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Evaluating advance efficiency of Bangladeshi online banks using stochastic frontier analysis

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Online bank advance efficiency and various factors causing the efficiency level of banks are investigated using stochastic frontier technique for the period 2001-2007. A sample of 20 banks are used following four different groups like NBs (National Banks), ISBs (Islamic Banks), FBs (Foreign Banks), and PBs (Private Banks). A group wise, year wise, and individual banks with their efficiency scores are compared in this study. The significant variations of advance efficiency of banks during this reference period were observed. The year wise average efficiency of banks was estimated (0.516) from the advance frontier model while group wise average technical efficiency was 0.592. Nationalized Commercial Bank had the highest advances producing group compared to others; Private Banks are at the lowest level in producing advances. ISBs, FBs, and PBs are observed inefficient in producing advances. The most efficient banks are found to be government owned Sonali and Janata Bank with efficiency score (0.94) while lowest efficient bank was experienced by Shahajalal Islamic Bank with efficiency score of 0.34.

Key words: Advance efficiency, translog production function, stochastic frontier analysis.

INTRODUCTION

There has been a widespread discussion on lack of sufficient technical efficiency of banks in developing countries compared to their counterparts in the developing world (Das, 1997; Shanmugan and Lakshmanasamy, 2001; Kumar and Verma, 2003; Kumbhakara and Sarkar, 2003; De, 2004; Mohan and Ray, 2004; Das et al., 2005). Even some works have been done for Bangladesh banking sector (Raihan, 1998; Choudhury et al., 1999; Choudhury 2002). No attempt has been made to check the performance and efficiency measure of the commercial banks with advance output. Again, question arises how successfully the nationalized private commercial banks are serving the country, how far they have achieved their desired goals. Studies on online Bangladeshi banks will give answer to such questions. This study intends to reveal the overall performance of commercial banks with loan default and measuring technical advance efficiency of banks in Bangladesh.

Stochastic production frontier model proposed by Battese and Coelli (1995) is used in this paper to measure advance efficiency of banks individually and in accordance with four groups namely NBs, IBs, FBs, and PBs in Bangladesh. To determine the important factors causing advance efficiency differential on banking industry in Bangladesh is also of interest in this study. The remainder of the paper is organized as follows. Section two begins with a formulation of stochastic Translog production frontier model with its functional form. Likelihood ratio (L-R) test statistic is explained here for the purpose of testing null hypotheses. A detailed description of variables, sources and different types of

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data used are discussed in this paper. In section three, we have analyzed advance frontier model in measuring efficiency for different banks of Bangladesh. The last section contains concluding remarks.

MATERIALS AND METHODS

Bank efficiency based on stochastic frontier analysis

The stochastic frontier model proposed by Battese and Coelli (1995) can be expressed as:

$$\ln(Y_{it}) = \beta X_{it} + (V_{it} - U_{it}),\ i = 1, 2, ..., N;\ t = 1, 2, ..., T \quad .....(1)$$

where Y_{it} is the output of the i^{th} bank in t^{th} period; X_{it} is a vector of input quantities; β_i 's are unknown parameters to be estimated; V_{it}**'s** random variables which are assumed to be i.i.d., $N(0, \sigma_v^2)$ and independent of U_{it} ; U_{it} **'s** are non-negative random variables which are assumed to account for technical inefficiency in output and to be independently distributed as truncations at zero of the $N(\mu, \sigma_u^2)$ distribution; where $U_{it} = Z_{it}\delta$; where; Z_{it} is a $(1 \times p)$ vector of variables which may influence the inefficiency of bank industry and δ is a $(p \times 1)$ vector of parameters to be estimated. The impact of the inefficiency term, as measured by the contribution of its variance to overall variance, is denoted by $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$. The technical inefficiency effect U_{it} in the stochastic frontier model is specified as follows;

