \varepsilon, i = 1, 2, .., m \quad (4)$$

where,

$r = 1, 2, \ldots, s$ - the number of generated outputs;

$i = 1, 2, \ldots, m$ - the number of inputs used;

y_{rk} - the amount of output r produced by the DMU;

u_r - the weight of output r;

x_{ik} - the amount of input i used by the DMU; and

v_i - the weight of input i.

The problem above (equation: 1- 4) is nonlinear, non-convex, with a linear and fractional objective function and linear and fractional constraints. Using a simple transformation developed by Charnes and Cooper (1962), the above CCR ratio model can be reduced to the linear program form by restricting the denominator of the objective function to unity, and adding this as a constraint to the problem so that the linear programming methods can be applied. Therefore, the numerator of equation (2) is being maximized and the linear programming form of the problem is as follows:

Maximize $h_k = \sum_{r=1}^{s} u_r y_{rk}$ (5)

Subject to

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \quad (6)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad (7)$$

$$u_r \geq \varepsilon, \ (r = 1,...,s) \quad (8)$$

$$v_i \geq \varepsilon, \ (i = 1,...,m) \quad (9)$$

The above model is the envelopment form of CCR model and provides Farrell's output-oriented technical efficiency (TE) measure under the assumption of constant returns-to-scale. The solution to above problem is interpreted as maximum possible out that can be produced by *k*-th university given the available inputs (resources). The restrictions (6) and (7) form the convex reference technology. The restriction (8) restricts the output slack and restriction (9) input slack variables to be non-negative. This CCR model measures the technical efficiency and provides the efficiency scores of sample universities (h_k^*), where $0 \leq h_k^* \leq 1$.

If $h_k^* = 1$, then university under evaluation is a frontier point, i.e., there is no other universities that are operating more efficiently than this university. Otherwise, if $h_k^* < 1$, then the university under evaluation is inefficient, i.e., this university can either increase its output levels or decrease its input levels (Kumar & Gulati 2008).

The Variables

According to the DEA methodology, in order to analyse the efficiency of public and private universities, it was assumed that each university is considered as Decision Making Unit (DMU). In measuring efficiency of higher education, it is generally important to account for the multi-product nature of educational production (Thanassoulis et al., 2008). Educational efficiency refers to the relationship between inputs and investments that occurs in the educational system and the outcomes obtained (De La Orden et al., 1997; Lockheed & Hanushek, 1994). In university

efficiency assessment there is no definitive standard guide of selecting the inputs and outputs. Generally, human and financial resources are considered as agreed inputs for universities, and the outputs arise from teaching and research activities (Johnes, 1996). Based on previous studies this study selects inputs and outputs in applying DEA in the evaluating relative efficiencies among universities in Bangladesh. The human resources of the universities are the academic staffs that universities employ to educate the students to produce graduates and research output with certain level of quality; and the non-academic staffs for supporting services (Cunha & Rocha, 2012, Selim & Bursalioglu, 2013; Veiderpass & Mckelvey, 2014; Wolszczak-Derlacz, 2017). The main financial resource is the revenue or educational expenditure of the university (Aristovnik & Obadic, 2011; Katharaki & Katharakis, 2010; Selim & Bursalioglu, 2013). The main output of teaching and research activities is concentrated on graduates (Gökşen et al., 2015; Kipesha & Msigwa, 2013; Veiderpass & Mckelvey, 2014) and the research funding (Abbott & Doucouliagos, 2003; Johnes, 2006; Kuaha & Wong, 2011) which is considered as the outcomes of the universities' performance and merit (Jongbloed & Vossensteyn, 2001).

Therefore, the decision making units (DMUs) of this study are the universities under study. This study selects widely used three inputs and three outputs by previous studies to measure the relative efficiency of universities in Bangladesh. Inputs include number of full-time academic staffs, number of non-academic staffs and the expenditure per student, measured as the ratio of total annual expenditure of the institute over the number of enrolled students to neutralize the size disparity between universities. Three outputs considered are the number of bachelor graduates, number of masters graduate produced and the research fund allocated by the respective university. Graduates from research programs like MPhil and PhD are not included since private universities in Bangladesh are not allowed to offer such programs and many of the public universities are not offering these programs yet.

