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# Efficiency Assessment of Public Education & Health Sector in Selected Middle-Income Countries with Special Reference to Millennium Development Goals (MDGs)

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**ABSTRACT**

This study investigates relative efficiency of public education and health sector in selected middle income countries with special reference to Millennium Development Goals (MDGs). The study uses data for two reference years; 2000 (implementation year of MDGs for developing countries) and 2015 (the final year of MDGs). Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) are used to calculate relative efficiency, operating scale of the countries (DMUs) and productivity change in relative efficiency over time respectively. The paper conceptualizes relative efficiency of the countries in discretionary, multi-criteria input-output variables context to investigate efficiency differences among the countries and deduce important takeaways. Educational expenditure, teachers at primary level, health expenditure, birth attended by skilled staff are used as input variables while enrollment at primary level, completion of primary level education, infant survival per annum and child survival per annum are used as output variables. The DEA results show that all countries could not operate at efficient level to target MDGs. The level of efficiency was not same under different DEA specifications in both the periods. Some countries were inefficient because of their size; either having too large size or too small size of operation. The sources of change in efficiency over the time were either because of real change in efficiency or change in technology frontier or both. The study identified a set of institutional and individuals factors which contribute to the efficiency and inefficiency of DMUs under investigation.

**Keywords**
Efficiency, Data Envelopment Analysis (DEA), Public Education, Health, Malmquist Productivity Index (MPI)

**JEL Classification**
C14 H51 H52 I18 I21 I28

## 1. Introduction

Scarcity of resources is supposed to be the main economic problem faced by all economic agents while making various economic choices[4]. Hence, every individual wants to get maximum benefits from the given resources by utilizing these scares resources

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[4] Robbins (1932).

efficiently. Equally important, the same idea is required at societal and macro level to ensure efficient allocation of resources for the welfare of the general masses.

Health and education are the basic needs as well as fundamental rights of every individual and thus considered main factors of Human Development (Ul-Haq, 1995). It is the responsibility of every government to provide basic education and health facility to their people. In every budget, government allocate sufficient amount of their revenue to the education and health sector. The percentage of expenditure allocated to these sectors varies across the countries. Mostly, in developed countries the percentage expenditure allocated to these two sectors are comparatively high than developing countries. Therefore; the education level, quality and health performance indicators of developing countries are mostly unsatisfactory comparatively.

The member countries of United Nation (UN), during their Millennium Meeting in 2000, signed an agreement and set time-bounded goals, known as Millennium Development Goals (MDGs). These goals are related to poverty, education and health[5]. After this agreement, all member countries focused on these sectors and allocated resources to these sectors while keeping in mind the goals. In the UN report of 2015, most of the countries have not achieved health and education related targets of MDGs. In developing countries, some countries performed better in achieving those targets while some of developing countries did not perform well and could not achieve MDGs targets.

The purpose of this study is to answer the basic yet important question why all the developing countries could not perform equally despite of assigning equal targets? There might be issues in the targets set by the UN or might be different possible reasons that why majority of the countries could not achieve MDGs. This study has important lessons learnt for developing countries while now pursuing Sustainable Development Goals; an extension of MDGs.

Studies are available that examined efficiency in health or/and education sector across the countries however; there exist a significant gap in literature related to efficiency in health and education sector with reference to MDGs goals and targets. Most of the studies focused on calculating efficiency scores by DEA or Frontier Disposal Hull (FDH) methods (Asandului et al., 2014; Gupta & Verhoeven, 2001; Pang & Herrera, 2005). Some studies focus comparing efficiency in education and health sectors among OECD and developed countries (Afonso & Aubyn, 2006; Afonso et al., 2010; Aristovnik, 2012) with few exceptions which compared efficiency in these two sectors in developing countries context (Gupta & Verhoeven, 2001; Pang & Herrera, 2005; Wang & Alvi, 2011; Jimenez and Lockheed, 1995). However; to the best of our knowledge we could not find any study which specifically focuses on calculating efficiency in health and education sector by considering

[5]https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Annexe%20MDG2011.pdf

the MDGs targets and goals. Efficiency in health and education sector (combined) among developing countries is not studied extensively. Most of the studies have selected countries within specific geographical region. The selection of DMUs is very critical and efficiency scores are very sensitive to numbers and types of DMUs. So, by comparing efficiency among countries based on region is very critical. Most of the studies have only calculated efficiency scores for specific time or year and did not considered changes in efficiency over a period of time. Majority of the studies did not consider the returns to scale in health and education sector and ignored the scale of country at which they are currently operating.

In light of the above discussion, the main objective of this study is to examine health and educational performance of selected middle income countries in context of MDGs by using multi-criteria input and output approach. Data Envelopment Analysis (DEA), a nonparametric multi-criteria technical efficiency assessment method is used for two different periods; 2000 and 2015. The paper uses an interesting idea by taking into consideration countries as productive units which use certain resources as inputs and process it into desirable outputs such as health and education outcomes. In this context, each country is considered as a Decision Making Unit (DMU). We select these two time periods because 2000 was the starting year of MDGs and 2015 was the end year of MDGs targets. The selection of countries (DMUs) is based on their per capita income level and considered only selected middle income countries[6] as DMUs. The study selects only middle income countries in order to ensure homogeneity among DMUs as DEA analysis is sensitive to selection of DMUs. Variables (specifically output variables) are selected based on MDGs targets and goals related to education and health sectors. The study calculated overall technical efficiency, pure technical efficiency, scale efficiency and supper efficiency. Returns to scale for each DMU and for both periods are also calculated to observe operating level of each country and the size of each country. To study that how DMUs are performing overtime and how their productivity changing overtime, Malmquist Productivity Index (MPI) is also calculated.

