A stochastic frontier model for measuring online bank profit efficiency

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This study revisited an alternative profit efficiency function specified by Berger & Mester, (1997) and we applied Battese & Coelli, (1995) inefficiency model as a unified and consistent framework in exploring the determinants of important factors causing profit efficiency differential on banking industry in Bangladesh. Using stochastic frontier technique we estimated bank specific profit efficiency for the period 2000 to 2007. This study attempted to examine the changes in the profit efficiency in accordance with NBs (Nationalized Commercial Banks), ISBs (Islamic Banks), FBs (Foreign Banks) and PBs (Private Banks) and significant variations of efficiencies across different kinds of banks in time periods. We found that the profit inefficiency has declined over the reference period and Translog Production Function is more preferable than Cobb-Douglas Production Function. Our results showed that Nationalized Commercial Banks were significantly inefficient and on the contrary ISBs, FBs, and PBs were efficient in producing profit and noteworthy. The estimated year wise average efficiencies of the sample banks from the profit efficiency model was 0.664 while group wise average profit efficiency was 0,639. Dhaka Bank is highly efficient with score 0.89 and AB Bank was found lowest efficient with score 0,35 according to the sample data.

Introduction

Bank efficiency studies are of crucial importance for operational and academic proposes (Berger & Humphrey, 1997). So far, there is quite a fair amount of research that studied banking efficiency in less developed countries, for example Saudi (Al-Faraj, Alidi & Bu-Bshait, 1993), Bangladesh (Sarker, 1999; Raihan, 1998; Hasan & Kabir 1999; Choudhury, 2000; Choudhury & Raihan, 2002; Rahman, 2003; Hasan & Baten, 2005; Nadim, Shubhankar & Haque, 2007), Kuwait (Limam, 2002), Turkey (Isik & Hassan, 2002a; 2002b), Jordan (Isik & Hassan, 2003), Bahrain (Hassan, Samad & Islam, 2003), Malaysia (Sufian & Ibrahim, 2005); Pakistan (Limi, 2004), and U.A.E. (Rao, 2005).

Profit efficiency indicates how well a bank is predicted to perform in terms of profit relative to other banks in the same period for producing the same set of outputs. Despite the wide agreement on the relevance of profit efficiency analysis, the technical difficulties with the measurement and decomposition of profit inefficiency were the main reasons for the small number of empirical studies on banking profit efficiency. Both parametric and non-parametric techniques have been employed to compute efficiency scores (Berger & Humphrey, 1997; Manthos & Fotios, 2008). Nevertheless, the majority of these studies limit their efficiency analysis to the cost side (*e.g*. Berger, Hunter & Timme, 1993; Resti, 1997), recent studies have given more attention to profit efficiency. Indeed, among the 130 studies surveyed by Berger and Humphrey (1997), only fourteen of those studies employ a profit efficiency perspective. Some studies (e.g., Guevara & Maudos, 2002) provide banking profit efficiency scores for several European countries, including Portugal.

Studies that applied the profit efficiency found some evidence of improved profit efficiency. (see Berger & Humphrey 1992; Berger, Hancock, & Humphrey 1993; Kaparakis, Miller & Noulas, 1994; Kwan & Eisenbeis, 1996; Berger & Mester, 1997; Bikker, 2001; Oludele *et al*., 2010; Tahir, AbuBaka & Haron, 2010). The majority of studies investigating banking profit efficiency adopt a parametric approach following the prominent works of Berger and Mester (1997), DeYoung and Nolle (1996) and DeYoung and Hasan (1998). The few available studies that estimate profit frontier functions report efficiency levels that are much lower than cost efficiency levels, implying that the most important inefficiencies are on the revenue side (Maudos *et al.,* 2002). Maudos and Pastor (2003), and Joana and Elvira (2007) studied an alternative profit efficiency scores with a non-parametric approach.

To our knowledge, there is no study that has focused exclusively on the profit efficiency of Bangladesh banking sector using stochastic frontier analysis. Therefore this study intends to reveal the overall performance of commercial banks with loan default and measuring bank efficiency in Bangladesh in the context to both productivity and profitability. The present paper utilize the concept of alternative profit efficiency and apply Battesse and Coelli

(1995) model, which is assumed to behave in a manner consistent with the stochastic frontier concept and it is used to examine the profit efficiency level of banks in Bangladesh. The main focus of our study is to measure the bank profit efficiency in accordance with NBs (Nationalized Commercial Banks), ISs (Islamic Banks), FBs (Foreign Banks) and PBs (Private Banks) in Bangladesh. To determine the important factors causing profit efficiency differential on banking industry in Bangladesh is also of our interest.