The Data

In order to make a comparative study of the efficiency of public and private universities in Bangladesh, all 15 public universities out of 46 and 20 private universities out of 98 in operation which have been producing graduates for at least a decade are selected for study, analysing the UGC/Bangladesh Annual Reports since

its inception. The first private university in Bangladesh came in its operation in 1993 and produced first bachelor graduates in 1997 and by 2008, 20 such private universities and 15 public universities are identified. To have a meaningful and robust study the study period is, therefore, selected over the period 2008–2018. A panel data of all graduate producing 15 public and 20 private universities is constructed over the study period 2008-18. Data of the variables of the study are mostly collected from UGC/Bangladesh Annual Reports of the year 2008 - 2018. Other sources of data are Ministry of Education website, Bangladesh Bureau of Education Information and Statistics (BANBEIS) website, and relevant publications from Bangladesh Bureau of Statistics (BBS).

Empirical Results and Discussion

The DEA is powerful method used for evaluation of technical efficiency of production units. This method is capable of using more parameters of input and output to evaluate which of units examined is the most effective and to compare other units with it. To do so, a homogenous group of units is needed, and it is necessary to follow the rules for evaluation of efficiency – either to compare the measured values between the units for the same unit in different points in time, or it is possible to apply both time and unit perspective respecting condition of ceteris paribus. This study empirically estimate the efficiency of sample 35 universities in Bangladesh, both public and private, applying both time and unit perspective. A descriptive analysis of the variables of the model is present before going the efficiency measurements.

Descriptive Statistics of the Variables

There are two types of variables – input variables and output variables. Descriptive statistics of the input and output variables are presented in Table-1. Table shows that average number of both academic and non-academic staffs is higher in public universities compare to private universities in Bangladesh, and public universities on average employs five times more non-academic staffs than private universities and there is more disparity among public universities (Standard Deviation, S.D =1012.4) in employing non-academic staffs compare to private universities (S.D = 155.8). It also reveals that public universities on average spend more per student compare to private universities in Bangladesh.

In producing graduates, public universities on average produce both bachelor and masters graduates more than private universities, though there is higher disparity (expressed by standard deviation) of producing graduate among public universities. It is surprising that average allocation of research fund by private universities three times more than the public universities, though more disparity is also revealed among private universities in research fund allocation.

Table 1

Mean and Standard Deviation of Input and Output Variables of Public and Private Universities in Bangladesh

	Public University		Private University	
	Mean	Standard Dev.	Mean	Standard Dev.
Input Variables				
Number of Teachers	584.7	510.2	319	191.3
Number of Non-academic Staffs	1242.7	1012.4	245.5	155.8
Expenditure/ Student (‘000 Tk.)	101.8	76.1	87.7	95.3
Output Variables				
No. Bachelor Graduates	1768.3	2356.6	976.9	888.7
No. Masters Graduates	1217.6	1682.6	491.1	733.2
Research Funds (‘000 Tk.)	11856	32612	33834	95169
Observations (k x t)	165	165	220	220

Comparative Efficiency of Public and Private Universities in Bangladesh

In measuring of efficiency of different universities of Bangladesh in DEA, output-oriented approach of CCR-CRS model has been used in estimating the linear programming of the system of equation (5) - (9) putting the data of the respective university (DMU) over the sample period. Output-oriented efficiency scores measures how much quantity outputs can proportionally be increased with the given quantity of inputs. The CCR-CRS model is considered suitable as universities have no direct

influence on the size of the government budget subsidy (Nazarko & Šaparauskas, 2014). The calculations are carried out with the use of Lindo 6.1 and MS Excel 2007 software.