## 2. Literature review

The literature on relative efficiency in health and education sector, across the countries, is mostly related to developed, European, OECD and emerging countries. Afonso et al. (2005) calculated efficiency and performance of public sector expenditure in seven sectors[7] as a whole and separately as well for 23 industrialized OECD countries during 1990 and 2000. They calculated Public Sector Performance (PSP) index and used Free Disposable Hull (FDH) for calculating efficiency. Another study by Afonso & Aubyn (2006) examined the efficiency in educational expenditure among 25 OECD countries. They compare the

[6] The classification of countries is based on World Bank’s countries classification

[7] Administrative, Education, Health, Public Infrastructure, Distribution, Stability and Economic Performance

efficiency in educational output and its determinants by carrying DEA and Tobit analysis. Wang & Alvi (2011) examined the relative efficiency and determinants of efficiency in ten OECD and seven Asian countries by implementing DEA and Tobit model. The results show that in OECD countries US, Germany and New Zealand shown highest relative efficiency while in Asian countries Japan was relative efficient country in public expenditure. Further they concluded that by increasing the share of private spending, government could increase the efficiency. Asandului et al. (2014) calculated the efficiency of healthcare system in 30 European countries for the year 2010. They used non-parametric DEA method for the analysis. Out of 30 countries only six countries were efficient. Similarly in another study Samut & Cafri (2016) evaluated the efficiency in health sector by calculating efficiency of hospitals across 29 OECD countries during 2000 and 2010. Afonso & Kazemi (2017) analysed both input and output oriented efficiency in public spending among 20 OECD countries by using data for the period 2009-2013. Mandl et al. (2008) examined the variation in public spending specially in education and Research & Development (R&D) sector and efficiency in these spending among 27 countries. Similarly, Aristovnik (2012) analysed the impact of Information and Communication Technology (ICT) on performance of education sector and their efficiency in European and OECD countries. By implementing DEA analysis, the findings reveal that there is a significant variation across countries in ICT efficiency.

Studies are also available that examined efficiency in health and/or education sector in developing countries. Jimenez & Lockheed (1995) compared the relative efficiency in public and private education at secondary level in five selected developing countries. Using DEA analysis, the results confirmed that efficiency of private schools is higher than public schools in relative terms. Pang & Herrera (2005) also examined the efficiency in public expenditure with special focus on health and education across 140 developing countries as a whole and region wise separately for the time period 1996 to 2002. Androniceanu & Ohanyan (2016) analysed the effect of International Monetary Fund (IMF) financial assistance program on comparative performance of education and healthcare system in two developing countries i.e. Romania and Bulgaria. Grigoli & Kapsoli (2018) calculated the efficiency in health expenditure in 80 developing and emerging countries during 2001-2010. A comprehensive study on efficiency in health and education sectors along with infrastructure sector was conducted by Herrera & Ouedraogo (2018) for 175 countries for the period 2006-2016 by using non-parametric techniques.

Some studies are also available that compared the cross countries efficiency in higher education sector. Agasisti & Pérez-Esparrells (2010) compared efficiency of 57 Italian and 46 Spanish universities in two time periods 2000-01 and 2004-05. For the comparison of efficiency in higher education, they used DEA. In overall, the efficiency of Spanish Universities is higher than Italian Universities. Agasisti & Johnes (2009) evaluated the efficiency in higher education across Italian and English universities during four year from 2001 to 2004. Joumady & Ris (2005) examined the performance of higher educational institution in eight European countries during 1994/95 by using DEA analysis. They considered 209 institutions of different characteristics and examined their technical efficiency.

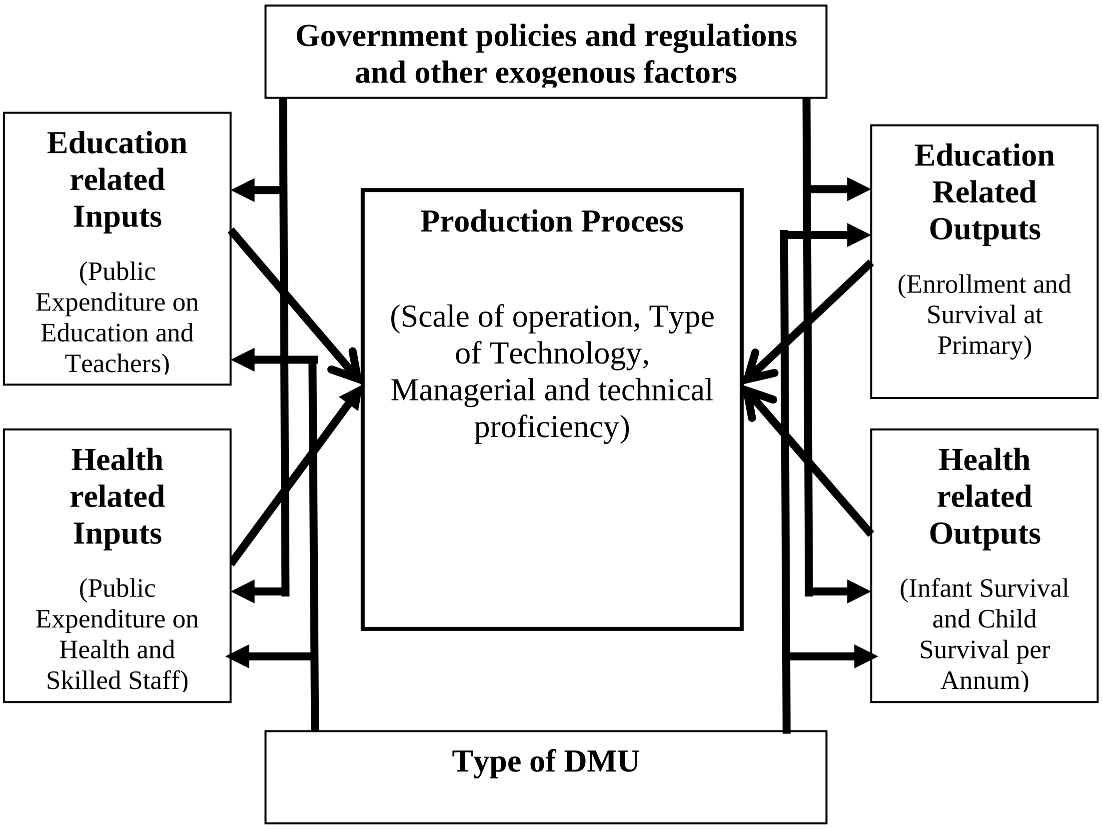
## 3. Material and methods

### 3.1 Theoretical framework

The Pure theory of public expenditure presented by Samuelson (1954) described that there are two types of economic quantities; one is called input and the other is called output. Everyone always wants to maximize the output while inputs/factors are those economic quantities which everyone always wants to minimize. Furthermore, the theory also stated that there is lack of efficiency in providing the public goods to the people due to not existing of market price for public goods. However, the efficiency in public expenditure could be measured that how much benefit government provided to their masses by using the revenue resources. We compare the cost and welfare of activities to assess how beneficial is government intervention while providing public goods. A state is said to be more efficient when it provides potentially possible maximum welfares to their residents from the use of given inputs (i.e. taxes) or if the public cost is lower than the welfare of an activity for the general masses.

