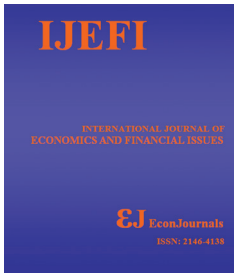

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Profit Efficiency of Bangladeshi Banks: A Stochastic Frontier Approach

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ABSTRACT

This paper examines the profit efficiency of the banks in Bangladesh using the stochastic frontier approach. The paper is prepared based on the secondary data only and the sample contains data from 25 banks including state owned banks and private conventional banks in Bangladesh from the year 2011-2020. Translog function has been employed to construct the profit function and Battese and Coelli, 1995 (BC95) model has been used to determine the profit efficiency. The efficiency performance reveals that, on average, banks in Bangladesh are 80.73% profit efficient. Dutch-Bangla Bank Limited (DBBL) is the most profit efficient banks with a score of 92.56% in 2020. While Dhaka Bank is the least profit efficient banks with a score of 15.42%. Banks belong to the 3rd generation and 2nd generation are the most profit efficient. Besides, none of the inefficiency determinant is statistically significant to explain variation in the profit inefficiency as the dataset is small and only limited to Bangladeshi banks. Moreover, diagnostic tests such as Normality test, M3T statistics test and Likelihood Ratio (LR) test have been performed to confirm the existence of inefficiency. This paper shall provide important insight of state owned banks and private conventional banks in Bangladesh to the managements, regulators and other concerned parties.

Keywords: Profit Efficiency, Stochastic Frontier Approach, Generation Wise Banks, Intermediation Approach, Inefficiency, COVID-19
JEL Classifications: C33, G21, N25

1. INTRODUCTION

A sound and competitive financial system is capable of improving a country's financial stability and economic growth as it makes the sector more enduring to both internal and external shocks. The financial sector of Bangladesh is highly dominated by banking industry and this industry has experienced significant progress recently in terms of number of banks, growth in assets and deposits, number of branches and account holders. In Bangladesh, there are 61 scheduled banks and these banks have a total of BDT 20,429.300 billion of assets and a total of BDT 15,181.400 billion of deposits (Source: CEIC Data), 10937 branches (Source: CEIC Data) and 13.24 crore bank account holders (Uddin, 2020). Despite such progress, industry experts express that banking industry of Bangladesh is at severe risk due to overcapacity, supervision gaps and market indiscipline. Therefore, it has become imperative to measure the efficiency of commercial banks in Bangladesh to produce necessary policy options for regulators, managers of banks and public by using sophisticated approach. Considering this situation, bank efficiency is one of the best indicators of sound banking system and it is often examined using a parametric approach named stochastic frontier analysis (SFA) and non- parametric method known as data envelopment analysis (DEA). There are numerous studies which conduct the bank efficiency such as Baten and Kamil (2010) employed SFA model to measure profit efficiency of banks in Bangladesh. Raju (2017) assessed the cost and profit efficiency of state-owned, conventional and Islamic banks in Bangladesh using both accounting ratios and SFA method. Cost and profit efficiency of national commercial banks and private banks in Bangladesh are examined by Baten et al. (2015). These studies have found various problems in the banking industry which are liable for increasing profit inefficiency

such as growing amount of NPLs, high interest rate spread, high amount of operational costs etc. Therefore, this paper may help give policy recommendation to eliminate such problems associated with bank profit efficiency. For my analysis, 3 input prices, 3 outputs, 2 controls variables and 9 determinants of inefficiency have been taken to see their impact on profit efficiency. There are many studies regarding profit efficiency have been conducted in developed and developing countries but very few studies on this issue are conducted on the banks in Bangladesh. Given this, the present study would examine and compare the performance of state-owned banks and private conventional banks from the perspective of profit efficiency based on stochastic frontier approach (SFA) over the period of 2011 to 2020.

The rest of the paper is structured as follows: Section 2 reviews the previous studies on this topic; section 3 presents the details of the data and methods revealing the sample collection technique, selected variables and mathematical model; section 4 shows the results of the analysis; finally, section 5 concludes the results of the paper.

2. LITERATURE REVIEW

Pasiouras et al. (2009) presented the international evidence on the effect of banking regulations and restrictions on bank activities on the banks' cost and profit efficiency using the stochastic frontier analysis. The sample covering the period of 2000-2004 consists of a panel dataset of 2853 observations from 74 countries' 615 publicly listed commercial banks. The results suggest that higher official supervisory power and disclosures and incentive requirements of market discipline influence cost and profit efficiency positively. Stricter capital requirements positively affect the cost efficiency but it has negative influence on profit efficiency. On the other hand, the paper finds opposite result in terms of restrictions on bank activities, having a negative impact on cost efficiency and positive impact on profit efficiency. The overall efficiency score has been found 0.8789 and 0.7679 for cost and profit efficiency respectively.

Lu et al. (2019) applied parametric SFA approach to examine the cost and profit efficiency of banks in New Zealand from 2002 to 2011. The results indicate that banks from foreign countries are more cost and profit efficient than domestic banks. The paper also shows that locally incorporated subsidiaries of foreign banks are more efficient than foreign banks operating as branch banks. The study indicates due to an increase in banking market concentration level, large banks usually gain more in terms of profit efficiency. Bank size has been found positively associate with cost and profit efficiency. Moreover, the study shows significant impact of equity capital ratio, asset quality, interest rate, inflation and unemployment conditions on both cost and profit efficiency.

Baten and Kamil (2010) examined the changes in profit efficiency in accordance with the nationalized commercial banks, Islamic banks, Foreign banks and Private banks during the period 2000-2007 by employing stochastic frontier technique. The analysis shows that Banks in Bangladesh, on average, are year wise 66.4% profit efficient while it is 63.9% under group wise. It has been found that foreign banks have the most profit efficiency (68.8%) along with private banks. From the result of maximum likelihood estimates, capital and material have been found statistically significant while labor and time have been found statistically insignificant. Moreover, it is observed that time, total assets and Herfindahl-Hirschman index have significant negative impact on bank profits.

