IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON EFFICIENCY OF BANGLADESH BANKING INDUSTRY

A DISSERTATION SUBMITED TO THE SHAHJALAL UNIVERSITY OF SCIENCE AND TECHNLOGY, SYLHET, BANGLADESH FOR THE AWARD OF THE DEGREE OF MASTERS OF PHILSOPHY IN STATISTICS

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TO

MY PARENTS

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**ABSTRACT**

**Introduction:** ICT has now become the engine block of banking institutions worldwide and the Bangladesh banking industry is no exception. Today, ICT is important not only to serve existing customers satisfactorily, but also to reduce cost and maintain the ability to improve the competitiveness of the bank.

**Objective:** This study measures the impact of ICT factor on cost and profit efficiency of the 3 state-owned commercial banks and 17 private commercial banks in Bangladesh employing a panel set of data during 2008-2017 and formulates the Stochastic Cobb-Douglas and Trans-log Cost and Profit Frontier models on state-owned commercial banks and private commercial banks in Bangladesh. Also, it estimates and compares the cost and profit efficiency on State-owned Commercial Banks and Private Commercial Banks individually and group-wise in Bangladesh using Stochastic Cobb-Douglas and Trans-log Cost and Profit Frontier models, Data Envelopment Analysis cost and profit models. Finally, the impacts of ICT components on operating cost and profit efficiency for SOCBs and PCBs banks in the context of Tobit Regression Model is measured

**Methodology:** For this purpose, we concentrated on the most efficient two methods SFA and DEA are used to measure the cost and profit efficiency on sample data of Bangladesh banks and the analytical framework of the SFA and DEA have been developed. Then the Tobit Regression Model was used for finding the IT determinants of Cobb-Douglas, Trans-log stochastic frontier analysis and VRS cost minimization data envelopment analysis. Finally, Ordinary Least Square method was used for only profit DEA model.

**Result:** The maximum likelihood estimates were found for efficiency and inefficiency part using both Cobb-Douglas and Translog stochastic cost and profit frontier analysis models.

**Findings of SFA analysis:** In the Cobb-Douglas cost and profit frontier analysis models, the average cost efficiency of the state–owned commercial banks was 59.2% whereas the average profit efficiency was 27.6% during the study period. The average cost efficiency score was 65.8% and the average profit efficiency score was 50.5% for the private commercial banks. In Translog stochastic cost and profit frontier analysis models, the average cost efficiency was 81.3% and the average profit efficiency was 84.4% for the state-owned commercial banks but the average cost efficiency score was found 66.3% and the average profit efficiency score was recorded 53.9% for the private commercial banks. Moreover, Translog Stochastic Frontier model was found more preferable than the Cobb-Douglas Stochastic Frontier model using the Likelihood Ratio Test.

**Findings of DEA analysis:** InVRS DEA cost and profit Model, the average technical, allocative and cost efficiency scores were 81.4%, 91.8%, and 74.4% respectively among the state-owned banks. The average cost efficiency score (41.4%) was higher than the average profit efficiency (18.8%) score for the state-owned commercial banks. In the private commercial banks, the average technical, allocative and cost efficiency scores were 41.4%, 59.5%, and 92% respectively. In the private commercial banks, the average cost efficiency score (41.4%) was recorded higher than the average profit efficiency (18.8%) score.

**Findings of IT determinants of SFA and DEA by Tobit Regression Analysis:** There was no significant IT variable for the cost and profit efficiency of Stochastic Translog frontier Model for State-owned Commercial Banks but the IT personnel expenses ɸ5 (0.0006) and credit card transaction ɸ8 (0.000006) were positively significant for the cost efficiency of private commercial banks. In IT determinants profit efficiency of Stochastic cobb-Douglas profit frontier model, the IT personnel expenses ɸ5 (0.0018) and Credit Card Transaction ɸ8 (0.0013) were found positively significant. In IT determinants of cost and profit efficiency of Data Envelopment Analysis model for state-owned and private commercial banks, the IT Investment ɸ3 (0.00032) and IT personnel expanses ɸ5 (-0.00154) were positively significant for the cost efficiency of the state-owned commercial bank.

**Findings of IT determinants of profit DEA by OLS Analysis:** In IT determinant of profit efficiency of Data Envelopment Analysis, the credit card transaction ɸ8 (0.000006) and credit card expenses ɸ8 (0.0002) were positively significant for the cost efficiency of the private commercial bank. The IT personnel expenses ɸ5 (0.0015) and credit card transaction ɸ8 (0.00008) were positively significant for the profit efficiency of the private commercial bank.

**Conclusion:** The impact of the IT factors on the cost and profit efficiency of Bangladesh Banks has been observed. The IT factors had a more positive impact on the private commercial banks rather than the state-owned commercial banks. The Private commercial banking system was found technologically more advanced. In the case of OLS Profit Model for VRS-DEA, the IT factors were more significant for the private commercial banks rather than the state-owned banks.

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# CHAPTER ONE

## **INTRODUCTION**

## **Background of the study**

## 

Bringing out changes socially, information and technology have telling impacts. Disparities among personal, social, cultural, economic, educational, values have been lessened as the technology is becoming more affordable these days. Even though the internet has been spread worldwide, Bangladesh is still struggling to delineate the proper picture of the internet. De facto, the online banking sector is a complementary part of the banking sector as a whole. It is a new dimension to the banking sector to create numerous opportunities for marketing products as well as managing organizations both domestically and internationally.

Impediment on the economic progress of the country that is created by underdeveloped banking technology and it is partly recognized by numerous international organizations. By the Information and Communication Technology and electronic communication network, the Online Banking system performs their main task of managing and executing banking transactions via Internet, Intranet and Extranet. The computer hardware and software, electronic payment system, network environment, electronic hardware, legal bindings, etc. are the required material for the Internet banking. With the advancement of technology, e-business has become popular all over the world so the business process in the world is finally getting easier where e-business, especially in the banking sector, can disrupt the conventional business process. The convenience of e-business is a crock point and it is easily managed through online banking system. Technology has opened up new markets, new products, new services and efficient distribution channels for the banking industry. Online electronics banking, mobile banking, and internet banking are just a few examples among so many. Electronic banking does not mean 24 hours of access via cash only through an automated teller machine (ATM) or because of direct deposit of paychecks to checks or savings accounts, many customers worry. With the expansion of global information and communications technology (ICT) infrastructure and the Internet, E-banking will play a leading role in the national economic development of any country. However, advanced technology, suitable software, infrastructure, skilled manpower, and cyber law are crucial for implementing e-banking in the country. In this age of information and communication technology, the function of banking has changed radically in developed countries. Huda, Momen and Ahmed (2004) commented that the importance of information technology for their success in the banking sector is clearly recognized the importance of information technology to their continued success in Bangladesh. Rahman (2010) the Governor of Bangladesh Bank is argued that Bangladesh Bank has achieved a historic milestone in the trade and business arena and most recently with the introduction of e-commerce has taken away from the conventional banking is a giant stride towards digital Bangladesh.

Pertaining to the erstwhile issue and as previous efficiency studies stress out, a bank may pursue many goals. On the one hand, profit efficiency is naturally its ultimate goal. On the other hand, cost efficiency is an important means of reaching long-run profit efficiency. Yet Berger and Mester (1997) showed that profit efficiency could not be positively correlated with cost efficiency, suggesting that the measures of profit efficiency possibly will include output features that reflect the higher quality or greater market incorporate much different information than a respective cost part of the estimated profit equation. Today the performance and enhanced efficiency of banks are more competitive in the Bangladeshi banking industry. The bank has recently advocated launching an automated clearing house system. It pushes the upward transition of banking system from the manual to the online. It shows that successful development of ICT in banking will help to enhance productivity and positive impact on raising economic growth in the country. Foreign commercial banks (FCBs) played a leading role in adopting advanced technology in retail banking in the early nineties, whereas state-owned commercial banks (SOCBs) and Private commercial banks (PCBs) came could offer such services in limited form in the late nineties

## **1.2 Statement of the Problem**

The way of performing transactions for financial institutions is changed by science and technology. These technological changes have shaken today's banks. Technology has made our life easier, comfortable, and luxurious in this regard The potential success of new technology is never-ending series of questions regarding its design, its value to its users, ultimate use and acceptability. The ICT sectors are called the heart of the bank. Information technology environment changes rapidly. Recently, the number of internet users is increased in Bangladesh and due to a decrease in the physical branches of banking; most of the transactions are conducting via e-banking channels, online Internet bank, and m banking services. So the customer demands are fulfilled easily in banking activities electronically. In Bangladesh, rapid growth of e-banking is expected. Foreign commercial banks (FCBs) played the pioneering role in adopting modern technology in this country. But at present, several private commercial banks (PCBs) and also state-owned commercial banks (SCBs) offer limited services of telebanking, internet banking and e-banking facilities within the branches of individual bank in a closed network environment. So, one of the challenges faced by the banking industry in Bangladesh is to find out the impact of ICT factors on bank performance. This study analyses the impact of ICT factors on the efficiency of Bangladesh Banking industry with the present status of cost and profit efficiency score. For this purpose at first the cost and profit efficiency of banks in Bangladesh is estimated using parametric (stochastic frontier analysis) and non-parametric (data envelopment analysis). Then next we identify the determinant of ICT by Tobitt Regression model.

## **1.3 Research Motivation**

The financial institutions in Bangladesh seem to increasingly adopt ICT banking and improving banking capabilities. However increasing competition among the banks leading to losing their customers, but information and technology by facilitating, service definition and new product (diversity) and increasing efficiency at all levels of banking industry value chain, both reduce the risk and create quality competitive advantages. Some researchers asserted that ICT investments can really promote the enterprises operational performance by reducing costs, raising profit margin, upgrading production levels, increasing service quality, advancing customer satisfaction and improving overall operations. In contrast, other researchers do not demonstrate the positive effect of ICT investments and concluded that ICT spending brought no significant contributions to the enterprises operations, and so the "ICT productivity paradox" has been an issue of continuous debate for decades. The differences among research objects, methodologies and performance indices result in consistent conclusions obtained in the literature. In this respect, some researchers used parametric method (SFA) for estimating the banking efficiency and showed that one or two of the component of ICT had a great impact on the bank efficiency but they did not use gigantic variables related to ICT (Rai & Patnayakuni 1997; Surulivel, et al. 2013; Safari & Yu 2014). Similarly, few researchers used both SFA & DEA method to analyze the impact on cost & profit efficiency but unable to measure the impact of ICT variable (Rom 2013; Lee & Menon 2000). Furthermore, one researcher (Chu-Fen li, 2007) estimated the technical efficiency of individual banks and group banks by using whole ICT oriented variable on analyzed DEA and SFA method and also measured the correlation and regression analysis among the IT variables in terms of pre-tax profit and total IT expenses. He showed that IT investment can improve profit significantly but could neither reduced operating cost nor enhances operational efficiency significantly. But he did not work the exact cost and profit efficiency. In the context of Bangladesh, a number of studies on the cost and profit efficiency of banking in Bangladesh by using SFA and DEA (Hasib & Mahmud, 2018; Shamim Ara 2016 ; Baten 2015) but there have been no studies about the impact of ICT in the banking sector on the cost and profit efficiency. Also there have been some empirical studies about the impact of ICT on banking in Bangladesh. (Haque & Reza 2009; Sadekin & Sheik 2016; Alam 2017) asserted that ICT investments is becoming an important factor in the future development of Bangladesh banking industry. To explore the effects of ICT spending on banking performance in Bangladesh, this study measures the impact of ICT factor on the cost & profit efficiency of the banks in Bangladesh and also will be able to provide a framework of the performance evaluation using data envelopment analysis (DEA) involving linear programming and stochastic frontier approach (SFA).

## **1.4 Significance of the study**

It is very important to the fact that in the modern age, ICT is a crucial resource of an organization like land, labour, and capital. The banking industries are influenced by technology, mostly in the following three aspects:

1. ICT increases competition and the degree of contestability among the banks.

Due to the development of technology, the traditional banking system is disappearing. A new bank can easily enter the market and competitions have been raised. Firms always face the challenges of new firms entering the market. New markets, good products, proper services and efficient delivery channels for the banking industry are all these lead to a more competitive market environment. The contestability in banking is also raised for entry and exit of some sub-financial markets.

1. Technology impacts the economy of scale in banking.

Banks try to lower their cost. They want instead of being a big bank, trying to keep the moderate economy of scale. The economic scale helps to protect the business structure of banks and maintain their competitive attitude. ICT improves the economy of scale in the banking industry.

3. Technology provides better services in the economy

Technology is the new door of banking and financial services to conduct their activities Such as A popular delivery mechanism ATM reduces the hassle to get the money at any time. The bank has changed its transaction system, rationalize its branch network strategy, and widen the range of delivery option by advanced technology. So people get large facilities through an internet bank. As a result, investors are increasing day by day.

**1.5 Objectives of the study**

The main objectives of this study are to estimate the impact of ICT factor in the cost and profit efficiency of Banks in Bangladesh. For this purpose, the specific objectives of this study are

* To formulate Stochastic Cobb-Douglas and Trans-log Cost and Profit Frontier models on state-owned commercial banks and private commercial banks in Bangladesh.
* To articulate the inefficiency models in the context of SFA Cobb-Douglas and Trans-log cost and profit models on SOCBs and PCBs in Bangladesh
* To observe the cost and profit efficiency on SOCBs and PCBs banks in Bangladesh by VRS DEA cost and profit model.
* To investigate the impacts of ICT components on operating cost and profit efficiency for SOCBs and PCBs banks in the context of Tobit Regression Model
* To compare the cost and profit efficiency of SOCBs and PCBs banks individually and group wise.
* To give a recommendation to the policymakers based on the findings

## **1.6 Scope and Limitation of the study**

Specifically the study undertakes to investigate the use and development of some classes of ICT applications which are as follows: ATM, Credit cards, IT personnel Expenses and IT investment from selected 20 banks ATM, Credit cards, IT personnel Expenses and IT investment from selected 20 banks which are available for the ICT data. Another ICT factors cannot be used because banks are unwilling to disclose data bothering on these issues for competitive reasons. So data obtained from published reports and banks officials are expected to serve as the basis for this analysis.

## 

## **1.7 Dissertation layout**

The dissertation has divided into six chapters. The layout of the study is organized as follows.

Chapter one (Introduction), the key purpose of this analysis is to frame the different method for determining the ICT impact on the cost and profit efficiency scores of the state-own commercial banks and private commercial banks in Bangladesh. This chapter illustrates the background of the study, Research motivation, objective of the study, significance of the study, the research’s chapter layout and the research’s conclusion

## Chapter two (Basic Concept of Efficiency Measurement and ICT Oriented Banking Industries), we have introduced a basic foundation on efficiency measurement. In order to understand the basic concept of efficiency measurement, we have discussed the Technical efficiency, productivity, production frontiers, cost and profit efficiency, parametric versus non-parametric, Stochastic Frontier Analysis, Data Envelopment Analysis, allocative and overall efficiency, Tobitt-regression model and OLS method.

Chapter three (Literature Review), we have discussed reviews briefly the previous studies the impact of ICT on the banking sector by using frontier studies.

Chapter four (Methodology), It begins with a detailed construction of variables, sources and different types of data used in the study. The empirical method is emphasized in this chapter too. We have formulated Stochastic Cobb-Douglas and Translog cost and profit models with its functional form. Also, we have formulated the VRS Data Envelopment Analysis for both cost and profit model. Finally, the Tobit regression is used for finding the ICT determinant

Chapter five (Result and Discussion) is intended to serve the objectives of the research. The cost and profit efficiency scores are analyzed by Stochastic Cobb-Douglas and Translog cost and profit models. Also, we have found the cost and profit efficiency scores by the VRS data Envelopment Analysis model. Finally, the Tobbit regression model is applied to find ICT determinant.

Chapter six (Summary and recommendation) is the final chapter. It comprises discussions of major findings of the study and finally recommended on this research.

## **1.8 Conclusion**

The importance of cost and profit efficiency analysis and the impacts of the ICT factor on the banking sectors in Bangladesh are scrutinized. This chapter also explains the research background, statement of the problem, research motivation, significance of the study, objectives of the study, scope and limitation of the study which presents a clear overview of the study. The thesis layout points out all the chapters clear image for easy understanding.

**CHAPTER TWO**

# BASIC CONCEPT OF EFFICIENCY MEASUREMENT AND ICT ORIENTED BANKING INDUSTRIES

## **2.0 Introduction**

Banking efficiency is an essential part of the financial sector as a whole plays a key role in allocating the economy’s financial resources. Efficient banking systems help maximizes the effectiveness of macroeconomic policies. Bank efficiency is a socially optimal goal because it reduces the average cost of financial transactions and therefore increases the welfare of the society. Due to the increasing competition, the bank is keen to improve management skills. The regulatory authorities need to evaluate the efficiency of the banking sector before going global. At present, most banks in Bangladesh are using electronic banking services. If banks use e-banking, they can be profitable. Domestic and foreign private banks operating in Bangladesh are on the way to launch electronic banking facilities in the country. Private Banks are ahead of government banks in indigenous banks. The main objectives of this study are to measure the impact of ICT factor on efficiency of Bangladesh Banking industry. For this purpose at first we estimated the cost and profit efficiency of banks in Bangladesh using parametric (stochastic frontier analysis) and non-parametric (data envelopment analysis). Then next we identify the determinant of ICT by Tobitt Regression model. In section 2.1 to 2.13 we have tried to describe the concept of related studies such as: Technical efficiency, productivity, cost & profit efficiency, parametric & non-parametric method, production frontier, stochastic production frontier, data envelopment analysis, measures of efficiency and productivity, Tobit regression model and OLS model and ICT status of banking industry.

## **2.1Technical Efficiency**

## The technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output conditioned on the level of inputs used by the firm. Technical inefficiency is therefore defined as the amount by which the level of production for the firm is less than the frontier output. Technical efficiency is obtained from the error term in frontier model and this error can be decomposed into two components: one is a random error which is associated with random factors such as measurement errors in production and weather, which the labor does not have control over, other is an non-negative random variable associated with farm-specific factors which leads to the firm not attaining maximum efficiency of production. That is it is associated with technical inefficiency of the farm and ranges between zero and one.

## **2.2 Productivity**

## The productivity of a firm is as the ratio of the output(s) that it produces to the input(s) that it uses.

## Productivity= output(s)/ input(s).

## When the production process involves a single input and a single output this conversion is trivial matter. However when there is more than one input (which is often the case) then a method for aggregating these inputs into a single index of inputs must be used to obtain ratio measure productivity.

## **2.3 Production Frontiers**

## The production frontier represents the maximum output received from each input level. To illustrate the concept of production frontier one can use an important class of technologies having a single output y and an n-dimensional vector of input x. Suppose the production possibility set satisfies. A general representation of the frontier technology is given as . The function f(.) is the production frontier and equation gives the upper boundary of . Given input the maximum producible output can be achieved. In the form of maximization the production frontier is expressed by

## .

## The production frontier serves as a standard against which to measure the technical efficiency of production. Production frontier reflects the current state of technology in the industry. Firms in that industry operate either on that frontier if they are technically efficient or beneath the frontier if they are not technically efficient.

## **2.4 Concept of Profit and Cost Efficiency**

Banks try to maximize profits by reducing costs. On this basis, when the performance of production units are analyzing, there are two main efficiency concepts, cost and profit efficiencies are used.

Profit efficiency is the ratio of predicted actual profit to predicted maximum profit, which could be earned if a bank was as efficient as the best practice bank after adjusting for random error. Profit efficiency is ability to achieve maximum profits for a given set of output and the estimated values in logarithm are bounded between 0 and 1. The higher the profit efficiency score is, the more profit efficient the bank will be. If the score is 1, it means the most profit efficient bank. The profit efficiency is defined as



Where pi = observed profit for the i-th banks, pi\*frontier profit for the i-th banks. Profit inefficiency *=*.