The link between government input(s) and output(s) and the efficiency in this production process is given in figure-1. A government uses different inputs (monetary and non-monetary) to produce an output. The choice of input and output variable is based on MDGs targets and past literature (Afonso & Aubyn, 2006; Asandului et al., 2014; Mandl et al., 2008; Gupta & Verhoeven, 2001; Jimenez & Lockheed, 1995 etc.). The inputs for this study are public expenditures for basic education and health care services and physical capital in health and education sectors while the output is any facility or welfare gained by the masses i.e. Improvement in education and health. Here, in this process the efficiency is measured by the input/output ratio. Small value of the ratio means that less amount of a set of inputs is required to produce given level of output. Following figure 1 offer interconnection between factor inputs and outputs.

**Figure 1: Theoretical framework for the efficiency in production process**[8]




## 3.2 DEA framework

The Data Envelopment Analysis (DEA) model was first proposed and developed by Farrell (1957) and Charnes et al. (1978). The DEA model is used to measure the efficiency (relative efficiency) of different organizations or production units. The organizations or production units are called Decision Making Units (DMUs). The main function of the DMUs is to employ a specific combination of inputs to produce an efficient output or a set of efficient outputs.

The Mathematical form of the DEA model can be explained for each DMU and presented in output-input ratio by giving specific weight.

$$Efficiency\ Score = {Weighted\ Output(s)} \big/ {Weighted\ Input(s)} \quad \textbf{(1)}$$

A DMU is said to be relatively efficient if the efficiency score in equal to one, and relative inefficient if the score is otherwise.

[8] See Khan and Sulaiman, 2016.

### 3.2.1 The input oriented DEA model

The DEA analysis is based on linear programming. For n DMUs, $D_1, D_2, D_3, D_4, \ldots \ldots \ldots D_n$, the input oriented efficiency under CRS and VRS specification is defined by the given minimization problem as under;

$$\boldsymbol{Min\ \emptyset - \varepsilon\left(\sum_{j=1}^{m} sl_j^{\ -} + \sum_{k=1}^{l} sl_k^{\ +}\right)} \tag{2}$$

$$\boldsymbol{Constrain\ Function\ for\ CRS} \begin{cases} \sum_{i=1}^{n} \rho_i It_{ij} + sl_j^- = \emptyset IT & j = 1,2,\ldots.,m \\ \sum_{i=1}^{n} \rho_i Ot_{kj} - sl_k^+ = OT & k = 1,2,\ldots.,l \\ \rho_i \geq 0 & i = 1,2,\ldots.,n \end{cases} \tag{3}$$

$$\boldsymbol{Constrain\ Function\ for\ VRS} \begin{cases} \sum_{i=1}^{n} \rho_i It_{ij} + sl_j^- = \emptyset IT & j = 1,2,\ldots.,m \\ \sum_{i=1}^{n} \rho_i Ot_{kj} - sl_k^+ = OT & k = 1,2,\ldots.,l \\ \sum_{i=1}^{n} \rho_i = 1 & i = 1,2,\ldots.,n \end{cases} \tag{4}$$

In equation (2), (3) and (4), $\emptyset$is the efficiency score measure the technical efficiency of $i^{th}$ DMU, $IT$ is the vector of inputs and $OT$ is the vector of outputs, $sl_j^-$ and $sl_k^+$ are the slacks of inputs and outputs respectively. In case of input oriented efficiency, $\emptyset \leq 1$. A DMU is said to be inefficient and lie inside the frontier, if the value of $\emptyset$ is less than one. Alternatively, a DMU is said to be efficient if the value of $\emptyset$ is equal to one and hence the DMU will be lie on production frontier curve. $\rho$is the measure of weight given to $i^{th}$ DMU and give location to $i^{th}$ DMU according to its efficiency score. In input oriented efficiency model the objective is to achieve the fixed level of output by utilizing the possible minimum level of inputs.

### 3.2.2 Supper efficiency

After calculating overall technical, pure technical and scale efficiency for the year 2000 and 2015, we also calculated super efficiency by relaxing the assumption of maximum score of 100 percent (equal to one) for efficient DMUs. Super efficiency score enable us to rank DMUs according to their efficiency score. The study calculated input-oriented CRS supper efficiency model which is first time proposed by Andersen & Petersen (1993). This model rank efficient DMUs under CRS specification of DEA model. The study also calculates supper efficiency for input oriented VRS DEA model. This model allows us to rank pure technically efficient DMUs after allowing the constraint of maximum score beyond one (100 percent). The Objective and constraint functions under CRS and VRS based input oriented supper efficiency is calculated by the following problem.

$$\boldsymbol{Min\ \emptyset^S} \tag{5}$$

$$\boldsymbol{Constrain\ Function\ for\ CRS}\begin{cases}\sum_{i=1}^{n}\rho_i It_{ij} \leq \emptyset^s IT & j = 1,2,\ldots,m\\ \sum_{j=1}^{n}\rho_i Ot_{kj} \geq OT & k = 1,2,\ldots,l\\ \rho_i \geq 0 & i = 1,2,\ldots,n\end{cases} \quad \textbf{(6)}$$

$$\boldsymbol{Constrain\ Function\ for\ VRS}\begin{cases}\sum_{i=1}^{n}\rho_i It_{ij} \leq \emptyset^s IT & j = 1,2,\ldots,m\\ \sum_{j=1}^{n}\rho_i Ot_{kj} \geq OT & k = 1,2,\ldots,l\\ \sum_{i=1}^{n}\rho_i = 1 & i = 1,2,\ldots,n\end{cases} \quad \textbf{(7)}$$

In equations (5), (6) and (7) $\emptyset^s$ are the supper efficiency scores associated to each DMU.

### 3.2.3 Returns to scale

Next, to investigate Returns to Scale (RTS) in production process of each DMU, the study compare the efficiency score under CRS and VRS specifications. The returns to scale is calculated by taking the ratio of CRS based efficiency score and VRS based efficiency score for each DMU and the score are them compared with score obtained from non-increasing return to scale. Finally, the following conclusion is drawn;

i. First, CRS/VRS efficiency scores are obtained. If the ratio is equal to one, the DMU will follow CRTS and the DMU size is optimal.
ii. If the ratio is less than one, the DMU may face a disadvantage of its operation (The DMU size are either too small or too big).