$$U_{it} = Z_{it}\delta + W_{it} \quad .....(2),$$

where, the random variable, W_{it} follows truncated normal distribution with mean zero and variance σ^2 , such that the point of truncation is $-Z_{it}\delta$. After obtaining the estimates of U_{it} the technical efficiency of the i-th bank industry at t-th time period is given by:

$$TE_{it} = \exp(-U_{it}) = \exp(-Z_{it}\delta - W_{it}) \quad .....(3).$$

In the present study the functional form of Translog advance frontier production is considered as:

$$\begin{aligned}\ln(Y_{it}) &= \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln M_{it} + \beta_3 \ln L_{it} + \beta_4 T \\ &+ \tfrac{1}{2}\left(\beta_{11} \ln K_{it}^{\ 2} + \beta_{22} \ln M_{it}^{\ 2} + \beta_{33} \ln L_{it}^{\ 2} + \beta_{44} T^2\right) \\ &+ \beta_{12} \ln K_{it} * \ln M_{it} + \beta_{13} \ln K_{it} * \ln L_{it} + \beta_{14} \ln K_{it} * T + \beta_{23} \ln M_{it} * \ln L_{it} + \beta_{24} \ln M_{it} * T \\ &+ \beta_{34} \ln L_{it} * T + V_{it} - U_{it} .....(4),\end{aligned}$$

where, the subscripts i and t represent the i-th online bank industry and the t-th year of observation, respectively; $i = 1, 2, ..., 20$; $t = 1, 2, ..., 7$; Y_{it} denotes the output variables (advance) of the ith online bank industry in the t-th period in values (taka); K_{it} denotes capital (fixed assets of a online bank in a year which also adds premises, furniture and fixture) of i-th online bank industry in the t-th period; M_{it} represents materials (the sum of expenditure on printing and stationeries and postage, telegrams and telephones etc) of i-th online bank industry in the t-th period; L_{it} represents labor (the total number of employees which include officers, sub-ordinates and clerks) of i-th online bank industry in the t-th period; T represents year of observation; "ln" refers to the natural logarithm.

Further the technical inefficiency effects are the function of some explanatory variables defined as follows:

$$U_{it} = \delta_0 + \delta_1 TA + \delta_2 HI + \delta_3 NB + \delta_4 ISB + \delta_5 FB + \delta_6 PB + W_{it} \quad .....(5),$$

where δ_0 is the intercept term and δ_j $(j = 1, 2, 3, 4, 5, 6)$ is the parameter for the j-th explanatory variable, TA=Total Assets, HI=Herfindahl Index.

NB is the dummy variable for Nationalized Commercial Banks: NB=1 if an observation involves a Nationalized Commercial Bank, zero otherwise.

ISB is the dummy variable for Islamic banks: ISB=1 if an observation involves an Islamic bank, zero otherwise.

FB is dummy variable for Foreign Banks: FB=1 if an observation involves a Foreign Bank, zero otherwise.

PB is dummy variable for Private Banks: PB=1 if an observation involves a Private Bank, zero otherwise.

Likelihood ratio tests and hypothesis

The likelihood ratio test is used to determine whether Translog production function is better. The hypotheses require testing with the generalized likelihood ratio test statistic defined by

$$\lambda = -2\{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \cdots\cdots(6)$$

where $L(H_0)$ and $L(H_1)$ are the value of the likelihood function for the advance frontier model under the null and alternative hypotheses. Under the null hypothesis, this test statistic is assumed to be asymptotically distributed as mixture of chi-square distribution with degree of freedom equal to the number of restrictions involved. The restrictions imposed by the null hypothesis are rejected when λ exceeds the critical value (Taymaz and Saatci, 1997).

The following null hypotheses will be tested:

$H_0 : \beta_{ij} = 0,$ the null hypothesis that identifies an appropriate functional form either the restrictive Cobb-Douglas or Translog production function.

$H_0 : \gamma = 0,$ the null hypothesis specifies that the technical inefficiency effects in online banks are zero. If the null hypothesis is accepted this would indicate that σ_u^2 is zero and hence that the U_{it} term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least square (OLS).