Background of Bangladesh banking industry and its importance

The banking system of Bangladesh consists of four nationalized commercial Banks, around forty private commercial banks, nine foreign multinational banks and some specialized banks. Grameen Bank is a specialized micro-finance institution, which revolutionized the concept of micro-credit and contributed greatly towards poverty reduction and the empowerment of women in Bangladesh. Banks are the main vehicles for mobilizing invisible funds and channeling those funds to faster the growth of the productive sectors of the economy. Question arises how successfully the nationalized private commercial banks are serving the country, how far they have achieved their desired goals? The nationalized commercial banks are overcome with the vicious problem of corruption, inefficiency, loan default etc. although the private commercial banks are efficient in their commercial activities and solving the problem of loan default.

The Bangladesh banking sector relative to the size of its economy is comparatively larger than many economies of similar level of development and per capita income. Private Banks are the highest growth sector due to the dismal performances of national/government banks. Foreign Banks are also the growth sector due to the performances of national commercial banks. They tend to offer services providing disbursed loan and defaulted loan as well as are playing a pioneer role in introducing modern financial products and services. Out of the specialized banks, two (Bangladesh Krishi Bank and Rajshahi Krishi Unnayan Bank) were created to meet the credit needs of the agricultural sector while the other two (Bangladesh Shilpa Bank (BSB) and Bangladesh Shilpa Rin Sangtha (BSRS)) are for extending term loans to the industrial sector. The total size of the banking sector at 26.54% of GDP dominates the financial system, which is proportionately large for a country with a per capita income of only about US$540. The non-bank financial sector, including capital market institutions is only 3.22% of GDP, which is much smaller than the banking sector. Access to banking services for the population has improved during the last three decades. While population per branch was 57,700 in 1972, it was 19,800 in 1991. In 2001 it again rose to 21,300, due to winding up of a number of branches and growth in population. Compared to India's 15,000 persons per branch in 2000, this indicates that the banking system in Bangladesh is a significant problem.

Table 1: List of online banks considered in this study

List of Online Bank's Name	Serial Number
Sonali Bank	1
Janata Bank	2
Islami Bank	3
Shahajal Islami Bank	4
Al Arafah Bank	5
Bank Asia	6
The city Bank	7
National Bank	8
Prime Bank	9
Uttara Bank	10
One Bank	11
UCB Bank	12
Pubali Bank	13
Priemer Bank	14
Mutual Bank	15
South East Bank	16
Eastern Bank	17
AB Bank	18
Dhaka Bank	19
DBBl	20

Methodology

A stochastic profit frontier model

In the banking sector, econometric measurement of inefficiency has been undertaken mainly through estimating a cost function. The implementation of the profit function approach is rather difficult due to chronic data problems, as the profit function requires price data for outputs, which is hard to construct in banking.

The profit efficiency is measured as the ratio between observed profit (P) to the corresponding profit frontier (P^*), i.e. $PE = P/P^*$. The stochastic frontier analysis, as developed by Aigner, Lovell and Schmidt (1977) and applied to banking by Ferrier and Lovell (1990), Berger and Mester (1997) specifies a particular form for the cost (profit) function, usually a translog form, and allows for random error. It assumes that these errors consist of inefficiencies, which follow an asymmetric distribution (usually a truncated or half normal distribution), and random errors that follow a symmetric distribution (usually the standard normal distribution). While there are various methods of measuring profit efficiency (see Lovell, 1993; Coelli, Rao & Battese, 1998; Kumbhakar & Lovell 2000), in the present study we revisited an alternative profit efficiency function of (Berger & Mester, 1997) and applied (Battese & Coelli, 1995) which explicitly account for statistical noise.

Let N be the number of banks. Suppose the ith bank has a vector of X independent inputs that determine profit. Then, the stochastic profit function is defined as:

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

where

P_{it} is the logarithm of profit 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** corresponds to the random fluctuations, and is assumed to follow a symmetric normal distribution around the frontier i.e., $N(0,\sigma_v^2)$ and independent of U_{it}; for profit function, $U_{it} \le 0$ (0 for highest profit) accounts for bank's inefficiency and is assumed here to follow a truncated normal distribution i.e., $N\left(\mu,\sigma_u^2\right)$; 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 parameterization from Battese and Corra (1977) are used replacing σ_u^2 and σ_v^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$. The inefficiency effect U_{it} in the stochastic frontier model is specified as follows:

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

where,

the random variable, W_{it} follows truncated normal distribution with mean zero and variance σ^2, such that the point of truncation is $-Z_{it}\delta$. Parameters of the stochastic frontier given by equation (1) and inefficiency model given by equation (2) are simultaneously estimated by using maximum likelihood estimation; the methodology was advanced by Battese and Coelli (1993; 1995), and the software, Front41, was produced by Coelli (1996). After obtaining the estimates of U_{it} the profit efficiency of i-th bank industry at t-th time period is given by:

$$PE_{it} = P/P^* = \exp(-U_{it}) = \exp(-Z_{it}\delta - W_{it}) \quad \ldots (3)$$

An empirical stochastic frontier model of profit inefficiency

We used an alternative profit function specification, where the dependent variable is given by $\ln(P)$ indicates the value of profit (P) over all banks in the sample, and is added to every firm's dependent variable in the profit function. This transformation allows us to take the natural log of profits, given that profits can obtain negative values.

The functional form of the profit Translog stochastic frontier production model is defined as:

$$\begin{aligned}\ln(P_{it}) &= \beta_0 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + \\ &\tfrac{1}{2}\left(\beta_{11}\ln X_{1it}^{\,2} + \beta_{22}\ln X_{2it}^{\,2} + \beta_{33}\ln X_{3it}^{\,2}\right) \\ &+\beta_{12}\ln X_{1it} * \ln X_{2it} + \beta_{13}\ln X_{1it} * \ln X_{3it} + \\ &\beta_{23}\ln X_{2it} * \ln X_{3it} + V_{it} - U_{it}\end{aligned} \quad \ldots . (4)$$

where

the subscripts i and t represent the i-th bank industry and the t-th year of observation, respectively; $i = 1, 2, \ldots, 20$; $t = 1, 2, \ldots, 7$;

P_{it} denotes the profit of the ith bank industry in the t-th period in values (taka);

X_{1it} denotes prices of physical capital of i-th bank industry in the t-th period;

X_{2it} represents materials prices of i-th bank industry in the t-th period;

X_{3it} represents prices of labor of i-th bank industry in the t-th period;

"ln" refers to the natural logarithm.

Further, the bank industry specific inefficiency is considered as a function of some explanatory variables and the inefficiency effects model is defined as:

$$\begin{aligned}U_{it} &= \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 NB + \delta_5 ISB + \\ &\delta_6 FB + \delta_7 PB + W_{it}\end{aligned} \quad \ldots (5)$$

where

δ_0 is the intercept term and δ_j $(j = 1, 2, 3, 4, 5, 6, 7)$ is the parameter for the j-th explanatory variable, Z_1 =Time, Z_2 =Total Assets, Z_3 = Herfindahl-Hirschman 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;

Measurement of variables

One of the crucial debated issues in the banking literature is output measurement. Under production approach output is measured by the number and type of transactions or accounts and inputs used are only physical units such as labor and capital, since, only physical inputs are needed to provide financial services. Under intermediation approach, financial institutions are thought of as primarily intermediating funds between savers and investors. Under this approach, the inputs of the bank are essentially financial capital, and outputs are measured by the volume of loans and investments outstanding. The present study adopts production approach to specify outputs and inputs of commercial banks. All nominal values are converted to real by deflating with GDP deflator and all values are in their natural logarithms.

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 rest of them are collected from annual accounts of Scheduled Commercial Banks published by Bangladesh Bank, the central bank of Bangladesh.

Dependent variable

Profit (Y): Banks and other financial institutions are simply businesses organized to maximize the profitability and that is why the performance of a commercial bank is measured by its profit efficiency. In this study we have used profit is equal to the pre-tax profit for all commercial banks. The dependent variable is now $\ln\left(P+|P^{min}|+1\right)$, where, $|P^{min}|$ is the absolute value of the minimum value of profits in the appropriate sample. In practice, the constant term $|P^{min}|+1$ is added to every bank's profit so that the natural log is taken of a positive number. This adjustment is necessary since a number of banks in the sample exhibit negative profits in the sample period. The dependent variable is ln(l)=0 for the bank with the lowest value of P. The nominal profit values are deflated by respective consumer price index.

Independent variables

(X_1): the price of physical capital which is equal to depreciation over fixed capital and investment in leasing. It is the input variable representing the fixed assets of a bank in a year which also adds premises, furniture and fixture and the figures are deflated by capital price index.

(X_2): For the banking sector, price of material has been 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.

(X_3): the price of labor and is calculated as total salaries and staff expenses over full time number of staff.