## 3.3 Malmquist Productivity Index (MPI)

Malmquist Productivity Index (MPI) is an important technique in DEA framework which has been used for productivity measurement of a DMU over time based on technology of base year. The total productivity change of a DMU from one period to other period can be decomposed into two parts; firstly, it may be due to change in efficiency (real change in productivity) and secondly, it may be due to shift in efficient frontier because of change in technology.

Let us consider to calculate MPI across two time periods i.e. $t$ & $t+1$.

$$MPI_i^t = \frac{D_i^t(It^{t+1}, Ot^{t+1})}{D_i^t(It^t, Ot^t)} \quad \textbf{(8)}$$

$$MPI_i^{t+1} = \frac{D_i^{t+1}(It^{t+1}, Ot^{t+1})}{D_i^{t+1}(It^t, Ot^t)} \quad \textbf{(9)}$$

$$MPI_i^{G.Mean} = \left\{\frac{D_i^{t+1}(It^{t+1}, Ot^{t+1})}{D_i^t(It^t, Ot^t)}\right\} \times \left[\left\{\frac{D_i^t(It^t, Ot^t)}{D_i^{t+1}(It^t, Ot^t)}\right\}.\left\{\frac{D_i^t(It^{t+1}, Ot^{t+1})}{D_i^{t+1}(It^{t+1}, Ot^{t+1})}\right\}\right]^{1/2} \quad \textbf{(10)}$$

Here, the subscript $i$ shows that we are calculating MPI based on input oriented DEA. $It\ and\ Ot$ are inputs and outputs vectors respectively while $D_i^t and\ D_i^{t+1}$ show the distance function at two different time periods. In the above equation (10), the first part is called change in efficiency across time periods while the second part is called change in technology or shift in frontier.

### 3.4 Data

The study used secondary data for analysis for two different time periods; 2000 and 2015. The selection of these two time periods is due to MDGs as these goals were set in 2000 and completed in 2015. The countries (DMUs) were selected by the World Bank on the basis of income per capita. The main sources of data are World Development Indicator (WDI), Millennium Development Goals, The World Bank; United Nation MDGs Database.

**Table 1: Input and Output Variables with Name, Definition and Unit of Measurement and Reference Source of Selection**

| Input/ Output | Variable | Description/Operation Definition | Unit | Reason for Selection |
|---|---|---|---|---|
| **Input** | **Educational Expenditure** | Total public educational expenditure measured in current US $. | USD | Gupta & Verhoeven (2001) |
| **Input** | **Teachers at Primary Level** | Total teachers employed at primary level. | Numbers | Afonso & Aubyn (2005) |
| **Input** | **Health Expenditure** | Total public sector expenditure measured in current US $. | USD | Gupta & Verhoeven (2001) |
| **Input** | **Birth Attended by Skilled Staff** | Total number of children attended by skilled staff during birth. | Numbers | MDGs Target 5.2 |
| **Output** | **Net Enrollment Rate at Primary** | Total number of children enrolled at primary level | Numbers | MDGs Goal 2.1, Gupta & Verhoeven, 2001 |
| **Output** | **Completed Primary** | Total number of enrolled students who completed primary level education | Numbers | MDGs Target 2.2, Hauner & Kyobe (2010) |
| **Output** | **Infant survival** | Total number of children survived under the age of one year. | Numbers | MDGs Target 4.2, Afonso & Aubyn (2005) |
| **Output** | **Child survival** | Total number of children survived under the age of five years. | Numbers | MDGs Target 4.1, Afonso & Aubyn (2005) |

## 4. Results and discussion

### 4.1 Efficiency analysis for the year 2000

The results of DEA model for the year 2000 is presented in table-2 below. The first column of the table describes name of a country (DMU). Column 2 and 3 present overall technical efficiency scores of countries and their ranking on the basis of CRS specification respectively. The CRS results show that out of 64 countries, only ten (10) countries are relative efficient having score one and ranked as one in order (Shown as bold). The ten efficient DMUs in public health and education sector under CRS are Albania, Argentina, Belarus, Bhutan, Cameroon, Ghana, Macedonia, Pakistan, South Africa and Vanuatu. In the remaining inefficient DMUs, Costa and Cuba are only 2 percent inefficient (score=0.98) while Iran and Peru are the most inefficient DMUs having efficiency scores 0.30 and 0.28 respectively. It means that for Costa and Cuba there is a need of only two percent improvement to reach to the desirable efficient level while Iran and Peru need almost 70 percent improvement (70 percent inefficient) in the usage of input resources to become efficient while targeting selected MDGs.

The CRS model shows technical efficiency mixed with scale efficiency. To calculate the pure technical efficiency, we run the DEA model under Variable Returns to Scale (VRS).The efficiency score and raking of countries based on VRS specification is presented in column 4 and five. The VRS efficiency gives the pure technical efficiency of a DMU that how efficiently they convert inputs into desirable outputs. In our case, out of 64 countries 29 countries are relative efficient having score equal to one and ranked as one. It means that almost half of DMUs are efficient technically. Panama and Cuba are only one and two percent technically inefficient (99 and 98 percent efficient) respectively. Technically, most inefficient DMUs in education and health sector for the year 2000 are Vietnam, Indonesia and Kiribati.

Column six gives the Returns to Scale (RTS) information of countries in health and education sector. RTS specification gives information about the operating size of DMU and show that the inefficiency is either due to small size or large size. A country will be operating at optimal size if RTS is constant and will be operating at small size if RTS is increasing and will be operating at large size if RTS is decreasing. The results show that ten (10) relative efficient DMUs are operating at optimal level showing the RTS as constant. Only two countries have shown increasing RTS which means that they are inefficient in term of scale efficiency due to small size of health and education sector and can achieve the optimal size of operation and become efficient by increasing the size of health and education sector. The other remaining DMUs are inefficient in term of scale efficiency because they are operating above the optimal level and shown decreasing RTS.