The linear programming of DEA computes the relative efficiency scores of the DMUs, sample universities in this study, which is the ratio of outputs to inputs for each university and express how well the production process converts inputs into outputs (i.e. effective implementation of the production plan). The efficiency score is usually expressed as either a number between 0-1 or 0 -100%. A decision making unit with a score less than 1 is deemed inefficient relative to other units. In other words, score of 1 implies that the DMU is technically efficient. Appendix-A1 and Appendix-A2 present estimated Technical Efficiency scores of 15 public universities and 20 private universities of Bangladesh over the study period 2008-2018. Results indicate that both public and private universities are characterized with large asymmetry between sample universities in both group and over the period in the same university as regards their technical efficiency that ranges between 0.10 to 1. Summary of the results is presented in Table-2.

Table 2 shows that over the sample period the average of efficiency score of public universities vary between 0.562 to 0.807 and between 0.49.1 to 0.776 in private universities' cases. This suggests that over the period, given the available inputs, public universities on average can produce 56.2% to 80.7% of the optimum (efficient) output and the private universities on average 49.1% to 77.6% of optimum outputs. In other words, over the period, capacity utilization of inputs in public and private universities ranges from 56.2% to 80.7% and 49.1% to 77.6% respectively, and the magnitude of technical inefficiency in public and private universities are to the tune of between 43.8% to 19.3% and 51.9% to 22.4% respectively. Variation of the efficiency or inefficiency score of different universities over time are due to variation of students enrolment in different years in the respective private universities, and in case of public universities it may be due overestimates of the annual budget to have from government anticipating a certain rate of growth that actually do not happen in most cases. This left their resources unutilized. The connotation of this finding is that public universities have the scope of producing on an average (1/0.807=) 1.24 times to

(1/0.562=) 1.78 times as much as outputs from the same level of inputs. The figure is (1/0.776=) 1.28 and (1/0.491=) 2.04 times in private university cases.

Table 2

Efficiency Score of Public and Private Universities of Bangladesh

Year	Average of Efficiency Scores		Average Inefficiency (%)		No. of Efficient DMUs				No. of Inefficient DMUs			
	Public	Private	Public	Private	Public		Private		Public		Private	
					Freq	%	Freq	%	Freq	%	Freq	%
2008	0.694	0.624	30.6%	37.6%	6	40%	5	25%	9	60%	15	75%
2009	0.599	0.638	40.1%	36.2%	5	33%	5	25%	10	67%	15	75%
2010	0.695	0.738	30.5%	26.2%	5	33%	6	30%	10	67%	14	70%
2011	0.644	0.753	35.6%	24.7%	4	27%	7	35%	11	73%	13	65%
2012	0.725	0.641	27.5%	35.9%	6	40%	4	20%	9	60%	16	80%
2013	0.581	0.491	41.9%	50.9%	4	27%	4	20%	11	73%	16	80%
2014	0.670	0.659	33.0%	34.1%	4	27%	3	15%	11	73%	17	85%
2015	0.723	0.632	27.7%	36.8%	5	33%	3	15%	10	67%	17	85%
2016	0.807	0.552	19.3%	44.8%	7	47%	5	25%	8	53%	15	75%
2017	0.644	0.776	35.6%	22.4%	5	33%	7	35%	10	67%	13	65%
2018	0.562	0.668	43.8%	33.2%	4	27%	5	25%	11	73%	15	75%
Aver.						**33%**		**25%**		**67%**		**75%**

Table 2 also reveals that over the study period, only 33% public universities on an average are considered to be efficient (with score 1.0) while it is only 25% among private universities. These universities together define the best practice or efficient frontier. The resource utilization process in these universities is functioning well and is not characterizing any waste of inputs. In DEA terminology, these universities are called peers and set an example of good operating practices for inefficient universities to emulate (Kumar & Gulati 2008). The inefficiency of the rest 67% public and 75% private universities presents the deviations of the universities from the best practice frontier. These universities can improve their efficiency by utilizing full capacity of

the inputs or reducing the amount of inputs at the inefficiency rate of the respective universities.