Hadhek et al. (2018) estimated the profit efficiency of 37 Islamic banks from 15 countries during 2005-2014 using the SFA approach. The empirical analysis shows that, on average, the profit efficiency level is 25.7%. Bank size, GDP per capita and demand density have been found statistically significant to have negative impact on profit efficiency whereas profitability ratio (EBP) is found to be positive and statistically significant.

Hendrawan and Nasution (2018) conducted a study to assess the profit efficiency of 21 Indonesian banks on the IDX from the years 2008 to 2017 by employing the SFA model. The research shows that maximum efficiency score is 0.69 and the efficiency score of the banking sector in the capital market of Indonesia is 0.43 and therefore, banking system in the capital market of Indonesia is thought to be inefficient. From the analysis, it is concluded that Bank Rakyat Indonesia is the most efficient bank. The study presents that total loans, securities, price of labor and inflation have significant impact on the profits of banks.

Delis et al. (2009) performed the analysis of cost and profit efficiency of the Greek Banking system from 1993 to 2005 based on SFA model. The results indicate the lower score of cost efficiency than the profit efficiency but the difference has been found quite significant between levels of cost and profit efficiency. Compared to smaller banks, larger banks have been found less profit efficient. Furthermore, state owned banks have emerged to be less profit efficient. Moreover, the paper also made comparison between the parametric (SFA) and non-parametric (DEA) approaches. The results of the DEA method indicate higher average inefficiency compared to the SFA approach.

Pasiouras et al. (2007) investigated the impact of regulatory, supervision and environmental factors on bank efficiency by employing the stochastic frontier analysis and Tobit regression. A panel dataset of 3086 observations from 677 publicly listed commercial banks in 88 countries during 2000-2004 have been used. From the analysis, it is evident that restrictions on the banking activities affect profit efficiency. The results also report that profit efficiency is improved by the capital adequacy and the impact of government ownership of banks is significant. Bank size has been found to be statistically significant to influence profit efficiency positively. It is reported that stock market capitalization improves profit efficiency but this efficiency is reduced by higher inflation. Moreover, profit efficiency has been influenced by GDP growth. Lastly, property rights protection is negatively influencing profit.

Rusmita and Putri (2020) examined the level of cost and profit efficiency of the listed Islamic banks in Indonesia using the SFA method. Dataset is formed based on cross-section and panel data obtained from 7 banks from 2015 to 2019. The analysis reports that the average profit efficiency score is 55.35%.

Ariff and Luc (2008) performed the cost and profit efficiency of 28 Chinese commercial banks from 1995 to 2004 by employing Tobit regression. The findings show that overall profit efficiency level is 50.50%. On average, national and city based joint-stock banks have appeared to be more cost and profit efficient than state-owned banks. On the other hand, medium-sized banks have been found to be significantly more efficient.

Tahir et al. (2010) performed the relative efficiency level of Malaysian domestic and foreign commercial during 2000-2006 by employing accounting-based ratio and stochastic frontier approach. Based on accounting ratios, domestic banks have higher interest margin and operating costs than foreign banks while foreign banks enjoy slightly higher profit ratios relative to domestic banks. According to the results of SFA method, domestic banks have proved to be more cost efficient but less profit efficient compared to the foreign banks. Overall, profit efficiency scores are 63.8% for domestic banks and 76.9% for foreign banks.

Mghaieth and Khanchel (2015) used the SFA approach to investigate the cost and profit efficiency's determinants of Islamic banks before, during and after the financial crisis of 2008. The sample consists of 62 Islamic banks of 16 countries covering the regions of MENA and South East Asia from 2004 to 2010. Results of the panel data show that banks have average profit efficiency of 82.47%. According to the regression results, Islamic banks which are having high profitability ratio and equities are the most profit efficient. The research reports that bank size, capital adequacy ratio, ROAA and operational cost have significant impact on profit efficiency.

Srairi (2010) used a stochastic frontier model to investigate the cost and alternative profit efficiency of the Gulf banking industry. The sample consists of an unbalanced panel data of 71 commercial banks for the period of 1999-2007. The paper reports that profit efficiency is increased by financial depth, capital ratio, degree of monetization and concentration and GDP per capita. The results reveal that banks in Gulf region are more profit efficient than cost efficient as profit efficiency score is 71% higher than cost efficiency score (56%).

Akhigbe and McNulty (2003) researched the profit efficiency of USA's small banks for the sample period of 1990 to 1996. The result reveals that small banks are more profit efficient compared to the large banks for the sample period. From the analysis of single frontier approach, it has been reported that, 69.67% profit efficiency is enjoyed by small banks in metropolitan statistical areas (MSAs) where banks in non-MSAs have a score of 78.62%. Regression analysis shows that profit efficiency increases due to the increase of bank size. Lastly expense-preference (EP), structure performance (SP) and lender-borrower relationship development play significant role in explaining the profit efficiency of US small commercial banks.

Baten et al. (2015) employed stochastic frontier analysis to estimate the cost and profit efficiency of national commercial banks and private banks in Bangladesh from 2001 to 2010. The analysis shows that Translog cost and profit models are preferable to Cobb-Douglas cost and profit models. The average profit efficiency is recorded 91.1% and Eastern Bank was found to be the most profit efficient whereas Janata Bank is ranked in the last.

Belousova et al. (2018) examined how the profit efficiency of Russian banks affected by the type of ownership during the period 2004 to 2015 by combining the stochastic frontier analysis with intermediary approach. The findings show that foreign owned banks are most profit efficient than state-owned banks and domestic private banks. During the economically stable periods of 1st quarter of 2004 to the 2nd quarter of 2008 and 2014 to 2015, foreign banks enjoyed the higher profit efficiency than other domestic banks in Russia. However, during the financial turmoil periods, state-owned banks were more profit efficient than any other banks due to state support.

Raju (2017) used the basic accounting ratios and stochastic cost and profit approaches to assess the cost and profit efficiency of state owned, conventional and Islamic banks in Bangladesh during 2011-2015. Based on accounting ratios, conventional commercial banks are more cost and profit efficient than other two types of banks. As per the result of stochastic profit frontier, conventional banks have the higher alternative profit efficiency than Islamic banks and state-owned banks.