The CRS and VRS efficiency model has the assumption that a DMU can get a maximum score of one (100 percent) and is bound between 0 and 1. Now by relaxing this assumption, we can rank the efficient DMUs as it allows the efficient DMUs to get score above one. For this, the study also calculates supper efficiency under CRS and VRS specification. Supper efficiency is used to rank the efficient DMUs. The scores of inefficient DMUs remains the same as they are already getting score below one. Under CRS specification supper efficiency score indicate that within efficient DMUs, Vanuatu is ranked at number one because the supper efficiency score is 3.44 which is maximum among all the DMUs' score. Bhutan get second highest score under CRS supper efficiency and ranked at number two while Ghana is at number 10 and get minimum score among efficient DMUs. Under VRS supper efficiency specification, we see that some countries are ranked as infeasible and ranked as one. The meaning of infeasible score under VRS supper efficiency is that the scores of these DMUs are extremely large in number and they are the most efficient DMUs. Therefore, we give top ranking of one to all those five DMUs which marked as "infeasible" under VRS supper efficiency model.

**4.2 Efficiency analysis for the year 2015**

The results of relative efficiency calculated by DEA model under different specifications for the year 2015 is presented in table-3. Total numbers of selected DMUs for the year 2015 are 42 selected middle income countries. The result of CRS model is presented in column two. CRS efficiency score gives the overall relative efficiency (both technical and scale combined) of a DMU under the assumption that all DMUs are operating at efficient frontier. The CRS results show that out of 42 countries, eight (08) countries i.e. Belarus, Domenici, Ecuador, Pakistan, Panama, Sao Tome, Vincent & Grenadines and Fiji are relative efficient having score one and ranked as number one in order. In the remaining inefficient DMUs, Maldives, Serbia and Peru are only one percent inefficient (99 percent efficient) and Grenada, Macedonia, Tajikistan and Romania are only two percent inefficient (98 percent efficient). Total 28 countries get score above or equal to 0.90 and show 90 percent or above efficiency level. The most inefficient DMUs are Mexico, China and Brazil respectively.

To calculate the pure technical efficiency, we run the DEA model under Variable Returns to Scale (VRS) specification. The efficiency score and raking of countries based on VRS specification is presented in column 4 and 5. The VRS efficiency gives the pure technical efficiency of a DMU that how efficiently they convert inputs into outputs. In our case, out of 42 countries 17 countries are relative efficient in education and health having score equal to one and ranked as one. A total of 38 DMUs scored above or equal to 90 percent. The most inefficient DMU under VRS in health and education sector is also Brazil having score of 0.71.

Returns to Scale (RTS) information of countries in health and education sector are presented in column 6. RTS specification gives information about the operating size of DMU and show that inefficiency is either due to small size or large size of a DMU. The results show that seven (07) relative efficient DMUs are operating at optimal level showing the RTS as constant. Fourteen (14) countries have shown increasing RTS which means that they are inefficient in term of scale efficiency due to small size of health and education sector and can achieve the optimal size of operation and become efficient by increasing the size of health and education sector. The remaining DMUs are inefficient in term of scale efficiency because they are operating above the optimal level and shown decreasing RTS.

Sao Tome is ranked at number one because the supper efficiency score is 4.47 which is maximum among all DMUs' scores. Belarus and Domenici get second and third highest score under CRS supper efficiency and ranked as number two and three respectively while Fiji is at number 08 and get minimum score among efficient DMUs. Under VRS supper efficiency specification, we see that some countries are marked as infeasible and ranked as one. The meaning of infeasible score under VRS supper efficiency is that the scores of these DMUs are extremely large and they are most efficient DMUs. Therefore, we give top ranking of one to all these Six DMUs which marked as “infeasible” under VRS supper efficiency model. The minimum scores of efficient DMUs under VRS supper efficiency specification are assigned to Indonesia, Panama and Tajikistan.

**4.3 Malmquist Productivity Index (MPI) analysis**

Change in productivity, over the time from 2000 (base period) to 2015 (current period), in health and education sector has been assessed via Malmquist Productivity Index (MPI). The MPI shows change in efficiency from one period to other period along with sources of change in efficiency. Thirty three (33) middle income countries based on their classification as middle income countries in 2000 and 2015 were selected for MPI analysis and the results are presented in table-4. The first column present the names of DMUs, the score of MPI based on CRS DEA specification is presented in column two while column three and four presents the sources of change in efficiency i.e. change in efficiency and change in frontier respectively. The Malmquist Index score show that out of 33 DMUs, sixteen have scored less than one while seventeen DMUs reported score greater than 1. It means that sixteen DMUs reported decline in change in efficiency from period 2000 to 2015 while seventeen DMUs reported improvement in efficiency from base period to the current period. The efficiency from one period to another period changed because of two reasons; improvement in technical efficiency of DMUs or because of change in technology (frontier shift). If the score of change in efficiency is less than, equal to or greater than one it means that real efficiency increased, remains constant or decreased respectively from 2000 to 2015. The analysis shows that for twenty five DMUs ‘change in efficiency’ score is observed less than one which indicate that real technical productivity of these DMUs has improved over time. The change in efficiency score of three DMUs are equal to one it means that the real efficiency of these DMUs did not change over time. The remaining five DMUs efficiency has been decreased over time (see column 3). The result of shift in frontier indicates that twenty two DMUs reported a positive shift in DEA frontier across the period while eleven DMUs reported decline in DEA frontier across the periods. For Albania, Azerbaijan, Cuba Kyrgyz, Macedonia, Pakistan and South Africa the source of increase in productivity was technological change during the period. Brazil, Bulgaria, Indonesia, Iran, other countries like Mexico, Panama, Russia, Thailand, Uzbekistan and Vietnam reported positive change in productivity due to real technical efficiency change. The reason of decline in productivity in Belarus, Belize, Domenici, Dominican Republic, Ecuador, Fiji, Georgia, Kazakhstan, Mongolia, Romania and Sri Lanka was change in efficiency frontier (technological change) across the periods.