Only two public universities are found most efficient with technical efficiency (TE) score of 1, while only one private university is found efficient with the same score. Universities with technical efficiency score less than 1 is deemed to be relatively inefficient. This study also made an attempt to segregate inefficient universities into four categories based on quartile values of average technical efficiency scores obtained over 2008-2018 as cut-off points following Kumar & Gulati (2008). 'Marginally Inefficient' category universities are those universities which attained TE score above the third quartile value but less than 1. In the 'Above average' efficient category, those universities have been included which attained TE score between median value and third quartile value; while 'Below Average' fall between median and first quartile value. 'Most Inefficient' universities are those universities which attained the TE score below the value of first quartile. Table-3 presents the number of universities in these four categories along with the descriptive statistics of technical efficiency that universities obtained over time.

Table 3

Descriptive Statistics of Different Categories of University

Statistics	University in Group		Marginally Efficient		Above Average		Below Average		Most Inefficient	
	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private
Freq (N)	15	20	2	5	5	6	3	4	3	4
Av. TE Score	0.67	0.65	0.80	0.84	0.70	0.67	0.60	0.56	0.40	0.40
Std Dev.	0.19	0.18	0.0424	0.0515	0.0385	0.0306	0.0436	0.0299	0.0643	0.1046
Minimum	0.35	0.26	0.77	0.78	0.66	0.64	0.55	0.53	0.35	0.26
Q1	0.59	0.55	0.77	0.79	0.67	0.65	0.55	0.53	0.35	0.29
Median	0.68	0.65	0.80	0.86	0.70	0.66	0.62	0.56	0.37	0.43
Q3	0.77	0.78	0.83	0.88	0.74	0.68	0.63	0.59	0.47	0.48
Maximum	1.00	0.96	0.83	0.89	0.76	0.72	0.63	0.60	0.47	0.48
Tech. Ineff (%)	33%	35%	20%	16%	30%	33%	40%	44%	60%	60%
Interval	0.48, 0.86	0.47, 0.83	0.84							

Among these categories, the universities belonging to 'marginally inefficient' and 'most inefficient' category requires special attention. The 'marginally inefficient' category universities are operating at a high level of operating efficiency even though they are not fully efficient. These universities can attain the status of efficient universities by bringing little improvements in the resource utilization process. Therefore, the management and regulatory authorities must pay special attention to enhance their efficiency. The 'most inefficient' category universities are worst performers in the sample and lack vitality in terms of the efficiency of resource utilization. These universities may be considered as 'target universities' that requires special care from the regulatory authorities (like, UGC and Ministry of Education) to pull them up, at least to a moderate efficiency level.

Conclusion

In order to allocate and utilize educational resources efficiently assessment of the efficiency of the institutions of higher education is vital (Kuah & Wong, 2011). This study applied data envelopment analysis (DEA) to explore the relative efficiency of universities, both public and private universities of Bangladesh, which provides some interesting results concerning the efficiency measurement of like and comparable decision-making units (DMUs, here universities) relative to one another and helps alleviate the problem of compared DMUs based on numerous outputs. (Alabdulmenem, 2017). The output-oriented approach of CCR model has been used to measure the technical efficiency of different universities in Bangladesh, a perfectly efficient university registers an efficient score of 1.0, and relative efficiency of other universities is being compared to this score. Results show that over the study period the average of efficiency scores of public universities varied between 0.562 to 0.807 and private universities between 0.49.1 to 0.776. Over the same period only 33% public universities on average are found efficient while it is only 25% among private universities, and only a few them were consistently efficient. The deviation of the efficiency score of the universities from perfectly efficient score of 1.0 reveals that most of the universities of both groups fall behind in performance due to poor utilization of available resources they have. Since there are considerable differences in relative efficiency between public and private universities and universities as a whole, UGC/Bangladesh as government monitoring authority and the management of individual universities find ways of capacity utilization and act to improve

institutional efficiency. The study suggests that there is an ample scope for improvement in the performance of inefficient universities by choosing an appropriate input-output mix.