Time (X_4): To find the productive efficiency of a bank over time we have used time as the input variable. In this study we have collected data of seven years from 2001 to 2007 and used 1 for year 2001, 2 for 2002 and so on.

Explanatory variables

(Z_1): Total asset of bank used as the influencing variable and is the sum of all assets and their book value.

(Z_2): The Herfindahl-Hirschman index takes into accounts both the relative size and number of banks in the banking sector. Mathematically, HHI is described as follow: $HHI = \sum_{i=1}^{N} S_i^{\,2}$ where N is the number of banks and S_i is share of the i^{th} bank. HHI is known as measure of competition which is measured as the sum of squared of the output share of each 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 respectively. The dummy variables can take either 1 or 0 depending on data availability or not respectively.

Likelihood ratio tests and hypothesis

The following hypotheses requires testing with the generalized likelihood ratio test statistic is defined by

$$\lambda = -2\left\{\ln\left[L(H_0)/L(H_1)\right]\right\} = -2\left\{\ln\left[L(H_0)\right]-\ln\left[L(H_1)\right]\right\} \quad \ldots (7)$$

where

$L(H_0)$ and $L(H_1)$ are the value of the likelihood function for the profit frontier model under the null and alternative hypothesis. 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 & Saatci, 1997). These are obtained by using the values of the log–likelihood functions for the banking industries and the stochastic frontier production function.

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. It specifies that the second-order coefficients of the stochastic frontier production function are simultaneously zero.

$H_0 : \gamma = 0,$ the null hypothesis specifies that the technical inefficiency effects in banks are zero. This is rejected in favor of the presence of inefficiency effects. Here γ is the variance ratio, explaining the total variation in output from the frontier level of output attributed to technical efficiency and defined by $\gamma = \sigma_u^2 / \left(\sigma_u^2 + \sigma_v^2\right)$. This is done with the calculation of the maximum likelihood estimates for the parameters of the stochastic frontier models by using the computer program frontier version 4.1 developed by Coelli (1996). If the null hypothesis is accepted this would indicate that $\sigma_u^{\,2}$ 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.

Results and discussion

In this section Ordinary Least Square Estimates (OLS) and Maximum Likelihood Estimates (MLE) of the parameters reported in the context of bank specific profit efficiency of Bangladesh followed by Translog stochastic frontier model. The ordinary least square estimates of parameters were obtained by grid search in the first step and then these estimates were used to estimate the maximum likelihood estimates of the parameters treated as the profit frontier estimates of Translog stochastic frontier production model.

The ordinary least squared estimates of profit efficiency model were presented in the Table 2. First order coefficients of the parameters of profit efficiency model were statistically significant in case of OLS estimation at different level of significance but some second order variables were found statistically insignificant. In OLS estimates all first order parameters in profit efficiency model showed positive sign. All input variables except some second order variables were indispensable contributors to boost the bank profit efficiency in Bangladesh.

Table 2: OLS estimates of translog stochastic frontier production function: Profits frontier

Variables	Parameters	Coefficients	S.E	t-value
Constant	β_0	1,692**	1,693	1,693
Capital	β_1	0,616***	-1,398	-1,398
Material	β_2	0,873*	4,538	4,538
Labor	β_3	0,466*	-2,371	-2,371
Capital*Capital	β_{11}	0,212@	-0,029	-0,029
Material*Material	β_{22}	0,355**	-2,303	-2,303
Labor*Labor	β_{33}	0,049@	0,624	0,624
Time*Time	β_{44}	0,023@	0,754	0,754
Capital*Material	β_{12}	0,212@	0,442	0,442
Capital*Labor	β_{13}	0,107@	1,105	1,105
Capital*Time	β_{14}	0,044@	-0,803	-0,803
Material*Labor	β_{23}	0,149@	-0,214	-0,214
Material*Time	β_{24}	0,064**	-2,129	-2,129
Labor*Time	β_{34}	0,030*	2,323	2,323
Sigma-squared	0,25333467			
Log likelihood function	-94,605314			

*,**,*** Significance level at 1%, 5%, 10% consecutively

@ means insignificant, S.E = Standard Error

The maximum likelihood estimates (MLE) of parameters in the profit efficiency model along with inefficiency estimates reported in the Table 3 and 4. The maximum likelihood estimates of the coefficients of capital and material were found to be significant with the values -0,696 and 0,887 respectively while the coefficients of labor and time found insignificant with 0,062 and 0,053 respectively. The insignificance of the estimated labor coefficients was not surprising given that most banks may be still overstaffed even after many years of reforms.