## Table 2: Results of DEA model under different specifications for the year 2000

| Country | CRS Specification | | VRS Specification | | Returns to Scale | Supper Efficiency Under CRS | | Supper Efficiency Under VRS | |
|---|---|---|---|---|---|---|---|---|---|
| | Score | Rank | Score | Rank | (RTS) | Score | Rank | Score | Rank |
| Albania | **1.00** | **1** | **1.00** | **1** | Constant | **1.29** | **7** | 20.46 | 3 |
| Algeria | 0.93 | 4 | **1.00** | **1** | Decreasing | 0.93 | | 21.27 | 2 |
| Argentina | **1.00** | **1** | **1.00** | **1** | Constant | **1.64** | **5** | 1.67 | 11 |
| Armenia | 0.92 | 5 | 0.94 | 4 | Decreasing | 0.92 | --- | 0.94 | --- |
| Azerbaijan | 0.95 | 3 | **1.00** | **1** | Decreasing | 0.95 | --- | 6.49 | 4 |
| Belarus | **1.00** | **1** | **1.00** | **1** | Constant | **3.20** | **3** | 3.20 | 7 |
| Belize | 0.70 | 14 | 0.86 | 12 | Decreasing | 0.70 | --- | 0.86 | --- |
| Bhutan | **1.00** | **1** | **1.00** | **1** | Constant | **3.27** | **2** | 5.07 | 5 |
| Botswana | 0.91 | 6 | 0.91 | 7 | Increasing | 0.91 | --- | 0.91 | --- |
| Brazil | 0.65 | 17 | 0.87 | 11 | Decreasing | 0.65 | --- | 0.87 | --- |
| Bulgaria | 0.64 | 18 | 0.86 | 12 | Decreasing | 0.64 | --- | 0.86 | --- |
| Cabo | 0.73 | 12 | 0.74 | 18 | Decreasing | 0.73 | --- | 0.74 | --- |
| Cambodia | 0.43 | 34 | **1.00** | **1** | Decreasing | 0.43 | --- | 1.18 | 19 |
| Cameroon | **1.00** | **1** | **1.00** | **1** | Constant | **1.20** | **9** | 1.21 | 17 |
| Colombia | 0.67 | 16 | 0.79 | 16 | Decreasing | 0.67 | --- | 0.79 | --- |
| Costa | 0.98 | 2 | **1.00** | **1** | Decreasing | 0.98 | --- | 1.04 | 22 |
| Cote | 0.46 | 31 | 0.80 | 15 | Decreasing | 0.46 | --- | 0.80 | --- |
| Cuba | 0.98 | 2 | 0.98 | 3 | Increasing | 0.98 | --- | 0.98 | --- |
| Dominica | 0.61 | 21 | 0.89 | 9 | Decreasing | 0.61 | --- | 0.89 | --- |
| Dominican Republic | 0.45 | 32 | 0.87 | 11 | Decreasing | 0.45 | --- | 0.87 | --- |
| Ecuador | 0.34 | 40 | 0.90 | 8 | Decreasing | 0.34 | --- | 0.90 | --- |
| Egypt | 0.67 | 16 | **1.00** | **1** | Decreasing | 0.67 | --- | 1.01 | 23 |
| Fiji | 0.48 | 29 | **1.00** | **1** | Decreasing | 0.48 | --- | 2.60 | 9 |
| Georgia | 0.57 | 24 | **1.00** | **1** | Decreasing | 0.57 | --- | 3.25 | 6 |
| Ghana | **1.00** | **1** | **1.00** | **1** | Constant | **1.09** | **10** | 1.16 | 20 |
| Guatemala | 0.40 | 36 | 0.89 | 9 | Decreasing | 0.40 | --- | 0.89 | --- |
| Guyana | 0.45 | 32 | 0.82 | 13 | Decreasing | 0.45 | --- | 0.82 | --- |
| India | 0.87 | 8 | 0.89 | 9 | Decreasing | 0.87 | --- | 0.89 | --- |
| Indonesia | 0.61 | 21 | 0.65 | 20 | Decreasing | 0.61 | --- | 0.65 | --- |
| Iran | 0.30 | 42 | 0.93 | 5 | Decreasing | 0.30 | --- | 0.93 | --- |
| Jordan | 0.71 | 13 | **1.00** | **1** | Decreasing | 0.71 | --- | 1.21 | 18 |
| Kazakhstan | 0.47 | 30 | 0.92 | 6 | Decreasing | 0.47 | --- | 0.92 | --- |
| Kiribati | 0.52 | 27 | 0.54 | 21 | Decreasing | 0.52 | --- | 0.54 | --- |
| Kyrgyz | 0.84 | 9 | **1.00** | **1** | Decreasing | 0.84 | --- | 1.01 | 24 |
| Lao | 0.50 | 28 | **1.00** | **1** | Decreasing | 0.50 | --- | 1.51 | 13 |
| Lebanon | 0.33 | 41 | 0.94 | 4 | Decreasing | 0.33 | --- | 0.94 | --- |
| Lesotho | 0.58 | 23 | 0.75 | 17 | Decreasing | 0.58 | --- | 0.75 | --- |
| Macedonia | **1.00** | **1** | **1.00** | **1** | Constant | **2.22** | **4** | 2.87 | 8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mauritania | 0.48 | 29 | 0.91 | 7 | Decreasing | 0.48 | --- | 0.91 | --- |
| Mauritius | 0.38 | 37 | 0.80 | 15 | Decreasing | 0.38 | --- | 0.80 | --- |
| Mexico | 0.48 | 29 | **1.00** | **1** | Decreasing | 0.48 | --- | 1.43 | 14 |
| Moldova | 0.36 | 39 | **1.00** | **1** | Decreasing | 0.36 | --- | **infeasible** | **1** |
| Mongolia | 0.68 | 15 | **1.00** | **1** | Decreasing | 0.68 | --- | 1.36 | 15 |
| Myanmar | 0.37 | 38 | 0.88 | 10 | Decreasing | 0.37 | --- | 0.88 | --- |
| Namibia | 0.45 | 32 | 0.82 | 13 | Decreasing | 0.45 | --- | 0.82 | --- |
| Nicaragua | 0.41 | 35 | 0.91 | 7 | Decreasing | 0.41 | --- | 0.91 | --- |
| Nigeria | 0.45 | 32 | **1.00** | **1** | Decreasing | 0.45 | --- | 1.10 | 21 |
| Pakistan | **1.00** | **1** | **1.00** | **1** | Constant | **1.27** | **8** | 1.28 | 16 |
| Panama | 0.63 | 19 | 0.99 | 2 | Decreasing | 0.63 | --- | 0.99 | --- |
| Peru | 0.28 | 43 | **1.00** | **1** | Decreasing | 0.28 | --- | **infeasible** | **1** |
| Philippines | 0.59 | 22 | 0.86 | 12 | Decreasing | 0.59 | --- | 0.86 | --- |
| Romania | 0.89 | 7 | **1.00** | **1** | Decreasing | 0.89 | --- | 1.93 | 10 |
| Russia | 0.81 | 10 | **1.00** | **1** | Decreasing | 0.81 | --- | 1.01 | 25 |
| South Africa | **1.00** | **1** | **1.00** | **1** | Constant | **1.49** | **6** | 1.55 | 12 |
| Sri Lanka | 0.56 | 25 | 0.86 | 12 | Decreasing | 0.56 | --- | 0.86 | --- |
| Tajikistan | 0.58 | 23 | 0.90 | 8 | Decreasing | 0.58 | --- | 0.90 | --- |
| Thailand | 0.55 | 26 | **1.00** | **1** | Decreasing | 0.55 | --- | **infeasible** | **1** |
| Tonga | 0.46 | 31 | 0.82 | 13 | Decreasing | 0.46 | --- | 0.82 | --- |
| Tunisia | 0.75 | 11 | 0.82 | 13 | Decreasing | 0.75 | --- | 0.82 | --- |
| Ukraine | 0.40 | 36 | **1.00** | **1** | Decreasing | 0.40 | --- | **infeasible** | **1** |
| Uzbekistan | 0.44 | 33 | 0.80 | 15 | Decreasing | 0.44 | --- | 0.80 | --- |
| Vanuatu | **1.00** | **1** | **1.00** | **1** | Constant | 3.44 | **1** | **infeasible** | **1** |
| Vietnam | 0.57 | 24 | 0.68 | 19 | Decreasing | 0.57 | --- | 0.68 | --- |
| Zambia | 0.62 | 20 | 0.81 | 14 | Decreasing | 0.62 | --- | 0.81 | --- |