Further $H_0 : \eta = 0,$ the null hypothesis that the technical inefficiency effects are time invariant i.e., there is no change in the technical inefficiency effects over time. If the null hypothesis is true, the generalized likelihood ratio statistic λ is asymptotically distributed as a chi-square (or mixed chi-square) random variable.

Data set

We have used data for the period of 2001-2007 from 20 commercial banks of Bangladesh. Banks are grouped into four categories: (i) National Banks (NBs), (ii) Islamic Banks (ISBs), (iii) Foreign Banks (FBs), (iv) Private Banks (PBs). Most of the data are collected from the annual reports of the specific banks of Bangladesh and the rest of them are collected from annual accounts of Scheduled Commercial Banks published by Bangladesh Bank, the Central Bank of Bangladesh.
All nominal values are converted on real by deflating with GDP deflator and all values are in their natural logarithms.

Dependent variables

Advance (Y): Advances are used as output and equal to total loans and advances. These values are also deflated by relevant consumer price index (CPI).

Independent variables

Capital (X_1): Capital is the input variable used to represent the fixed assets of a bank in a year which also adds premises, furniture and fixture. Capital figures are deflated by capital price index.
Labor (X_2): Labor is the inputs to measure the productivity of a firm. Here labor means number of employee and is measured as the total number of employees which include officers, sub-ordinates and clerks.
Material (X_3): Material is used as the sum of expenditure on printing and stationeries and postage, telegrams and telephones etc. Material prices are deflated by non-food price index.
Time (X_4): To find the productive efficiency of a bank over time is used as the input variable. Data used in this study for seven years from 2001 to 2007 and considered 1 for year 2001, 2 for 2002 and so on.

Explanatory variables

Total Asset (Z_1): Total asset is used as the influencing variable and it is the sum of all assets and courses of their book value.
Herfindahl Index (Z_2): Herfindahl index is known as measure of competition which is measured as the sum of squared of the output share of each of bank in the output of considered total banks in Bangladesh.

NB, ISB, FB, and **PB** are bank group specific dummies for National Bank, Islamic Bank, Foreign Bank, and Private Bank respectfully. The dummy variables can take either 1 or 0 depending on data availability or not respectively.

RESULTS

Estimation of advances efficiency model

Ordinary Least Square Estimates (OLS) and Maximum Likelihood Estimates (MLE) estimates of the parameters of Translog frontier production function are reported in Tables 1 - 3. First, by grid search the ordinary least square estimates of parameters are obtained and then OLS estimates are used to estimate the maximum likelihood estimates of the parameters in the context of Translog production function.

Hypothesis tests of advances frontier model

The results of various hypothesis tests of the advances frontier model are presented in Table 4.
Since the hypothesis $H_0 : \gamma = 0$ is rejected, so we can conclude that there is a technical inefficiency effect in the model. From the outcome it is observed that the null hypothesis $H_0 : \beta_{ij} = 0$ is rejected and so Translog production function is more favorable. The null hypothesis $H_0 : \eta = 0$ is rejected indicating that the technical inefficiency effect differs significantly over time (Table 5).

DISCUSSION

All the coefficients of the first order parameters are found statistically significant at 1 percent level of significance but the second order coefficients of material and time are insignificant. The significant result indicated that these input variables importantly affect the level of producing bank advances.

The maximum likelihood estimates of the parameters of advances frontier model using Translog production function are mentioned in Table 3. We observe that all the first-order coefficients except labor and second-order coefficients are found significant excluding interaction variables material and labor, material and time, labor and time. In case of producing advances we can infer that the number of labor is not an affecting variable. Hence, to uphill the advances productivity the bank authority needs to improve the skill of employees. The most significant variable is capital which includes all physical value of fixed assets to increase efficiency of a bank. In both OLS and MLE we have observed that the coefficient of labor holds negative sign which is not surprising but indicating that some banks may be still overstaffed even after many years of reforms.

Table 1. OLS estimates of translog advances frontier production function.

