

# **Operational Performance of the Bangladesh Rural Electrification Program and its Determinants with a Focus on Political Interference**

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## **1. Introduction**

Corruption is the abuse of power that uses public resources for private gain (Andvig, 2006). The majority of studies on corruption indicate that corruption discourages investment and foreign aid (Davis, 2004; Wei, 1999). Therefore, corruption is costly and is an obstacle to economic development (Beenstock, 1979; Macrae, 1982). In particular, corruption is pervasive in developing countries (Sharma, 2006). On the other hand, some studies find positive consequences of corruption for economic development (Rock et al., 2004).

According to surveys on corruption conducted by Transparency International, Bangladesh has been ranked as one of the most corrupt countries since 2001. In addition, the World Bank reports that Bangladesh's level of corruption has been

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increasing in the last 10 years (Transparency International, 2007; World Bank, 2007a).

In 2007, for example, Sheikh Hasina, the Prime Minister from 1996 to 2001 and the leader of the Awami League, one of two major parties in Bangladesh, was accused of taking kickbacks in a power plant deal (The Daily Star, 2007).

Amid such corruption, Bangladesh's Rural Electrification Program (REP), which was implemented in the late 1970s with the assistance of the United States Agency for International Development (USAID), had successfully established anticorruption systems for maintaining governance (USAID, 2006). As a consequence, the REP has been growing in size nationwide during the last three decades, has increased the number of electrified households and has brought numerous economic and social benefits to rural people, including improvements in agricultural productivity and the creation of new jobs (Barkat et al., 2002). Because of the well-designed systems, the REP in Bangladesh is often considered one of the best examples of rural electrification in the international cooperation arena (Gunaratne, 2002). Attempts have been made to apply Bangladesh's experience to other regions' rural electrification programs such as India, Nepal and Senegal (ADB, 2003; Sato et al., 1999).

However, the reputation of the recent REP started to deteriorate because of political interference. During the initial stage of the program, the scale of operation was small, covering only limited areas. Over the past 30 years, the program has

expanded throughout the entire country. With the successful expansion of the program, it is conceivable that politicians and bureaucracies could no longer ignore the program and recognized it as fruitful for their political interests, such as extending their influence (Bai et al., 2008). For instance, the government has pledged to construct 40-kilometer-long new lines in areas under constituencies of all Members of Parliament (MPs). It has been said that because of political and bureaucratic influence, 87% of scheduled programs could not be implemented in the past 22 years (The Independent, 2006).

The objective of this study is, therefore, to see how the REP's operational performance changes over time, using "efficiency" as criteria. Furthermore, through the assessment of historical changes in efficiency, this study tries to analyze factors that affect the efficiency of the program, with a focus on political interference. Here, we tried to examine in detail whether political interference has an impact on efficiency. Therefore, if a statistically significant negative correlation exists between efficiency deterioration and political interference, then we could argue that corruption may cause adverse effects on the operational performance of the REP.

The Government of Bangladesh (GoB) has committed to providing electricity for all by 2020. To achieve the GoB's vision, it is useful to have a better understanding of diminishing returns to scale for the incremental investments in the REP resulting from

the efficiency changes. Previous studies on rural electrification discussed social and economic impacts and effectiveness of institutional models (Barkat et al., 2002; Sato et al., 1999). However, few studies discussed the efficiency of the REP quantitatively and explicitly examine relationships between operational efficiency and political intervention. In this sense, this study is a first attempt to review the historical efficiency changes of the REP in Bangladesh using a quantitative approach.

In the next section, the organizational structure of the Bangladesh power sector and an overview of the REP are discussed. Section 3 discusses the methodology and describes the data set used for this study. Section 4 shows the estimation results. Section 5 provides concluding comments.

## **2. Review of the Power Sector in Bangladesh**

### *2.1. Electric Power Distribution*

This section discusses the electric power distribution sectors in Bangladesh and gives an overview of the REP, which is mainly responsible for the provision of electricity to rural Bangladesh.