Cost inefficiency measures the change in a bank’s variable cost adjusted for random error, relative to the estimated cost needed to produce an output bundle as efficiently as the best-practice bank in a sample facing the same exogenous variables, which include variable input prices, variable output quantities and fixed inputs. It arises due to technical inefficiency, which results in the use of an excess or sub-optimal mix of inputs given input prices and output quantities. The cost efficiency is defined by



Where ci = observed cost for the i-th bank and ci\*= frontier cost for the i-th bank. Cost inefficiency =. The value of cost inefficiency can be equal to or greater than one. It is equal to one for the best-practice commercial bank within the given sample. If it is greater than one, then the bank is thought of wasting a certain proportion of its resources relative to a best practice bank facing the same condition. Thus, the higher value of cost inefficiency is, the greater the inefficiency is. For example, a value of 1.17 implies that a bank has costs that are 17 percent above minimum defined by the frontier. It also means that 17 percent of its costs are wasted relative to the “best-practice” commercial bank producing the same output and facing the same conditions.

**2.5 Parametric versus Non- parametric**

In the literature dealing with the efficiency study, two major concepts are frequently used for measuring this frontier function: non parametric and parametric approaches. The non-parametric approach known under the name of DEA method (Data Envelopment Analysis) consists in estimating the frontier by using non-parametric mathematical linear programming. The method offers the advantage of simple application and restrictive assumptions are not required in advance with regard to the functional form. Its main disadvantage lies in the fact that this technique is unable to decompose the deviations of certain banks from the efficient production frontier into components: inefficiency and random error parts. Another assumption needed in the SFA is to distinguish the inefficiencies from random components of the error terms. The deviation as a whole is considered as inefficiency, irrespective of whether it derives from inefficient operation or exogenous effects independent of management. An additional problem is that the method disregards prices. The procedure rather focuses on measuring technological efficiency, based on technological and not economic optimization. The parametric methods are considered to be more sophisticated compared to non-parametric techniques, whereby the estimation of efficiency is based on economic optimization, given the underlying assumption of a stochastic optimal frontier. The parametric techniques mostly frequently used include the Stochastic Frontier Approach (SFA) and the Distribution Free Approach (DFA). Parametric methods allow for incorporating both input allocative and technical efficiencies. The SFA decomposes random error terms and the production unit inefficiency and takes into account the existence of exogenous shocks. DEA is a non-parametric method for calculating relative efficiency scores in a multi input-output production environment. It measures the performance of all decision-making units compared to the generated efficient frontier. Best-practice banks, which constructs the DEA frontier, produce given output combinations with the lowest level of inputs or achieve the highest level of output with a given level of inputs, i.e. operates with an optimal input-output combination. Firms, which do not operate on the optimal frontier, suffer a certain level of efficiency loss. The SFA was independently developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977). Another parametric but more rarely used technique is the so called thick frontier approach (TFA). This approach divided banks into four quartiles regarding their average cost or profit. Then the cost or profit curve is estimated separately for all groups of the banks. The estimated cost/profit function for banks in the smallest/largest average cost/profit quartile is interpreted as the cost/profit efficient frontier. A disadvantage of the TFA is that the result is very sensitive to the selection on the number of quintiles’. In addition econometric problems may arise since the banks are pre-sorted using average cost or profit, which are essentially dependent variables are quite widespread, Fries and Taci (2005) argue that parametric methods, which are more robust to data problems, would constitute more suitable empirical tools for analyzing banking efficiency.

## **2.6 Stochastic Production Frontier**

## 

## The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a firm’s actual production point lies on the frontier then it is perfectly efficient. If it lies below the frontier then it is technically inefficient, with the ratio of the actual to potential production defining the level of efficiency of the individual firm (Figure 2.1).

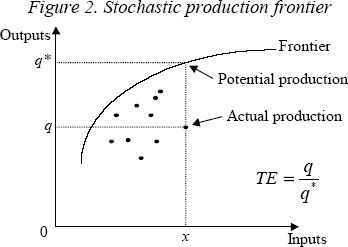


Fig-2 1 Stochastic Production Frontier

## The measurement of productive efficiency empirically is dated back to Farrell (1957). Farrell’s definition of technical efficiency leads to the development of methods for estimating the relative technical efficiencies of firms. The common feature of these estimation techniques is that information is extracted from optimum observations from a body of data to determine the best practice production frontier (Lewin and Lovell 1990).

## In traditional economic theory, efficiency is defined as an outcome of price taking competitive behavior (Coelli et al, 1998). Thus if no uncertainty is assumed, a production function is described as the maximum level of output that can be obtained from given inputs and the technology available (Kumbhaker and Lovell, 2000). However, actual output may typically fall below the maximum that is technically possible. The focus of interest of many applications is the deviation of actual from maximum output, which is a measure of inefficiency.

### 2.6.1 Stochastic Cobb-Douglas Production Frontier Analysis

Cobb-Douglas functional form, a first-order flexible functional form of production function, which was proposed by Cobb and Douglas in 1928, is widely used in the existing literature to estimate the relationship between inputs and outputs. He developed the production theory by using labour, capital, production, value and wages for the manufacturing firms. The firms are capable to effectively assign all supplies relative to whatever behavioral aims presented to the manufactures (Fare et al. 1985). Additionally, Berger and Humphery (1997) modified the production function model to concentrate on the financial sector’s efficiency. The efficiency of the financial sector means the efficient allocations of financial resources that are imperative to increase productivity. This shows that the economy has the upper hand to transfer the input of saving resources for more productivity output. In order to measure statistical noise, Ainger et al. (1997) added symmetric error part to the frontier. The model depicted as:

 i=1 2…N; t=1 2 ….T

Where Yit is (the logarithm of )of the production of the i-th firm in the tth time period;

Xit is a matrix of outputs and price of inputs independent variables in logarithm form;

β is an vector of unknown parameters; *‘Vit’* are random variables which are assumed to be iid, **. And, ‘*Uit*’ are non-negative random variables which are assumed to be identically distributed as normal variates.

**Technical Efficiency**

The term TEit is express as technical efficiency for the ith  firm in the tth time period define by using stochastic frontier model as follows (Battse and coelli, 1998) :

TEit =

Here *Uit* is the stipulation of the in efficiency model. The maximum likelihood estimates are used to measure the parameters of the stochastic frontier model.

### 2.6.2 Stochastic Cobb-Douglas Cost Frontier Model

Generally, the Cobb-Douglas form of the cost function is as following



And by taking logarithms on both sides of the function, the general model of the Cobb-Douglas cost form is turned to



Where Cit is total costs for *i*-th bank at *t* time, yit is the *j*-th output of *i*-th bank at *t* time, wmit is the price of the *m*-th input of *i*-th bank at *t* time, and and are parameters to be estimated as the cost elasticity’s of the outputs and inputs. The main assumption of the Cobb-Douglas cost function is to satisfy the linear homogeneity restriction, that is, the Cobb- Douglas cost function homogeneous of degree one in input prices, only if =1. This restriction suggests that a proportional increase of all inputs prices leads to the equal proportional increase of total costs.

The Cobb-Douglas cost function is simple to examine the relationship and the estimation results are easy to explain, which is agreed by Christopoulos and Tsionas (2001). They adopted the Cobb-Douglas function as a simplified model to demonstrate the stochastic cost frontier with control for heteroscedasticity. However, as a first-order approximation of cost or production function, it causes the most serious shortcoming of the Cobb-Douglas function, only representing a constant value for elasticity of scale. Therefore, it makes sense that Kuenzle (2005) pointed out that it is not possible to evaluate whether different firms exhibit different values for scale economies by using the Cobb-Douglas function. Therefore, to address this issue, more and more researchers prefer to use more flexible functional forms like translog functional form which is a second-order flexible approximation of function.

## **2.7 Stochastic Translog Frontier Analysis**

## Aigner Lovell and Schmidt (1977) and Meeusen and Van der Broeck (1977) developed the stochastic composed error frontier methodology. In the formulation of the model Aigner Lovell and Schmidt (1977) specified the error term equal to the sum of two parts one normal and the other from a one sided normal distribution.

The stochastic production frontier [AignerLovellSchmidt (1997) Battese and Corra (1977) and Meeusen and Van Den Broeck(1997)] model allow for technical inefficiency but they also acknowledge the fact that random shock outside the control of producers can affect output. The main virtue of stochastic frontier models is that at these effects can be separated from the contribution of variation in technical efficiency.

The stochastic Frontier Analysis (SFA) acknowledges the random noise around the estimated production frontier. An appropriate formulation of a stochastic frontier model in terms of a general production function for the ith production unit is



Where  denotes the production unit being evaluated and’s are the parameters to be estimated. The residual  i-th firm is composed error by a random shock  and an inefficiency component.  is the two-sided “noise” component and  is the non-negative technical inefficiency component of the error term. The noise component  is assumed to be independently and identically distributed and symmetric distributed independently of. The maximum likelihood estimates are used to measure the parameters of the stochastic frontier model.

### 2.7.1 Stochastic Translog Cost Frontier Analysis

To estimate the cost, a transcendental logarithmic functional form is selected. This functional form is widely used because it is a flexible functional form. The study uses the Translog stochastic frontier functions by Battese and Coelli (1995) which was produced by Coelli (1995). According to this approach, the estimation of banks’ relative efficiency using panel data is obtained by estimating a cost function of the general form:

 i=1 2………n; t=1 2 ………….T

Where Cit  is total cost in logarithm form of bank i in period t; Xit is a matrix of outputs and price of inputs independent variables in logarithm form; β is an vector of unknown parameters; *Vit* are random variables which are assumed to be iid, ** and independent of *Uit*. And, *Uit* are non-negative random variables which are assumed to be identically distributed as normal variates and the value of the error term in the cost function is equal to zero on the average. The important point here uit is estimated as functional from of vector of appropriate explanatory variables under this one-step approach, the formulation is



Where uit follows a truncated-normal distribution with mean and variance, zit is a vector of explanatory variables, i.e., that may influence of the banks; δ is vector of parameters to be estimated and ωit is defined by the truncation of normal distribution N(0,σ2), such that the point of truncation is - zit δ. So, to assure that uit isnon-negative, the condition is ωit > - zit δ.

the maximum likelihood estimation allowed to generate estimates of all parameters of the frontier function as well as estimates of the unknown parameters δ. After solving the maximum likelihood problem, Technical efficiency estimation formula are solved

 TEit =

Here *Uit*  is the stipulation of the in efficiency model .

### 2.7.2 Stochastic Translog Profit Frontier Analysis Model

To estimate profit efficiency of banks, the study uses the translog stochastic frontier profit function by Battese and Coelli (1995) which was produced by Battese and Coelli (1995).According to this approach, the estimation of bank’s is obtained by estimating a profit function of the general form

i=12………n; t=12………T

Whereis the profit after tax of of ith bank in period t measured by revenues minus costs; is a constant to ensure the natural log of profits to be positive. is total profit in logarithm form of bank i in period t Xit is matrix of outputs and price of inputs independent variables in logarithm form; *Vit* are random variables which are assumed to be iid, ** and independent of *Uit*.

### 2.8 Data Envelopment Analysis

### 2.8.1 Efficiency and productivity

Farrell (1957) laid the foundation to measure efficiency and productivity studies at the micro level. His contribution highlighted new insights on two issues: how to define efficiency and productivity, and how to calculate the benchmark technology and efficiency measures. The fundamental assumption is to depart from the assumption of perfect input-output allocation but to allow for inefficient operations. Inefficiency is defined as the distance of a firm from a frontier production function accepted as the benchmark. The basis for this measure is the radial contraction/expansion connecting inefficient observed points with (unobserved) reference points on the production frontier. If a firm’s actual production point lies on the frontier it is perfectly efficient. If it lies below the frontier then it is inefficient, with the ratio of the actual to potential production defining the level of efficiency of the individual firms Farell proposed efficiency consists of two components: technical efficiency and allocative efficiency. The former reflects the ability of a DMU to minimize input use as to produce a given amount of output. The latter reflects the ability of a DMU to use inputs in optimal proportions, given their respective prices and the production technology. Together, these two measures represent a total efficiency measure (Coelli et al., 1997). Efficiency ratios take on a value between zero and one, where one indicates that the DMU is fully efficient. For example, an efficiency score measured against a cost frontier of 90% signifies that the DMU could have reduced costs by 10% without altering its output vector. The estimation of efficiency can be categorized according to the assumptions and techniques used to construct the efficient frontier. On the one hand, parametric methods estimate the frontier with statistical methods. On the other hand, nonparametric methods rely on linear programming to calculate piecewise linear segments of the efficient frontier. Parametric methods impose an explicit functional form for both the frontier and deviations from it that is inefficiency. Nonparametric methods, in contrast, do neither impose any assumptions about functional form of the frontier nor any distributional assumptions about inefficiency. This entirely deterministic construction of the frontier attributes the entire difference between an inefficient observed DMU and an efficient reference DMU on the frontier exclusively to inefficiency. Estimation of the frontier, in turn, allow for random noise in the analysis. This involves the estimation of a stochastic frontier. Thus, in the context of a production function, the output of a firm is a function of inputs subject to a production technology and inefficiency arising in the employment of that technology. Non-parametric methods, in turn, also allows random error in observed input-output combination

Technical efficiency is the ability of the firm to maximize outputs from the given set of inputs and allocative efficiency is the ability of the firm to use theses inputs in optimal proportion given their respective prices. Combining these two measures provides a measure of productive efficiency. Farrell illustrated his ideas using a simple example involving firms that use two inputs (x1 and x2) to produce a single output (y). If the isoquant of the benchmark efficient firm is known, the efficiency of any firm can be calculated. In the Figure 2.2 below observation  utilities two input factors to produce a single output.’ is the efficient isoquant estimated with an available technique. The same level of output could have been produced by radically contracting the use of both inputs back to point which lies on the isoquant associated with the minimum level of inputs required to produce.

## The technical efficiency of a production unit operating at is most commonly measured by the ratio

## TAE 18p_0

Fig-2. 2 Technical and Allocative Efficiencies

## Which is equal to[1-BA/OB]. It will take a value between zero and one and hence an indicator of the degree of technical inefficiency of the production unit. A value of one indicates the firm is fully technically efficient. For instance the point is technically efficient because it lies on the efficient iso-quant. If the input price ratio represented by the scope of the iso-cost line’ in figure 2.2 is also known allocative efficiency may also be calculated. The allocative efficiency (AE) of a Production Unit operating at is defined to be the ratio . Since the distance represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point instead of the technically efficient but allocatively inefficient Point The total economic efficiency EE “is defined to be the ratio

## 

## Where, the distance CA can also be interpreted in terms of a cost reduction. The product of technical efficiency and allocative efficiency measures provides the measure of overall economic efficiency.

## .

All three measures are bounded by zero and one.

There is an increasing concern in measuring and comparing efficiency of firms under different environments and activities. One of the simplest and easiest ways to measure efficiency is:

Efficiency =

If a firm produces only one output, using one input this could be done easily. However, this method is often inadequate as firms normally produce multiple outputs by using various inputs related to different resources. The measurement of relative efficiency which involves multiple, possibly incommensurate inputs and outputs was first addressed by Farrell (1957). The aim of this technique is to define a frontier of most efficient decision making units (banks) and then to measure how far from the frontiers are the less efficient units. The relative efficiency can be measured as:

Efficiency =

By using usual notations, this efficiency measure can be written as:

Efficiency of unit j =

Where u1 is the weight given to output 1.

*Y*1j  is the amount of output 1 from unit j.

V1 is the weight given to input 1

X1j  is the amount of input 1 to unit j

This measure of efficiency assumes a common set of weights to be applied across all units. This raises the problem of how much an agreed common set of weights can be applied to all units. In cases where there is only one input and one output, often efficiency is measured as an output-input ratio. But, a typical bank will have multiple inputs and outputs. Efficiency can be measured by using a weighted average of the outputs and a weighted average of inputs. When comparing efficiency between banks, the above measure can be most readily applied when a common set of weights for the banks is applicable.

In this research we discuss some popular extensions of basic DEA models. If price data are available then it is possible to measure allocative, technical efficiency as well as overall cost, revenue and profit efficiency. To calculate these main types of efficiency, a set of linear programs should be solved.

### 2.8.2 Extensions of Basic DEA Models

In this research we discuss some popular extensions of basic DEA models. The input-oriented DEA model under the assumption of variable return to scale can be used for calculation of input-oriented technical efficiency and cost efficiency. Input-oriented model under the assumption of variable return to scale is often termed as BCC model, which can be written in the following form (Dlouhy et al. 2007):

To calculate cost efficiency is necessary to solve the following cost minimization DEA

Where θq is input-oriented technical efficiency (TEq) of Decision Making Unit (DMUq) in the in- put-oriented DEA model, yrq  is produced amounts of rth output (r = 1,2,...,s) for DMUq, xiq is consumed amounts of ith input (i = 1,2,...,m) for DMUq, yrj is produced amounts of rth output (r = 1,2,...,s) for DMUj (j = 1, 2,...,n), xij is consumed amounts of ith input (i = 1,2,...,m) for DMUj (j = 1, 2,...,n), λj is weight assigned to the DMUj (j = 1,2,…,n).



### 2.8.3 VRS Cost Minimization DEA Model

To calculate cost efficiency is necessary to solve the following cost minimization DEA model (Coelli et al. 2005):

Where Wiq  is a vector of input prices of jth bank and Xiq\* is the minimizing vector of input quantities for jth bank, given the input prices wiq and the output levels yrq.

The overall cost efficiency (CEq ) is defined as the ratio of minimum cost of producing the outputs to observed cost of producing the outputs for the DMUq (Coelli et al. 2005)



The overall cost efficiency can be expressed as a product of technical and allocative efficiency measures. Therefore, the allocative efficiency of the DMUq can be calculated as ratio of overall cost efficiency (CEq) to input oriented efficiency of the (TEq). These three measures (technical, allocative and overall cost efficiency) can take values ranging from zero to one, where a value of one in case of TE,AE and CE indicates full efficiency. If production unit is fully technically efficient (TEq=1) and displays allocative efficiency (AEq=1); it is also overall cost efficient (CEq=1)This production unit uses minimum amount of inputs for producing given level of outputs, while the proportion of inputs will guarantee the minimum possible costs. The production unit which is technically efficient (TEq =1) but does not demonstrate allocative efficiency (AEq<1), is not overall cost efficient (CEq <1). This production unit uses minimum amount of inputs for producing the given outputs , while the proportion of inputs will not guarantee the minimum possible costs. The production unit which reaches allocative efficiency (AEq =1), but does not reach technical efficiency (TEq <1) cannot be marked as overall cost efficient (CEq< 1). The proportion of inputs will guarantee the minimum possible costs, but this combination of inputs is not minimal for a producing of given outputs. If the production units fails to demonstrate any of these three types of efficiency (TEq<1; AEq<1;CEq<1), Then the value of overall cost efficiency can be interpreted as a potential costs saving that can be achieved if the production unit uses the inputs in optimal combination. Potential costs saving can be calculated by subtracting the value of overall cost efficiency from the number one.

The output-oriented DEA model under the assumption of variable return to scale can be used for calculation of output-oriented technical efficiency and revenue efficiency. Output-oriented model un- der the assumption of variable return to scale can be written in the following form (Dlouhy et al. 2007):



Where ϕq is output-oriented technical efficiency (TEq) of DMUq in the output-oriented DEA model.

To calculate revenue efficiency the following revenue maximization DEA problem is necessary to solve (Coelli et al. 2005):



Where prq is a vector of output prices of DMUq and y*\** is the revenue maximising vector of output quantities for DMUq, given the output prices prq and the input levels xiq.

The overall revenue efficiency (REq) is defined as the ratio of observed revenue to maximum revenue for the DMUq (Coelli et. al., 2005):



The overall revenue efficiency can be expressed as a product of technical and allocative efficiency measures. Therefore, the allocative efficiency of the DMUq can be calculated as the ratio of revenue efficiency (REq) to output-oriented technical efficiency (TEq) of the DMUq. These three measures (technical allocative and overall revenue efficiency) can take values ranging from zero to one, where a value of one in case of TE, AE and RE indicates full efficiency. If the production unit is fully technical- ly efficient (TEq = 1) and displays allocative efficiency (AEq = 1); it is also overall revenue efficient (REq = 1). This production unit achieves the maximum possible outputs at given inputs, while the proportion of outputs will guarantee the maximum possible revenues. If the production unit is technically efficient (TEq = 1) but doesn’t demonstrate allocative efficiency (AEq<1), it isn’t also overall revenue efficient (REq<1). This production unit achieves the maximum possible outputs using a given inputs, but the proportion of inputs will not guarantee the maximum possible revenues. If the production unit fails to demonstrate any of these three types of efficiency (TEq<1; AEq<1; REq<1), then the value of overall revenue efficiency can be interpreted as potential revenue increasing that can be achieved if the production of outputs in optimal combination. Potential

### Revenues increasing can be calculated by subtracting the value of overall revenue efficiency from the number one

### 2.8.4 VRS Profit Maximization of DEA model

If we have to access to price data on both inputs and outputs, then the profit efficiency can be calculated. The profit maximization DEA problem is specified as follows :

Max 

Where all notations used comply with previous definition

The overall profit efficiency (PEq) can be defined as the ratio of observed profit to maximum profit for the DMUq (Coelli et al.,2005):

PE =

However, this measure need not be bounded by zero and one. It could be negative if a profit is negative, or it could be undefined if maximum profit is zero (Coelli et al. 2005). The value of overall profit efficiency can be interpreted as potential profit increasing that can be achieved if the production unit uses the inputs and outputs in optimal combination.