Hassan et al. (2009) measured and compared the cost and profit efficiency using the SFA approach where the sample data consists of 37 conventional banks and 43 Islamic banks from 21 OIC countries. The overall result of the efficiency report that average bank is better in profit generation than utilizing the resources. Also over the years, profit efficiency is more stable than the level of cost efficiency but in terms of overall sample, cost and profit efficiency of conventional versus Islamic banks do not have significant difference. Large conventional banks have the highest profit efficiency whereas lowest profit efficiency have been scored by the small conventional banks and African conventional banks.

Isik and Hassan (2002) examined the impact of corporate control, bank size, ownership and governance on the cost and alternative profit efficiency of banks in Turkey by employing the stochastic frontier approach. The results reveal that average profit efficiency is 84% and the Turkish banking industry's oligopolistic nature has contributed less than optimal competition in the deposit and loan markets. The results also show that Turkish banks do not require greater cost efficiency to have high profit efficiency and the cost inefficient banks can operate in the imperfect market.

Vivas (1997) examined the profit efficiency of Spanish savings banks based on thick frontier approach over the period of 1986 to 1991. The result reveals that the most and least profitable savings banks have 40% average difference in estimated profits and the difference has arises due to the scale, input prices, output mix, branching intensity and profit inefficiency. The result also suggests that standard profit function is not appropriate for the banks in Spain.

Wahyuni and Pujiharto (2016) measured the profit efficiency over the period of 2010 to 2014. The results show that overall, there is a profit efficiency in the Shariah banks in Indonesia which is <1. Both Shariah banks and Shariah business units incur profit

inefficiency. At the time of global financial crisis of 2008-2009, the profit efficiency declined for the Shariah banks but Shariah business units did not have declining profit efficiency. The result also indicates that profit efficiency is positively affected by bank size but capital adequacy do not have any impact on profit efficiency.

Hassan (2005) employed a panel data to investigate the efficiency of the Islamic banking industry of the world over the period of 1995 to 2001 by employing both SFA and DEA methods. From the findings, under SFA method, on average, 84% profit efficiency has been achieved. 74% of allocative efficiency is generated while technical efficiency score is about 84%. The results also show that ROA and ROE are highly correlated with the efficiency measures. The results also indicate that increase in productivity growth in Islamic banks is due to the changes in technology not change in technical efficiency. Lastly it has been found that higher efficiency has been associated with greater profitability.

Semih and Philippatos (2007) examined the cost and profit efficiency and found that inefficiencies in management in the CEE banking market are significant enough. They conducted the research based on the stochastic frontier approach (SFA) and the distribution-free approach. The average cost regarding efficiency levels is significant enough with the efficiency level of 72% and 77% by the prospects towards DFA and SFA. Also in the profit efficiency level, it is considered as the relatively lower cost-efficient. SFA describes that almost one-third of banks are in inefficiencies and DFA describes almost one-third of inefficiencies. They also found that foreign banks are more cost-efficient. On the other hand, they are less profit efficient compared with the domestic private banks and state-owned banks.

Now based on the results of different papers studied above, it has been found that bank efficiency in terms of profit efficiency has only been investigated for the overall banks in the sector. Other categories such as generation wise profit efficiency and profit efficiency level during COVID-19 have not been conducted in Bangladesh. So there is an absent of complete picture of profit efficiency. Therefore, to deliver a complete scenario, generation wise bank profit efficiency and profit efficiency level during global catastrophic event such as COVID-19 pandemic have been incorporated in this paper.

3. DATA AND METHODS

Profit efficiency of banks is measured in terms of the efficient profit frontier that is the best practice bank. Profit efficiency is defined as the maximum profit to the actual profit. The Translog profit functions developed by Christensen et al. (1973) has been employed in this paper which includes both inefficiency component and random component.

3.1. Sample Selection Procedure

Preparing this paper requires a panel data set constructed from secondary sources including Profit and Loss Statement and Balance Sheet of the sample banks. The sample covers bank level data for the 25 scheduled banks in Bangladesh for the past 10 years (2011-2020). The sample of banks consists of 4 state-owned banks and 21 private conventional banks. The macro-level data have been collected from the World Bank open data.

3.2. Model Design and Specification

This paper examines the profit efficiency of banks in Bangladesh and determines the factors that affect the banks' profit inefficiency using the Stochastic Frontier Approach (SFA). The SFA was first developed by Meeusen and Van Den Broeck (1997) and Aigner et al. (1977). The SFA model deploys a procedure to estimate the efficiency score of banks in relation to the best practice frontier or in other word, the best practice banks in terms of profit. The SFA method captures the both random error and inefficiency components. Among various SFA model available for bank efficiency studies, model created by Battese and Coelli (1995) (BC95, hereafter) has been chosen for two key reasons. Firstly, panel data model is allowed by BC95 to capture inefficiency impact on stochastic frontiers. This suits panel data set developed in this paper and allows to estimate the time verifying efficiency at bank-level. Secondly, the estimations of the parameters of stochastic frontier model and the inefficiency model in a one-step approach simultaneously are permitted by the BC95 model unlike the Aigner et al. (1997)'s standard two-step stochastic frontier model.

The profit model in its general format is as follows:

$$lnTP_{it} = TP\left(y_{it}, p_{it}, \beta\right) + v_{it} + (-u_{it}) \quad (1)$$

Where,
TP = Total profit at time t of the bank i
y_{it} = Vector of outputs
p_{it} = Vector of input prices
β = Vector of unknown scalar parameters to be estimated
v_{it} = Random error term follows the standard normal distribution or N (0, σ_v^2) distribution.
($-u_{it}$) = Inefficiency terms for profit function follows a half normal distribution or N (m_{it}, σ_u^2) distribution where mean, m_{it} is explained as:

$$m_{it} = \delta_0 + z_{it}\delta + w_{it} \quad (2)$$

Here, z_{it} is the vector of observable explanatory variables, represented as exogenous variables which affect the inefficiency of bank i at time t. δ is defined as the vector of parameters to be estimated and w_{it}. is the error term.

The parameters of equation (1) and (2) are calculated in one stage regression model using the Maximum Likelihood Estimation method. The efficiency scores of each bank are estimated from the estimated frontiers as $PEF_{it} = exp\ (-u_{it})$ having the range of value between 0 and 1.