In the inefficiency effects model, a positive coefficient value increased the level of inefficiency and vice-versa. The most expected result observed in inefficiency effects model of profit efficiency and the result for the estimated coefficient of time with 0,053 indicated that day by day the level of efficiency is being increased. It was observed that total assets and the Herfindahl-Hirschman Index were negatively significant in this model. Hence total assets and Herfindahl-Hirschman Index were found decreasing the level of inefficiency. Other explanatory variables in the inefficiency model were the dummies of four banks group taking value 0 or 1. From the coefficients of these variables it was clear that Foreign Banks and Private Banks were more efficient in profits making than that of their counterparts Nationalized Commercial Banks and Islamic Banks. The negative coefficient of time indicated that the profit level tended to increase by 1,37 per cent per year over the time period.

Table 3: Maximum-likelihood estimates of translog production function: Profit frontier

Variables	Parameters	Coefficients	S.E	t-value
Constant	β_0	5,106*	0,724	7,051
Capital	β_1	-0,696*	0,299	-2,328
Material	β_2	0,887*	0,147	6,031
Labor	β_3	0,062@	0,121	0,509
Capital*Capital	β_{11}	0,081*	0,011	7,058
Material*Material	β_{22}	-0,514*	0,151	-3,392
Labor*Labor	β_{33}	0,036***	0,023	1,541
Time*Time	β_{44}	0,029*	0,005	5,831
Capital*Material	β_{12}	0,257*	0,103	2,496
Capital*Labor	β_{13}	-0,048*	0,010	-4,994
Capital*Time	β_{14}	-0,063**	0,028	-2,256
Material*Labor	β_{23}	-0,010@	0,037	-0,256
Material*Time	β_{24}	0,010@	0,034	0,295
Labor*Time	β_{34}	0,036**	0,018	1,977

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

Table 4: Maximum likelihood estimates of the parameters of inefficiency effects model

Variables	Parameters	Coefficients	S.E	t-value
Constant	δ_0	2,493*	0,967	2,578
Time	δ_1	0,053@	0,084	0,633
Total Assets	δ_2	-0,192***	0,120	-1,604
Herfindahl-Hirschman Index	δ_3	-0,058@	0,213	-0,272
NB Dummy	δ_4	1,404**	0,788	1,782
ISB Dummy	δ_5	1,687*	0,509	3,311
FB Dummy	δ_6	-0,440@	0,829	-0,530
PB Dummy	δ_7	-0,158@	0,513	-0,308
Sigma-squared		0,860*	0,103	8,312
Gamma		0,99999*	0,00021	28454,734

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

The estimated results of the profit efficiency model were reported in the Figures 1, 2 and 3 according to group wise, year wise and bank wise respectively. It was observed that on an average, Bangladeshi banks were 66,4 per cent efficient in profits making services relative to the best performing bank during the study period. In case of profit efficiency, foreign banks were most efficient (68,8 per cent) along with private banks (68,7 per cent). These findings are in line with the argument that foreign banks are superior as they normally have advanced technology and skills; sophisticated services and broader international networks (Levine, 1996; Unite & Sullivan, 2003). National banks and Private banks were relatively less efficient than foreign banks, these results contradicted with the finding of (Iza, Nor & Mazlina, 2009) but supported with the result of (Tahir *et al*., 2010). From this study it was revealed that Government owned banks were least efficient that increase profits level with 58,4 per cent. However, the implication of the result of (Raulin, 2008) is that foreign banks are not always more efficient than domestic banks in developing countries, and even in a country with low income level. During the period 2001 to 2004, profit efficiency of nationalized commercial banks were almost stable and it was around 45,8 per cent but in the following year efficiency scores increased dramatically and it became almost doubled with 87,5 per cent. The findings of this study suggest that foreign banks are more profit efficient than domestic banks and it was supported by (Kiyota, 2009). Again the efficiency of NBs decreased in the years 2006 and 2007. On the other hand private banks were very consistent over time. These results were supported by Mahesh and Meenakshi (2006).