## Table 3: Results of DEA model under different specifications for the year 2015

| Country | CRS Specification | | VRS Specification | | Returns to Scale (RTS) | Supper Efficiency Under CRS | | Supper Efficiency Under VRS | |
|---|---|---|---|---|---|---|---|---|---|
| | Score | Rank | Score | Rank | | Score | Rank | Score | Rank |
| Albania | 0.87 | 14 | 0.92 | 8 | Increasing | 0.87 | --- | 0.92 | --- |
| Azerbaijan | 0.86 | 15 | 0.90 | 10 | Increasing | 0.86 | --- | 0.90 | --- |
| Belarus | **1.00** | **1** | **1.00** | **1** | Constant | **1.61** | **2** | **2.16** | **5** |
| Belize | 0.92 | 8 | 0.95 | 5 | Increasing | 0.92 | --- | 0.95 | --- |
| Brazil | 0.66 | 22 | 0.71 | 13 | Decreasing | 0.66 | --- | 0.71 | --- |
| Bulgaria | 0.89 | 13 | 0.92 | 8 | Increasing | 0.89 | --- | 0.92 | --- |
| China | 0.72 | 21 | 0.84 | 12 | Decreasing | 0.72 | --- | 0.84 | --- |
| Colombia | 0.84 | 16 | 0.84 | 12 | Increasing | 0.84 | --- | 0.84 | --- |
| Cuba | 0.96 | 4 | 0.99 | 2 | Decreasing | 0.96 | --- | 0.99 | --- |
| Dominica | **1.00** | **1** | **1.00** | **1** | Constant | **1.59** | **3** | **1.60** | **7** |
| Dominican Republic | 0.92 | 8 | 0.93 | 7 | Increasing | 0.92 | --- | 0.93 | --- |
| Ecuador | **1.00** | **1** | **1.00** | **1** | Constant | **1.48** | **5** | **infeasible** | **1** |
| El Salvador | 0.90 | 10 | 0.91 | 9 | Increasing | 0.90 | --- | 0.91 | --- |
| Fiji | **1.00** | **1** | **1.00** | **1** | Decreasing | **1.00** | **8** | **infeasible** | **1** |
| Georgia | 0.94 | 6 | 0.95 | 5 | Increasing | 0.94 | --- | 0.95 | --- |
| Grenada | 0.98 | 3 | 0.99 | 2 | Increasing | 0.98 | --- | 0.99 | --- |
| Indonesia | 0.82 | 18 | **1.00** | **1** | Decreasing | 0.82 | --- | **1.01** | **10** |
| Iran | 0.79 | 19 | 0.88 | 11 | Decreasing | 0.79 | --- | 0.88 | --- |
| Kazakhstan | 0.94 | 6 | 0.94 | 6 | Decreasing | 0.94 | --- | 0.94 | --- |
| Kyrgyz | 0.95 | 5 | 0.95 | 5 | Increasing | 0.95 | --- | 0.95 | --- |
| Macedonia | 0.98 | 3 | 0.98 | 3 | Increasing | 0.98 | --- | 0.98 | --- |
| Malaysia | 0.83 | 17 | 0.90 | 10 | Decreasing | 0.83 | --- | 0.90 | --- |
| Maldives | 0.99 | 2 | 0.99 | 2 | Increasing | 0.99 | --- | 0.99 | --- |
| Mexico | 0.78 | 20 | 0.91 | 9 | Decreasing | 0.78 | --- | 0.91 | --- |
| Moldova | 0.96 | 4 | 0.96 | 4 | Increasing | 0.96 | --- | 0.96 | --- |
| Mongolia | 0.96 | 4 | 0.96 | 4 | Increasing | 0.96 | --- | 0.96 | --- |
| Pakistan | **1.00** | **1** | **1.00** | **1** | Constant | **1.49** | **4** | **1.56** | **8** |
| Panama | **1.00** | **1** | **1.00** | **1** | Constant | **1.01** | **7** | **1.01** | **10** |
| Peru | 0.99 | 2 | **1.00** | **1** | Decreasing | 0.99 | --- | **1.04** | **9** |
| Romania | 0.98 | 3 | **1.00** | **1** | Decreasing | 0.98 | --- | **infeasible** | **1** |
| Russia | 0.84 | 16 | 0.91 | 9 | Decreasing | 0.84 | --- | 0.91 | |
| Sao Tome | **1.00** | **1** | **1.00** | **1** | Constant | **4.74** | **1** | **63.07** | **3** |
| Serbia | 0.99 | 2 | 0.99 | 2 | Decreasing | 0.99 | --- | 0.99 | |
| South Africa | 0.93 | 7 | **1.00** | **1** | Decreasing | 0.93 | --- | **infeasible** | **1** |
| Sri Lanka | 0.91 | 9 | **1.00** | **1** | Decreasing | 0.91 | --- | **1.70** | **6** |
| Tajikistan | 0.98 | 3 | **1.00** | **1** | Decreasing | 0.98 | --- | **1.01** | **10** |
| Thailand | 0.82 | 18 | 0.94 | 6 | Decreasing | 0.82 | --- | 0.94 | |
| Turkey | 0.89 | 12 | **1.00** | **1** | Decreasing | 0.89 | --- | **infeasible** | **1** |
| Ukraine | 0.87 | 14 | 0.98 | 3 | Decreasing | 0.87 | --- | 0.98 | |
| Uzbekistan | 0.93 | 7 | **1.00** | **1** | Decreasing | 0.93 | --- | **4.15** | **4** |
| Vietnam | 0.90 | 11 | **1.00** | **1** | Decreasing | 0.90 | --- | **infeasible** | **1** |
| Vincent & Grenadines | **1.00** | **1** | **1.00** | **1** | Constant | **1.03** | **6** | **562.47** | **2** |