3.3. Construction of the Variables

To define input prices and outputs, the intermediation approach has been adopted to examine the profit efficiency of the sample banks (e.g. Berger and Mester, 1997; Delis et al., 2009; Isik and Hassan, 2002; Srairi, 2010). The intermediation approach considers banks as financial intermediaries between savers and investors. Loans and other assets are regarded as the outputs of

banks while deposits and other liabilities are taken as the inputs under the intermediation process.

Measurement of profit efficiency needs data on total profit, input prices and outputs. The dependent variable is total profit *(TP)* where the profit after tax is taken as the *TP*. Under this paper, banks are viewed as multi-product firms which generate three outputs by employing three input prices. Finally, to capture the impact of inefficiency components on profit functions, various environmental, bank specific and macroeconomic variables have been included in the model as independent variables.

3.3.1. Input prices and outputs

Input prices are measured as flows of expenditures divided by the corresponding quantity. Cost of labor (p_1) is calculated as ratio of personnel expense such as salaries and allowances to the total assets; cost of borrowed funds (p_2) measured as interest expense divided by total deposits and lastly cost of physical capital (p_3) defined as the operating expenses minus salaries and allowances which is then divided by total fixed assets.

The outputs include loans (y_1) calculated using gross loans and advances; Other earnings assets (y_2) which comprise total assets minus loans and advances minus fixed assets and finally, off balance sheet items (y_3). All three output vectors are in million taka and they are deflated using GDP deflator.

3.3.2. Other variables affecting profit and inefficiency

Besides input prices and outputs, there are control variables that have impact on the profit function such as equity and time trend. Moreover, there are other variables which may belong to the inefficiency function or they may belong to the frontier. Therefore, to determine the effect of inefficiency on profit function various explanatory variables such as market concentration ratio *(MC)*, bank size *(SIZE)*, credit risk *(CRDRISK)*, profitability ratio *(ROA)*, financial intermediation ratio *(FIR)*, operational cost *(CIR)*, economic growth *(GDPGR)*, interest rate *(INT)* and inflation rate *(INF)* have been included into the model. The summary of the each variable is presented in Table 1.

3.3.3. Rationale of the explanatory variables

a) Equity: Equity capital can be defined as the managerial risk preferences of banks as it has impact on the allocation of banks' asset portfolios and forms an alternative sources of funds to deposits. Equity capital varies across banks but common elements included in the equity capital are paid-up capital, retained earnings, gains from revaluation and reserves. Equity has been used in the model to control the differences in risk preferences (Pasiouras et al., 2009). Delis et al. (2009) includes equity in order to capture insolvency risk, capitalization and various risk preferences across banks. Equity is included into the profit efficiency function for few reasons. Firstly, it captures managerial risk preference in terms of maximization and minimization problems. Risk averse managers might be interested in holding equity capital than that of debt capital which is liable of cost minimization. Secondly, lower level of default risk is associated with higher level of equity. Finally, equity financing is the most expensive source of financing and neglecting it could result in bias inefficiency score.

b) Time trend: Year dummy as a time trend variable is included in the model to capture the technological changes over time (Pasiouras et al., 2009).

c) Market concentration ratio: The market concentration ratio refers to the likelihood of competition between the banks and also in the market as a whole. The ratio is constructed by dividing the total assets of the three largest state-owned banks named Sonali bank, Rupali bank and Janata bank with the total assets of industry. This variable is added in the inefficiency function to see how the profit frontier as well as the relative profit efficiency of the sample banks get influenced by the asset market concentration. Considerable market power is granted to large banks when a concentrated market exists because it provides them with a power to charge higher price for their products and services and generate higher revenues. Result of Lu et al. (2019) suggests that large banks are more profit efficient than cost efficient when there is a rise of market concentration as it has significant negative impact on profit inefficiency. Srairi (2010) found significant positive influence of concentration ratio on profit efficiency.

d) Bank size: The effect of bank size on profit efficiency has been examined in several papers where bank size is measured as the natural logarithm of total asset consistent with the studies of Hadhek (2018), Hassan (2005) and Srairi (2010). Banks will operate more efficiently and generate more profit due to the increase in bank size or economies of scale. It is expected that bank size and profit efficiency are positively associated as large banks have always been in forefront in terms of technological innovation, broad range of customer services, higher market share and economies of scale. When bank size increases, cost and profit efficiencies fall systematically (Isik and Hassan 2002). According to Hassan (2005) and Srairi (2010), there exists a positive relationship between profit efficiency and bank size. Bank size has significant positive impact on profit efficiency (Lu et al., 2019).

e) Credit risk: To incorporate the impact of credit risk on the profit efficiency, Non-Performing Loans (NPL) to total loans has been taken as a proxy for credit risk (Fries and Tacy, 2005). It is expected that the coefficient of credit risk variable (NPL/total loans) has negative impact on profit efficiency as higher NPLs lower the profit efficiency. Banks having poor credit risk management are not efficient in their operation (Isik and Hassan 2002). Semih and Philippatos (2007) suggests that efficient banks are effective in assessing credit risk.

f) Profitability ratio: Return on assets (ROA) is taken as a proxy for profitability ratio where it is calculated by dividing the net income with total assets of bank. Higher ROA indicates higher ability of banks and better performance. According to Mghaieth and Khanchel (2015), profit efficiency and ROA are positively correlated. While Semih and Philippatos (2007) did not find any relation between bank efficiency and ROA. Ariff and Luc (2008) suggests that banks which are more profitable are more efficient even though the study did not find significant relationship between profit efficiency and profitability.

g) Financial intermediation ratio: The financial intermediation ratio refers to the degree of intermediation through which