Responsibility of electricity distribution in Bangladesh is largely shared by the following institutions: Bangladesh Power Development Board (BPDB), Dhaka Electric Supply Authority (DESA), and Rural Electrification Board (REB)/Palli

Bidyut Samity (PBS, which in English word means rural electric cooperatives) of the REP. BPDB is responsible not only for distribution of electricity but also for generation and transmission. Its distribution jurisdiction mainly covers urban areas. DESA provides electricity to the metropolitan area of Dhaka. Finally, REB/PBS are responsible for the distribution of electricity in rural areas.

BPDB was established in 1972, a year after the independence of Bangladesh. It was the sole utility, responsible for generation, transmission, and distribution of electricity. However, its financial condition deteriorated because of “negligence in management” as typified by a low bill collection rate and high system losses (nontechnical loss) reflecting power theft and inaccurate meter readings. Therefore, major donors required a restructuring of BPDB. In response to the request for restructuring of BPDB, DESA was established in 1990 and distribution function for the greater Dhaka area was transferred from BPDB to DESA as a part of the dismantling process.

Despite the reform, the goal of sound management at DESA had remained unattained since DESA took over the facilities and employees of BPDB. Because of the unremedied poor performance of BPDB and DESA, some donors suspended assistance to them (USAID, 2006). While other power sector entities in Bangladesh suffered from poor management, REB/PBSs achieved relatively favorable business conditions. Therefore, the REP attracted continuous assistance from multiple donors,

unlike the other distribution entities.

## *2.2. Bangladesh Rural Electrification Program*

Why had the REP been admired, unlike others? What mechanisms of preventing corruption did the REP apply? Here, we analyze the program and try to understand how the REP established anticorruption systems.

As discussed briefly above, the history of the REP goes back nearly 30 years. In the 1970s, less than 3% of the population in Bangladesh had access to electricity. Almost all rural areas, which accounted for more than 90% of the nation's geographical area, were not covered by the national grid because of operational difficulties. In response, the GoB attached top priority to the acceleration of the provision of electricity to rural areas to stimulate economic growth and social development through international cooperation. As a result, in 1976, the GoB engaged two American firms, the National Rural Electric Cooperative Association (NRECA) and Commonwealth Associates Inc. (CAI) to carry out a comprehensive feasibility study on rural electrification in Bangladesh, financed by USAID. In response to the results of the study, it was decided that the US cooperative model would be applied to Bangladesh, which successfully electrified rural America in the 1930s. As the first step in implementing the program, the REB was established in 1977, with the

responsibility of implementing countrywide rural electrification. The actual operation of the program is conducted through a rural electric cooperative known as PBS, based on the cooperative concept that would ensure direct participation by beneficiaries. REB is positioned as a central agency under the GoB, responsible for organizing, financing, administering, and monitoring the activities of PBSs. It was created to systematize the program based on the experience of the Philippines where the NRECA supported a rural electrification program before the project in Bangladesh (Sato et al., 1999). The role of PBS is to construct electricity distribution facilities in rural areas, manage and operate the facilities, and conduct electric power distribution activities under the supervision of REB.

The program is carefully designed to prevent fraud and keep its independency and autonomy using various anticorruption measures. In each PBS, the beneficiaries elect their representatives and the elected people form a board of directors that has a right to make decisions on all aspects of management of PBSs. Thus, the board of directors is quite influential. Members of political parties are excluded from being board members to avoid political intervention in project operations. This reflects the lesson learned from the Philippine case. In addition, as part of the corruption prevention measures, the working routes of meter readers and those who serve bills are changed regularly. Transparency and accountability of PBSs' affairs are also ensured to build trust with

local people as well as donors. All PBSs need to collect and report all kinds of data associated with operations and management to REB on a monthly basis. The collected data are combined in the form of a monthly report called management information system (MIS) and is made publicly available. In addition, instruction manuals of day-to-day operations are prepared for both PBS and REB staff members for smoother and more coherent project operations. Technical training for new PBS staff members is provided by REB. Also noteworthy is that the performance target agreement (PTA) was introduced to assess and improve the work performance of PBSs. Based on negotiations with the REB, every year each PBS sets performance targets, including system loss, growth in consumers, and debt amount. The employees of PBSs are given a bonus or a penalty, depending on the attainment of targets. This incentive scheme encourages employees to achieve their targets and improves the operational efficiency of each PBS.