Variables	Parameters	Coefficients	S.E	t-value
Constant	β_0	8.922*	0.727	12.273
Capital	β_1	-0.634*	0.264	-2.397
Material	β_2	1.219*	0.384	3.175
Labor	β_3	-0.863*	0.201	-4.297
Time	β_4	0.533*	0.079	6.784
Capital*Capital	β_{11}	0.628*	0.104	6.052
Material*Material	β_{22}	-0.099@	0.157	-0.630
Labor*Labor	β_{33}	0.486*	0.073	6.630
Time*Time	β_{44}	-0.004@	0.011	-0.339
Capital*Material	β_{12}	0.021@	0.095	0.220
Capital*Labor	β_{13}	-0.365*	0.067	-5.446
Capital*Time	β_{14}	-0.106*	0.021	-5.029
Material*Labor	β_{23}	-0.080@	0.086	-0.926
Material*Time	β_{24}	-0.005@	0.028	-0.189
Labor*Time	β_{34}	0.031**	0.016	1.999
Sigma-squared		0.047		
Log likelihood function		23.857		

*,**,*** Significance level at 1,5, 10% consecutively. @ means insignificant, S.E = standard error.

Table 2. Maximum-likelihood estimates of translog advances frontier production function and inefficiency effects model.

Variables	Parameters	Coefficients	S.E	t-value
Constant	β_0	8.952*	0.819	10.936
Capital	β_1	-0.857*	0.216	-3.965
Material	β_2	0.701**	0.393	1.785
Labor	β_3	-0.062@	0.193	-0.323
Time	β_4	0.563*	0.031	18.278
Capital*Capital	β_{11}	0.497*	0.083	6.010
Material*Material	β_{22}	-0.189@	0.177	-1.067
Labor*Labor	β_{33}	0.348*	0.047	7.356
Time*Time	β_{44}	-0.016*	0.006	-2.724
Capital*Material	β_{12}	0.160***	0.103	1.550
Capital*Labor	β_{13}	-0.330*	0.049	-6.691
Capital*Time	β_{14}	-0.083*	0.005	-15.816
Material*Labor	β_{23}	-0.078@	0.085	-0.920
Material*Time	β_{24}	0.006@	0.016	0.398
Labor*Time	β_{34}	0.011@	0.013	0.887

Total assets and Herphindahl index gives negative sign in advances inefficiency model indicating that both total assets and Herphindahl index reduce inefficiency. Here the important thing is that the competition among the bank decreases the advances inefficiency. From the coefficients of the dummy variables it is observed that ISB, FB, and PB dummies are significant at 5 percent level and all of them are positive sign indicating that they are highly inefficient.

The year wise average advances efficiency of 20 banks are delineated in Figure 1. From the analysis it is observed that in the year 2001 the technical efficiency is

Table 3. Inefficiency effects of model estimates.

Variables	Parameters	Coefficients	S.E	t-value
Constant	δ_0	2.357*	0.514	4.585
Total Assets	δ_1	-0.240*	0.036	-6.582
Herpindahl Index	δ_2	-0.025@	0.032	-0.787
NB Dummy	δ_3	0.044@	0.499	0.087
ISB Dummy	δ_4	0.743**	0.444	1.674
FB Dummy	δ_5	0.770**	0.441	1.744
PB Dummy	δ_6	0.801**	0.438	1.830
Sigma-squared		0.031*	0.004	8.054
Gamma		.98711*	0.000054	66947.359

*,**,*** Significance level at 1, 5, 10% consecutively. @ means insignificant, S.E = standard error.

Table 4. Likelihood-ratio test of hypothesis of the stochastic advances frontier production function.

Null hypothesis	Log-likelihood function	Test statistic	Critical value	Decision
$H_0 : \gamma = 0$	23.85	78.04	3.38	Reject H_0
$H_0 : \beta_{ij} = 0$	-30.86	133.46	19.35	Reject H_0
$H_0 : \eta = 0$	23.86	100.88	3.38	Reject H_0

Notes: All critical values are at 5% level of significance.