Table 1: Summary of the variables

Variable	Notation	Measure
Dependent variables		
Total profit	*TP*	Profit after tax
Input prices		
Cost of labor	P_1	Personnel expenses (salaries and allowances) divided by Total assets
Cost of borrowed funds	P_2	Interest expenses divided by Total deposits
Cost of physical capital	P_3	(Operating expenditure - salaries and allowances) divided by Total fixed assets
Outputs		
Loans	Y_1	Gross loans and advances
Other earnings assets	Y_2	Total assets - loans and advances - fixed assets
Off balance sheet items	Y_3	Total off balance sheet items
Control variables		
Equity	*EQ*	Total equity
Time trend	*t*	Year
Determinants of inefficiency		
Environmental variable		
Market concentration ratio	*MC*	Total assets of three major state owned banks (Sonali Bank, Rupali Bank and Janata Bank) divided by Total assets of the banking industry.
Bank specific variables		
Bank size	*SIZE*	Natural logarithm of total assets
Credit risk	*CRDRISK*	Non-Performing Loans (NPL) divided by Total loans
Profitability ratio	*ROA*	Net income divided by Total assets
Financial intermediation ratio	*FIR*	Total loans divided by Total deposits
Operational cost	*CIR*	Operating expense divided by operating income
Macroeconomic variables		
Economic growth	*GDPGR*	GDP Growth Rate
Interest rate	*INT*	Interest rate spread (lending interest rate - deposit interest rate)
Inflation rate	*INF*	CPI index

Source: Author's self - contribution

deposits are converted into loans by banks. This ratio is measured by taking total loans to total deposits (Srairi, 2010). This ratio is included in the profit function in order to capture the differences in banking sectors in terms of their ability to transform deposits into loans. Profit efficiency is expected to have positive association with financial intermediation ratio. Intermediation ratio is positively significant to influence profit efficiency as per the result of Srairi (2010).

h) Operational cost: Impact of operational cost on profit efficiency is calculated by taking cost to income ratio as a proxy. The cost to income ratio is calculated as operating expense divided by operating income. A smaller cost to income ratio indicates that the bank is more efficient in conducting its business related activities and it also means that the performance of bank will also rise. A cost to income ratio that is <1 indicates that it is a healthy bank. Ariff and Luc (2008) found cost to income has significant negative impact on profit efficiency suggesting efficient banks can control costs better and seek opportunities to enhance revenues. In contrast, Mghaieth and Khanchel (2015) finds a positive and statistically significant relation between operational costs and profit efficiency.

i) Economic growth: GDP growth rate has been taken as a proxy for economic growth which is a determinants of inefficiency for profit function. It is expected that banks operating in expanding markets enjoy higher level of profit efficiency. Also banks will benefit via good credit repayment by debtors due to higher economic growth. Moreover, when favorable economic condition is achieved, borrowers will be efficient to service their debts. As a result, banks will enjoy their expected efficiency. It is expected that GDP growth rate has positive impact on profit efficiency. Pasiouras et al. (2009) finds significant negative impact of real GDP growth on profit inefficiency.

j) Interest rate: To capture the impact of interest rate on profit inefficiency, interest rate spread is taken as a proxy. Interest rate spread is the difference between the lending interest rate and deposit interest rate. Interest rate spread will be positive when lending rates are increased but it is expected to have negative impact on the asset quality of the borrowers who then find lending expensive and as a result, their ability to repay the loans get reduced. However, it is also expected that higher spread will positively affect the bank earnings and consequently its profit efficiency. Fries and Taci (2005) reports a positive association between bank inefficiency and interest rates. This suggests that higher interest rate will cause the interest expense to rise which adversely affects the credit risk management of banks. Lu et al. (2019) finds positive influence of interest rate on profit inefficiency.

k) Inflation rate: Impact of inflation rate on the profit efficiency of banks mostly depends on whether it is anticipated or unanticipated. Banks which can anticipate inflation timely are able to adjust rate of interest properly. Therefore, they are able to generate high profit by imposing high interest rates on loans. But if inflation is unanticipated, lower profits and losses are generated by banks as they fail to adjust inflation rate timely. According to Pasiouras et al. (2009), inflation rate has a strong and positive influence on the profit inefficiency of banks. As per Lu et al. (2019) inflation rate has significant negative impact on profit inefficiency suggesting banks are able to anticipate inflation rate and adjust interest rates properly to have higher profits.

After discussing about the rationale of the explanatory variables (except equity and time variables), the following hypotheses have been developed to check whether they have significant impact on profit inefficiency.

H_1: Market concentration ratio has negative impact on profit inefficiency
H_2: Bank size has negative impact on profit inefficiency
H_3: Credit risk has positive impact on profit inefficiency
H_4: Profitability ratio has negative impact on profit inefficiency
H_5: Financial intermediation ratio has negative impact on profit inefficiency
H_6: Operational costs has positive impact on profit inefficiency
H_7: Economic Growth has negative impact on profit inefficiency
H_8: Interest rate has positive impact on profit inefficiency
H_9: Inflation rate either has positive or negative impact on profit inefficiency.

Now using three input prices, three outputs and equity and time variables, specification of the stochastic profit frontier model based on BC95 is as follows:

$$\ln TP = \alpha_0 + \alpha_1 ln(p_1) + \alpha_2 ln(p_2) + \alpha_3 ln(p_3) + \alpha_4 \frac{1}{2}(\ln(p_1))^2$$
$$+\alpha_5 \frac{1}{2}(ln(p_2))^2 + \alpha_6 \frac{1}{2}(ln(p_3))^2 + \alpha_7 \ln(p_1) ln(p_2)$$
$$+\alpha_8 \ln(p_1) ln(p_3) + \alpha_9 \ln(p_2) ln(p_3) + \beta_1 ln(y_1) + \beta_2 ln(y_2)$$
$$+\beta_3 ln(y_3) + \beta_4 \frac{1}{2}(ln(y_1))^2 + \beta_5 \frac{1}{2}(ln(y_2))^2 + \beta_6 \frac{1}{2}(ln(y_3))^2$$
$$+\beta_7 ln(y_1) ln(y_2) + \beta_8 ln(y_1) ln(y_3) + \beta_9 ln(y_2) ln(y_3)$$
$$+\gamma_1 ln(p_1) ln(y_1) + \gamma_2 ln(p_1) ln(y_2) + \gamma_3 ln(p_1) ln(y_3)$$
$$+\gamma_4 ln(p_2) ln(y_1) + \gamma_5 ln(p_2) ln(y_2) + \gamma_6 ln(p_2) ln(y_3)$$
$$+\gamma_7 ln(p_3) ln(y_1) + \gamma_8 ln(p_3) ln(y_2) + \gamma_9 ln(p_3) ln(y_3)$$
$$+d_1 lnequity + d_2 \frac{1}{2}(lnequity)^2 + \theta_1 t + \frac{1}{2}\theta_2 t^2 + v_{it} + (-u_{it})$$