**Table 4: Malmquist Productivity Index (MPI) analysis (2000 is base period and 2015 is current period)**

| Country (DMUs) | Based on Input-Oriented CRS | | | Change in Productivity | Change in Efficiency | Shift in Frontier |
|---|---|---|---|---|---|---|
| | Malmquist Index | Efficiency Change | Frontier Shift | | | |
| Albania | 2.71699 | 1.09325 | 2.48523 | Increased | Decreased | Upward |
| Azerbaijan | 3.40103 | 1.11239 | 3.05742 | Increased | Decreased | Upward |
| Belarus | 0.45250 | 1.00000 | 0.45250 | Decreased | Constant | Downward |
| Belize | 0.38226 | 0.73439 | 0.52051 | Decreased | Increased | Downward |
| Brazil | 1.97190 | 0.99079 | 1.99024 | Increased | Increased | Upward |
| Bulgaria | 1.68722 | 0.78787 | 2.14148 | Increased | Increased | Upward |
| Colombia | 0.92634 | 0.82876 | 1.11775 | Decreased | Increased | Upward |
| Cuba | 2.59667 | 1.03569 | 2.50719 | Increased | Decreased | Upward |
| Dominica | 0.59918 | 0.64349 | 0.93113 | Decreased | Increased | Downward |
| Dominican Republic | 0.32780 | 0.49657 | 0.66013 | Decreased | Increased | Downward |
| Ecuador | 0.21486 | 0.38152 | 0.56317 | Decreased | Increased | Downward |
| Fiji | 0.25136 | 0.50007 | 0.50266 | Decreased | Increased | Downward |
| Georgia | 0.46556 | 0.59935 | 0.77677 | Decreased | Increased | Downward |
| Indonesia | 1.79807 | 0.81386 | 2.20931 | Increased | Increased | Upward |
| Iran | 1.26497 | 0.40580 | 3.11722 | Increased | Increased | Upward |
| Kazakhstan | 0.49445 | 0.57549 | 0.85918 | Decreased | Increased | Downward |
| Kyrgyz | 2.29275 | 1.02357 | 2.23996 | Increased | Decreased | Upward |
| Macedonia | 2.33637 | 1.00918 | 2.31512 | Increased | Constant | Upward |
| Mexico | 1.57580 | 0.69200 | 2.27719 | Increased | Increased | Upward |
| Moldova | 0.76436 | 0.41929 | 1.82297 | Decreased | Increased | Upward |
| Mongolia | 0.36647 | 0.68751 | 0.53304 | Decreased | Increased | Downward |
| Pakistan | 1.75203 | 1.00000 | 1.75203 | Increased | Constant | Upward |
| Panama | 1.79264 | 0.66671 | 2.68879 | Increased | Increased | Upward |
| Peru | 0.54764 | 0.28947 | 1.89189 | Decreased | Increased | Upward |
| Romania | 0.51748 | 0.89894 | 0.57566 | Decreased | Increased | Downward |
| Russia | 2.28680 | 0.98098 | 2.33115 | Increased | Increased | Upward |
| South Africa | 4.21227 | 1.07322 | 3.92488 | Increased | Decreased | Upward |
| Sri Lanka | 0.65025 | 0.65482 | 0.99302 | Decreased | Increased | Downward |
| Tajikistan | 0.68073 | 0.60609 | 1.12314 | Decreased | Increased | Upward |
| Thailand | 1.78594 | 0.65546 | 2.72470 | Increased | Increased | Upward |
| Ukraine | 0.58997 | 0.43848 | 1.34547 | Decreased | Increased | Upward |
| Uzbekistan | 1.30986 | 0.51579 | 2.53950 | Increased | Increased | Upward |
| Vietnam | 1.18014 | 0.65504 | 1.80164 | Increased | Increased | Upward |

## 5. Conclusion and recommendations

This study examined the relative efficiency in public education and health sector in selected middle income countries regarding MDGs targets for two different time periods; 2000 and 2015. Educational expenditure, teachers at primary level, heath expenditure, birth attended by skilled staff are used as inputs; enrollment at primary level, survival at primary level, Infant and child survival per annum are used as outputs. DEA technique has been utilized to measure efficiency under CRS, VRS and Supper Efficiency specification to calculate overall relative efficiency, pure technical efficiency and ranking of efficient DMUs. Returns to Scale of DMUs are also calculated to observe the size of DMU while MPI technique is used to investigate the change in productivity and sources of change in productivity across the two periods.

The results of the study indicate that the level of efficiency is different among DMUs under different DEA specification in both time periods. The result is mixed; most of the countries show technical inefficiency in achieving the MDGs targets related to health and education sector. Some countries are inefficient because there size of operation is too big or too small. Some countries shown improvement in productivity and efficiency over time either because of improvement in technical efficiency or technological improvement.

The results of this study suggest that there is a vast scope for further improvement both in education and health sectors. Countries could increase their efficiency both technically and scale wise. To achieve the targets of MDGs, particularly health and education related targets; countries need to increase resources for health and education sectors. There is also need to utilize these resources efficiently and optimally. There is a great potential for inefficient countries to improve their performance in health and education sectors with given resources. The results suggest that inefficiency is observed in both; technical and scale related aspects.

The current study has some limitations and there exist space for further detail investigation of phenomenon in future. The study evaluated efficiency for two time periods only and one could study it for multi time periods and analyze it through panel data approach. Various economic, social, environmental determinants could be investigated for the source of efficiency/inefficiency in health and education sector. There is also need of efficiency analysis of both sectors separately. The study may also be conducted for a large sample of data by including lower income countries.

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