Table 5. Advance efficiency of banks in Bangladesh.

Bank's name	2001	2002	2003	2004	2005	2006	2007	Mean efficiency
Sonali Bank	0.99	0.99	0.83	0.82	1.00	0.96	1.00	0.941
Janata Bank	0.87	1.00	0.91	0.91	0.97	0.96	0.99	0.943
Islami Bank	0.67	0.67	0.74	0.77	0.72	0.76	0.98	0.759
Shahajal Islami Bank	0.38	0.36	0.27	0.29	0.33	0.36	0.39	0.341
Al Arafah Bank	0.30	0.40	0.37	0.36	0.41	0.44	0.42	0.385
Bank Asia	0.35	0.46	0.48	0.49	0.57	0.52	0.53	0.486
The city Bank	0.48	0.45	0.44	0.45	0.52	0.50	0.36	0.457
National Bank	0.52	0.52	0.47	0.44	0.40	0.44	0.45	0.462
Prime Bank	0.50	0.52	0.51	0.57	0.60	0.69	0.66	0.579
Uttara Bank	0.62	0.52	0.37	0.33	0.34	0.35	0.37	0.412
One Bank	0.46	0.41	0.32	0.37	0.33	0.37	0.34	0.370
UCB Bank	0.49	0.42	0.42	0.41	0.42	0.41	0.47	0.434
Pubali Bank	0.53	0.51	0.44	0.41	0.39	0.48	0.54	0.472
Premier Bank	0.25	0.36	0.38	0.46	0.42	0.36	0.36	0.371
Mutual Bank	0.29	0.33	0.41	0.57	0.54	0.57	0.51	0.462
South East Bank	0.44	0.51	0.62	0.66	0.59	0.50	0.48	0.543
Eastern Bank	0.62	0.51	0.48	0.50	0.37	0.39	0.32	0.457
AB Bank	0.78	0.74	0.64	0.41	0.46	0.53	0.37	0.562
Dhaka Bank	0.60	0.47	0.37	0.38	0.40	0.50	0.50	0.459
DBBl	0.48	0.41	0.43	0.43	0.42	0.48	0.31	0.424

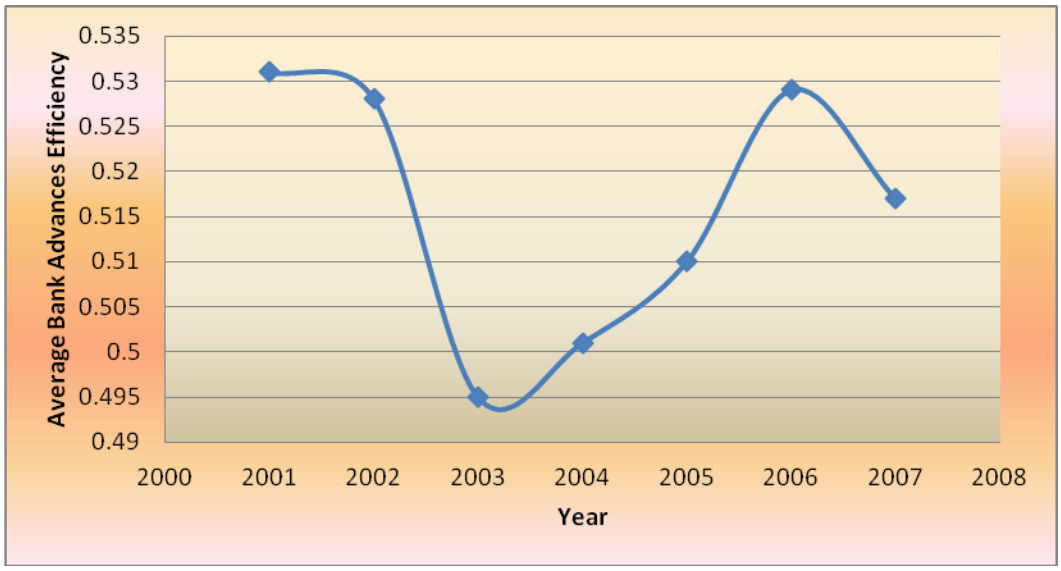

Figure 1. Year wise average advances efficiency of Banks in Bangladesh.