Where, the following constraints with the symmetry being $\delta_{ij} = \delta_{ji}$ is used for linear homogeneity:

$$\sum_j^3 \beta_j = 1, \sum_j^3 \gamma_{jh} = 0, \sum_j^3 \delta_{ij} = 0$$

Lastly, the following equation has been developed to incorporate the impact of determinants of inefficiency on profit efficiency.

$$m_{it} = \delta_0 + \delta_1 MC + \delta_2 SIZE + \delta_3 CRDRISK + \delta_4 ROA$$
$$+\delta_5 FIR + \delta_6 CIR + \delta_7 GDPGR + \delta_8 INT + \delta_9 INF + w_{it}$$

4. DATA ANALYSIS

Profit efficiency of banking sector is important and it is either positively or negatively affected by various factors including bank size, credit risk, inflation rate etc. The profit efficiency score will determine the best and worst performing banks and the determinants of inefficiency will indicate which variables are causing problems for banks in terms of profit inefficiency. The results obtained by using BC95 model are presented as follows-

4.1. Year Wise Average Profit Efficiency Scores

Table 2 summarizes the average profit efficiency scores of sample banks in Bangladesh during the period of 2011-2020, estimated by the stochastic frontier approach with a translog profit function. It is observed that banks in Bangladesh, on average, are 80.73% profit efficient in terms of making profit oriented services compared to the best performing bank during the sample periods. Based on the result obtained, it can be concluded that around one-fifth of the profits of banks got vanished due to the existence of inefficiency over the sample period. Differently put, the banks in Bangladesh could improve their profits by 19.27% to match the performance of the best practice bank in the industry. From the investigation, highest profit efficiency score is obtained in 2011 (0.8921) while the lowest score is experienced in 2020. One possible reason is due to the impact of COVID-19 outbreak, banks could not perform efficiently and in this process, had to give up most of their incomes from profit oriented services. It can be seen that over the sample period, profit efficiency of banks fluctuated a lot and had become more profit inefficient as the efficiency scores have decreased from 0.8921 in 2011 to 0.6896 during 2020.The causes behind the decreasing nature of profit efficiency in recent times could be the increased expenses to stay relevant in intense competition imposed by other banks, increasing trend of loan loss provision and impact of Covid-19.

4.2. Five Top and Worst Performing Profit Efficient Banks Over the Years

Tables 3 and 4 report the five top and worst performing banks in terms of profit efficiency. It is observed that not only the private conventional banks but also some state-owned banks have been the best performing profit efficient banks in the most recent year. The five top performing efficient banks during 2020 are Dutch Bangla bank Ltd - DBBL (with 92.56%), Trust bank (92.56%), Sonali bank (91.62%), Eastern bank Ltd- EBL (86.97%) and Janata bank (86.70%). Possible reasons could be that among the top five, private banks might have learnt the advantages of technical supports to reduce their costs and they have the advantage to learn from the experience of older state-owned banks. On the other hand, Sonali bank and Janata bank have the advantages of economies of scale, bigger asset sizes and market shares due to being state owned banks. These advantages certainly had help them reduce their costs, increase their net profit and ultimately, profit efficiency scores. Moreover, high profit efficiency scores could have been achieved due to the Corona Virus stimulus package introduced during the lockdown in 2020. Banks could have used their stimulus package in

Table 2: Year wise average profit efficiency scores

Year	Profit efficiency
2020	0.6896
2019	0.7845
2018	0.8152
2017	0.8744
2016	0.8099
2015	0.8406
2014	0.8414
2013	0.7308
2012	0.7965
2011	0.8921
Overall	**0.8073**

Source: Author's self - contribution based on the output from STATA 12.0

Table 3: Five top performing profit efficient banks over the years

Year	Ranking of the five top performing profit efficient banks				
	1	2	3	4	5
2020	DBBL (0.9256186)	Trust Bank (0.9255877)	Sonali Bank (0.9162208)	EBL (0.8696852)	Janata Bank (0.8669621)
2019	Trust Bank (0.947899)	Bank Asia (0.927484)	Sonali Bank (0.9162208)	EBL (0.8696852)	AB Bank (0.8966012)
2018	Southeast Bank (0.9302983)	Sonali Bank (0.9288629)	NCC Bank (0.927290)	Dhaka Bank (0.9195475)	Bank Asia (0.9113004)
2017	Southeast Bank (0.956076)	EBL (0.9399673)	Rupali Bank (0.9391907)	National Bank (0.9373465)	Premier Bank (0.9331146)
2016	Dhaka Bank (0.9515038)	Southeast Bank (0.9509907)	National Bank (0.9492931)	BRAC Bank (0.9387072)	NCC Bank (0.9385935)
2015	Southeast Bank (0.9454165)	Agrani Bank (0.927393)	Uttara Bank (0.9254281)	IFIC (0.9211793)	BRAC Bank (0.9207833)
2014	Agrani Bank (0.9431147)	Southeast Bank (0.9353799)	One Bank (0.9259363)	NCC Bank (0.9240212)	Bank Asia (0.9222421)
2013	Bank Asia (0.9177309)	Pubali Bank (0.9047738)	MTB (0.9040965)	Agrani Bank (0.9002042)	EBL (0.8991213)
2012	Agrani Bank (0.947138)	Jamuna Bank (0.9406456)	BRAC Bank (0.9286896)	NCC Bank (0.9278697)	Uttara Bank (0.922664)
2011	Agrani Bank (0.9640146)	NCC Bank (0.9602143)	One Bank (0.9531149)	Dhaka Bank (0.9527599)	National Bank (0.9470545)