## **2.9 Tobit Regression Model**

In revealing the ICT factors affecting cost and profit efficiency levels of Bangladesh banks, this study uses TOBIT regression considering the efficiency scores have the features of censored value between 0 and 1.

Koop (2008) specifies that the TOBIT model is a regression model that has the dependent variable which is censored at zero. The regression equation for the TOBIT model is as follows

( Koop ,2008; Verbeek,2012):



Where y∗it is unobserved or latent variable

yit is observed dependent variable for observation unit-i at time-t.

β is the vector of unknown parameters which determines the relationship between

the independent variables and the latent variable.

Xi is the vector of explanatory variables,

In the TOBIT regression model, it is adopted some tradi-tional assumptions regarding parameters and error term. Those assumptions are ([Verbeek, 2012](#page13)) and uit are i.i.d. normally distributed, independent of xi1, . . . . . . , xiT, with the means of zero and variances  respectively. Regarding the estimator, Koop [(2008)](#page13) stipulates that OLS method is not appropriate for the TOBIT regression since the OLS estimator is biased for the censored observations. The more points we have in the censored observations, the worse the bias will be. Hence, the parameters of the TOBIT regression model is properly estimated by the estimator taking into account the censored nature of the dependent variable. The estimator is the Maximum likelihood method.

## **2.10 Ordinary Least Squares Regression** (**OLS**)

**Ordinary Least Squares regression (OLS)** is more commonly named [linear regression](https://www.xlstat.com/en/products-solutions/feature/linear-regression.html) (simple or multiple depending on the number of explanatory variables).

In the case of a model with p explanatory variables, the OLS regression model writes

where Y is the dependent variable, β0, is the intercept of the model, Xj corresponds to the jth explanatory variable of the model (j= 1 to p), and e is the random error with expectation 0 and variance σ².

In the case where there are n observations, the estimation of the predicted value of the dependent variable Y for the ith observation is given by:



The OLS method corresponds to minimizing the sum of square differences between the observed and predicted values. Where β is the vector of the estimators of the βi parameters, X is the matrix of the explanatory variables preceded by a vector of 1s, y is the vector of the n observed values of the dependent variable, p\* is the number of explanatory variables to which we add 1 if the intercept is not fixed, wi is the weight of the ith observation, and W is the sum of the wi weights, and D is a matrix with the wi weights on its diagonal.

## **2.11. ICT Oriented Bangladesh Banking Industries**

Today, information and communication technology has become the heart of the banking sector and the banking industry is at the heart of every powerful economy. Electronic banking system has become the key technology driven revolution in financial transaction management. The modernization of ICT has set the stage for remarkable improvement in the global banking system. For example the development of global networks has significantly reduced the cost of transferring global funds. Banks that use ICT-related products like online banking, electronic payments, security investments can provide high quality customer service at low cost. Technology has already enabled most banks in Bangladesh to introduce innovative products to their customers in the form of ATM / postal facilities, mobile / tele banking, web banking, 'anytime' and 'anywhere' banking. Customers of banks have felt the positive impact of the technical solutions implemented by the banks. Banks play an important role in the economic and social conditions of a country. The major part of bank’s profits is usually spread. But due to the continuous contraction, the profitability of the banks is under tremendous pressure. It becomes imperative for banks to reduce transaction costs to increase their profitability. The use of technology in banks reduces costs. Banks have realized that the cost of transactions is reduced from the brick and mortar structure of branches to online delivery channels like ATMs, POS terminals, mobile phones, internet, etc. Each of these channels has its own unique benefits when it comes to improved customer service and reduced transaction costs. The main difference between online banking and traditional banking is that in traditional banking, the customer will need to go the branch for the basic banking needs viz. withdrawal or deposit of cash, transfer of funds, statement of accounts etc. Banks also enjoy lower overheads, deployment, premises and maintenance costs, thereby reducing transaction costs. Low is one of the major reasons for the popularity of online business.

## **2.12 Status of E-banking in Bangladesh**

E-Banking facilitates instant access to account information, maintain control over the finances, saving time, avoiding trips and phone calls to the bank. It enables account access that isn’t limited to a specific PC and usages of money management software like Quicken and Microsoft Money. Time of writing and clearing out bills, buying stamps, writing checks, and writing addresses on envelops every month could be saved. E-banking takes just minutes to setup an on-line bill payment; and bills are paid directly from bank checking account. Further, setting up of future bill payments, or scheduling of monthly payments could be made. It has only to be ordered whom to pay, how much to pay, and when to pay; and the bank take care of the rest. After the implementation of WTO treaty in 2005 many banks across the globe have come with new solutions with minimum possible banking expenditure. At present most of the banks in Bangladesh are using electronic banking services in this and other forms. Nevertheless, the banks can be profitable if they use e-banking. Local and foreign private banks operating in Bangladesh are the pioneers to introduce the electronic banking facilities in the country. Among the indigenous banks, the private banks are ahead of the public banks. BRAC Bank, Dutch-Bangla Bank, Prime bank, City bank, Mutual Bank, Southeast bank, One bank, UCB Limited bank, Premier Bank, Islami Bank, Al –arafah Bank, Social Islami bank, Eastern Bank, Exim bank, Mercantile Bank, Shahjalal Islami bank and Dhaka Bank are some of the banks marching towards e-banking. Among the four Nationalized Commercial Banks (NCBs), Janata bank has some access to the electronic banking facilities. Bangladesh Bank, the Central Bank of Bangladesh, is also trying to formulate the structure of electronic banking facilities.

The e-banking services provided by the banks in Bangladesh could be divided in three groups: ATM Services, Internet Banking (i-Banking), and SMS Banking. The scopes of these services are vast, but the banks in Bangladesh do not provide all of these services. Some of the banks provide these or other services and charge fees for ATM transaction, SMS and i-Banking while the western banks inspire clients to do ATM banking without fee or a minimum fee to reduce banking expense. Dutch-Bangla Bank Limited (DBBL) was the first bank in Bangladesh to introduce ATM and e-banking in 2003, and further additions and features are continuously being added and upgraded. DBBL has adopted the same exact automation solution used by international banking giants (DBBL Annual Report, 2009). A DBBL client has unlimited access to banking from any DBBL branch, ATM and Point of Sale (POS). ATM access to all DBBL clients is unlimited and free of cost. All of these services are affordable for everyone. With 800 ATMs nationwide DBBL has the largest ATM network in Bangladesh which gives its clients full access to 'anytime anywhere' banking. All international and many local banks use the ATM network of DBBL for their clients. However, if a client of a member bank uses a DBBL ATM, the member bank may add a transaction charge to its client. DBBL has an off-site Data Recovery Site (DRS) which ensures that customer records are safe, backed-up, and up to date in the event of a major catastrophe at the Electronic- Banking Division headquarters. Since 2004, DBBL has introduced mobile and SMS banking. With a mobile phone, customers can perform many banking operations. DBBL is a primary license holder for both VISA and Master card. It is authorized to issue and accept payments from both organizations. DBBL offers also Visa and Master card Debit Cards. It does also Internet and SMS Banking and provides other services. DBBL has established drawing arrangement network with banks located in the important countries of the world namely in the United Arab Emirates, State of Kuwait, State of Qatar, State of Bahrain, Italy, Canada and United States of America. Bangladeshi Wage Earners can send their money with confidence, safety and speed to their respective beneficiaries in Bangladesh in shortest possible time. DBBL has set up a representation agreement with Western Union Financial Services Inc, USA, which is a reliable international money transfer company. Using the service of DBBL, Bangladeshi Wage Earners can send and receive money quickly from over 225,000 Western Union Agent located in 197 countries and territories worldwide only by visiting any branches of Dutch- Bangla Bank Limited in Bangladesh. DBBL offers banking facilities through a wide range of mobile phones. Customer using HTML browser has access to the internet banking facilities of DBBL. Premier Bank has set up Wide Area Network using Radio, Fibre-Optics & other communication systems to provide branch banking to its customers (Premier Bank Annual Report, 2009). Customer of one branch is now able to deposit and withdraw money at any of the branches. All Branches are included in the Wide Area Network. So, no TT/DD or cash carrying is necessary. Premier Bank has been giving SMS Banking Service since 2006. The customers of Premier Bank can have information about banking transactions and inquiries through SMS Banking. They can check their balance, stop a cheque payment, or get statements. Its SMS Banking provides the customers with real time account information by using mobile phones and instruction capabilities from the mobile phones at ‘anywhere, anytime, anyhow’. The service is available round the clock seven days a week. Premier Bank SMS banking service is free for customers. Prime Bank Limited provides Internet Banking with a secure connection of the client’s access to the accounts 24hours a day, 7 days a week from any Internet connection (Prime Bank Annual Report, 2009). It provides the opportunity to verify account balances, transfer funds, and pay loans, every time when the customers log on to their on-line account. The customers can monitor account activity, get real-time account balance, and transfer funds at convenience. Prime bank's Internet Banking requires no special software; it is available through its website. Account access isn't limited to a specific PC with special software installed and data stored. Anywhere the customers have access to the Internet, have access to their Prime bank accounts. Prime bank's Internet Banking lets the customers download their latest on-line account information. Prime bank's Internet Banking gives opportunity of bill paying for its customers through Prime bank's Bill Payer program. Islami Bank Bangladesh Limited (IBBL) provides different services of e-banking to its customers (Islami Bank Annual Report, 2009). It has introduced ATM, SMS banking and Internet banking. For SMS banking registration is required. Under SMS banking of IBBL customers get different services. SMS and i-Banking facilities, however, are applicable only for online branches. The contract could be terminated by either side giving 30 days’ prior notice. The Internet Based Banking of IBBL is called i-Banking which has been introduced since 2009. IFIC Bank issues VISA Credit Cards for both local and international use (IFIC Bank Annual Report, 2009). The Local Cards can be used at any ATM displaying VISA Logo for withdrawal of cash and for purchase of goods & services at any POS displaying VISA Logo within Bangladesh. The International Cards, on the other hand, can be used at any ATM and POS displaying VISA logo anywhere in the world. International credit card of IFIC Bank is a dual currency card and could be used at home & abroad. IFIC credit cardholders can enjoy 20 to 50 days interest free period depending on the date of transaction and the date of statement generation. IFIC Bank Limited provides also opportunity for SMS Banking Card Services to its clients. Under Card Services the clients of IFIC can have Push /Pull Services. All Account & Card Holder of IFIC Bank are eligible to apply for SMS Banking and Card Services. Now most of the Private Commercial banks perform E-bankiing. Banking sector of Bangladesh consists of six state-owned commercial banks (SOCBs), thirty nine private commercial banks (PCBs), nine foreign banks (FBs), two specialized banks (SBs), and four non-scheduled banks. According to the BIBM report, SOCBs are large in terms of shares in assets and number of branches; they could cover only around 72.3 per cent of their branches under computerization by 2015 while the PCBs and FCBs brought 99.5 and 100 per cent of their branches, respectively, under computerization. The following graph shows computerization status of bank branches during 1998-2015 in Bangladesh. The total computerization of bank branches for all banks was shown on the graph which stood at 75.1% in 2015 due to the growth of computerization of govt. banks in last few years.

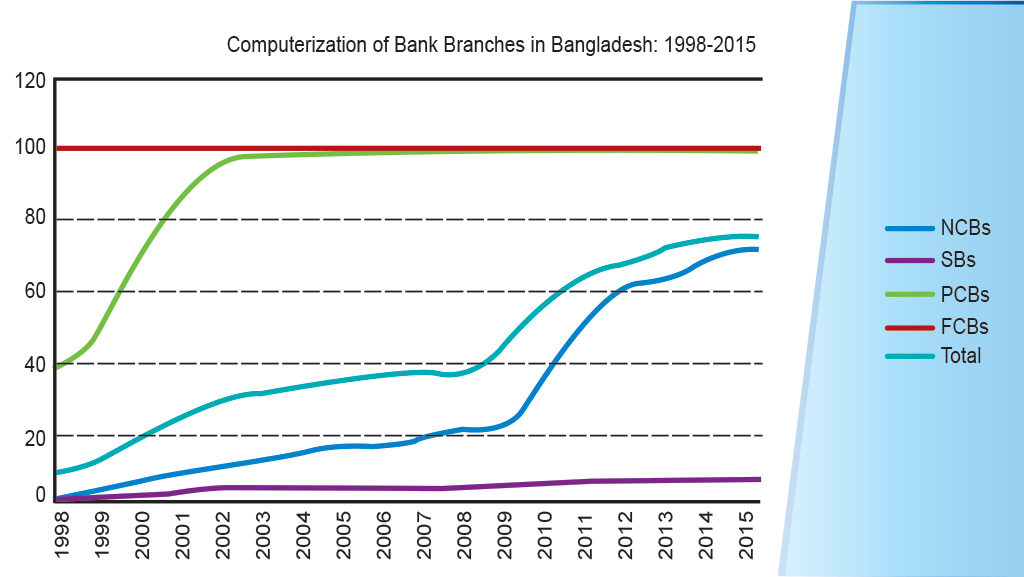


Fig-2 3: Computerization of Bank Branches in Bangladesh: 1998-2015

## **2.13 Trends in IT Adoption of State-owned and Private Commercial banks According to this Study**

The following Figure shows the trend in IT adoption in the State owned commercial banks and Private Commercial Banks over the period 2008 to 2017. It is evident from the graph that, out of different innovative technology driven products and services, the State-owned Commercial banks is observed in adopting highly ATM Expenses and credit card expenses where the IT investment and credit card expenses are highly adopted for the Private commercial bank during the period 2008-2017.

**Fig-2 4: Trend in IT Adoption of State-owned Commercial Bank**

**Fig-2 5: Trend in IT Adoption of Private Commercial Bank**

## **2.14: Conclusion**

In this chapter, the important topics of theoretical concept of this study are discussed. The concept of productivity, production frontier, Technical efficiency, SFA, DEA, Tobbit Regression, OLS models are explained elaborately which helps the properly understanding for this research. Also, ICT oriented banking industry are discussed.

# CHAPTER THREE

## **LITERATURE REVIEW**

## **3.0 Introduction**

This chapter illustrates the previous finding on efficiency. The studies of efficiency using frontiers approaches of banking did not start until Sharman and Gold (1985) initiated their own. They applied the frontier approach to the banking industry by focusing on the operating efficiency of the branches of a saving bank and then number of studies has been conducted using frontiers approaches to measure efficiency. While there has been extensive literature available in examining the efficiency features of contemporary banking sector, particularly the work on US and European banking markets and similarly in rest of world but Studies on ICT in banking is still in its infancy. Because of the lack of relevant empirical studies in the field of banking, some studies described in this section are thus related to other service organizations, manufacturing firms and hospital institutions. In this study, both the financial ratio analysis and parametric econometric approach were more widely used for evaluating performance, while nonparametric linear programming approach was scarcely used. Some econometric-based studies adopted SFA as the analytic tool and Cobb-Douglas function as the theoretical model. However, this type of research is gradually changing as a number of recent studies have sought to apply various techniques to estimate efficiency of banking based on ICT sector. Here, we briefly review the relevant literature in different Tables as follows