Unfortunately, despite such efforts to maintain good governance, political interference in the program has become pronounced recently. The program is often under strong political pressures that demand construction of new electric lines in areas of interest to politicians with disregard to predetermined master plans. Hence, the recent program has been dubbed a “politically biased” program (The Independent, 2006). This study therefore attempts to measure changes in the REP’s operational



performance with an application of methodology which is introduced in the following chapter.

### **3. Methodology and Data**

#### *3.1. Assessment of Efficiency*

In general, “efficiency” is defined as the ratio between inputs and outputs. The idea of efficiency is either to minimize inputs for given outputs or maximize outputs for a given set of inputs. The measurement of efficiency can be classified into parametric and nonparametric approaches. In the literature on efficiency analysis, parametric stochastic frontier analysis (SFA) and nonparametric Data Envelopment Analysis (DEA) are most commonly used (Hirschhausen et al., 2006). Both methods have advantages and disadvantages. In this paper, DEA is employed based on the study by Bagdadioglu et al. (1996) because it can easily handle multiple inputs and outputs and is more suitable for electricity distribution systems which distribute electricity to different categories of customers (industrial, commercial, residential customers and so on) at different voltages with different tariffs.

The DEA model, originally suggested by Charnes et al. (1978), uses a mathematical programming technique to estimate the efficient frontier and hence is often referred as the CCR model. It is a method used to both evaluate and identify

relative efficiencies of different types of producers called decision making units (DMU). In the DEA model, efficiency is defined as the ratio of the weighted sum of outputs to weighted sum of inputs. DEA identifies a set of the most efficient best practice DMUs and the inefficient and less productive DMUs. DEA computes efficiency relative to the best-practice frontier. Here, efficiency is expressed numerically on a scale of zero to one. The frontier DMUs get a score of 1. The CCR model is expressed as follows:

$$\text{Max.} \quad \frac{\sum_{q=1}^Q u_q y_{qk}}{\sum_{p=1}^P v_p x_{pk}} \quad \frac{\sum_{q=1}^Q u_q y_{qk}}{\sum_{p=1}^P v_p x_{pk}} \quad (1)$$

$$\text{subject to:} \quad \frac{\sum_{q=1}^Q u_q y_{qi}}{\sum_{p=1}^P v_p x_{pi}} \leq 1 \quad \frac{\sum_{q=1}^Q u_q y_{qi}}{\sum_{p=1}^P v_p x_{pi}} \leq 1$$

$$v_p \geq 0 (p = 1, 2, \dots, P), u_q \geq 0 (q = 1, 2, \dots, Q), i = 1, 2, \dots, k, \dots, N$$

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where  $u_q$  is the weight given to output  $q$ ,  $v_p$  is the weight given to input  $p$ ,  $y_{qk}$  is the amount of output  $q$  produced by DMU  $k$ , and  $x_{pk}$  is the amount of input  $p$  produced by DMU  $k$ . The fractional program in Equation (1) can be subsequently converted to a linear programming format and then using the duality principle the equivalent representation is obtained as shown in Equation (2).

$$\text{Max.} \quad \theta \quad (2)$$

subject to:

$$-\sum_{i=1}^N x_{pi} \lambda_i + \theta x_{pk} \geq 0$$

$$\sum_{i=1}^N y_{qi} \lambda_i \geq y_{qk}$$

$$\lambda_i \geq 0$$

where  $\theta$  is the efficiency score and  $\lambda_i$  the dual variables which are weights in the dual model for the inputs and outputs of the  $N$  DMUs.

The CRS model assumes a constant returns-to-scale (CRS) assumption. To take variable returns-to-scale (VRS) into account, Banker et al. (1984) extended the CCR model by relaxing the CRS assumption. The model as shown by Banker et al. (1984) is referred to as the BCC model, adding a convexity constraint  $\sum_{i=1}^N \lambda_i = 1$  to the CCR model. The CRS assumption implies that all DMUs operate at the optimal scale.

However, the assumption is too restrictive. In the case of developing countries such as Bangladesh, there are significant regional differences in terms of sizes so that the scale of operation of DMUs differs greatly. Therefore, the less restrictive BCC model, which takes the size of DMUs into consideration, seems more suitable in this case. For that reason, this study employs the input-oriented BCC model.