Source: Author's self - contribution based on the output from STATA 12.0

Table 4: Five worst performing profit efficient banks over the years

Year	Ranking of the five worst performing profit efficient banks				
	5	4	3	2	1
2020	UCB (0.6673615)	One Bank (0.4721902)	IFIC Bank (0.4474975)	Rupali Bank (0.2369423)	Dhaka Bank (0.1541769)
2019	Janata Bank (0.6857982)	UCB (0.6673615)	One Bank (0.6068312)	Rupali Bank (0.2731613)	Dhaka Bank (0.1666363)
2018	UCB Bank (0.7303395)	IFIC Bank (0.6629859)	Rupali Bank (0.5996562)	City Bank (0.5759244)	AB Bank (0.4281285)
2017	The City Bank (0.7930609)	Prime Bank (0.7885529)	Uttara Bank (0.6851936)	Sonali Bank (0.6803663)	AB Bank (0.6631232)
2016	Mercantile Bank (0.7557)	AB Bank (0.6225609)	Uttara Bank (0.5901052)	Sonali Bank (0.5674859)	Rupali Bank (0.1684959)
2015	Mercantile Bank (0.7949)	Premier Bank (0.685237)	Prime Bank (0.6810503)	Rupali Bank (0.6175005)	AB Bank (0.5843963)
2014	IFIC Bank (0.7276263)	Premier Bank (0.6934751)	National Bank (0.6857381)	Prime Bank (0.6777935)	Rupali Bank (0.653385)
2013	Rupali Bank (0.5650604)	Southeast Bank (0.5151089)	Trust Bank (0.5140083	National Bank (0.2777018)	Sonali Bank (0.249344)
2012	National Bank (0.7009696)	Prime Bank (0.6914206)	AB Bank (0.6314697)	Trust Bank (0.479579)	Southeast Bank (0.4715256)
2011	Uttara Bank (0.8692065)	Trust Bank (0.8404573)	Prime Bank (0.7950043)	Southeast Bank (0.7514055)	AB Bank (0.7148845)

Source: Author's self - contribution based on the output from STATA 12.0

providing more loans to large borrowers and this might have helped increase their interest income which ultimately influenced the profit efficiency scores. Trust bank, which is managed by the Bangladesh Army's highest position holders who had clear idea about the situation of the country during COVID-19 might have handled the bank's profit efficiently and obtained higher profit efficiency score.

On the contrary, top five worst performing profit efficient banks in 2020 are Dhaka bank (with 15.42%), Rupali bank (with 23.69%), IFIC bank (with 44.75%), One bank (with 47.22%) and United Commerce bank –UCB (with 66.74%). Dhaka Bank obtained the 1st highest profit inefficiency position. It has a profit inefficiency level of almost 85% which means on average, they have lost 85% of their profits generated from revenue making services. The possible explanation is that they maintained their costs using various technological advantages which they introduced during COVID-19 period but to maintain that technical supports, they might have to compromise their profit efficiency. Besides, Rupali bank appears most of the times in the category of the lowest profit efficiency score. One important reason is that Rupali bank has the lowest amount of profit after tax compared to other state-owned banks.

4.3. Profit Efficiency between State Owned Banks and Private Conventional Banks

Table 5 incorporates the profit efficiency between state owned banks and private conventional banks. It has been observed that

private conventional banks are more profit efficient than state owned banks. State owned banks have the advantages in the areas of economies of scale, asset size, market share and public confidence. These factors might be helpful in reducing the costs of the banks but not helpful in increasing the profit. Private conventional banks, on the other hand, are quick in adapting the learning effect from the state owned banks and they have vast research and development team responsible for introducing new technology in financial services and wider customer oriented services resulting higher profit efficiency. Therefore, it can be concluded that profit efficiency is likely to be driven by revenues rather than costs (Pasiouras et al., 2009). But profit efficiency of both categories of banks have been in fluctuated situation over the periods.

4.4. Generation Wise Five Top Performing Profit Efficient Banks in Recent Years

Table 6 indicates the profit efficiency scores of the five top performing banks based on the generation of banks. It is observed that most profit efficient banks are from 3rd and 2nd generation banks except during the period of COVID -19 for obvious reasons. One explanation is the learning effect where new banks observe the experience of the older banks and implement in their operation. Another fact is that these banks belong to the category of private conventional banks who are efficient in terms of technological innovation in banking products and customer services which in turn, help increase their profit efficiency. Banks having the attributes of bigger assets size and economies of scale fall under first generation banks. They might be more cost efficient than profit efficient.

Table 5: Profit efficiency between state owned banks and private conventional banks

Years	Profit efficiency of state owned banks	Profit efficiency of private conventional banks
2020	0.6550	0.6973
2019	0.6459	0.8123
2018	0.8032	0.8177
2017	0.8641	0.8763
2016	0.6043	0.8490
2015	0.8002	0.8482
2014	0.8155	0.8464
2013	0.6461	0.7470
2012	0.8808	0.7797
2011	0.9325	0.8840

Source: Author's self - contribution based on the output from STATA 12.0

4.5. Five Top and Worst Performing Profit Efficient Banks during COVID-19

Table 7 presents the five top and worst performing profit efficient banks during COVID-19. During the COVID-19 pandemic, profit efficiency scores of five top performing banks were quite satisfactory. As banking activities were operated from home, banks were able to reduce their operating expenses and increase net profits. Finally, in terms of best and worst performing banks during that period, Dutch Bangla bank Ltd (DBBL) followed by Trust bank were the most profit efficient banks while Dhaka bank followed by Rupali bank were the worst performing profit efficient banks respectively.