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table-3. 1 Literature Survey on Bank Efficiency Studies based on Stochastic Frontier Analysis | | | | | | | | | |
|  | | | | | | | | | |
| **Studies** | **Sample periods** | | **Dependent** | **Independent Variables** | | | **Objectives** | **Major Findings** | |
|  |  | | **Variable** | **Output(Y) /** | | |  |  | |
|  |  | |  | **Input Prices(W)/** | | |  |  | |
|  |  | |  | **Explanatory Variable(z)** | | |  |  | |
|  |  | |  |  | | |  |  | |
| Duygun et al. | 34 emerging | | Total cost | Y1: Loans | | | To obtain the efficiency | Confirm the importance of | |
| (2015) | Economies | |  | Y2: Securities investment | | | and productivity | the regulated equity capital | |
|  | from 2005-2008; | |  | Y3: Off-balance sheet | | | decomposition in the | ratio as a constraint on cost | |
|  | Cost efficiency; | |  | Items | | | banking systems of | minimizing behavior. | |
|  | SFA; Trans-log; | |  | W1: price of fund | | | emerging economies |  | |
|  | Inefficiency model; | |  | W2: price of labour | | |  |  | |
|  |  | |  | W3:price of physical | | |  |  | |
|  |  | |  | capital | | |  |  | |
|  |  | |  | Z1:Equity to Asset ratio | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Le Thi Thanh | Vietnam from | | Total cost | Y1: Total loans | | | To measure the cost | Average Cost efficiency: 8% | |
| Ngan (2014) | 2007-2012 | | Operating | Y2: Total securities | | | and profit efficiency of | to 20%, average profit | |
|  | Cost efficiency; | | profit | W1: Price of labour | | | Vietnam commercial | efficiency: 61 -68% | |
|  | Profit efficiency | |  | W2: Price of fund | | | Bank | State-owned commercial bank | |
|  | SFA; Translog | |  | W3: Price of physical | | |  | Was more profit efficient and | |
|  |  | |  | Capital | | |  | Less cost efficient than foreign | |
|  |  | |  |  | | |  | Banks. | |
|  |  | |  |  | | |  |  | |
| F. Aiello | Italia from | | Total cost | Y1: Total loans | | | To evaluated the cost | Both cost & profit efficiency | |
| G. Bonanno | 2006-2011; | | Profit | Y2: Total securities | | | and profit efficiency of | level ranges around 95%. | |
| (2013) | Cost efficiency; | |  | Y3: Total Commission | | | Italian Bank |  | |
|  | profit efficiency; | |  | W1: Price of labour | | |  |  | |
|  | SFA; Translog | |  | W2: Price of funds | | |  |  | |
|  |  | |  | W3: Price of physical | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| **Studies** | **Sample periods** | | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) /**  **Input Prices(W)** | | | **Objectives** | **Major Findings** | |
|  |  | |  |  | | |  |  | |
|  | Malaysian commercial | | Total cost | Y1: The sum of total loans | | | To derive both net and | Net efficiency: ranges from | |
| Abdul-Majid | Bank; from:1996-2002; | |  | Y2: Other earning Assets | | | gross efficiency | 1.019 to 1.217, average 1.066; | |
| et al. (2011) | Net efficiency and gross | |  | W1: Price of labour | | | Estimates | Gross efficiency: ranges from | |
|  | efficiency ;SFA; Trans- | |  | W2: Price of financial | | | To decompose the | 1.032 to 1.688, average 1.340 | |
|  | Log, DEA; Malamquist | |  | Capital | | | Productivity change. | productivity change of 2.68 % | |
|  | Productivity index | |  | W3: Price of physical | | | To determine the | Technological changes | |
|  |  | |  | Capital | | | Impact of Islamic | Impacted | |
|  |  | |  |  | | | banking on | Negatively on Islamic bank | |
|  |  | |  |  | | | Performance. |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Izaz M.Tahir & | Islamic banks in | | Total cost | Y1: Other earning Assets | | | To measure the cost | Cost & profit efficiency : | |
| sudin Haron | Four regions from | | Profit | W1: Price of labour | | | and Profit efficiency of | Far East and Central Asia : | |
| (2010) | 2003-2008 | |  | W2: Price of | | | Islamic bank in Africa | 29.8 % and 41.8 % | |
|  | Cost efficiency; | |  | Physical capital | | | Europe, Far East , | Middle East:43.5 % and45.4 % | |
|  | profit efficiency; | |  |  | | | Asia & Middle Asia. |  | |
|  | SFA; Translog | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Shen et al. | 10 Asian countries | | Total cost | Y1: Loans | | | To measure and | Joint-stock banks are more | |
| (2009) | and regions; | |  | Y2: Other earning assets | | | Compare the cost | efficient than state-owned | |
|  | from 1998-2005; | |  | Y3: Non-interest income | | | efficiency score | Banks | |
|  | Cost efficiency; | |  | Y3: Non-interest income | | | for 285 commercial |  | |
|  | SFA; Fixed effect | |  | W1: Price of funds | | | Banks among ten |  | |
|  | model, | |  | W2: Price of labour | | | Asian countries |  | |
|  | Random effect model | |  | W3: Price of fixed assets | | | and regions. |  | |
|  |  | |  |  | | |  |  | |
| **Studies** | **Sample periods** | | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) /**  **Input Prices(W)/**  **Explanatory variable (z)** | | | **Objectives** | **Major Findings** | |
|  |  |  | | |  |  | | |
| Kosak et al. | 5 new EU Member | |  | Y1: Total loans | | | To examines bank cost | Average CE: overall, 0.88; | |
| (2009) | States and 3 Baltic | | Total Cost | Y2: Securities | | | efficiency for five new | Czech Republic, 0.81; | |
|  | States ,From 1996-2006; | |  | Y3: Other earning Assets | | | Asian banking industry. | Estonia, 0.95; Hungary, 0.90; | |
|  | Cost efficiency; | |  | Fund | | | EU Member States | Lithuania, 0.94; Latvia, 0.93; | |
|  | SFA; Trans-log | |  | W1: Price of Borrowed | | | from Central and | Poland, 0.92; Slovenia, 0.91; | |
|  | Inefficiency model; | |  | W2: Price of physical | | | Eastern Europe and the | Slovakia, 0.77 | |
|  |  | |  | Capital | | | three Baltic States | The level of competition is | |
|  |  | |  | W3: Price of labour | | |  | more important than | |
|  |  | |  | Z1:Equity Ratio(z) | | |  | ownership to improve cost | |
|  |  | |  |  | | |  | efficiency. | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Kasman and | 8 Central and | | Total cost | Y1: Loans | | | To measure the cost | Average cost efficiency: 0.81 | |
| Yildirim | eastern European | | Profit | Y2: Total deposits | | | And profit efficiencies | Average profit efficiency: | |
| (2006) | Countries | |  | Y3: Other earning assets | | | In commercial banking | 0.63: Cost and profit | |
|  | from1995-2002; | |  | W1: Price of funds | | | in the eight Central and | efficiency vary dramatically | |
|  | Cost efficiency and | |  | W2: Price of labour | | | Eastern European | across countries; Foreign | |
|  | Profit efficiency; | |  | W3: Price of capital | | | Countries | banks are more efficient than | |
|  | SFA; Trans-log | |  |  | | |  | domestic banks | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Fries and Taci | 15 Transition countries | | Total cost | Y1: Loans | | | To examine the cost | Without country-level | |
| (2005) | from1994-2001; | |  | Y2: Deposits | | | efficiency of 289 banks | factors Cost Efficiency: 0.63, | |
|  | Cost efficiency; | |  | W1: Price of labour | | | in 15 East European | With country-level factors | |
|  | SFA; Translog | |  | W2: Price of physical | | | Countries. | CE: 0.71 | |
|  |  | |  | Capital | | |  | Private banks are more | |
|  |  | |  | Z1: Capital Adequacy | | |  | efficient than state-owned | |
|  |  | |  | Ratio | | |  | banks; Foreign ownership | |
|  |  | |  | Z2: Capital Equity Ratio | | |  | imposes the managerial | |
|  |  | |  |  | | |  | ability. | |
|  |  | |  |  | | |  |  | |
| **Studies** | **Sample periods** | | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) /**  **Input Prices(W)**  **Explanatory variable(Z)** | | | **Objectives** | **Major Findings** | |
|  |  | |  |  | | |  |  | |
| Carvallo and | 16 Latin American and | | Total cost | Y1: Loans | | | To estimate the cost | Average Cost Efficiency: | |
| Kasman | Caribbean countries | |  | Y2: Deposits | | | Efficiency of Latin | 0.822.The efficiency level | |
| (2005) | from 1995-1999; Cost | |  | Y3: Other earning assets | | | American and | significantly varies across | |
|  | efficiency; SFA; | |  | W1: Price of labour | | | Caribbean Countries. | country and the largest | |
|  | Translog | |  | W2: Price of funds | | | Also estimate the | economy was the most. | |
|  |  | |  | W3: Price of physical | | | determinant. Of | Cost efficient | |
|  |  | |  | Capital | | | Inefficiency. |  | |
|  |  | |  | Z1:Non-performing loan | | |  |  | |
|  |  | |  | Z2:ROA | | |  |  | |
|  |  | |  | Z3: ROE | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Hasan and | Hungary from 1993- | | Total cost | Y1: Total loans | | | To analyzes the | Cost Efficiency: 0.71 (overall), | |
| Marton (2003) | 1998;Cost efficiency; | |  | Y2: Total investments | | | experiences and | 0.67 (domestic), 0.74 | |
|  | SFA; Translog; | |  | Y3: Non-interest or | | | developments of | (foreign)Foreign banks were | |
|  | Cost inefficiency | |  | fee-related income | | | Hungarian banking | More efficient than domestic | |
|  |  | |  | Y4: Total interest of | | | sector during the | bank. | |
|  |  | |  | borrowed fund | | | transitional process |  | |
|  |  | |  | W1: Price of fund | | | from a centralized |  | |
|  |  | |  | W2: Price of labour and | | | economy to a market- |  | |
|  |  | |  | related expense | | | oriented system. |  | |
|  |  | |  | Z1:loan loss provision | | |  |  | |
|  |  | |  | Z2:Equity capital | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| **Studies** | **Sample periods** | | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) /**  **Input Prices(W)**  **Explanatory Variable(Z)** | | | **Objectives** | **Major Findings** | |
| Christopoulos | Greece bank | | Total Cost | Y1: Loans | | | To measure the cost | Small and medium-sized banks | |
| et al. (2002) | From :1993-1998; | |  | Y2: Investments | | | efficiency of the Greek | are almost fully efficient, | |
|  | Cost efficiency; | |  | Y3: Liquid assets | | | banking system. | large banks efficiency range | |
|  | SFA; Translog (TL) | |  | W1: Price of funds | | |  | from 0.6-0.95 | |
|  |  | |  | W2: Price of labour | | |  |  | |
|  |  | |  | W3: Price of capital | | |  |  | |
|  |  | |  |  | | |  |  | |
| Christopoulos | Greece Bank | | Total Cost | Y1: Loans | | | To measure the | Average Allocative | |
| and Tsionas | from 1993-1998; | |  | Y2: Investments | | | Technical efficiency | Efficiency: ranges | |
| (2001) | Technical | |  | Y3: Liquid assets | | | and allocative | From :14.16%-25% | |
|  | Efficiency(TE); | |  | W1: Price of funds | | | Efficiency of the Greek | Average Technical | |
|  | Allocative Efficiency | |  | W2: Price of labour | | | Banking sector in the | Efficiency ranges | |
|  | (AE); SFA; Cobb- | |  | W3: Price of capital | | | deregulation period. | From:80.78-94.30 | |
|  | Douglas | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| Mertens and | Ukraine from 1998; | | Total | Y1: Interbank loans | | | To estimate cost and | Cost efficiency: 0.67 (SFA), | |
| Urga (2001) | Cost efficiency | | Cost | Y2: Client loans | | | profit efficiency and | 0.81 (TFA); Profit efficiency: | |
|  | Profit efficiency; | | Profit | Y3: Investments in | | | scale and scope | 0.72 (SFA), 0.66 (TFA). | |
|  | SFA; Translog; | |  | securities and other | | | economies for 79 from | Non-performing loan was | |
|  | Inefficiency model; | |  | investments | | | 168 Ukrainian | Positively significant for | |
|  |  | |  | W1: Price of funds | | | commercial banks | An inefficiency model. | |
|  |  | |  | W2: Price of labour | | |  |  | |
|  |  | |  | Z1: Capital, | | |  |  | |
|  |  | |  | Z2: fixed assets, | | |  |  | |
|  |  | |  | Z3: non-performing ratio | | |  |  | |
|  |  | |  |  | | |  |  | |
|  |  | |  |  | | |  |  | |
| **Studies** | **Sample periods** | | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) /**  **Input Prices(W)/**  **Explanatory variable(Z)** | | | **Objectives** | **Major Findings** | |
|  |  | |  |  | | |  |  | |
| Altunbas et al. | Japanese Bank | | Total cost | Y1: Total loans | | | To investigates the | Inefficiency level range | |
| (2000) | from 1993- 1996 | |  | Y2: Total securities | | | impact of risk and | between 5% and 7% | |
|  | Cost efficiency; | |  | Y3: Total off-balance | | | quality factors | with no discernible | |
|  | SFA; Translog | |  | Sheet-items | | | on banks cost and | trend across size classes. | |
|  | Inefficiency Model | |  | W1: Price of labour | | | to evaluate scale and |  | |
|  |  | |  | W2: Price of funds | | | X-inefficiencies as well |  | |
|  |  | |  | W3: Price of physical | | | as technical change. |  | |
|  |  | |  | Capital | | |  |  | |
|  |  | |  | Z1: Equity Capital | | |  |  | |
|  |  | |  | Z2: NPL ratio | | |  |  | |
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## **3.1 Literature Survey on Bank Efficiency Studies based on Stochastic Frontier Analysis**

Duygun, M., et.al (2015) Productivity decomposition is developed to include exogenous factors such as policy constraints. Ngan, Le Thi Thanh. (2014) Stated owned commercial banks (SOCB) was more efficiency than other domestic commercial banks and foreign banks in terms of profit efficiency. Francesco & Graziella (2013) evaluated that the average levels of cost and profit efficiency were both around 90% and they were quite stable over time. Abdul Majid et al. (2011) estimated the cost efficiency of Malaysia banks using stochastic frontier approach (SFA) from 1996-2002. The result suggested that the net efficiency ranges from 1.019 to 1.217, average 1.066; Gross efficiency: ranges from 1.032 to 1.688, average cost efficiency is 1.340.Izaz M. & Haron (2010) examined that Islamic banks in Europe were relatively more cost and profit efficient than the other group of banks. Banks in the Middle East region were significantly less efficient than Islamic banks in Africa but more efficient than banks in the Far East and Central Asia. Shen et al. (2009) provide a comparison of cost efficiency in ten Asian banking industries found that china had the fourth position after India, Singapore and Malaysia, to improve the managerial performance of the banking sector to achieve robust competitive power in the international stage. Kosak et al.(2009) shows that the level of competition in the banking sector plays a more important role for cost efficiency improvements than the ownership structure itself. Kasman, A. and Yildirim, C. (2006) indicated that foreign banks perform, on average, better than domestic banks. Fries, S. and Taci, A. (2005), Private banks are more efficient than state-owned banks, but there are differences among private banks. Carvallo and Kasman, (2005) estimated that the efficiency level significantly varies across country and the largest economy is the most efficient. Casu and Girardone (2004), derived from the estimation of an alternative profit function seem to suggest that the efficiency gap among countries decreased substantially over the years under study. Christopoulos et. Al (2002) show that larger banks are less efficient than smaller ones. Christopoulos and Tsionas (2001), found that technical inefficiency is close to 20 per cent, allocative inefficiency is also a sub- stantial part of costs, averaging 14 per cent, and both components have improved drastically in the deregulation period. Mertens and Urga, (2001) estimated that small banks operate more efficiently in terms of cost but are less efficient in terms of profit . Altunbas et al (2000) optimal bank size is considerably smaller when risk and quality factors are taken into account when modeling the cost characteristics of Japanese bank.

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| Table-3. 2 : Literature Survey on Bank Efficiency Studies based on Stochastic Frontier Analysis with ICT Data | | | | | |
|  | | | | | |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices(W)** |  |  |
|  |  |  | **Explanatory variable(Z)** |  |  |
|  |  |  |  |  |  |
| M.R. Safari | Iranian banks; | Total cost | Y1:Total loan | To measure the | TE of public bank 0.73, |
| L. Z. Yu | from 1995 to 2011; |  | Y2:Securities | Technical efficiency | TE of private bank 0.83 |
| (2014) | Technical Efficiencies; |  | Y3: Non-interest income | level of Iranian bank | Private bank was more efficient |
|  | SFA; Translog |  | W1:Price of labor | To investigate the | than Public bank. |
|  |  |  | W2:Price of fund | degree of IT factor | The IT variable had |
|  |  |  | Z1:Hardware investment | which influence on | significantly influence |
|  |  |  | Z2:Software investment | the efficiency of bank | on the bank |
|  |  |  | Z3:IT services | To compare the |  |
|  |  |  |  | efficiency level of |  |
|  |  |  |  | private and public bank. |  |
| S.T.Surulivel | Indian Private Sector | Total Cost | Y1:Loan & Advances | To measures & | Cost Efficiency; |
| C.Vijayabanu | Banks; from 2009-2013; | Pre-Tax | Y2:Investment | compare the Cost | old pri. sector;94.9%; |
| R.Amudha | Cost efficiency; SFA; | Profit | W1:Price of labor | efficiency level of | New pri. sector; 82.6% |
| B.Charumathi | Translog; |  | W2:Price of deposit | Indian old private & | New private sector bank were |
| (2013) | Cost Inefficiency |  | W3:Price of Physical | New Private banking | more efficient than old Private |
|  |  |  |  |  | sector bank. |
| **Studies** |  |  |  |  |  |
| **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices(W)**  **Explanatory variable(Z)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
|  |  |  | Capital | Sector | IT reduced the cost inefficiency |
|  |  |  | Z1:IT Investment | To evaluated the | both old and new private sector |
|  |  |  |  | impact of IT on the | to banks. |
|  |  |  |  | cost efficiency of |  |
|  |  |  |  | Indian Banking. |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Elena Beccalli | 737 European Banks; | Total cost | Y1:Loan | To observe the | IT investment appears to have |
| (2007) | From:1995–2000 | Total profit | Y2:Total securities | Investment of (IT)- | positive influence on |
|  | Cost efficiency; |  | Y3:Off balance sheet | Hardware, software | Accounting profits |
|  | Profit efficiency; |  | Items | and other IT services | and profit efficiency |
|  | SFA; Translog ; |  | W1:Price of labour | influences the |  |
|  |  |  | W2:Price of deposit | performance of banks. |  |
|  |  |  | W3:Price of Fixed Assets |  |  |
|  |  |  | Explanatory variable | . |  |
|  |  |  | Z1:Equity |  |  |
|  |  |  | Z2:IT investment |  |  |
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## **3.2 Literature Survey on Bank Efficiency Studies based on Stochastic Frontier Analysis with ICT Data**

Mojtaba & Liu (2014) showed that components of ICT (Software Investment, IT services, except Hardware Investment) and ownership, bank size had a significant influence on technical efficiency levels and privately-owned banks due to type of governance structure had successful performance in effective use of ICT components, compared to publicly-owned banks. S.T.Surulivel, et.al.(2013) explored the old private sector bank cost inefficiency reduced by 28% for the study period by Information Technology (IT) and for new private sector banks cost inefficiency reduced by 11.3% Information Technology (IT). Beccalli (2007) investigated that IT investment impacted positively on profit efficiency.

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| Table-3. 3 Literature Survey on Bank Efficiency Studies based on Data Envelopment Analysis | | | | | |
|  | | | | | |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices** |  |  |
|  |  |  | **(W)/ Input (X)** |  |  |
|  |  |  |  |  |  |
| R. Gulati & | Indian banks; | Profit | Y1:Deposit | To assess the impact | Profit efficiency of banks are |
| S. Kumar | from 2003 to 2013; |  | Y2:Advance | of the global | declined by 3% mildly during |
| (2016) | Profit efficiency; DEA |  | X1:Investment | financial crisis on | the global financial crisis, |
|  |  |  | X2:Total assets | bank efficiency in | but then recovered quickly |
|  |  |  |  | India. | after the crisis. |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| K. kocisova | Slovak and Czech | Cost | X1:Total deposit | To measure & | Slovak: Czech bank; |
| (2015) | commercial banks; | Profit | X2:No of employee | compare the cost, | Cost Efficiency ;55.13: 89.43, |
|  | From;2009–2013; |  | X3:Fixed assets | profit & revenue | Revenue Effi; 80.81: 96.43, |
|  | Cost Efficiency; |  | Y1:Total loan | efficiency of the | Profit Efficiency; 10.31: 51.58, |
|  | Profit efficiency; |  | Y2:other earning assets | Slovak &Czech bank. | Czech banks were most cost, |
|  | Revenue efficiency; |  | W1:price of deposit |  | revenue & profit efficient |
|  | DEA ; Model: VRS |  | W2: price of labor |  |  |
|  |  |  | W3:price of fixed assets |  |  |
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|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
| kharimhadeh | Indian commercial |  | Y1:Loan | To estimate the cost, | Model ;VRS; CE:TE:AE; |
| (2012) | banks; during 2000 – |  | Y2:Investment | technical & allocative | 0.991: 0.995: 0.991 |
|  | 2010;Cost Efficiency | Cost | X1:Deposit | efficiency of Indian | Model ;CRS; CE:TE:AE; |
|  | Technical efficiency |  | X2:Fixed Assets | Banking Industry | 0.936: 0.969:0.958 |
|  | Allocative efficiency; |  | X3: No of employee | using VRS and CRR | Public sector banks were more |
|  | DEA; VRS, CRS |  | W1:Price of labor | DEA model. | Efficient than private sector |
|  |  |  | W2:price of fixed assets |  | banks. |
|  |  |  | W3:price of deposit |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Gardener et al. | Five South East |  | Y1: Net loans | To estimate the | Mean (TE, CE): |
| (2011) | Asian Countries |  | Y2: Other earning | efficiency of five South | Indonesia (58.2, 41.9), |
|  | from1998-2004; |  | X1: Fixed assets | East Asian Countries | Malaysia (85.9, 71.9), |
|  | Technical efficiency; | Cost | X2: Deposits |  | Philippines (79.1, 57.4), |
|  | Cost efficiency; |  | X3: No of employee |  | Thailand (70.4, 49.8), |
|  | DEA; Model: VRS and |  | W1: Price of fixed assets |  | Vietnam (80.1, 61.8) |
|  | Tobit regression |  | W2: Price of deposits |  | Efficiency has significantly |
|  |  |  | W3: Price of personnel |  | declined over 1998-2004; |
|  |  |  | Costs |  | foreign banks are more |
|  |  |  |  |  | efficient than domestic banks; |
|  |  |  |  |  | State-owned banks have |
|  |  |  |  |  | greater efficiency than |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| E. Brack | French banks compared |  | Y1:Commission & fee | To compare the cost | CE of French was around 86.40 |
| R. jimborean | to Europe and the |  | Y2:Loan | efficiency of French | to 91.52%, Spanish banks was |
| (2009) | United States |  | X1:Fixed assets | banks compared to | around 95.07% to 98.32%, |
|  | from 1994-2006; | Cost | X2:Borrower Fund | Europe and the | French Banks were most cost |
|  | cost efficiency; DEA |  | X3:No of employee | United States | inefficient than other EU & |
|  | Model: VRS |  | W1:Price of labor |  | USA bank. |
|  |  |  | W2:price of fixed assets |  |  |
|  |  |  | W3:price of borrower fund |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Pasiouras | 95 countries from | Cost | Y1: Loans | To estimate Technical | The average bank in |
| (2008) | 2003;Technical and |  | Y2: Other earning assets | and scale efficiency | sample could improve |
|  | Pure Technical |  | Y3: Non-interest income | Using DEA method. | its overall technical |
|  | efficiency; DEA; CRS ; |  | X1: Customer deposits | To investigate the | efficiency by 33.20% |
|  | and Tobit regression; |  | and short term funding | impact of control | and pure technical |
|  |  |  | X2: Equity | variable using | efficiency by 29.20% |
|  |  |  | X3: Total Cost | Tobbit regression | while it deviates5.5% |
|  |  |  |  | Model. | from its efficient size |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
| Ariff and Can | China from 1995-2004; |  | Y1: Loans | To investigate the | Cost efficiency: 0.798; |
| (2008) | Cost efficiency and |  | Y2: Investments | Cost & profit efficiency | Profit efficiency: (SPE); |
|  | Profit efficiency; DEA; |  | X1: Labour | of Chinese banking | 0.505, (APE):0.439; |
|  | CRS cost model, | Cost | X2: Fixed Assets | Industry. | joint-stock banks (national . |
|  | Standard Profit |  | X3: Deposits |  | and city-based), on average, |
|  | efficiency( SPE) | Profit | W1: Price of labour |  | appear to be more cost and |
|  | Alternative Profit |  | W2: Price of fixed assets |  | profit efficient than state- |
|  | efficiency (APE) |  | W3: Price of deposits |  | owned banks while medium- |
|  |  |  |  |  | sized banks are significantly |
|  |  |  |  |  | more efficient than small |
|  |  |  |  |  | and large banks |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Chen et al. | China from 1993-2000; |  | Y1: Loans | To estimate the | All banks mean efficiency: |
| (2005) | Technical, allocative | Cost | Y2: Non-interest income | Technical, allocative | Technical efficiency, |
|  | efficiency and cost | Profit | X1: Deposits | and cost efficiency | 0.720-0.853; |
|  | efficiency; DEA; VRS |  | X2: Fixed assets | of Chinese banking | Allocative efficiency, |
|  |  |  | W1: Price of deposits | Sector. | 0.634-0.693; |
|  |  |  | W2: Price of fixed assets |  | Cost efficiency, 0.426-0.582 |
|  |  |  |  |  | The large state-owned banks |
|  |  |  |  |  | smaller banks are more |
|  |  |  |  |  | efficient than medium |
|  |  |  |  |  | sized Chinese banks. |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)/** **Explanatory Variable(Z)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
| Casu and | 5 EU countries from |  | Y1: Total loans | To investigate | Productive efficiency, |
| Molyneux | 1993-1997; |  | Y2: Other earning assets | Productive-efficiency | Average: 0.65 |
| (2003) | Productive-efficiency; | Cost | X1: Total cost | score using DEA | The efficiency gap among |
|  | DEA ; VRS |  | X2: Total customers | method then estimate | countries grew wider over |
|  | Tobit regression; |  | and short term funding | the determinants of | the period 1993-1997; |
|  |  |  | Z1: Country dummies, | efficiency scores | Country-specific factors |
|  |  |  | Z2: Equity to total assets | by Tobit Regression | are important determinants |
|  |  |  | ratio, | model. | in explaining differences in |
|  |  |  | Z3:Return on average |  | banking efficiency |
|  |  |  | equity, |  |  |
|  |  |  | Z4:bank type Dummy |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Tsionas et al. | Greek from 1993-1998; |  | Y1: Loans | To measure technical | The majority of the Greek |
| (2003) | Technical and allocative | Cost | Y2: Investments | and allocative | banks operate close to |
|  | efficiency; DEA; |  | Y3: Liquid assets | efficiency. Also, | best market practices, |
|  | CRS ; Malamquist Total |  | W1: Price of labor | productivity change is | 0.984 (TE), 0.974 (AE) |
|  | Factor Productivity |  | W2: Price of capital | computed using | the positive but not |
|  |  |  | W3: Price of deposits | the Malmquist Total | substantial TFP change |
|  |  |  |  | Factor Productivity. | for the medium-sized banks |
|  |  |  |  |  | and to technical change |
|  |  |  |  |  | improvement for larger |
|  |  |  |  |  | banks. |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objective** | **Major Findings** |
|  |  |  |  |  |  |
| Lozano-Vivas | 10 EU countries from | Cost | Y1: Loans | To investigate the | **B**asic/complete, DEA |
| et al. (2002) | 1993; Cost efficiency; |  | Y2: Deposits | cost efficiency | Mean CE: Belgium(0.42/0.79), |
|  | DEA; Basic, complete, |  | Y3: Other earning assets | differences of a | Denmark (0,2/0.75), |
|  | VRS Model |  | X1: Personnel expenses | sample commercial | France (0.24/0.41), |
|  |  |  | X2: Non-interest expense | banks. | Germany (0.27/0.58), |
|  |  |  |  |  | Italy (0.25/0.33), |
|  |  |  |  |  | Luxembourg (0.49/0.62), |
|  |  |  |  |  | Netherlands (0.37/0.52), |
|  |  |  |  |  | Poland (0.16/0.8), |
|  |  |  |  |  | Spain (0.19/0.82), |
|  |  |  |  |  | UK (0.22/0.59) |
|  |  |  |  |  | Country-specific efficiency |
|  |  |  |  |  | Play an important role on the |
|  |  |  |  |  | behavior of banking industry. |
|  |  |  |  |  |  |
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## **3.3 Literature Survey on Bank Efficiency Studies based on Data Envelopment Analysis**