Because this study deals with time series panel data, the DEA window analysis approach is applied. This approach can be used to examine the performance trends of a DMU over time. In the window analysis, each time period for each DMU represents an independent observation. In doing so, the performance of one DMU is compared

with not only the performance of other DMUs in the same time period but also against that of itself in other time periods. Charnes et al. (1985) employed window analysis using panel data of various maintenance units of the US Air Force and a detailed outline of their approach is provided in their study.

### *3.2. Selection of Input and Output Variables*

It is often arguable what kind of input and output variables should be chosen for the DEA model. Thakur et al. (2006) point out in their study that, in general, the inputs must reflect the resources used, and the outputs must reflect the utility's service levels and to what extent the utility is meeting its objectives of supplying electricity to consumers. In addition, selection of input and output variables depends on data availability. Jamasb and Pollitt (2000) review selected empirical studies of the relative efficiency of electricity utilities, and summarize the input and output variables used frequently and widely in the previous studies. The summary shows that operating costs, number of employees, transformer capacity, and network length as input variables, and energy delivered and number of customers as output variables are most frequently used.

In this study, a two-input/three-output model is employed in view of previous studies, data availability, and characteristics of rural electrification. Table 1 presents

the input and output variables used in this study. The input variables are distribution lines and operation and maintenance (O&M) costs. The output variables are the number of household connections, total power sales, and total operating revenue. The reason why the number of household connections is employed as an output variable is that the ultimate goal of the REP is to provide electricity for all people. Total power sales reflect total services provided including industry and commercial sectors. Total operating revenue represents the profitability of each PBS. Data measured in monetary units, such as O&M cost and total operating revenue, are adjusted based on 1996 prices using the World Development Indicators (WDI) from the World Bank (World Bank, 2007b).

### *3.3. Tobit Regression*

Using computed DEA efficiency scores, factors contributing to efficiency are examined as a second step. A Tobit model is used in this analysis instead of ordinary least squares. A Tobit model, in simplest terms, is a regression model. It was proposed by James Tobin in 1958 (Tobin, 1958). The Tobit model is employed when the dependent variable is censored and limited. Efficiency scores from the DEA range between zero and one. The Tobit model can deal with this kind of censored data. In this study, with the DEA efficiency scores as the dependent variable, the Tobit model adopts

the following expression:

$$y_i^* = \beta x_i + \varepsilon_i, \quad (3)$$

$$\begin{cases} y_i = 0 & \text{if } y_i^* \leq 0, \\ y_i = y_i^* & \text{if } 0 < y_i^* < 1, \\ y_i = 1 & \text{if } y_i^* \geq 1, \end{cases}$$

$$y_i = \beta_0 + \beta_1 MP_i + \beta_2 AREA_i + \beta_3 AGE_i + \beta_4 CUSDENS_i + \beta_5 CUSMIX_i + \varepsilon_i, \quad (4)$$

where  $y_i^*$  is a latent variable,  $x_i$  is a vector of independent variables,  $\beta$  is the set of parameters to be estimated, and  $\varepsilon_i$  is the error term.

The DEA efficiency scores are the dependent variables of the Tobit model (Equation 3 and 4). In Equation 4,  $y_i$  denotes the efficiency of the  $i$ -th PBS. Table 2 describes the independent variables employed in the Tobit model. One of the objectives of this study is to examine the relationship between efficiency and political interference. One difficult task is, however, to obtain a political indicator representing “political interference”. The following are cases of political interference on rural electrification not only in Bangladesh but also in other developing countries. Politicians try to extend distribution lines to unprofitable areas where their constituents live. In the case of Bangladesh, distribution lines should be constructed according to the revenue criteria. Nevertheless, there are cases wherein distribution lines are extended into noncommercial areas due to strong political pressures in defiance of the criteria. If electricity has been cut off in their constituent’s house