Table 5: Yea-wise average profit efficiency of banks in Bangladesh

Year	Mean
2001	0,584
2002	0,586
2003	0,609
2004	0,661
2005	0,765
2006	0,705
2007	0,738
Mean	**0,664**

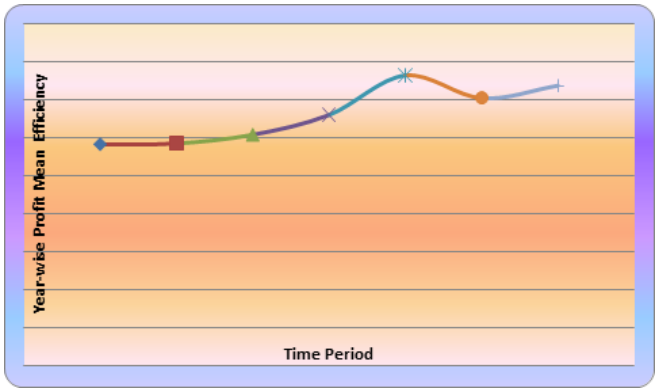

Figure 1: Year-wise average profit efficiency over time

The year wise average profit efficiency of 20 banks in Bangladesh displayed in Table 7 and figure 2. From this investigation we observed that the highest average profits efficiency was in 2005 and the inefficiency score was 76,5 per cent and in 2001 the profit efficiency was 58,4 per cent. In 2007 the profit efficiency increased by 26,36 per cent dramatically from 2001. This study contradicted the findings of (Dilruba & Khandakher, 2005; Hamim *et al.*, 2006) in particular for nationalized commercial banks and for Islami Banks. From the Figure 2 the over all situation of banks' performance was to be clearly understood. Time has an important affect in reducing profit inefficiency. In case of profit efficiency model the efficiency gradualy increased.

Table 6: Year-wise bank group level profit mean efficiency

Year	NB	ISB	FB	PB
2001	0,338	0,567	0,349	0,662
2002	0,463	0,438	0,505	0,651
2003	0,456	0,488	0,700	0,647
2004	0,458	0,396	0,856	0,723
2005	0,875	0,705	0,897	0,741
2006	0,786	0,792	0,762	0,663
2007	0,713	0,816	0,748	0,723
Mean	**0,584**	**0,600**	**0,688**	**0,687**

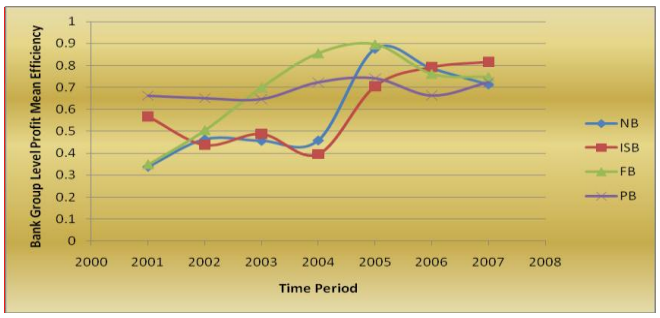

Figure 2: Bank group level profit mean efficiency over time

Bank wise profits efficiency of 20 banks showed a more clear perception about the performance of an individual bank and the individual profit efficiency portrayed in Table 8 and figure 3. The most efficient banks during the study period were found to be Dhaka bank (with 89,9 per cent), South East bank (with 87,6 per cent), Prime bank (with 85,7 per cent), Eastern bank (with 83,8 per cent), and Bank Asia (with 77,3 per cent). On the contrary, the most inefficient banks during the data period were AB bank (with 35,4 per cent), National bank (with 43,2 per cent), Sonali bank (with 44,7 per cent), and DBBl with (57,4 per cent). At the beginning of the study period Uttara bank was most efficient in profits making but it could not retain its position at the end of the period. Opposite scenario observed in case of Islamic banks and during 2001 to 2004 Islamic banks were comparatively less efficient to raise profits level but at the end of the race their growth surprisingly increased. In 2001-2004 the average profit efficiency was around 45 per cent and in 2006-2007 it was around 98 per cent. Hence Islamic banking system has been enjoying considerable profits efficiency for two years according to this study. Moreover, foreign banks were very much efficient in producing profits making as they were at the top position which was really an alarming threat to the Nationalized Commercial banks (NBs) because reverse situation has been taken place to the NBs.