Racchita & Kumar (2016) found that the impact of global financial crisis on profit efficiency of Indian banking industry was modest and short-lived since the profit efficiency declined only by about 3 percentage points during the crisis years and experienced a quick rebound in the post-crisis period. Kristina (2015) showed that the Czech banks were more cost, revenue and profit efficient than Slovak ones during the whole analyzed period. Majid (2012) examined that selected Public Sector Banks were more efficient than Private sectors during the study period in India. Gardener et al. (2011) showed that state-owned banks exhibited greater efficiency than their local private sector peers. Among country-level factors, national banking development shows a strong and positive link with bank efficiency. Estelle & Ramona (2009) evaluated cost efficiency of French was around 86.40 to 91.52%.and Spanish banks was around 95.07% to 98.32%, while in the other countries a declined in cost efficiency is noted. Pasiouras F. (2008) investigated the impact of several regulations related to capital adequacy, private monitoring, banks’ activities, deposit insurance schemes, disciplinary power of the authorities, and entry into banking on banks technical efficiency. Ariff and Can. (2008) showed that joint-stock banks (national and city-based), on average, appear to be more cost and profit efficient than state-owned banks while medium-sized banks are significantly more efficient than small and large banks. Chen et.al. (2005) showed that the large state-owned banks and smaller banks are more efficient than medium sized Chinese banks. Casu and Molyneux (2003) estimated that the EU’s Single Market has been a small improvement in bank efficiency levels. Tsionas et.al. (2003), showed that the majority of the Greek banks operate close to best market practices, while allocative inefficiency costs seem to be more important than technical inefficiency costs. Hasan and Marton (2003) investigated that foreign banks were more efficient than domestic banks. Lozano-Vivas et al. (2002) showed that country-specific environmental conditions exercise a strong influence over the behavior of each country’s banking industry.

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| Table-3. 4: Literature Survey on Bank Efficiency Studies based on SFA and DEA | | | | | |
|  |  |  |  |  | |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices** |  |  |
|  |  |  | **(W)/ Input (X)** |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Y. Dong, | Chinese banking sector | Total Cost | Y1:Total loans | To estimate the cost | The SFA efficiency scores are |
| R. Hamilton, & | From; 1994 to 2009 |  | Y2:Other earning assets | efficiency of Chinese | Slightly higher than DEA & |
| M. Tippett | DEA, SFA, New DEA |  | Y3:Non-interest income | Banks. | new DEA model. |
| (2013) |  |  | W1:Price of borrowed | To measure the |  |
|  |  |  | Funds | correlation between |  |
|  |  |  | W2:Price of Physical | frontier efficiency. |  |
|  |  |  | Capital |  |  |
|  |  |  | W3:Price of labor |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| E. Fiorentino | German bank; | Total | Y1:Interbank loans | To estimate and | DEA provides better result than |
| A. Karmann | From 1993 and 2004 | Operating | Y2:Commercial loans | compare cost | SFA. |
| M..Koetter | SFA; Translog; | Cost | Y3:Securities | efficiency by using |  |
| (2006) | DEA; VRS |  | X1:Fixed assets | SFA and DEA |  |
|  |  |  | X2:Employees |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
|  |  |  | X3:Borrowed funds |  |  |
|  |  |  | W1:Price of fixed assets |  |  |
|  |  |  | W2:Price of labor |  |  |
|  |  |  | W3:Price of funds |  |  |
|  |  |  |  |  |  |
| Casu and | 5 EU countries | Total cost | Y1: Total loans | To examine the cost | Average: CE: 0.86 (FF), |
| Girardone | from 1993-1997; | Gross | Y2: Other earning | and profit efficiency of | 0.87 (TL)/Average: PE: |
| (2004) | Cost efficiency (CE) | Profit | Assets | large banking firms. | 0.76 (FF), 0.75 (TL); |
|  | Profit efficiency; (PE) |  | W1: Price of labour |  | CE; VRS:0.54 to 0.9 |
|  | SFA; Frontier Flexible |  | W2: Price of funds |  | from 1993to 1997 |
|  | (FF), Translog(TL) |  | W3: Price of fixed |  | Efficiency levels are not |
|  | DEA; VRS |  | Assets |  | converged; |
|  |  |  |  |  | Country-specific variables |
|  |  |  |  |  | are important to interpret |
|  |  |  |  |  | banking inefficiency; |
|  |  |  |  |  | Profit efficiency shows a |
|  |  |  |  |  | sharp growth over time. |
|  |  |  |  |  |  |
| Sturm and | Australia from1988- |  | Y1: Loans | To measure the | DEA: Average |
| Williams | 2001;DEA and SFA; |  | Y2: Off-balance | impact of foreign | TE. 0.73 (1991) - 0.94 |
| (2004) | Technical Efficiency, |  | Sheet items | bank entry on banking | (2000), SE- 0.84 |
|  | Scale Efficiency, |  | W1: Number of employees | efficiency in Australia | (1994)-0.98 (2001); |
|  | Input efficiency; |  | W2: Price of deposits | during the post- | SFA: TE 0.833 |
|  |  |  | W3: Price of equity capital | deregulation period | foreign banks more efficient |
|  |  |  |  | using DEA, MI and | than domestic banks. |
|  |  |  |  | SFA. |  |

## **3.4: Literature Survey on Bank Efficiency Studies based on SFA and DEA**

Dong et.al. (2013) did not find positive impact of Chinese banking sector. Also the application of their multiple techniques results in more robust and convincing assessment of bank performance. Fiorentino et.al.(2006) showed that accounting for systematic differences among commercial, cooperative and savings banks was important to avoid misinterpretation about the status of efficiency of the total banking sector. Casu and Girardone (2004) estimated that profit efficiency was higher than cost for large banks.Sturm and Williams (2004) found that bank efficiency has increased post-deregulation and the competition resulting from diversity in bank types was important to prompt efficiency improvements.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table-3. 5: Literature Survey on Bank Efficiency Studies based on SFA and DEA with ICT data | | | | | |
|  | | | | | |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices** |  |  |
|  |  |  | **(W)/ Input (X)/** |  |  |
|  |  |  | **Explanatory variable(Z)** |  |  |
|  |  |  |  |  |  |
| S.Rom (2013) | Tunisian bank; | Total cost | Y1:Total Credit | To measure the | Cost efficiency: SFA: |
|  | From: 1998-2009; |  | Y2:Security Profitably | performance of | 0.954; DEA 0.755 |
|  | Model: SFA: Translog; |  | X1:No of Employee | Information | The impact of IT investments |
|  | Tobitt Regression |  | X2:Physical Capital | Technology | of Tunisian banks performance |
|  | DEA: CCR, OLS |  | W1:Price of labor | Investment | was positive |
|  |  |  | W2:Price of Physical |  |  |
|  |  |  | Capital |  |  |
|  |  |  | IT Investment(Z1) |  |  |
|  |  |  |  |  |  |
| Chu-fen li | Taiwan bank; | Total | X1:Total IT expenses | To compare technical | CobbTE: 0.395; TRANTE |
| (2007) | From 1996-2000; TE; | Operating | X2:number of IT | efficiency among | : 0.408; CCRTE:0.409; |
|  | Model ;SFA: Cobb- | Cost | Personnel | various types of bank | BCCTE: 0.687 |
|  | douglas; | Pre-tax | X3:number of ATMs | To assess the impact | Total IT spending can probably |
|  | DEA: CCR,BCC, | profit | X4:number of PCs and | of IT Investment on | Improved profits significantly, |
|  | Tobit Regression; OLS |  | Terminals | operational efficiency | but can neither reduced |
|  |  |  | X5:number of financial |  | operating costs nor enhanced |
|  |  |  | cards issued |  | operational significantly. |
|  |  |  | X6:diversification of IT  Services |  |  |

## **3.5 Literature Survey on Bank Efficiency Studies based on SFA and DEA with ICT data**

Syrinedhane Ben Rom(2013) investigated that the analysis of the internal determinants of banks’ efficiency levels showed that size and managerial capacity positively and significantly affect the Tunisian banks’ cost efficiency. Chu-Fen li(2007) explored, banks can reduce operating costs by increasing the number of financial cards issued and improve operational efficiency by installing more automated teller machines and providing customers with a wide variety of information technology services.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table-3. 6: Literature Survey on Bank Efficiency Studies of Bangladesh Banking Industry based on SFA and DEA | | | | | |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices** |  |  |
|  |  |  | **(W)/ Input (X)** |  |  |
|  |  |  |  |  |  |
| M.M. Hasan | Bangladeshi banking | Total cost | Y1: other earning assets | To measure the cost | Average CE: 88.50%. |
| M.Hasan | Sector; | Total loans | Y2:Non-interest income | efficiency of | Public banks were less |
| (2018) | From: 2011-2015; |  | W1:Price of borrowed | Bangladesh banking | efficient than private and |
|  | SFA; Translog; |  | fund | sector using different | Islamic bank. |
|  | Cost efficiency; |  | W2:Price of physical | stochastic frontier |  |
|  |  |  | Capital | models. |  |
|  |  |  | W2:Price of labour |  |  |
|  |  |  |  |  |  |
| Shamim Ara | Bangladesh bank; | Total cost | Y1:Loan | To measure & compare | Commercial bank: Islamic |
| (2016) | From :2004-2008; | Total profit | Y2:Deposit | the cost & profit | bank; PE:0.68% and 0.92% |
|  | SFA; Translog; |  | W1:price of labor | efficiency of | CE: 0.88 % and 0.75% |
|  | Cost efficiency; |  | W2:price of fund | conventional and | Islamic banks were more profit |
|  | Profit efficiency; |  | W2:price of capital | Islamic bank | efficient than conventional |
|  |  |  |  |  | Banks. |
|  |  |  |  |  | Conventional banks were more |
|  |  |  |  | cost efficient. |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent** | **Independent Variables** | **Objectives** | **Major Findings** |
|  |  | **Variable** | **Output(Y) / Input Prices** |  |  |
|  |  |  | **(W)/ Input (X)** |  |  |
|  |  |  |  |  |  |
| M.M. Kasim | From: 2001-2010 | Total profit | Y2:Other Earning Assets | Compare the bank | 16.3% |
| M. Rahman | SFA; Translog; |  | Y3:Off balance sheet | wise & year wise cost | Average profit efficiency 91% |
| (2015) | Cost efficiency; |  | items | and profit efficiency of | Translog cost and Profit model |
|  | Profit efficiency; |  | W1:Price of labour | national commercial | were more preferable than |
|  |  |  | W2:Price of borrowed | bank and private | Cobb-douglas cost and profit |
|  |  |  | Fund |  | model. |
|  |  |  | W3:Price of Fixed Assets |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| Baten (2013) | Bangladesh bank | Total cost | Y1:Advance | To compare the cost | SFA; Mean ; CE; 93.7 |
|  | From: 2001-2010 | Total profit | Y2:Other Earning Assets | & profit efficiency | Mean; PE; 91% |
|  | SFA; Translog; |  | Y3:Off balance sheet | between SFA cost & | DEA; Profit CRS; |
|  | DEA; CRS ; |  | Items | profit CRS profit & | TE:68.8% and AE: 35.9% |
|  | Cost efficiency; |  | W1:Price of labour | cost DEA model of | Cost CRS; TE:70.3% |
|  | Profit efficiency; |  | W2:Price of borrowed | the national and | and AE:31.8% |
|  |  |  | Fund | private Commercial | SFA methods was better |
|  |  |  | W3:Price of Fixed Assets | banks. | efficiency than DEA |
|  |  |  |  |  |  |
| **Studies** | **Sample periods** | **Dependent**  **Variable** | **Independent Variables**  **Output(Y) / Input Prices**  **(W)/ Input (X)** | **Objectives** | **Major Findings** |
|  |  |  |  |  |  |
| Rahman | Branch of IBBL bank; | Total cost | Y1:Total Assets | To estimate the cost | Average CE: 82% to 84%, |
| & Islam | From 2003-2007; | Total Profit | Y2:Total investment | & profit efficiency | Average PE: 86% to 94%, |
| (2011) | Cost efficiency; |  | Y3:Total deposit | and compared branch | Larger branch size |
|  | Profit efficiency; |  | W1:price of labor | wise efficiency in | was associated with |
|  | SFA; Translog ; |  | W2:price of fund | Islamic Bank | higher efficiency |
|  |  |  | W3:price of capital | Bangladesh Limited. |  |

|  |
| --- |
|  |

## **3.6 Literature Survey on Bank Efficiency Studies of Bangladesh Banking Industry based on SFA and DEA**

Hasibul & Mahmudul (2018) measured the cost efficiency was lower among the state-owned banks than conventional (private) commercial banks and Islamic Sariah banks. Shamim Ara (2016) showed that profit efficiency for commercial bank and cost efficiency for islamic banks were expected to provide significant insights to policy makers and management considered optimal utilization of capacities and resources in Bangladesh Baten , Kasim & Rahman (2015) observed that the average cost inefficiency and profit efficiency were observed 16.3% and 91% respectively. Baten (2013) examined the cost inefficiency and profit efficiency was slightly higher for private banks than national commercial banks in case of both stochastic frontier analysis (SFA) and DEA type models. Rahman and Islam (2011) investigated that IBBL branches were less efficient in containing cost than profit efficiency.

## **3.7 Conclusion**

This section describes the summaries of literature review on parametric (SFA) and Non-parametric (DEA) methods, the current studies in Bangladesh and other countries. Also, this chapter scrutinizes the current gap in the literature and explained how this thesis will contribute to the prevailing literature

# CHAPTER FOUR

# METHODOLOGY

## **4.0 Introduction**

The methodology of this research is discussed by considering two important issues. The first issue is to measure the efficiency of the banks using parametric and non-parametric approach. The SFA is a popular parametric approach. The non-parametric approach is popularly known as DEA. These two methods are utilized to find the efficiency of the financial companies. The second issue is the Tobit regression analysis used to measure the impact of ICT factor on cost and profit efficiency of the banks. Also OLS regression model is used for profit efficiency of DEA. The chapter is separated into five segments. The first segment 4.1 explains the sample of banks. Section 4.2 describes the source of the data**.** Section 4.3 discusses about the descriptive statistics of data. Section 4.4 introduces the explanation of input and output variables. Section 4.5 the analytical framework of the Stochastic Frontier Analysis has shown. Section 4.6 the analytical framework of DEA analysis has shown. Section 4.7 illustrates the empirical models of SFA. Section 4.8 explains the empirical models of DEA. Section 4.9 explains the empirical models of Tobit Regression Model. Section 4.10 illustrates the empirical models of OLS regression Model. Section 4.11 discusses about the statistical software for analyses the data. Finally, section 4.12 concluding remarks are provided.

## **4.1 Description of the Sampled Bank**

The sample banks are categorized into two groups namely, state-owned commercial banks and private commercial banks which are shown on the Table 4.1. The aim of this study is to measure the impact of different components of ICT on the cost and profit efficiency of Bangladesh banks. We analyzed only 3 state-owned banks and 17 private commercial banks which are advanced on the operating system of the ICT sector.

Table-4 1: List of the Bank’s Name and Short From

|  |  |  |
| --- | --- | --- |
| Bank’s Name | Short Name | Group |
| Rupali Bank Limited | Rupali | State-owned Commercial Bank |
| Sonali bank Limited | Sonali |
| Janata Bank Limited | Janata |
| Dutch Bangla Bank | DBBL | Private Commercial Bank |
| Brac Bank Limited | Brac |
| City Bank Limited | City |
| Eastern Bank Limited | Eastern |
| Mercantile Bank Limited | Mercantile |
| Mutual Trust Bank Limited | Mutual Trust |
| Prime Bank Limited | Prime |
| Premier Bank Limited | Premier |
| One Bank Limited | One |
| South East Bank Limited | South East |
| UCB Bank Limited | UCB |
| IFIC Bank Limited | IFIC |
| Islami Bank Bangladesh Limited | IBBL |
| Al-arafah Islamic Bank Limited | Al-arafah |
| Shahjalal Islami Bank Limited | Shahjalal |
| Social Islami Bank Limited | Social |
| Exim Bank Limited | Exim |

## **4.2 Source of the Data**

Only 20 banks have selected for this analysis because the ICT data are not available for all the banks. The data set used in this study obtained from the annual reports of banks in the period 2008-2017. The link of the annual reports the samples of banks in Bangladesh are given below.