because of default of payment, politicians interfere with the disconnection policy to restore services without the bill being paid. In some cases, there is an issue of overemployment by political considerations (Barnes et al., 2007; ESMAP, 2005; Bó and Rossi, 2007). However, the relationship of these individual events to efficiencies is difficult to directly measure and quantify. Instead, this study employs an indirect political indicator, the proportion of MPs who belong to the ruling parties in each PBS. The reason is that the REP receives subsidies from the GoB. That is, MPs in the ruling parties can easily exercise power with regards to the allocation of the public funds in a relative sense. MPs in the ruling parties may require PBSs covering their constituencies to make or change a plan in line with their political interests. It is assumed that the more MPs there are in a PBS, the more often these things will happen. Therefore, we consider the proportion of MPs in the ruling parties as a political indicator. Amardesh Online (2008) is used in order to get necessary information about MPs. The following other variables which might influence the performance of PBSs are also controlled in the model, based on other studies (Berg et al., 2005; Estache et al., 2002; Hattori et al., 2003; Pombo et al., 2006; Scarsi, 1999) : service area (*AREA*), years of operation (*AGE*), customer density (*CUSDENS*), and customer structure (*CUSMIX*). *AREA* is a PBS's service territory. This variable aims at capturing the effect of the scale of operation. *AGE* represents the age of PBSs (years of the

establishment). *CUSDENS* is expressed as the number of total customers per area served by each PBS and captures the effect of a demographic characteristic. *CUSMIX* is the ratio between energy delivered to industrial customers and energy delivered to residential sales. Different voltages and tariffs are required by different customers. *CUSMIX* tries to see how much the difference in type of customers affects the efficiency of PBSs. The expected signs of the independent variables are also outlined in Table 2.

#### *3.4. Data for Analysis*

The study covers the 15 years following democratization, from 1991 to 2005. The data used to see the tendency of the REP's operational performance comprises information for 39 PBSs in 15 years for a total of 585 observations. During this period, new PBSs were continuously created and joined the program. For the analysis, only old 39 PBSs which were established before 1991 are included. Meanwhile, in the Tobit model, DEA efficiency scores as dependent variables are recalculated using the data of not only old PBSs but also young PBSs which were created after 1991. Therefore, the total number of samples is 788 in 15 years<sup>1</sup>.

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<sup>1</sup> The annual number of samples is described as follows: 39 PBSs in 1991 and 1992, 40 in 1993 and 1994, 45 in 1995 and 1996, 53 in 1996 and 1998, 54 in 1999, 55 in 2000, 61 in 2001, 63 in 2002, and 67 between 2003 and 2005.



The data used for this study is obtained from the following sources: Form 550, the MIS report, and Quarterly Progress Report. Every month, PBSs have to report their operational and financial statistics to the REB using the prescribed form, Form 550. All data and information in Form 550 is compiled into the REB's management information system (MIS). The REB produces a MIS report as a summary from the MIS. Financial data is not included in the MIS report. In this study, therefore, physical data is taken from the MIS report and financial data is directly taken from Form 550. Quarterly Progress Report is also being produced regularly by PBSs to the REB for the purpose of monitoring the activities of PBSs. For efficiency analysis, we use the MIS reports (REB, 1991–2005) and Form 550 (REB, 1991–2005) for June, which is the end of the fiscal year in Bangladesh. For Tobit analysis, we use the MIS reports (REB, 1991–2005) and Quarterly Progress Report (REB, 1993–2005)<sup>2</sup>.

## **4. Results**

### *4.1. DEA Efficiency Analysis*

The trend of average efficiency scores of 39 PBSs over the last 15 years estimated

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<sup>2</sup> Form 550, MIS reports and Quarterly Progress Report are used for the month of June. However, the Quarterly Progress Report is only available from 1993. For 1991 and 1992, data from 1993 are used. This is appropriate because from this report, only information on the size of the PBSs is extracted and the area covered by each PBS does not change significantly in a short time. Furthermore, the reports for 1996 and 1999 are unavailable, so data for September 1997 and September 2000 were used, respectively.

by the DEA model is presented in Figure 1. The result indicates that the average efficiency scores ranges between 0.856 and 0.929. Regarding the disparity among PBSs, the trend of standard deviations of efficiency scores is also presented in Figure 1. The disparity decreases first with the lowest standard deviation in 1996 and then turns to increase again. In addition, the trend of average efficiency scores shows two turning points: 1996 and 2001. Aggregate efficiency achieves a peak in 1996 and subsequently decreases after that; however, in 2001 it begins to gradually increase. In 1996 and 2001, national elections were held. After parliamentary democracy was reestablished, three national elections took place in the country. Bangladesh is polarized politically, having two major parties: the Bangladesh Nationalist Party (BNP) and the Awami League (AL). One of these two parties was in power in every election. There are prominent political conflicts between the two parties. It is often said that a change of a ruling party brings a change of policies.