Table 7: Profit efficiency of banks in Bangladesh

Bank's Name	2001	2002	2003	2004	2005	2006	2007	Mean Efficiency
Sonali Bank	0,220	0,382	0,194	0,291	0,987	0,579	0,479	**0,447**
Janata Bank	0,455	0,544	0,718	0,625	0,762	0,993	0,947	**0,721**
Islami Bank	0,266	0,397	0,293	0,468	0,686	0,583	0,797	**0,499**
Shahajal Islami Bank	0,589	0,584	0,599	0,126	0,682	0,867	0,989	**0,634**
Al Arafah Bank	0,846	0,332	0,570	0,594	0,747	0,926	0,661	**0,668**
Bank Asia	0,340	0,542	0,813	0,991	0,978	0,851	0,894	**0,773**
The city Bank	0,357	0,467	0,586	0,720	0,817	0,673	0,602	**0,603**
National Bank	0,607	0,635	0,314	0,318	0,261	0,446	0,443	**0,432**
Prime Bank	0,978	0,838	0,949	0,891	0,966	0,726	0,650	**0,857**
Uttara Bank	0,999	0,812	0,633	0,625	0,724	0,462	0,436	**0,670**
One Bank	0,282	0,477	0,437	0,947	0,865	0,967	0,983	**0,708**
UCB Bank	0,605	0,504	0,713	0,845	0,923	0,778	0,906	**0,753**
Pubali Bank	0,809	0,801	0,512	0,331	0,595	0,543	0,692	**0,612**
Priemer Bank	0,388	0,543	0,635	0,987	0,771	0,620	0,515	**0,637**
Mutual Bank	0,360	0,560	0,933	0,922	0,888	0,797	0,608	**0,724**
South East Bank	0,991	0,843	0,756	0,749	0,895	0,895	1,000	**0,876**
Eastern Bank	0,961	0,885	0,935	0,944	0,756	0,698	0,690	**0,838**
AB Bank	0,112	0,113	0,166	0,303	0,511	0,340	0,933	**0,354**
Dhaka Bank	0,994	0,965	0,926	0,932	0,819	0,725	0,935	**0,899**
DBBl	0,525	0,491	0,503	0,602	0,665	0,624	0,606	**0,574**

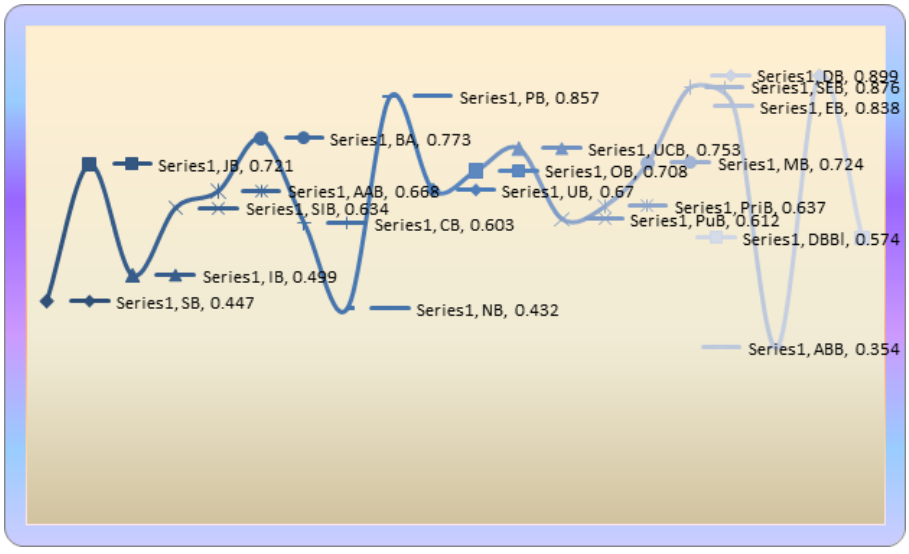

Figure 3: Bank-wise profit mean efficiency in Bangladesh

All NBs were inefficient to boost up the profitability. From the inefficiency model of the profit efficiency model we noticed that total assets were highly insignificant. Therefore the conclusion is that Nationalized Commercial Banks should properly handle their total assets make a standard solution to still existing overstaffed even after many years of reforms.

Hypothesis tests of profit efficiency model

The results of various hypothesis tests of the profit efficiency model were presented in Table 5. The all hypothesis tests were obtained using the generalized likelihood-ratio statistic (7).

Table 8: Generalized Likelihood-Ratio Test of Hypothesis of the Stochastic Profit Frontier Production Model

Null hypothesis	Log-likelihood function	Test statistic λ	Critical value*	Decision
$H_0 : \gamma = 0$	-94,59	107,77	3,38	Reject H_0
$H_0 : \beta_{ij} = 0$	-12,21	24,39	19,35	Reject H_0
$H_0 : \eta = 0$	-40,65	81,29	3,38	Reject H_0

Notes: All critical values are at 5% level of significance.
*The critical value are obtained from table of Kodde and Palm (1986). The null hypothesis which includes the restriction that γ is zero does not have a chi-square distribution , because the restriction defines a point on the boundary of parameter space.