1. <https://www.dutchbanglabank.com/investor-relations/financial-statements.html>
2. <https://www.bracbank.com/en/investor-relations>
3. <https://www.thecitybank.com/report/annualreports>
4. <https://www.ebl.com.bd/home/Annual_Reports>
5. <http://www.mblbd.com/home/annual_reports>
6. <https://www.mutualtrustbank.com/investor-relations/annual-report/>
7. <https://www.primebank.com.bd/index.php/home/financial_reports>
8. <http://premierbankltd.com/pbl/financial-reports/>
9. <https://www.onebank.com.bd/home/financial/annual-reports/>
10. <https://www.southeastbank.com.bd/annual_reports.php>
11. <https://www.ucb.com.bd/index.php?page=know-ucb/investor-relations/annual-report>
12. <http://www.ificbank.com.bd/annual_report.php>
13. <https://www.islamibankbd.com/annual_report.php>
14. <https://al-arafahbank.com/Annual-Reports.php>
15. <https://www.sjiblbd.com/Financial_Statements_2017.php>
16. <https://www.siblbd.com/home/annual_reports>
17. <http://www.eximbankbd.com/report/Annual_Reports>
18. <https://www.sonalibank.com.bd/PDF_file/annualreport/2018>
19. <https://www.jb.com.bd/about_us/annual_report>
20. [https://www.rupalibank.org](https://www.rupalibank.org/)

## **4.3 Descriptive Statistics of Data**

The analysis aims to include 20 banks of Bangladesh. The data are collected from the annual report of individual bank over the period 2008 to 2017. In this thesis all the data are yearly data and collected by two categories for the analysis such as Non-IT data and IT data. The summary Statistics of the data are shown in table 4.2.

Table-4 2: Summary Statistics of Non-IT (Output Input Quantity, Output and Input Price Variables) and IT Variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Min | Max | Mean | Standard deviation |
| Dependent Variable |  | | | |
| Operating cost | 513 | 66727 | 8216.35 | 11142.74 |
| Profit after tax | 422 | 31554 | 3438.935 | 3218.51 |
| Output Quantity |  | | | |
| Loan | 20084 | 748673 | 147780.1 | 122437.91 |
| Off balance sheet item | 2161 | 1148178 | 81650.28 | 107579 |
| Output Price |  | | | |
| POLOA | 0.002 | 0.777 | 0.073 | 0.063 |
| POB | 0.012 | 1.2 | 0.149 | 0.179 |
| Input quantity |  | | | |
| Total deposit | 10749 | 1064331 | 183325.5 | 179220.53 |
| Fixed assets | 293 | 33307 | 5236.98 | 6030.94 |
| Labor | 739 | 22890 | 4385.14 | 4787.55 |
| Input Price |  | | | |
| POD | 0.011 | 0.845 | 0.079 | 0.087 |
| POF | 0.015 | 0.403 | 0.114 | 0.087 |
| POL | 0.273 | 2.017 | 0.729 | 0.313 |
| Explanatory Variable |  | | | |
| Non-Interest Income | 45 | 98765 | 6989.059 | 12810.25 |
| Non-Performing Loan | 49 | 149302 | 11979.9 | 23128.05 |
| Return on Assets | 0.06 | 43 | 1.49 | 3.026 |
| Return on Equity | 0.2 | 49.74 | 14.46 | 6.66 |
| Capital Adequacy Ratio | 0.94 | 16.55 | 11.55 | 1.89 |
| IT VARIABLE |  | | | |
| IT Expenses | 10 | 1787 | 392.82 | 412.68 |
| IT Income | 12 | 2088 | 272.74 | 360.26 |
| IT Investment | 74 | 71234 | 4023.094 | 12798.66 |
| IT Personnel | 23 | 860 | 129.92 | 131.78 |
| IT personnel Expenses | 8 | 855 | 101.24 | 105.01 |
| ATM Transaction | 23 | 4467 | 635.41 | 844.87 |
| ATM Expenses | 2 | 1023 | 103.94 | 182.09 |
| Credit Card Transaction | 31 | 79302 | 8114.78 | 12142.3 |
| Credit Card Expenses | 2 | 4896 | 293.85 | 603.06 |

## **4.4 Definitions of the Variables**

As mentioned earlier that the data are collected from the annual reports of the 20 specific bank of Bangladesh during the period of 2008-2017. A short description of the variables is provided below:

### 4.4.1 Dependent Variable for SFA and DEA

Total Profit (π); Total profit is deducted of the total cost from total income. It takes after the tax.   
Total cost (c): Total cost includes the income paid to depositor, personnel expenses, and other operating expenses.

### 4.4.2 Output Quantity for SFA and DEA

Loan (Y1): The sum of long-term and short term loan, trade bills and bills discounted and other loans.

Off-balance Sheet Items (Y2): Off-balance Sheet Items is measures as the sum of guarantees, commitment and financial derivative instrument.

### 4.4.3 Input Price for DEA and SFA

Price of Fund (W1): Price of Fund is defined as the ratio of total interest expenses to all deposits.

Price of Fixed Assets (W2): Price of fixed assets is measured as the non- interest expenses divided by fixed assets.

Price of Labor (W3): Price of Labor is calculated as the ratio of personnel expenses to the number of staff.

### 4.4.4 Input Quantity for DEA

Total Fund (X1): Total Funds is measured by the sum of deposit and non-deposit funds as of the end of the respective years.

Fixed assets (X2): Fixed assets is measured by the book, the value of premises and fixed capital.

Labor (X3): The quantity of labor is measured by the total number of staff member in the bank.

### 4.4.5 Output Prices for DEA

Price of Loan (p1): Price of Loan is measured as the net interest income or net interest expenses divided by total loan.

Price of off balance sheet items (p2): Price of off balance sheet items is defined as the ratio of total operating expenses and the total securities

### 4.4.6 Explanatory variable for inefficiency model of SFA

Non-interest income (z1):Non-interest income is a bank and creditor income derived primarily from fees including deposit and transaction fees, insufficient fund fees, annual fees, monthly account service charges, inactivity fees, check and deposit slip fees and so on.

Non-performing loan (z2): A non-performing loan is a sum of borrowed money upon which the debtor has not made the scheduled payments for a specified period.

Return on assets (z3): Return on assets is the ratio of annual net income to total assets of a bank during a financial year.

Return on equity (z4): Return on equity is defined as the net profit divided by the shareholder average equity.

Capital adequacy ratio (z5): The capital adequacy ratio equals the sum of the bank’s tier one capital plus tier two capital divided by its risk-weighted assets.

### 4.4.7 Dependent Variable for Tobit Regression Model

Profit efficiency (p): The estimated Profit efficiency of Cobb-Douglas and Translog stochastic frontier analysis model.

Cost efficiency (c): The estimated Cost efficiency of Cobb-Douglas and Translog stochastic frontier analysis model.

### 4.4.8 Independent Variable for Tobit Regression Model

IT Expanses (X1): The total IT expanses refers to incurred expanses for maintainance and repair, rent, depletion of IT equipment and information sourcing services.

IT Income (X2): The total income from IT Sector in Bank.

IT investment (X3): IT investment is total IT budget of the bank which included hardware, software, network, security training and other IT purpose.

IT Personnel(X4): The total no of IT staff member in the bank.

IT Personnel Expenses (X5): IT personnel expenses are calculated as total salaries of IT staff expenses over full time number of staff.

ATM Card Transaction(X6): The total amount of deposit withdraw by ATM Card.

ATM Card Expenses (X7): The coduct of Banking Service Charge by using ATM Card.People can deposit their money in a bank account and they have entitled withdraw their money through ATM card.

Credit Card Transaction(X8): The total amount of deposit withdraw by Credit Card.

Credit Card Expenses (X9): credit card is used for repayment of the value of products and services. This service charge is calculated price of credit card.

4.5 Analytical Framework of Stochastic Frontier Analysis**:** The analytical framework of the Stochastic Frontier Analysis have shown below by the flowchart

Stochastic Frontier Analysis

Independent variable

Cobb-douglas Cost & Profit Frontier Model

Translog Cost & Profit Frontier Model

Output quantity

Loan

Off-balance Sheet items

Input Price

Price of Fund

Price of Fixed Assets Price of Labour

Dependent variable

Total Cost

Profit after tax

Explanatory Variable

|  |
| --- |
| Non-Interest Income  Non-Performing Loan  Return on Assets  Return on Equity  Capital Adequacy Ratio |

|  |
| --- |
| IT Variables  IT Expenses  IT Income  IT Investment  IT Personnel  IT Personnel Expenses  ATM Transaction  ATM Expenses  Credit Card Transaction  Credit card expenses |

Dependent variable

Cost Efficiency

Profit Efficiency

4.6 Analytical Framework of Data Envelopment Analysis**:** The analytical framework of the Data Envelopment Analysis have shown below by the flowchart

Data Envelopment Analysis

VRS Cost & Profit DEA Model

Independent variable

Output quantity

Total fund

Total Fixed Assets

Total Number of Labour

Input Price

Price of Fund

Price of Fixed Assets

Price of Labour

Output quantity

Loan

Off-balance Sheet items

Output Price

Price of Loan

Price of off balance sheet items

|  |
| --- |
| IT Variables  IT Expenses  IT Income  IT Investment  IT Personnel  IT Personnel Expenses  ATM Transaction  ATM Expenses  Credit Card Transaction  Credit card expenses |

Dependent variable

Cost Efficiency of DEA

Dependent variable

Profit Efficiency of DEA

## **4.7 Choice of SFA and DEA in Efficiency Measurement**

It is the primary subject to specify the functional form when measuring efficiency by using parametric frontier techniques such as measuring cost efficiency by utilizing stochastic cost frontier, measuring profit efficiency by adopting stochastic profit frontier, measuring technical efficiency by employing stochastic production frontier, etc. However, it is different to determine the exact form of the cost or production function in most industries, especially in the services sector. As banks are well known to provide services for depositors and investors to obtain profits, the exact functional form for estimating efficiency is hard to figure out. Therefore, we have to utilize some approximation to the cost or production function as more flexible functional forms developed in the previous efficiency literature for examining the relationship between the dependent variables and explanatory variables to estimate efficiency.

### 4.7.1 Empirical Stochastic Cobb-Douglas Cost Frontier Model

Stochastic frontier model of Battese and Coelli (1995) is used for panel data set, which has firm effects. The dataset are assumed to be truncated normally distributed for random normal variables and the variables are also permitted to vary systematically with time. The Cobb-Douglas stochastic frontier production function is easy to estimate and interpret. Moreover, it requires an estimate of a few parameters and uses the original unit of data (Coelli, 1995). The Cobb-Douglas stochastic frontier cost model functional form (Coelli, 1995) is defined as:

(1)



Where, *ln* is natural logarithm (that is log to base *e*, where e = 2.718). Yit represent the total cost of ith bank in period t LOAit is the loan of bank i in period t; OBSit is the off-balance sheet items of bank i in period t; ; POFit is the price of fund of bank i in period t; POFAit is the price of fixed assets of bank i in period t; POLit is the price of labour of bank i in period t; *v* is a two-sided error term assumed to be identically and independently distributed, u is a non-negative technical inefficiency component of the error term and *β’s* are unknown parameters to be estimated. Having obtained the parameters for each variable by banks using equation (1), the technical efficiency level for firms is predicted with equation (2). After this, the mean technical efficiency level for banks is obtained.

 (2)

Now, using the composed error term (*uit*) of the stochastic frontier production function model as in equation (2), the variation in actual output from the frontier output level is partially attributed to technical inefficiency defined by:

 (3)

That is, the parameter  is the proportion of the variance of technical inefficiency in the entire error variance. Where, σ2 is as defined before and  is the measure of technical inefficiency for banks.

We next find the determinants of technical efficiency of the banks using another factor.

### 4.7.2Empirical Inefficiency Stochastic Cobb-Douglas Cost Frontier Model

The empirical cost inefficiency function can be written for this study is:

 (4)

where uit is defined as the inefficiency term in the cost function; NIIit is the non- interest income of bank i in period t; NPLit is the non-performing loan of bank i in period t; ROAit is the return on assets of bank i in period t; ROEit is the return on equity of bank i in period t; CARit is the capital adequacy ratio of bank i in period t;

### 4.7.3 Empirical Stochastic Cobb-Douglas Profit Frontier Model

The Cobb-Douglas stochastic frontier profit model functional form (Coelli, 1995) is defined as:

(5)

Where *ln* is natural logarithm (that is log to base *e*, where e = 2.718). where,is the profits after tax of of ith bank in period t measured by revenues minus costs; is a constant to ensure the natural log of profits to be positive. LOAit is the loan of bank i in period t; OBSit is the off-balance sheet items of bank i in period t; ; POFit is the price of fund of bank i in period t; POFAit is the price of fixed assets of bank i in period t; POLit is the price of labour of bank i in period t; *v* is a two-sided error term assumed to be identically and independently distributed, u is a non-negative technical inefficiency component of the error term and *β’s* are unknown parameters to be estimated. Having obtained the parameters for each variable by banks using equation (5), the technical efficiency level for firms is predicted with equation (6). After this, the mean technical efficiency level for banks is obtained.

 (6)

Now, using the composed error term (*uit*) of the stochastic frontier production function model as in equation (7), the variation in actual output from the frontier output level is partially attributed to technical inefficiency defined by:

 (7)

That is, the parameter  is the proportion of the variance of technical inefficiency in the entire error variance. Where, σ2 is as defined before and  is the measure of technical inefficiency for banks.

We next find the determinants of technical efficiency of the banks using other factors.

### 4.7.4Empirical Inefficiency Stochastic Cobb-Douglas Profit Frontier Model

The empirical profit inefficiency function can be written for this study is:

(8)



where uit is defined as the inefficiency term in the cost function; NIIit is the non- interest income of bank i in period t; NPLit is the non-performing loan of bank i in period t; ROAit is the return on assets of bank i in period t; ROEit is the return on equity of bank i in period t; CARit is the capital adequacy ratio of bank i in period t;

### 4.7.5 Empirical Stochastic Translog Cost Frontier Analysis Model

The empirical cost formula functions for this study is given by



where Cit is defined as the total cost; LOAit is the loan of bank i in period t; OBSit is the off-balance sheet items of bank i in period t; ; POFit is the price of fund of bank i in period t; POFAit is the price of fixed assets of bank i in period t; POLit is the price of labour of bank i in period t; These model (9) are estimated by using maximum likelihood estimation; the methodology was advanced by Battese and Coelli (1995). The unknown parameters β,s are estimated.

### 4.7.6 Empirical Inefficiency Stochastic Translog Cost Frontier Analysis Model

The empirical cost inefficiency function can be written for this study is:



where uit is defined as the inefficiency term in the cost function; NIIit is the non-interest income of bank i in period t; NPLit is the non-performing loan of bank i in period t; ROAit is the return on assets of bank i in period t; ROEit is the return on equity of bank i in period t; CARit is the capital adequacy ratio of bank i in period t; These models (10) are estimated using the maximum likelihood parameter estimation (Battese & Coelli (1995). The computer program R (package-frontier for SFA & benchmarking for DEA) has been used to obtain the maximum likelihood parameter estimates of parameters in estimating the cost efficiency.

4.7.7 Empirical Stochastic Translog Profit Frontier Analysis Model

The functional forms for Profit frontiers are considered as Translog can be written as follows:

 Whereis the profits after tax of of ith bank in period t measured by revenues minus costs; is a constant to ensure the natural log of profits to be positive. LOAit is the Loan of bank i in period t; OBSit is the off-balance sheet items of bank i in period t; POFit is the price of fund of bank i in period t; POFAit is the price of fixed assets of bank i in period t; POLit is the price of labour of bank i in period t;

### 4.7.8 Empirical Inefficiency Stochastic Translog Profit Frontier Analysis Model

The empirical Profit inefficiency function can be written for this study is:



where uit is defined as the inefficiency term in the cost function; NIIit is the non-interest income of bank i in period t; NPLit is the non-performing loan of bank i in period t; ROAit is the return on assets of bank i in period t; ROEit is the return on equity of bank i in period t; CARit is the capital adequacy ratio of bank i in period t; These two models (11) and (12) are simultaneously estimated using the maximum likelihood parameter estimation (Battese & Coelli (1995). The unknown parameters β,s and δ’s are estimated. The computer program R( package-frontier for SFA & benchmarking for DEA) has been used to obtain the maximum likelihood parameter estimates of parameters in estimating the cost efficiency.

### 4.7.9 Likelihood Ratio Tests

The likelihood ratio test is an imperative feature of the method. It helps us to determine whether Cobb-Douglas or Translog production function is better or not. It also provides another likelihood ratio test where the null hypothesis is that there is no technical inefficiency and there is no interaction effect on the Translog Stochastic Cost and Profit Model. It is measured as follows:

 (13)

Where and  are the values of the likelihood function under the null and alternative hypothesis (note that this statistic has a mixed chi-square distribution). The null hypothesis is rejected when.

## **4.8 Data Envelopment Model Specification**

In this research we discuss some popular extensions of basic DEA models. If price data are available then it is possible to measure allocative, technical efficiency as well as overall cost, revenue and profit efficiency. To calculate these main types of efficiency, a set of linear programs should be solved. The assumption of variable returns to scale (VRS) was first introduced by Banker, Charnes and Cooper (1984).

The input-oriented DEA model under the assumption of variable return to scale can be used for calculation of input-oriented technical efficiency and cost efficiency. Input-oriented model under the assumption of variable return to scale is often termed as BCC model, which can be written in the following form (Dlouhy et al. 2007).

To calculate cost efficiency is necessary to solve the following cost minimization DEA

Where θq is input-oriented technical efficiency (TEq) of Decision Making Unit (DMUq) in the in- put-oriented DEA model, yrq  is produced amounts of rth output (r = 1,2,...,s) for DMUq, xiq is consumed amounts of ith input (i = 1,2,...,m) for DMUq, yrj is produced amounts of rth output (r = 1,2,...,s) for DMUj (j = 1, 2,...,n), xij is consumed amounts of ith input (i = 1,2,...,m) for DMUj (j = 1, 2,...,n), λj is weight assigned to the DMUj (j = 1,2,…,n).



### 4.8.1 VRS Cost Minimization DEA Model Specification

To calculate cost efficiency is necessary to solve the following cost minimization DEA model (Coelli and all, 2005):



Where Wiq  is a vector of input prices of jth bank (Price of fund, Price of Fixed assets and Price of Labor )

Xiq\* is the minimizing vector of input quantities for jth bank (Total fund, Fixed assets and Labor)

 are the rth output into jth bank (Loan, off-balance sheet items)

The overall cost efficiency (CEq ) is defined as the ratio of minimum cost of producing the outputs to observed cost of producing the outputs for the DMUq (coelli et al. ,2005)



The overall cost efficiency can be expressed as a product of technical and allocative efficiency measures and the value of overall cost efficiency must be bounded by zero and one.

### 4.8.2 VRS Profit Maximization DEA Model

If we have to access to price data on both inputs and outputs, then the profit efficiency can be calculated. The profit maximization DEA problem is specified as follows :

Max 

Where

*p*r are the rth output price (Price of Loan, Price of off-balance sheet items)

 are the rth output into jth bank (Loan, off-balance sheet items)

wi are the ith input price into jth bank (Price of fund, Price of Fixed assets and Price of Labor )

are the ith input into jth bank (Total fund, Fixed assets and Labor)

The overall profit efficiency (PEq) can be defined as the ratio of observed profit to maximum profit for the DMUq (Coelli et al. ,2005):

PE =

However, this measure need not be bounded by zero and one. It could be negative if a profit is negative, or it could be undefined if maximum profit is zero. (Coelli et al. 2005). The value of overall profit efficiency can be interpreted as potential profit increasing that can be achieved if the production unit uses the inputs and outputs in optimal combination.