Despite this circumstance, the casualty between the aggregate efficiency and regime changes is still arguable. For instance, there might be a time lag between changes of government and the impact of the efficiency since policies of a new government take time to be framed and implemented. Meanwhile, there might also be a possibility that even before election time, efficiency improvements are inhibited due to social and political turbulence with the impending election. Nevertheless, this

empirical study presents an interesting result: the turning points of efficiency coincide with changes of government.

As for the results of individual PBSs, the 15-year average efficiency scores of the PBSs are ranked in Appendix A. From this ranking, it turns out that, on average, the efficiency score of the 5 worst performing PBSs is 14 percent lower than that of the 5 best performing PBSs. In addition, the worst performing PBSs are relatively new while the operating years of the best performing PBSs are 1.4 times older than those of the worst performing PBSs. Furthermore, Table 3 shows the DEA efficiency scores of six districts for 39 old PBSs that were established before 1991 in order to examine the long-term trend of these older PBSs. It is found that a great improvement in efficiency occurred in the Chittagong district. In addition, the efficiency scores of the PBSs in the Barisal district are relatively low compared with those of other districts. This could be possibly linked to the geographical conditions. Barisal is located in the southern part of Bangladesh, surrounded by many rivers and bordering the Bay of Bengal to the south. So it is possible that it is susceptible to natural disasters such as cyclones and floods and it may damage power distribution networks resulting in low quality of service.

#### *4.2. Explaining Efficiency*

The results of the Tobit regression are presented in Table 4. Again, the dependent variable is the DEA efficiency score, so a negative sign on the coefficient reflects a negative effect of the efficiency of PBSs' performance. As shown in Table 4, all independent variables are statistically significant. Most importantly, *MP* is found to be negative. That is, the more MPs there are in a PBS, the less efficient the performance of the PBSs. As noted above in Section 2, if a majority of MPs belong to governing parties within a PBS, it is highly likely that the MPs will use their power to interfere with the operations of the PBS. The results suggest that, statistically, the presence of more MPs in ruling parties has a negative impact on the efficiency of PBSs. *AREA* also has a negative effect on efficiency. This is a conceivable result because a larger service area normally requires more power lines and as Claggett Jr. and Ferrier (1998) mentioned, line losses increase with increasing distances. Moreover, the expansion of the service territory means PBSs offer the service to more remote areas with less population so that the more electrical distribution infrastructure is needed to distribute a given amount of electricity. *AGE* has a positive sign. This could be because the older PBSs are more experienced and have accumulated better business know-how. In addition, there is a system whereby newly created PBSs can receive subsidies for a period of up to six years because it is difficult for PBSs to generate sufficient revenue in their early years of operation. This means that the subsidies are not applied to older

PBSs. Therefore, for older PBSs, costs must be financed not by subsidies but by PBSs themselves on a stand alone basis. This may create an incentive for better management. In addition, *CUSDENS* has a positive effect on efficiency levels, suggesting PBSs with higher customer density are more efficient than those with lower customer density. This is understandable because the higher the number of connections in certain power distribution networks, the lower the cost per unit. Therefore, PBSs with a dense customer structure have a cost advantage. Finally, efficiency scores are positively related to *CUSMIX*. This means that efficiency tends to be larger if the electricity is used more in industry, while efficiency is smaller if the electricity is used more in households. Industrial power consumption per unit is greater than that of residential power consumption. Therefore, industrial clients could potentially lead to increases in the efficiency of PBSs.

## **5. Discussion and Conclusion**

This article endeavored to empirically analyze the efficiency change of PBSs in the Bangladesh REP and detect the potential driving and restraining factors on PBSs' operational performance using a two-step DEA approach. The demand for electricity in Bangladesh is still growing. However, the electrification level in rural areas remains low (USAID, 2007), and the government has committed to achieving electrification

for all people by the year 2020 (Power Division, 2005). Therefore, electrification especially in rural areas, which makes up a substantial portion of the country's geographical area, should be accelerated. Despite the country's political, social, and economic instability, the REP in Bangladesh has achieved a certain level of results in terms of good system design, low system loss, and high bill collection rate. It has been admired as a best practice. Nevertheless, the recent program is said to be a "politically biased program." Therefore, this study intends to confirm the perception about the political meddling impacting the REP.