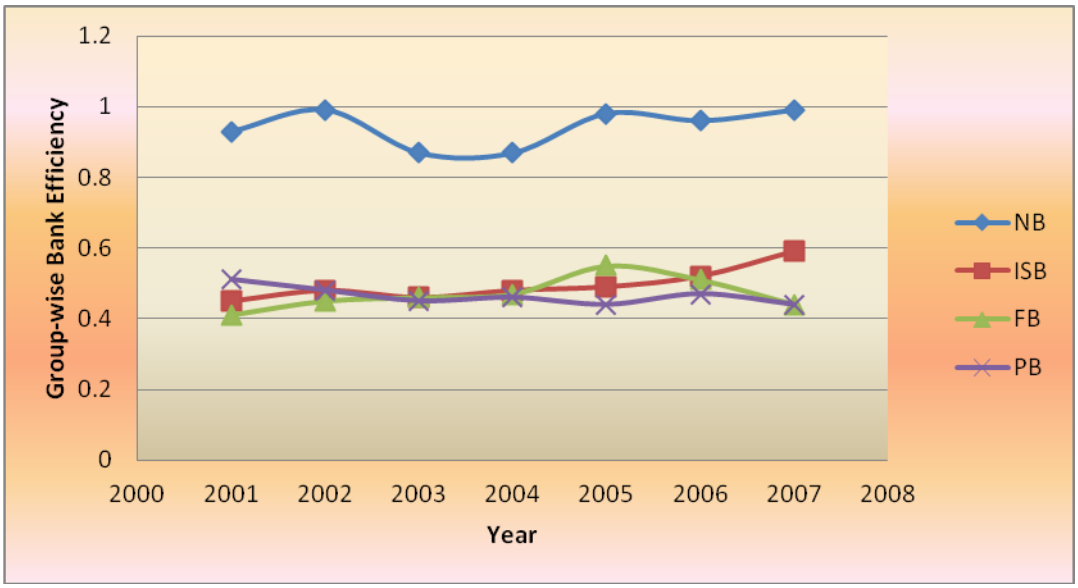

Figure 2. Group-wise bank advances efficiency.

highest with 53.1 percent and in the year 2003 it is lowest; although year wise bank's advances efficiency is almost around 50 percent. Hence from this result it is inferred that all banks excluding NBs have a wide chance to increase their advances efficiency through proper utilizing their total assets and labor.

The group wise bank efficiency has been revealed in Figure 2. The average advances efficiency of the banks during the study period is 0.516. This means that on an average Bangladeshi banks are 51.6 percent efficient in producing advances relative to the best practicing bank during the study period. It is very interesting that Nationalized Commercial Banks are highest advances producing group over the sample period 2001-2007 compared to their counterparts and on the other hand private banks are at the lowest level in producing advances. The estimated efficiency of NBs is 94.2% and ISBs, FBs, and PBs are 49.5, 47.1, and 46.2%, respectively. Hence huge gap is observed between NBs and others that support the findings of Mahesh and Rajeev (2006). But it is matter of hope that the advances efficiency levels are almost stable over the sample