## **4.9Empirical Tobit Regression Model**

The Specification of the Tobit Regression Model



where Eit is defined as the Stochastic Cobb-douglas, Translog and VRS data envelopment analysis of cost and profit efficiency estimate of the i-th bank in period t; ITEit is the IT expanse of bank i in period t; ITIit is the IT income of bank i in period t; ITINit is the IT investment of bank i in period t; ITPit is the IT personnel of bank i in period t; ITPEit is the IT personnel expenses of bank i in period t; ATMTit is the ATM transaction of bank i in period t; ATMEit is the ATM expenses of bank i in period t; CCT is the Credit Card Transaction of bank i in period t; CCE is the credit card expenses of bank i in period t. ξit is the error term.

## **4.10Empirical Model of Ordinary Least Square Method**

The Specification of the Ordinary Least Square Method

 (15)

Where PEit = profit efficiency Estimate of VRS data envelopment analysis model ; ITEit is the IT expanse of bank i in period t; ITIit is the IT income of bank i in period t; ITINit is the IT investment of bank i in period t; ITPit is the IT personnel of bank i in period t; ITPEit is the IT personnel expenses of bank i in period t; ATMTit is the ATM transaction of bank i in period t; ATMEit is the ATM expenses of bank i in period t; CCT is the Credit Card Transaction of bank i in period t; CCE is the credit card expenses of bank i in period t. ξit is the error term.

## **4.11 Used Statistical Software**

Statistical software R-3.5.0 and RStudio-1.1.447 is used in this study for the data analysis. The following packages are used under the statistical software R.

* Frontier is used to estimate the cost and profit efficiency from the Stochastic Cobb-douglas and Translog Production Frontier Models
* Plm is used for panel data
* Benchmarking is used to estimate the cost and profit efficiency from the VRS Data Envelopment Analysis.
* lmtest is used to likelihood ratio test.
* AER is used to estimate the ICT determinant for Tobbit regression analysis and ordinary Least square models.
* Microsoft words and Microsoft excel are used in this analysis for some graphic and descriptive analysis

## **4.12 Conclusion**

In this chapter, two objectives have been discussed. Firstly, empirical forms of method were mentioned. Moreover, in the methodology section SFA, DEA, Tobit Regression and OLS models are explained elaborately. Secondly, the variable, data collection process and statistical software are discussed.

# CHAPTER FIVE

# RESULT AND DISCUSSION

## **5.0 Introduction**

In this chapter, the results of stochastic frontier analysis and data envelopment analysis that measures the bank’s efficiency in Bangladesh are discussed. The efficiency estimates have been measured using a stochastic frontier production function proposed by Battese and Coelli (1995) applied to panel data. The sample banks are divided into two categories such as state-owned commercial bank and private commercial bank. Cobb-Douglas and Translog stochastic frontier cost, and profit function have used to measure the stochastic frontier analysis results. By using stochastic cost and profit frontier analysis, the year wise and bank-wise cost and profit efficiency of Bangladesh banks are estimated. Maximum Likelihood Estimates (MLE) of the parameters has been estimated on both efficiency and inefficiency model. Again by using the Data Envelopment Analysis (DEA), the technical efficiency, allocative efficiency and cost, and profit efficiency are obtained from the model of VRS cost DEA and VRS profit DEA. Then the impact of ICT factor has been measured by Tobit Regression model for both Cobb-Douglas and Translog Stochastic Frontier Analysis and Data Envelopment Analysis cost and profit model. But the Tobit regression model cannot be applied for estimating the ICT determinant of VRS profit model for data envelopment analysis because the Tobit model is used when the dependent variable is bounded [ 0,1]. So the ordinary least square method for VRS profit data envelopment analysis model is employed to determine the ICT factor. In section 5.1, the result of Cobb-Douglas and Translog stochastic frontier model is discussed. In section 5.2, the result of data envelopment analysis model is described. The impact of ICT component on cost and profit efficiency by SFA and DEA is shown in section 5.3. Then OLS estimation is discussed in case of profit DEA in section 5.4. In section 5.5 compare the result of SFA and DEA. Finally, conclude the result in section 5.6.

## **5.1 Cost and Profit Efficiency Results Based on Stochastic Frontier Analysis**

### 5.1.1: Maximum Likelihood Estimates of Cost and Profit for State-owned Commercial Banks using Cobb-Douglas Stochastic Frontier Model

The results of maximum likelihood estimates of state-owned commercial Banks using Stochastic Cobb-Douglas Frontier Cost and Profit Model are given in Table -5.1. In this result, there were not found any significant estimates in the Cost Cobb-Douglas model. Yet among the input prices, the price of fixed assets β4 (-0.179) & the Price of labor β5 (-0.032) were negative for the cost model. On the other hand, all the variables had a positive impact on the profit model and only the estimate of loan β1 (0.815) has gotten highly positively significant in the profit cobb-Douglas model. This study is contradicted by (Christopoulos and Tsionas; 2001).

Table-5. 1: Maximum Likelihood Estimates of Cost and Profit for State-owned Commercial Banks using Cobb-Douglas Stochastic Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept |  | 0.039 | 0.969 | 0.194 | 0.848 |
| LOA |  | 0.765 | 0.144 | 0.815\*\*\* | 0.0000 |
| OBS |  | 0.079 | 0.683 | 0.066 | 0.5897 |
| POF |  | 0.122 | 0.887 | 0.174 | 0.234 |
| POFA |  | -0.179 | 0.876 | 0.151 | 0.284 |
| POL |  | -0.032 | 0.962 | 0.029 | 0.901 |

### 5.1.2: Cost and Profit Inefficiency Estimates for State-owned Commercial Banks using Stochastic Cobb-Douglas Cost and Profit Frontier Model

The results of cost and profit inefficiency estimates of state-owned commercial banks for the Stochastic Cobb-Douglas Cost and Profit Frontier Model are given in Table -5.2. Indeed, all the variables had gotten insignificant from the inefficiency cost model but the non-performing loan (δ2) and the capital adequacy ratio (δ5) were negative with the coefficient of (-0.253) and (-0.162). Note that a negative sign indicates a negative impact of the variable on the bank inefficiency and therefore a positive effect on cost efficiency.Also in profit inefficiency model,the coefficient of return on assets δ3 (-0.555) was a negatively significant indication that the banks were more profitable on less investment. As can be seen that the coefficient of non-performing loan δ2 (0.263) was positively significant implies that the bank could not be able to maximize profit if they have much non-performing loan. Besides the capital adequacy ratio was insignificant but negative with the coefficient of δ5 (-0.131). The Sigma squared was positive and significant. The estimated gamma γ (1.00) shows that the strong impact of inefficiency score to bank’s profit variance.

Table-5. 2: Cost Inefficiency Estimates for State-owned Commercial Banks using Stochastic Cobb-Douglas Cost and Profit Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-Douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| NII | δ1 | 0.371 | 0.083 | -0.161 | 0.064 |
| NPL | δ2 | -0.253 | 0.415 | 0.263\*\* | 0.000 |
| ROA | δ3 | 0.059 | 0.782 | -0.555\*\*\* | 0.000 |
| ROE | δ4 | 0.012 | 0.979 | 0.048 | 0.402 |
| CAR | δ5 | -0.162 | 0.669 | -0.131 | 0.351 |
| Sigma Sq | б2 | 0.353 | 0.395 | 0.112\*\*\* | 0.000 |
| Gamma | γ | 0.967 | 0.085 | 1.00\*\*\* | 0.000 |

### 5.1.3: Maximum Likelihood Estimates of Cost and Profit for Private Commercial Bank using Cobb-Douglas Stochastic Frontier Model

Table -5.3 represents the maximum likelihood estimates of Stochastic Cobb-Douglas Cost and Profit Frontier Model of the private commercial bank. Among the outputs and input price, loan with the coefficient of β1 (0.554) and price of fixed assetsβ4 (0.09) were positively significant for the cost model. This result implies that they had been a positive influence on the bank’s cost model. On the other hand, the input price variable, price of fund was negative but significant with the coefficient of β3 (-0.149) seems to suggest that price of fund impacted negatively to total operating cost. Another output and input price, the off-balance sheet items β2 (-0.042) and price of labor β5 (-0.063) were found negatively insignificant for the Cobb-Douglas cost model. In the maximum likelihood estimates of Stochastic Cobb-Douglas Profit Frontier Model, only the input price variable, the price of labor was negatively significant with the coefficient of β5(-0.153) suggest that the price of labour impacted negatively for profit function. Another output and input price, the loan β1 (-0.008), off-balance sheet items β2 (-0.004) and price of fund β3 (-0.021) were negatively insignificant for the Cobb-Douglas profit model. This result is supported by the findings of (Christopoulos and Tsionas; 2001)

Table-5. 3: Maximum Likelihood Estimates of Cost and Profit for Private Commercial Banks using Cobb-Douglas Stochastic Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-Douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept |  | 2.66\*\*\* | 0.0000 | 5.21\*\*\* | 0.0000 |
| LOA |  | 0.554\*\*\* | 0.0000 | -0.008 | 0.743 |
| OBS |  | -0.042 | 0.328 | -0.004 | 0.874 |
| POF |  | -0.149\*\*\* | 0.0000 | -0.021 | 0.483 |
| POFA |  | 0.09\* | 0.047 | 0.043 | 0.359 |
| POL |  | -0.063 | 0.353 | -0.153\* | 0.011 |

### 5.1.4: Cost and Profit Inefficiency Estimates for Private Commercial Banks of Cobb-Douglas Stochastic Frontier Model

The cost and profit inefficiency estimates of private commercial banks for the stochastic Cobb-Douglas Cost and Profit Frontier Model are given in Table -5.4. The variable of non-interest income and return on equity were found significant from the cost inefficiency model. The negative coefficient of non-performing loan δ1 (-0.32) indicates a negative impact of the variable on the bank inefficiency and therefore a positive effect on cost efficiency. The highly positive coefficient of return on equity δ4 (0.871) increased bank cost inefficiency. Indeed, other variables were insignificant but the non-performing loan (δ2) and the return on assets (δ4) were negative with the coefficient of (-0.399) and (-0.344) that means they positively impacted on the bank’s cost efficiency. The estimated gamma parameter is 0.862 indicating that all the distance from the frontier is due to inefficiency. In profit inefficiency model, the coefficient of return on equity δ4 (2.38) was a highly positive significant indication that the banks were not profitable on his shareholder investment. The coefficient of non-performing loan δ2 (-0.572), return on assets δ3 (-1.704) and capital adequacy ratio δ5 (-1.75) was negatively significant implies that they could be a positive impact to maximize profit. The Sigma squared was positive and strongly significant. The estimated gamma was close to unity implies that the strong impact of inefficiency score to bank's profit variance. These results are supported by ( Ngan ;2014)

Table-5. 4: Cost and Profit Inefficiency Estimates for Private Commercial Banks of Cobb-Douglas Stochastic Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-Douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| NII | δ1 | -0.32\*\*\* | 0.0006 | -0.244 | 0.547 |
| NPL | δ2 | -0.039 | 0.518 | -0.572\* | 0.017 |
| ROA | δ3 | -0.344 | 0.178 | -1.704\* | 0.027 |
| ROE | δ4 | 0.871\*\* | 0.008 | 2.38\*\*\* | 0.0006 |
| CAR | δ5 | 0.356 | 0.297 | -1.75\* | 0.046 |
| Sigma Sq | б2 | 0.26\*\*\* | 0.000 | 3.41\*\*\* | 0.0000 |
| Gamma | γ | 0.862\*\*\* | 0.0000 | 1.00\* | 0.0000 |

### 5.1.5: Maximum Likelihood Estimates of Cost and Profit for State-owned Bank using Stochastic Translog Cost and Profit Frontier Model

Table-5.5 represents the results of maximum likelihood estimates of StochasticTranslog Cost and Profit Frontier Model. The results show that the output variables, loan with the coefficient of β1 (6.57) was highly significant. Among the inputs variable, the price of fund and price of labor with the coefficient value of β3 (-13.3) and β5 (-19.7) were significant and negative for the cost model. Also the square outputs, price of fund β33(-0.377) and price of labor β55(-3.24) were negatively significant and the mixed product of loan & price of fund β13 (1.11), loan & price of labor β15 (1.24) and off-balance sheet items & price of fixed assets β24 (0.268) were found to be significant but positive for the cost model and the loan & price of fund and β14 (-0.399) and price of fixed assets & price of fund β46 (-0.504) were negatively significant. On the contrary, In Translog Stochastic Profit Frontier Model, the majority of the variables were significant for the profit of the state-owned Bank. The output variable loanβ1 (-47.88) and theinputs prices, price of fixed assets β4 (-31.92) and price of labor β5 (-61.76) were negative for the profit model whereas the output variable off-balance sheet items β2 (15.73) and theinputs, price of fund β3 (47.24) was positively significant. Also, the square outputs, loan β11 (5.08) and the square input price of fund β33 (1.72) shown positively significant and also the square input fixed assets β44 (-4.789) and the price of labor β55 (-12.75) were negatively significant. The mixed product between loan & off-balance sheet items β12 (-1.77), loan & price of fund , β13 (-3.26), off-balance sheet items & price of fund β23(-1.59), price of fund & price of fixed assets β34 (-5.24), Price of fixed assets & price of labor β45 (-1.02) had found negatively significant where loan & price of labor β15 (1.54), off-balance sheet items & price of fixed assets β24 (0.462) and price of fund & price of labor β35 (2.26) were positively significant. These results are supported by Baten; 2013)

Table-5. 5: Maximum Likelihood Estimates of Cost and Profit for State-owned Bank using Stochastic Translog Cost and Profit Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Constant |  | -72.3\*\*\* | 0.0000 | 180.81\*\*\* | 0.0000 |
| LOA |  | 6.57\*\*\* | 0.0000 | -47.88\*\*\* | 0.0000 |
| OBS |  | 1.07 | 0.284 | 15.73\*\*\* | 0.0000 |
| POF |  | -13.3\*\*\* | 0.0000 | 47.24\*\*\* | 0.0000 |
| POFA |  | -1.01 | 0.531 | -31.92\*\*\* | 0.0000 |
| POL |  | -19.7\*\*\* | 0.0000 | -61.76\*\*\* | 0.0000 |
| (LOA)2 |  | 0.040 | 0.832 | 5.08\*\*\* | 0.0000 |
| LOA \* OBS |  | -0.258 | 0.086 | -1.77\*\*\* | 0.0007 |
| LOA \* POF |  | 1.11\*\*\* | 0.0000 | -3.26\*\*\* | 0.0000 |
| LOA \* POFA |  | -0.399\* | 0.021 | -0.43205 | 0.305 |
| Loan \*POL |  | 1.24\*\*\* | 0.0000 | 1.54\*\*\* | 0.0000 |
| (OBS)2 |  | 0.197 | 0.218 | 0.421 | 0.359 |
| OBS \* POF |  | -0.263 | 0.193 | -1.59\*\* | 0.001 |
| OBS \*POFA |  | 0.268\*\* | 0.002 | 0.46286 | 0.108 |
| OBS\*POL |  | 0.155 | 0.338 | 2.89\*\*\* | 0.0000 |
| (POF)2 |  | -0.377\* | 0.042 | 1.72\*\*\* | 0.0000 |
| POF \* POFA |  | -0.504\* | 0.035 | -5.24\*\*\* | 0.0000 |
| POF \*POL |  | -0.241 | 0.444 | 2.26\*\*\* | 0.0006 |
| (POFA)2 |  | -0.326 | 0.371 | -4.789\*\*\* | 0.0000 |
| POFA \*POL |  | 0.131 | 0.362 | -1.02\*\* | 0.002 |
| (POL)2 |  | -3.24\*\*\* | 0.0000 | -12.75\*\*\* | 0.0000 |

### 5.1.6: Cost and Profit Inefficiency Estimates for State-owned Commercial Banks using Stochastic Translog Frontier Model

The cost and profit inefficiency estimates for State-owned Commercial Banks illustrated in table-5.6. In cost inefficiency model, the majority of the estimates were significant except return on equity. The coefficient of non- interest income δ1 (0.896) was highly positively significant for the cost inefficiency model suggests that non- interest income did not impact banks cost. Also non-performing loan δ2 (-0.681), return on assets δ3 (-0.166) and capital adequacy ratio δ5 (-0.645) were a negatively significant indication that they could be importantly influenced on banks profit efficiency. There is a consistent view among scholars on the relationship between non-performing loan ratio and banking inefficiency. ( Altunbaş et al. ;2000, Mertens and Urga ; 2001, Girardone et al ;2004 and Carvallo and Kasman ; 2005) agree that non-performing loan ratio has a positive influence on inefficiency. The Sigma squared was positively significant. The estimated gamma was close to unity implies that the strong impact of inefficiency score to bank’s cost variance. In profit inefficiency model, the coefficient of non-interest income δ1 (-0.142), return on assets δ3 (-0.277), return on equity δ4 (-0.129) and capital adequacy ratio δ5 (-0.556) were negatively insignificant. So, therefore, a positive effect on profit efficiency. The Sigma squared was positive and significant. The estimated gamma is 0.918 implies that the strong impact of inefficiency score to bank’s profit variance. These results is supported by ( Ngan; 2014)

Table-5. 6: Cost and Profit Inefficiency Estimates for State-owned Commercial Banks using Stochastic Translog Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Trans-log | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| NII | δ1 | 0.896\*\*\* | 0.0000 | -0.142 | 0.432 |
| NPL | δ2 | -0.681\*\*\* | 0.0000 | 0.2286 | 0.203 |
| ROA | δ3 | -0.166\*\*\* | 0.0008 | -0.277 | 0.071 |
| ROE | δ4 | 0.0667 | 0.102 | -0.129 | 0.361 |
| CAR | δ5 | -0.645\*\*\* | 0.0000 | -0.556 | 0.062 |
| Sigma Sq | б2 | 0.0202\*\*\* | 0.0000 | 0.065\* | 0.029 |
| Gamma | γ | 1.00\*\*\* | 0.0000 | 0.918\*\* | 0.0005 |

### 5.1.7: Maximum Likelihood Estimates of Cost and Profit for Private Commercial Bank using Translog Stochastic Frontier Model

The results of maximum likelihood estimates using Trans-Log Stochastic Cost and Profit Frontier model of the private commercial banks are given in Table -5.7. This result shows that only the output variable off-balance sheet items was negatively significant with the coefficient of β2 (-2.767) implies that off-balance sheet item had not a great influence on the bank’s cost model. The square of inputs, the price of fund β33 (-0.106) was negatively significant and the price of fixed assetsβ44 (0.623) were positively significant. The interaction term of input price and outputs, loan & off-balance sheet items β12 (0.284), loan & price of fixed assets β14 (0.244), loan &price of labor β15 (0.619) were positively significant where off-balance sheet item & price of labor β25 (-0.753), Price of fund & price of labor β35(-0.152) and price of fixed assets & Price of labor β45 (-0.442) found negatively significant for the cost model. In Translog Stochasticprofit frontier model, the output variableoff-balance sheet items β2(-1.156) was negatively significant and theinputs, the price of fund β3 (2.295) was positively significant. Also the square input price of labour β55 (-0.325) shown highly negatively significant and also the mixed product, off-balance sheet items & price of fund β23 (-0.212), off-balance sheet items & Price of fixed assets β24(-0.237) were negatively significant and loan & off-balance sheet items β12 (0.148) and Price of fixed assets & price of labor β45 (0.449) were found positively significant. These results are supported by (Kosak et al.;2009).