In the first step, the study measured the efficiencies of PBSs from 1991 to 2005 using DEA. The results of the study indicate that the overall efficiency score varies from 0.856 to 0.929 over the 15-year period, with turnaround points in 1996 and 2001. The results also found that a gap still remains between the efficient PBSs and the inefficient PBSs. So far, the entire program is profitable and manages to stay in business because a small number of PBSs have high earnings, and it is still assisted by funds from various donors. Thus, the results imply a potential risk that the REP may fail in the future in terms of its financial viability and project sustainability.

In the second step, we performed Tobit analysis to determine what factors may affect on the efficiency level of PBSs. The results show that the proportion of ruling-party politicians in each PBS has a negative impact on efficiency. It has been

reported that political interference leads to “waste of resource, low staff morale and operational ineffectiveness” (Barnes and Foley, 2004). This study concludes that political interference has adverse effects on the operational efficiency of the REP. Meanwhile, customer density has a positive effect on efficiency. The finding is consistent with the results of Pombo and Taborda (2006). In addition, the area size of PBSs adversely affects efficiency, while the ages of the PBSs and the consumer mix have positive impacts on efficiency. The findings could demonstrate the plausibility of the DEA results.

Complete electrification throughout Bangladesh will take many years and thus the diminishing returns to scale of incremental investment for further rural electrification will be faced in the long run. With regards to this future perspective and challenge, we suggest that both Bangladesh and international donors revisit the original principle of the REP, eliminate political interferences from the program, and make sustained efforts to improve the efficiency of providing electricity to the rural poor and encouraging local economic development.

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Table 1. Input/ Output variables

Input	Distribution Lines (km)
	O&M Cost (Taka in 1996 price)
Output	No. of Household Connections
	Total Power Sales (MWh)
	Total Operating Revenue (Taka in 1996 price)

(Note) Taka is the currency of Bangladesh.

Table 2. Description of independent variables

Variables	Description	Expected Sign
MP	The proportion of Members of Parliament (MPs) who belonged to the then ruling party in each PBS (%)	Negative
AREA	a PBS's service area (km <sup>2</sup> )	Negative
AGE	The number of years since establishment of a PBS (years)	Positive
CUSDENS	Customer Density which is computed by dividing the number of customers in a PBS by the service area (No./km <sup>2</sup> )	Positive
CUSMIX	A ratio of industrial sales to household sales (MWh/MWh)	Positive

Table 3. District-wise DEA efficiency scores (39 old PBSs)

	Rajshahi	Khulna	Barisal	Chittagong	Dhaka	Sylhet
1991	0.882	0.888	0.858	0.853	0.905	0.944
1992	0.873	0.887	0.776	0.820	0.854	0.901
1993	0.893	0.894	0.764	0.846	0.891	0.907
1994	0.900	0.904	0.810	0.862	0.889	0.922
1995	0.925	0.922	0.851	0.916	0.919	0.921
1996	0.924	0.935	0.890	0.947	0.926	0.939
1997	0.899	0.885	0.861	0.949	0.881	0.926
1998	0.901	0.894	0.845	0.961	0.878	0.931
1999	0.880	0.855	0.820	0.941	0.865	0.876
2000	0.865	0.869	0.815	0.938	0.849	0.859
2001	0.862	0.856	0.825	0.936	0.859	0.854
2002	0.868	0.878	0.843	0.969	0.858	0.860
2003	0.874	0.882	0.852	0.968	0.863	0.833
2004	0.883	0.875	0.864	0.979	0.876	0.831
2005	0.875	0.861	0.852	0.977	0.873	0.841
Average	0.887	0.886	0.835	0.924	0.879	0.890
No. of PBSs	12	6	3	7	8	3

Table 4. Estimation result for Tobit model

Independent Variables	Coef.	Std. Err.	t-value		Elasticity
Constant	0.813	0.010	78.390		
MP	-0.014	0.007	-1.980	**	-0.009
AREA	0.000	0.000	-2.980	***	-0.027
AGE	0.005	0.000	10.620	***	0.064
CUSDENS	0.000	0.000	3.980	***	0.015
CUSMIX	0.018	0.003	5.760	***	0.018
No. of observations		788			
Log Likelihood		931.895			
Prob > chi2		0.000			

(Note) \*\*\* and \*\* indicate statistical significance at 1 percent and 5 percent levels, respectively.