4.6. Diagnostic Test for Profit Function

In Table 8, to confirm the existence of inefficiency term in the dataset, skewness tests of OLS residuals have been conducted. Two pre-estimation tests called *Normality test* and *M3T statistics test* have been performed. For both of these tests, null hypothesis (H_0) states no skewness or there is no inefficiency term in the dataset and alternative hypothesis (H_1) states presence of skewness. The result under the normality test shows a positively skewed residual with a skewness value of 43.65 and it is statistically significant since the P=0.0000. In case of M3T test, it is expected that the residuals will be skewed negatively for profit function. Now, H_0 under M3T

Table 6: Generation wise five top performing profit efficient banks in recent years

2020	Ranking of the five top performing profit efficient banks				
	1	2	3	4	5
1st generation	Sonali Bank (0.9162)	Janata Bank (0.8670)	AB Bank (0.8354)	Uttara Bank (0.7967)	National Bank (0.7802)
2nd generation	DBBL (0.9256)	EBL (0.8697)	Southeast Bank (0.8626)	NCC Bank (0.8103)	Prime Bank (0.7414)
3rd generation	Trust Bank (0.9256)	Mercantile Bank (0.7391)	Jamuna Bank (0.7343)	BRAC Bank (0.7303)	Premier Bank (0.7143)
2019	**1**	**2**	**3**	**4**	**5**
1st generation	AB Bank (0.8966)	Sonali Bank (0.8712)	Uttara Bank (0.8710)	Pubali Bank (0.8582)	National Bank (0.8130)
2nd generation	DBBL (0.9264)	NCC Bank (0.9069)	Southeast Bank (0.8799)	EBL (0.8704)	Prime Bank (0.8277)
3rd generation	Trust Bank (0.9479)	Bank Asia (0.9275)	Jamuna Bank (0.8963)	Premier Bank (0.8853)	Mercantile Bank (0.8744)
2018	**1**	**2**	**3**	**4**	**5**
1st generation	Sonali Bank (0.9289)	Janata Bank (0.8711)	National Bank (0.8528)	Pubali Bank (0.8461)	Agrani Bank (0.8134)
2nd generation	Southeast Bank (0.9303)	NCC Bank (0.9273)	Dhaka Bank (0.9196)	EBL (0.9093)	DBBL (0.7994)
3rd generation	Bank Asia (0.9113)	Premier Bank (0.9073)	MTB (0.9060)	Trust Bank (0.8812)	Mercantile Bank (0.8746)

Source: Author's self - contribution based on the output from STATA 12.0

Table 7: Five top and worst performing profit efficient banks during COVID-19

Five top and worst performing profit efficient banks during COVID-19 (year 2020)				
Top five				
DBBL (0.9256186)	Trust Bank (0.9255877)	Sonali Bank (0.9162208)	EBL (0.8696852)	Janata Bank (0.8669621)
Worst five				
Dhaka Bank (0.1541769)	Rupali Bank (0.2369423)	IFIC Bank (0.4474975)	One Bank (0.4721902)	UCB (0.6673615)

Source: Author's self - contribution based on the output from STATA 12.0

Table 8: Diagnostic test for profit function

Test for	Test	Hypotheses	Statistic	Critical value	Decision
Presence of the inefficiency term	Pre estimation				
	Normality Test	H_0: No Skewness	43.65 (P=0.0000)		Reject the H_0
	M3T test	H_0: No Skewness	−6.2471	−1.96 at a 5% significance level	Reject the H_0
	Post Estimation				
	Likelihood ratio (LR) test	H_0: $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \gamma = 0$	28.5066	8.574 at a 10% significance level	Reject the H_0

Source: Author's self - contribution based on the output from STATA 12.0

Table 9: Determinants of profit inefficiency

Z variable	Coefficient	Std. error	Z	P
MC	1139443	4208306	0.27	0.787
SIZE	−100057	465488.2	−0.21	0.830
CRDRISK	357358.8	1739238	0.21	0.837
ROA	5395535	25000000	0.22	0.829
FIR	206681.8	877868.5	0.24	0.814
CIR	−4508.98	18218.76	−0.25	0.805
GDPGR	1177.172	2172.962	0.54	0.588
INT	−3395.43	6200.797	−0.55	0.584
INF	−18156.9	77105.68	−0.24	0.814
Constant	742194.9	3788914	0.20	0.845

Source: Author's self - contribution based on the output from STATA 12.0

statistics test for profit function is rejected as −6.2471 is less than −1.96 at a 5% significance level. Therefore, it is confirmed that inefficiency is present in profit frontier.

Moreover, a post estimation test has also been conducted named Likelihood Ratio (LR) test. It compares the log-likelihood values of the OLS and SFA estimation. Here, H_0 means parameters of z variables along with the γ are jointly equal to zero whereas H_1 states they are not equal to zero. Under profit frontier, LR statistics is 28.5066 which is greater than critical value at 10% significance level. Therefore, H_0 of no skewness is rejected and the appropriateness of SFA model for profit function is confirmed.

4.7. Determinants of Profit Inefficiency

Table 9 shows the determinants which have effect on the profit inefficiency. Under profit inefficiency term, the expected signs between profit inefficiency and bank size, credit risk and inflation rate have been consistent with the previous studies. For example, according to Isik and Hassan (2002), higher level of credit risk will help increase the profit inefficiency. Here, Credit risk and profit inefficiency are positively associated which means if Credit risk defined as NPL to total loans increases, profit inefficiency will rise. But credit risk is not statistically significant to influence the profit inefficiency consistent with the findings of Hadhek et al. (2010) and Mghaieth and Khanchel (2015). Also, none of the expected result is of any use as all of the variables have been found to be statistically insignificant. Still, the result of each bank's profit efficiency score is reasonable as it is acceptable if no significant result is found under the X-efficiency study when the study contains small dataset and here the sample dataset contains only the 25 banks of Bangladesh from 2011 to 2020.

5. CONCLUSION

This paper investigates the profit efficiency of the state owned banks and private conventional banks of Bangladesh by employing the stochastic frontier approach from 2011 to 2020.The sample consists of 25 banks and panel data have been used for profit efficiency. Intermediation approach has been adopted to define the input prices and outputs of the model while Translog function is employed to develop SFA profit function. Moreover, various control variables and inefficiency determinants have been used to make the model more reliable. From the results, following issues have been observed. The overall profit efficiency score is 80.73%. In 2020, DBBL followed by Trust bank were the most profit efficient banks. In contrast, Dhaka bank was the least profit efficient banks during 2020. Most profit efficient banks are from 3rd and 2nd generation banks. During COVID-19, again DBBL followed by Trust bank were the most profit efficient banks. Lastly, none of the determinants of inefficiency has been found statistically significant. This paper has some limitations such as 4th generation banks, foreign banks and Islami Shariah based banks have been excluded from the study and to conduct study based on bank efficiency such as profit efficiency, large dataset is required. Therefore, for future study, these excluded banks could be added to get a robust conclusion. This study also suggests that banks in Bangladesh have the opportunity and scope to advance further in terms of profit efficiency.

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