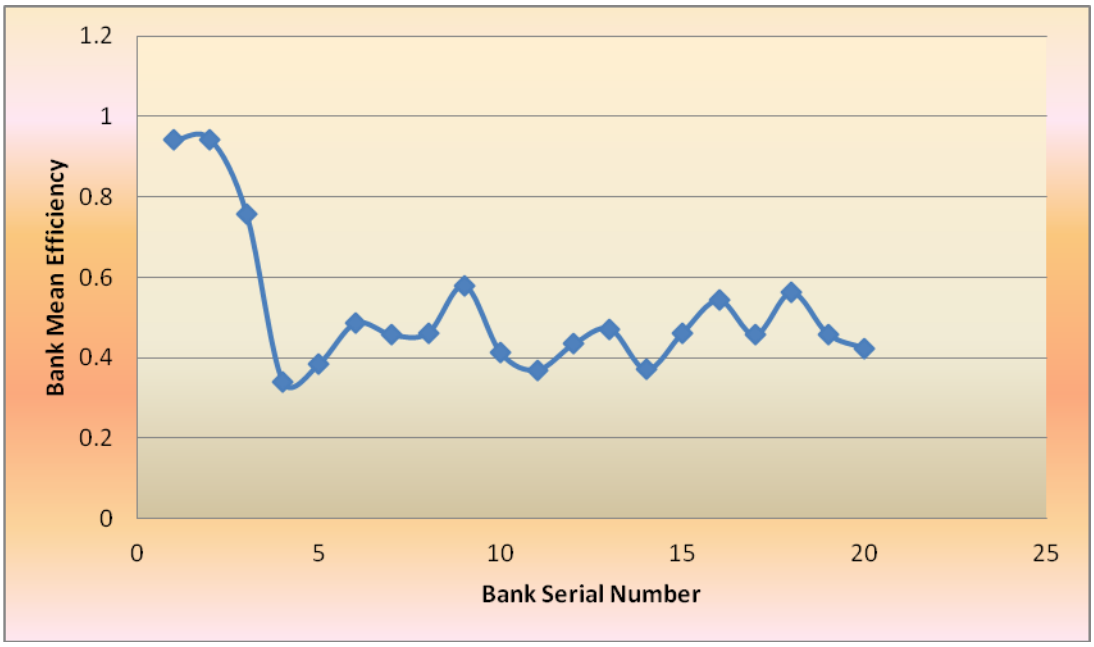

Figure 3. Advance efficiency of Banks in Bangladesh.

period.

The average advances efficiency of 20 banks was estimated for advances model which is displayed in Figure 3. The most efficient bank (Janata Bank) with an average technical efficiency of 94.3 percent, followed by Sonali Bank (94.1 percent) and Islami Bank Bangladesh ltd. (75.9 percent) showed advances services. Among the private banks, one bank and Premier bank are most inefficient banks with efficiency scores of 0.370 and 0.371, respectively. All other banks are identical. The temporal behavior of advance efficiency shows that it has declined marginally for the maximum banking industry in the year 2003; it may be because banks have taken time to adjust to the new regulation and competitive frame-work. However this differs at the bank group level. The advance efficiency of selected banks, which decreased in the year 2003 and increased for the remaining study period but the advance efficiency of Sonali Bank and Janata Bank are found almost stable.

Conclusion

This paper studied the development of online bank advance efficiency in Bangladesh and it applied the Stochastic Frontier Approach in evaluating the efficiency, to a sample of 20 banks during the period of 2001-2007. The findings showed that the average efficiency of the overall considered banks has increased after the year 2003 while the average efficiency trend has been decreased during the period, 2001 to 2003. The results suggested that the mean technical efficiency improved during the reference period. The technical efficiency of nationalized commercial banks was 94.2%, higher than the Islamic banks, foreign banks and private banks where the technical efficiency was 49.5, 47.1 and 46.2%, respectively. The most efficient banks were observed for both Janata bank (94.3%) and Sonali bank (94.1%) while most inefficient banks were found to be One bank and Premier bank with efficiency scores of 0.370 and 0.371 respectively.

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Appendix

Banks name	Serial number	Banks name	Serial number
Sonali Bank	1	One Bank	11
Janata Bank	2	UCB Bank	12
Islami Bank	3	Pubali Bank	13
Shahajal Islami Bank	4	Premier Bank	14
Al Arafah Bank	5	Mutual Bank	15
Bank Asia	6	South East Bank	16
The city Bank	7	Eastern Bank	17
National Bank	8	AB Bank	18
Prime Bank	9	Dhaka Bank	19
Uttara Bank	10	DBBl	20