Appendix A.

Ranking by DEA efficiency scores

Rank	PBS	Eff.Score	Age	Rank	PBS	Eff.Score	Age	
1	Dhaka_1	0.98	25	21	Chittagong_1	0.88	17	
2	Comilla_1	0.95	24	22	Naogaon	0.88	15	
3	Chandpur	0.95	24	23	Mymensingh_1	0.88	21	
4	Moulvibazar	0.94	24	24	Barisal_2	0.88	20	
5	Feni	0.94	21	25	Natore_1	0.88	24	
6	Noakhali	0.94	19	26	Joypurhat	0.88	19	
7	Habiganj	0.93	23	27	Kushita	0.87	20	
8	Narsinghdi_1	0.93	19	28	Satkhira	0.87	21	
9	Bogra	0.92	19	29	Rangpur_2	0.87	19	
10	Jessore_1	0.92	24	30	Pabna_1	0.87	23	
11	Chittagong_2	0.91	19	31	Madaripur	0.87	20	
12	Dinajpur_1	0.91	21	32	Bagerhat	0.86	19	
13	Pabna_2	0.91	23	33	Barisal_1	0.85	15	
14	Meherpur	0.90	18	34	Thakurgaon	0.85	19	
15	Sirajganj	0.90	24	35	Kishoreganj	0.85	15	
16	Jessore_2	0.90	24	36	Jamalpur	0.83	19	
17	Natore_2	0.90	24	37	Narsinghdi_2	0.81	15	
18	Laksmipur	0.89	15	38	Sylhet_1	0.80	15	
19	Tangail	0.89	24	39	Pirojpur	0.77	19	
20	Rangpur_1	0.89	21		Mean	0.89	20.2	
(Note)	Efficiency	scores	here	mean	15	years'	average	scores.

Age as of 2005.



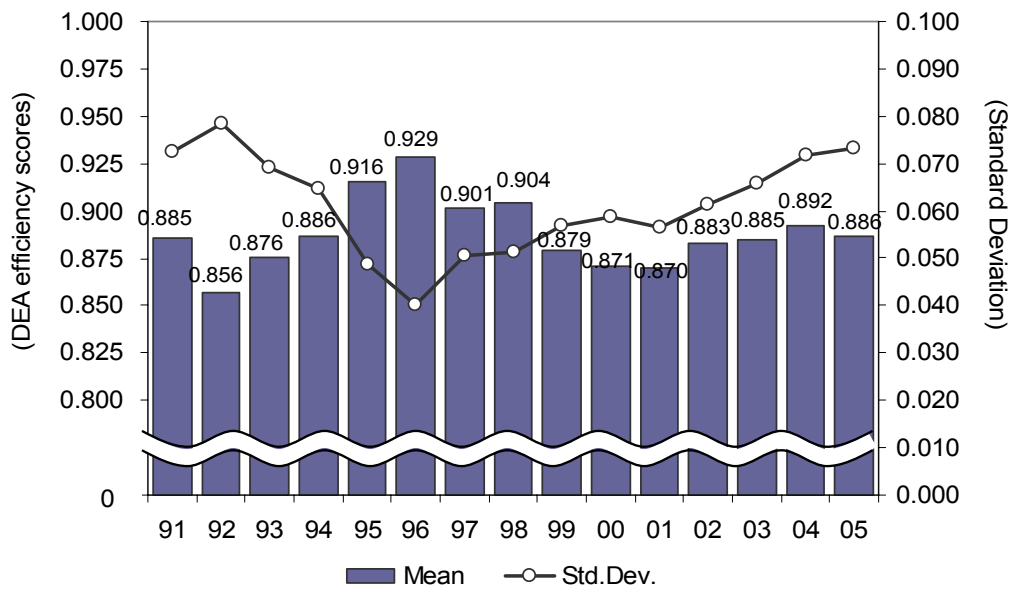


Figure 1. Aggregative DEA efficiency scores and the standard deviations

(39 PBSs, 1991-2005)