This study is an endeavour to empirically examine the efficiency of universities in Bangladesh, selecting limited number of input and output variables based on availability of data from different published sources. But still the findings of the study offer insights on how the considered inputs and outputs contribute to efficiency of the universities. An evaluation of the universities' efficiency incorporating more inputs (like, enrolment of different quality students, access to ICT facilities) and outputs (like, quality research outcomes) applying DEA approach may be addressed. Given the limitations of the study, findings will help education policy-makers identify the areas where to focus most in improving overall performance and formulate policies for university education in Bangladesh. The future research will extend this study considering measurement of the extent of pure technical and scale efficiencies of universities along with technical efficiency, and investigate inter-temporal variations of these efficiencies using the longitudinal data that this study used.

Note

[1] Composite inputs and outputs are developed by attaching some relative importance, or weight, to each input and output.

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Appendix A1: Technical Efficiency Score for Public Universities in Bangladesh

S.l	DMU	2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	DU	1.00	1	1.00	1	1.00	1	1.00	1	0.64	10	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
2	RU	0.80	9	1.00	1	0.63	10	0.23	14	1.00	1	0.56	7	0.68	7	0.84	7	1.00	1	1.00	1	0	
3	CU	1.00	1	0.96	6	0.73	7	0.63	9	1.00	1	0.41	12	0.44	11	0.68	10	0.98	8	0.81	6	0.07	14
4	JU	0.50	11	0.45	10	0.70	8	0.88	6	1.00	1	0.57	6	0.62	10	0.72	9	0.57	11	0.44	10	0.83	6
5	KU	0.89	8	0.19	12	0.36	13	0.36	12	0.31	13	0.22	13	0.41	12	0.33	12	0.55	12	0.59	8	1.00	1
6	JNU	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
7	IU	0.90	7	1.00	1	0.60	11	0.31	13	0.16	15	0.53	9	0.91	5	0.95	6	1.00	1	1.00	1	1.00	1
8	BUET	1.00	1	0.16	14	0.84	6	0.66	7	0.65	9	0.50	10	0.69	6	0.58	11	0.42	14	0.26	14	0.30	11
9	BAU	1.00	1	0.33	11	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	0.39	13	0.40	9
10	SBAU	0.32	13	0.49	9	1.00	1	0.89	5	0.90	7	1.00	1	0.67	9	0.32	13	0.66	10	0.40	12	0.26	13
11	BSMRAU	0.62	10	0.18	13	1.00	1	1.00	1	1.00	1	0.12	15	1.00	1	1.00	1	1.00	1	0.23	15	0.29	12
12	SUST	1.00	1	0.56	7	0.47	12	0.46	10	0.78	8	0.46	11	0.68	7	0.76	8	0.93	9	1.00	1	0.86	5
13	PSTU	0		0.56	7	0.25	14	0.45	11	0.29	14	0.55	8	0.37	13	0.33	12	0.50	13	0.41	11	0.39	9
14	HSTU	0.38	12	1.00	1	0.64	9	0.65	8	0.52	12	0.16	14	0.27	15	1.00	1	1.00	1	0.63	7	0.57	7
15	MSTU	0		0.10	15	0.20	15	0.14	15	0.62	11	0.64	5	0.31	14	0.33	12	0.50	13	0.50	9	0.46	8

DU= University of Dhaka; RU= University of Rajshahi; CU=University of Chittagong; JU=Jahangirnagar University; KU= Khulna University; JNU= Jagannath University; IU= Islamic University; BUET=Bangladesh University of Engineering & Technology; BAU=Bangladesh Agricultural University; SBAU= Sher-e-Bangla Agricultural University; BSMRAU= Bangabandhu Sheikh MujiburRahman Agricultural University; SUST= Shahjalal University of Science and Technology; PSTU=Patuakhali Science and Technology University; HSTU=Hajee Mohammad Danesh Science & Technology University; MSTU=Mawlana Bhashani Science and Technology University.