The estimates of variance ratios ($\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$) of profit efficiency model is 0.999 indicated that the inefficiency element U_{it} is stochastic. The first null hypothesis is $H_0 : \gamma = 0$, which specify that there is no technical inefficiency effect in the profit efficiency model. The hypothesis is rejected so we can conclude that there is a technical inefficiency effect in the model.

The second null hypothesis is $H_0 : \beta_{ij} = 0$, which specifies that Cobb-Douglas Production Function is more preferable than Translog Production Function. From the result it is observed that the null hypothesis is strappingly rejected and Translog Production Function is more favorable.

The third null hypothesis is $H_0 : \eta = 0$, which specifies that the technical inefficiency effect does not vary considerably over time in the profit efficiency model. The null hypothesis is rejected signifying that the technical inefficiency effect differs significantly.

Policy recommendations

Profit efficiency evaluation is useful for individual investment or loan decisions and bank profit efficiency results of banks can help improve their overall investment performance. Bank efficiency studies are of crucial importance for operational and academic proposes (Berger & Humphrey, 1997). The findings of the study have important policy implications for efficiently managing the financial institutions, especially the NB, ISB and PB banks. In particular, the NB should take appropriate actions for increasing their coverage in offering innovative technology driven services with a view to increasing their performance and raising their market competitiveness. Studies show that Islamic banks cannot operate with its full efficiency level if it operates under a conventional banking framework, their efficiency goes down in a number of dimensions. Profit efficiency of online banking can be significantly improved by time, total assets, Herfindahl-Hirschman Index because these were observed significant with negative values which represented decreasing the level of inefficiency.

It would be important for financial sector policies to encourage the banks to use any excess liquidity in the banking system for providing credit to productive activities. The Bangladesh Bank, being the regulator of the financial system, can play an important role through taking necessary measures to expedite the initiatives of the traditional banks in adopting such innovative technology driven products and services in their banking activities. On its part, this bank should strengthen its prudential oversight and closely monitor the liquidity situation in the banking system. In addition, it would be important for the Bangladesh Bank to continue its efforts in urging the banks to reduce their lending rates, increase competition among the financial intermediaries, and pursue strong monitoring and supervision measures so that the financial institutions reduce administrative cost by improving efficiency and reducing the burden of nonperforming loans. However, the digital investments through effective extension delivery program in the current political and economic environment in Bangladesh will provide bankers with skills essential to increasing efficiency. Finally, it may be mentioned that if the online banking (financial) system, is to become truly liquid and efficient it must develop more standardized and universally (or at least widely) tradable financial instruments.

Conclusion

Efficiency measurement has been the concern of researchers with an aim to look into the efficiency levels of different commercial banks in Bangladesh engaged in various production activities. Identifying determinants of efficiency levels is a major concern in efficiency analysis. This study sets out to provide estimates of bank profit efficiency and to compare efficiency estimates for NBs (National Banks), ISBs (Islamic Banks), FBs (Foreign Banks), and PBs (Private Banks) of Bangladesh banking industries using stochastic frontier analysis. We compared the profit (in) efficiencies of 20 Commercial Banks group wise, year wise and specific bank wise over time period.

The most important results were summarized below:

First, we analyzed the Translog Stochastic Frontier Production Function with distributional assumptions for an alternative profit efficiency model and the presence of one-sided error component was justified by the LR test

individually, which was highly significant for this model. We found that the profit inefficiency has declined over the reference period and Translog Production Function is more preferable than Cobb-Douglas Production Function.

Second, the most expected result observed in inefficiency model of profit function and the estimated coefficient of time with -0.370 indicated that day by day the level of efficiency was being increased. From the estimated coefficients of inefficiency model it was seen that time, total assets, Herfindahl-Hirschman Index were found significant with negative values represented decreasing the level of inefficiency.

Third, the estimated year wise average efficiencies of the sample banks from the profit model was 0,664 while group wise average technical efficiencies was 0,639. In case of profit efficiency, foreign banks were most efficient (68,8 per cent) along with private banks (68,7 per cent). From this study it was revealed that Government owned banks were least efficient that increase profit level with 58,4 per cent. During the years 2001 to 2004 profits efficiency of nationalized commercial banks were almost stable and it was around 45,8 per cent but in the following year efficiency scores increased dramatically and it became doubled with 87,5 per cent. Again the efficiency of NBs decreased in the years 2006 and 2007. On the other hand private banks were very consistent in this regard. In terms of profit model, Dhaka Bank is highly efficient with score 0.89 and AB Bank was lowest efficient with score 0.35 according to the sample data. These findings have important policy implications in improving profit efficiency among online banks in Bangladesh.

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