Appendix A2: Technical Efficiency Score for Private Universities in Bangladesh

S.l.	DMU	2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
		Score	Rank	Score	Rank		Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	NSU	0.65	11	0.48	14	0.80	11	0.49	14	0.54	13	0.32	12	0.39	18	0.32	17	0.17	19	1.00	1	0.62	12
2	IUB	0.83	6	0.58	10	0.86	10	0.32	19	0.56	12	0.51	7	0.57	11	0.91	5	1.00	1	0.63	14	0.30	18
3	AUST	0.34	14	0.56	12	0.60	13	1.00	1	0.68	9	1.00	1	0.86	7	0.63	12	0.56	8	0.88	10	0.38	17
4	EWU	0.45	13	0.72	8	0.59	14	0.48	15	0.46	15	0.25	15	0.52	13	0.57	13	0.22	17	1.00	1	1.00	1
5	BRACU	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	0.51	14	1.00	1	1.00	1	1.00	1	1.00	1
6	SUB	1.00	1	1.00	1	0.92	8	0.86	12	0.69	8	0.37	9	0.70	10	0.53	15	0.31	14	0.70	13	0.47	15
7	AIUB	0.81	7	0.71	9	1.00	1	1.00	1	0.96	5	0.50	8	0.92	5	0.70	8	0.41	13	1.00	1	0.71	10
8	DfIU	0.29	17	0.57	11	1.00	1	0.87	11	0.59	11	0.22	18	0.44	16	0.55	14	0.75	7	1.00	1	0.85	7
9	ULAB	0.28	18	0.13	20	0.34	18	0.42	17	0.37	17	0.31	13	0.54	12	0.67	9	0.54	9	0.99	8	0.68	11
10	NUB	0.74	9	0.85	7	0.97	7	1.00	1	1.00	1	0.23	16	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
11	PU	0.56	12	1.00	1	1.00	1	1.00	1	1.00	1	0.79	5	0.88	6	0.66	10	0.20	18	0.74	11	0.76	9
12	USTC	0.30	15	0.24	18	0.30	20	0.29	20	0.21	20	0.20	20	0.30	19	0.14	20	0.83	6	0.38	20	1.00	1
13	UAP	0.25	19	0.43	16	0.56	15	0.89	10	0.65	10	1.00	1	0.75	9	0.16	19	1.00	1	0.61	15	0.30	18
14	DIU	1.00	1	1.00	1	1.00	1	0.91	9	0.85	6	1.00	1	1.00	1	0.90	6	0.46	10	0.73	12	0.57	14
15	UDA	0.72	10	1.00	1	0.72	12	0.48	15	0.32	18	0.23	16	0.43	17	0.39	16	0.20	18	0.39	19	0.41	16
16	GUB	0.16	20	0.39	17	0.33	19	0.41	18	0.24	19	0.21	19	0.18	20	0.18	18	0.28	15	0.44	18	0.02	20
17	BUBT	0.30	15	0.45	15	0.42	17	1.00	1	0.40	16	0.35	10	0.77	8	1.00	1	1.00	1	0.57	16	0.92	6
18	UU	1.00	1	0.86	6	0.91	9	0.94	8	1.00	1	0.66	6	1.00	1	0.93	4	0.43	11	0.93	9	1.00	1
19	IIUC	0.80	8	0.55	13	1.00	1	1.00	1	0.81	7	0.35	10	0.96	4	0.74	7	0.42	12	0.52	17	0.77	8
20	IUBAT	1.00	1	0.23	19	0.43	16	0.70	13	0.49	14	0.31	13	0.45	15	0.65	11	0.25	16	1.00	1	0.59	13

NSU=North South University; IUB=Independent University, Bangladesh; AUST=Ahsanullah University of Science and Technology; EWU=East West University; BRACU=BRAC University; SUB=Stamford University, Bangladesh; AIUB=American International University Bangladesh; DfIU=Daffodil International University; ULAB=University of Liberal Arts Bangladesh; NUB=Northern University Bangladesh; PU=Prime University; USTC=University of Science & Technology, Chittagong; UAP=University of Asia Pacific; DIU= Dhaka International University; UDA= University of Development Alternative; GUB= Green University of Bangladesh; BUBT=Bangladesh University of Business and Technology; UU=Uttara University; IIUC= International Islamic university, Chittagong; IUBAT=International University of Business Agriculture and Technology.