Table-5. 7: Maximum Likelihood Estimates of Cost and Profit for Private Commercial Bank using Translog Stochastic Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Translog | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Constant |  | 15.18\* | 0.041 | 18.42\*\*\* | 0.0000 |
| LOA |  | 0.666 | 0.626 | -1.03 | 0.125 |
| OBS |  | -2.767\*\* | 0.006 | -1.156\*\* | 0.001 |
| POF |  | 0.299 | 0.704 | 2.295\* | 0.013 |
| POFA |  | -1.368 | 0.149 | 1.301 | 0.157 |
| POL |  | -0.489 | 0.764 | -0.908 | 0.412 |
| (LOA)2 |  | -0.230 | 0.224 | -0.152 | 0.074 |
| LOA \* OBS |  | 0.284\* | 0.016 | 0.148\* | 0.020 |
| LOA \* POF |  | -0.092 | 0.355 | 0.019 | 0.759 |
| LOA \* POFA |  | 0.244\* | 0.034 | -0.006 | 0.941 |
| Loan \*POL |  | 0.619\*\*\* | 0.0006 | 0.057 | 0.644 |
| (OBS)2 |  | -0.060 | 0.448 | -0.050 | 0.357 |
| OBS \* POF |  | 0.037 | 0.598 | -0.212\* | 0.013 |
| OBS \*POFA |  | -0.021 | 0.839 | -0.237\* | 0.016 |
| OBS\*POL |  | -0.753\*\*\* | 0.0000 | 0.177 | 0.141 |
| (POF)2 |  | -0.106\* | 0.042 | 0.124 | 0.067 |
| POF \* POFA |  | -0.049 | 0.382 | -0.115 | 0.197 |
| POF \*POL |  | -0.152\* | 0.035 | 0.183 | 0.146 |
| (POFA)2 |  | 0.623\*\*\* | 0.0000 | -0.503 | 0.0027 |
| POFA \*POL |  | -0.442\*\*\* | 0.0002 | 0.449\*\* | 0.0007 |
| (POL)2 |  | -0.076 | 0.630 | -0.325\*\*\* | 0.0552 |

### 5.1.8: Cost and Profit Inefficiency Estimates for Private Commercial Banks using Translog Stochastic Frontier Model

The cost and profit inefficiency estimates for private commercial banks illustrated in table-5.8. The coefficient of return on equity δ4 (0.341) and capital adequacy ratio δ5 (0.961) were found highly significant with a positive value that means they could not contribute to the bank’s cost efficiency. On the other hand, the coefficient of non-interest income δ1 (-0.305) was negatively significant. Also the coefficient of non-performing loan δ2 (-0.045) and return on assets δ3 (-0.229) was insignificant with a negative value. The Sigma squared is positive and significant. The estimated gamma is 0.669 implies that the strong impact of inefficiency score to bank’s profit variance. In profit inefficiency estimates model, the coefficient of return on assets δ3 (-2.513) and capital adequacy ratio δ5 (-2.806) were negatively significant so, therefore, a positive effect on profit efficiency. The coefficient of return on equity δ4 (2.868) was positively significant. The coefficient of non-performing loan δ2 (-0.467) was insignificant with a negative value. The Sigma squared was positive and significant. The estimated gamma was 0.918 implies that the strong impact of inefficiency score on the bank's profit. These results were supported by (Ngan ; 2014)

Table-5. 8: Cost and Profit Inefficiency Estimates for Private Commercial Banks using Translog Stochastic Frontier Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Translog | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| NII | δ1 | -0.305\*\*\* | 0.0000 | 0.058 | 0.807 |
| NPL | δ2 | -0.045 | 0.276 | -0.467 | 0.057 |
| ROA | δ3 | -0.229 | 0.107 | -2.513\*\* | 0.003 |
| ROE | δ4 | 0.341\* | 0.040 | 2.868\*\*\* | 0.0007 |
| CAR | δ5 | 0.961\*\*\* | 0.0000 | -2.806\*\* | 0.005 |
| Sigma Sq | б2 | 0.121\*\*\* | 0.0000 | 2.704\*\*\* | 0.0000 |
| Gamma | γ | 0.669\*\*\* | 0.0000 | 0.999\*\*\* | 0.0000 |

### 5.1.9: Year-wise Average Cost and Profit Efficiency of State-owned Bank using Cobb-Douglas Stochastic Frontier Analysis

The average profit and cost efficiency scores for the sample of state-owned banks are illustrated in Figure-5.1. As can be seen that the average profit efficiency was 27.6% less than the average cost efficiency of 59.2%. By considering costs, it emerges that banks would have used only has costs that are 59.7% to produce the same level of output in these years. On the other hand, they earned 27.6% of their potential profits; 72.4 % recovery of profitability would have been possible without increasing outputs. Also, it can be seen that it was fluctuated year by year in both cases of cost and profit. The profit efficiency of state banks was recorded 20% to 40% in the year 2008-2010, and then it attained the peak percentage amount of 60.6% in 2012. After that, it fell dramatically by 16.7% in 2013 which was the lowest percentage over the study period. Next year it has been slightly increased by 6%. Finally, it was observed that they again attained a slow upward trend of around 17%to20% until 2017. The cost efficiencies were around 53%to60% from 2008-2010, then it declined dramatically at the percentage of 38.4% of the year 2015 after then it increased over the period and the highest cost efficiency level was 71.5% in 2016. These results does not supported by (Ngan; 2014, and Kasman and Yildirim; 2006).

Fig-5.1: Year-wise Average Cost and Profit Efficiency of State-owned Bank using Cobb-Douglas Stochastic Frontier Analysis

### 5.1.10: Year-wise Average Cost and Profit Efficiency of Private Commercial Bank for Stochastic Cobb-Douglas Frontier Analysis

The year-wise average cost and profit efficiency scores for the sample of private commercial banks are illustrated in Figure-5.2. It is observed that the average cost efficiency of 65.8% was greater than the average profit efficiency of 50.5%. In the case of cost efficiency, it implies that banks would have incurred only has costs that were 65.8% of its actual cost. On the contrary, they could not 49.5% earned their potential profits. Also, it may be viewed that they were varied year by year in both cases of cost and profit. The profit efficiency of private commercial banks was recorded 40% in the year of 2008, and then slightly decreased at 31.7% in the next year. After then it remained constant at 47% in 2011 and 2012. Again it declined slowly and after 2014 it was gradually increasing and reaches the highest value at 66.7% in the last year of 2017. Conversely, the cost efficiencies were around 49.9 %-74.4% from 2008-2014, and it attained the peak percentage amount of 74.8% in 2013. After that, it has been a little drop of 71.5% in 2015 and 2016. In the last year of the study period, it has been slightly increased by 73.1% over the study period. These study is supported the findings of (Baten, 2013, Ara, 2016).

Fig-5. 2 Year-wise Average Cost and Profit Efficiency of Private Commercial Bank for Stochastic Cobb-Douglas frontier Analysis

### 5.1.11: Bank-wise Average Cost and Profit Efficiency of State-owned Banks using Cobb-Douglas Stochastic Frontier Analysis

The average cost and profit efficiency scores of individual state-owned banks from 2008-2017 are reported in Figure-5.3. The Janata bank was the most cost & profit efficient among the other banks with an average efficiency score of 62.8% and 38.4% respectively. Besides Sonali bank was the second cost efficient (51.7%) and profit efficient (26.4%) and Rupali bank was the less cost and profit efficient with the score of 63.2% and 18.2% respectively. Cost efficiency scores above 40% which implies that banks have costs that are 60% of their cost was wasted relative to the best practice banks have producing the same output and facing the same condition. This result confirms that throughout estimation, state-owned banks were more cost efficient rather than profit efficiency. These result are supported by (Aiello & Bonanno ; 2013).

Fig-5. 3 Bank-wise Average Cost and Profit Efficiency of State-owned Banks using Cobb-Douglas Stochastic Frontier Analysis

### 5.1.12: Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Cobb-Douglas Stochastic frontier Analysis

The average cost and profit efficiency scores of individual commercial banks from 2008-2017 are reported in Figure5.4. As presented the result, IBBL was the most profit efficient with an average efficiency score of 73.8% and the Brac bank was the most cost efficient bank with an average efficiency score of 89.3% among the other banks. Moreover, the social bank was the second cost efficient (82.3%) and the eastern bank was the second profit efficient (71.7%). Besides DBBL was the less cost efficient (34.1%) and Al- Arafah was the less profit efficient (37%) respectively. Furthermore, the southeast, al-Arafah, brace, and the prime bank had 60% above profit efficiency scores and the mercantile, one southeast, eastern and IBBL had cost efficiency scores more 70%. This result confirms that over the period of estimation, the majority of the private commercial banks were around 40% to 50% regarding profit efficiency and around 60% to 70% in terms of cost efficiency.

Fig-5. 4 Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Cobb-Douglas Stochastic Frontier Analysis

### 5.1.13: Year-wise Average Cost and Profit Efficiency of State-owned Commercial Bank using Trans-Log Stochastic Frontier Analysis

The year-wise average cost and profit efficiency scores for the sample of state-owned commercial banks are illustrated in Figure 5.5. It is observed that the average cost efficiency of 81.3% was less than the average profit efficiency of 84.4%. In case of cost efficiency, it implies that banks would have incurred only has costs that are 81.3% of its actual cost and 19.7% of its cost was wasted relatively to the best practice banks producing the same output and facing the same condition. Contrarily, banks were 84.4% efficient in profit making services relative to the best performing bank during the study period. Also, it may be viewed that they have fluctuated year by year in both cases of cost and profit. The profit efficiency of state banks was recorded 80% to 90% from 2008 to 2014, and then it fell dramatically at 63.7% in2015. After then again it went up at 80% in 2016 and last year of the study period it declined by 10%. Conversely, at the beginning of the study period, the cost efficiency was 80.6% then it decreased slightly in the next two year at 76.4% to 68.4% respectively after then it rose just over 90% from 2013-2014, and again it has been slightly decreased by 88.4% in 2015. Finally, it has been an upward trend for the last three years and it attained the peak percentage amount of 98.4% in 2017. These results are supported by the (Aiello & Bonanno ;2013) and contradicted (Baten ;2013, Ara ;2016).

Fig-5. 5 Year-wise Average Cost and Profit Efficiency of State-owned Commercial Bank using Translog Stochastic Frontier Analysis

### 5.1.14: Year-wise Average Cost and Profit Efficiency of Private Commercial Bank using Translog Stochastic Frontier Analysis

The year-wise average cost and profit efficiency scores for the sample of private commercial banks are illustrated in Figure 5.6. It is observed that the average cost efficiency of 66.3% was much than the average profit efficiency of 53.9%. In the case of cost efficiency, it implies that banks would have incurred only has costs that are 65.8% of its actual cost. On the contrary, they could not 49.5% earned their potential profits. Also in the case of profit efficiency, they have fluctuated over the study period. In 2008, the profit efficiency score of private commercial banks were 50%, then it decreased moderately at 32.8% in the next year. After then it remained 50% in 2011 and 2012. Again it declined slowly at 40.7% and finally, it was an upward trend and reaches the highest value at 66.7% in the last year of 2017. On the other hand, the cost efficiencies were around 51.1 % to 72.1% from 2008-2013, and then it has been slightly decreased by 71.2 %. After then, it remained steady at 70.1% in 2015 and 2016. In the last year of the study period, it was a little drop of 69.8%. This result was supported by (Casu and Girardone ; 2004, Baten; 2003, Ara; 2016 and Hasan & Hasan ;2018) who measured the private banks were most cost efficient rather than profit efficiency.

Fig-5. 6 Year-wise Average Cost and Profit Efficiency of Private Commercial Bank for Translog Stochastic Frontier Analysis

### 5.1.15: Bank-wise Average Cost and Profit Efficiency of State-owned Commercial Banks for Trans-Log Stochastic Frontier Analysis

The average cost and profit efficiency scores of individual state-owned banks from 2008-2017 are shown in Figure-5.7. The Janata bank was the most efficient among the other banks with an average cost and profit efficiency score of 90% and 89.5% respectively. Besides Rupali bank was the second cost inefficient (89%) and profit efficient (84%) and Sonali bank was the less cost and profit efficient with the score of 63.8% and 79.7% respectively. This result confirms that over the period of estimation, state-owned banks were 81.3% cost efficient and 84.4% profit efficient implies that with the same resources, these banks were able to more cost efficient to increase efficiency by 18.7% and 15.4% more profit efficient by choosing optimum quantities and input prices.

Fig-5. 7 Bank-wise Average Cost and Profit Efficiency of State-owned Banks for Translog Stochastic Frontier Analysis

### 5.1.16: Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Trans-Log Stochastic Frontier Analysis

The average cost and profit efficiency scores of individual private commercial banks from 2008-2017 are reported in Figure-5.8. As presented the result, IBBL was the most cost-efficient with an average efficiency score of 82.4% and conversely, the southeast and eastern banks were the most profit efficient bank with an average efficiency score of 68% among the other banks. Moreover, the eastern bank was the second cost efficient (77.9%) and the Brac bank was the second profit efficient (67.8%). Besides Exim bank was the less cost efficient (31.1%) and Mercantile was the less profit efficient (33.3%) respectively. Furthermore, the IBBL and the prime bank had 60% above profit efficiency scores and the Brac, mercantile, one, prime, premium and Shahjalal banks had cost efficiency scores more 70%. This result confirms that for the majority of the private commercial banks were around 40% to 50% regarding profit efficiency and around 60% to 70% in terms of cost efficiency. These results are supported by ( Ara; 2016)

Fig-5. 8 Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Translog Stochastic Frontier Analysis

Table-5. 9: Generalized Likelihood-Ratio Test of Stochastic Cost and Profit Frontier Model for State-owned and Private Commercial Bank

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | Null Hypothesis | Log-Likelihood Function | Test Statistics λ | Critical Value | Decision |
| Cost |  |  | -54.96 | 38.301 | Reject |
| Cobb-Douglas | -65.61 |
| Translog | -38.13 |
| State-owned |  | 32.30 | -0.0043 | 35.82 | Accept |
|  | -7.37 | 18.377 | 5.138 | Reject |
| Private  commercial |  | -33.64 | 1.3172 | 35.82 | Accept |
|  | -64.82 | 48.9 | 5.138 | Reject |
| Profit |  |  | 16.31 | 35.83 | Reject |
| Cobb-Douglas | -165.32 |
| Translog | -157.17 |
| State- owned |  | 34.03 | 2.799 | 35.82 | Accept |
|  | -7.94 | 36.98 | 5.14 | Reject |
| Private commercial |  | -165.93 | 88.654 | 35.827 | Reject |
|  | -165.32 | 112.54 | 5.138 | Reject |

Note: all critical values are at 5% level of significance and the critical values are obtained from table of Kodde and Palm (1986)

### 5.1.17: Result of Test of Hypothesis for Stochastic Cost and Profit Frontier Model

Table-5.9 reports the results of hypothesis tests conducted on the cost and profit frontier model. The hypothesis tests were obtained using the generalized likelihood-ratio statistic.

* The 1st null hypothesis is  which specifies that the Cobb-Douglas stochastic frontier model is more preferable than the Translog Stochastic Frontier Model for cost and profit efficiency model of state-owned and private commercial banks. From this result, it was observed that the null hypothesis is rejected in both cases of cost and profit efficiency model. So the Translog model was more preferable than the Cobb-Douglas for cost and profit efficiency model of state-owned and private commercial banks.
* The 2nd null hypothesis is, which specify that there is no technical inefficiency effect in the Cost efficiency model. The hypothesis is accepted for the state-owned and private commercial bank so there is a technical inefficiency effect in the cost model. In terms of profit model, the hypothesis is accepted for state-owned commercial bank and rejected for private commercial bank, so we can conclude that there is a no technical inefficiency effect in the profit model for the state-owned and has technical inefficiency effect for private commercial bank.
* The 3rd null hypothesis is  which specifies that there is an interaction effects on Translog Stochastic Cost and profit Frontier Model. From the result, it is observed that the null hypothesis is rejected in term of both cases in cost and profit efficiency. So we can conclude that there is an interaction effect in the Translog Stochastic Cost and profit Frontier Model for the state-owned and private commercial bank. This result was supported by (Baten; 2013 and Ngan; 2014)

## **5.2 Cost and Profit Efficiency Result based on Data Envelopment Analysis**

### 5.2.1: Bank-wise VRS Cost Efficiency of State- owned Commercial Bank using Data Envelopment Analysis

The results of VRS cost efficiency of state-owned commercial bank banks are presented in Table-5.10. The average technical, allocative and cost efficiency scores were 81.4%, 91.8%, and 74.4% respectively. Rupali bank was the most cost-efficient bank with the scores of 91.7% and their technical and allocative efficiency scores were 94.5% and 97% respectively which implies that Rupali bank saving 15.6% of their potential costs by using the inputs in optimal combination Sonali bank was the less cost efficient with their cost, technical and allocative efficiency scores of 59%, 62.8%, and 93.3% respectively. This result is similar to (Chen et. al.; 2005, Gardener et al.; 2011, kharimhadeh ; 2012) who examined the technical efficiency was greater than Allocative and cost efficiency.

Table-5. 10: Bank-wise VRS Cost Efficiency of State- owned Commercial Bank using Data Envelopment Analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Name of Banks | Cost DEA Model | | |
| Cost  Efficiency | Technical  Efficiency | Allocative  Efficiency |
| Rupali | 0.917 | 0.945 | 0.97 |
| Sonali | 0.59 | 0.628 | 0.933 |
| Janata | 0.724 | 0.860 | 0.852 |
| Mean | 0.744 | 0.811 | 0.918 |

TE=Technical Efficiency, AE= Allocative Efficiency, CE= Cost efficiency

### 5.2.2: Bank-wise VRS Cost Efficiency using Data Envelopment Analysis of Private Commercial Bank

The results of VRS cost efficiency of private commercial banks are presented in Table-5.11. The average technical, allocative and cost efficiency scores were 41.4%, 59.5%, and 92% respectively. These results show that prime bank was the most cost-efficient bank with the cost, technical and allocative efficiency score of 71.3%, 81%, and 92.3% respectively. Moreover, the mercantile bank was the second cost efficient with the cost, technical and allocative efficiency score of 64.5%, 78%, and 93% respectively. Besides DBBL bank was the less cost efficient with the cost, technical and allocative efficiency score of 22.3%, 34.6%, and 93.1% respectively. Furthermore, the allocative efficiencies had greater than technical efficiency in case of private commercial banks. This result is different from (Chen et.al.; 2005, Gardener et al.; 2011, kharimhadeh ; 2012).

Table-5. 11: Bank-wise VRS Cost Efficiency using Data Envelopment Analysis of Private Commercial Bank

|  |  |  |  |
| --- | --- | --- | --- |
| Name of Banks | Cost DEA Model | | |
| Cost Efficiency | Technical Efficiency | Allocative  Efficiency |
| DBBL | 0.223 | 0.346 | 0.931 |
| Brac | 0.251 | 0.365 | 0.91 |
| City | 0.38 | 0.464 | 0.891 |
| Mercantile | 0.645 | 0.78 | 0.93 |
| Mutual | 0.357 | 0.626 | 0.92 |
| One | 0.425 | 0.654 | 0.912 |
| Premium | 0.513 | 0.744 | 0.915 |
| Prime | 0.713 | 0.81 | 0.923 |
| Southeast | 0.468 | 0.657 | 0.915 |
| Eastern | 0.378 | 0.472 | 0.926 |
| UCB Limited | 0.439 | 0.788 | 0.904 |
| IFIC | 0.314 | 0.513 | 0.93 |
| IBBL | 0.528 | 0.559 | 0.943 |
| Al-arafah | 0.318 | 0.490 | 0.926 |
| Social | 0.401 | 0.573 | 0.908 |
| Exim | 0.313 | 0.706 | 0.923 |
| Shahjalal | 0.374 | 0.572 | 0.933 |
| Mean | 0.414 | 0.595 | 0.92 |

TE=Technical Efficiency, AE= Allocative Efficiency, CE= Cost efficiency

### 5.2.3: Year-wise Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis

The cost and profit scores of state-owned commercial banks using data envelopment analysis model over the period are presented in Figure-5.9. The average cost efficiency (74.4) was higher than profit efficiency (20.6%) score implies that state-owned commercial banks were more cost-efficient and less profit efficient. These results show that the banks were 74% cost efficient in the year of 2008 and 2009 then it increased slightly at 1% to 5% until 2013 after then it fallen and steady at 65% on the next year. Finally, it increased dramatically at a percentage of 91.8% in the last year. On the other hand, the profit efficiency scores were very low during the study period. In these years 2010, 2014 and 2016, the profit efficiency score had 30% above. Otherwise the rest of the years, the bank had 10% to 20% profit efficiency score. This result is supported (Ariff and Can; 2008) who showed that state-owned commercial banks were the most cost efficient.

Fig-5. 9: Year-wise Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis

### 5.2.4: Year-wise Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis

The cost and profit scores of private commercial banks using data envelopment analysis model over the period are presented in Figure-5.10. The average cost efficiency (41.4%) was higher than profit efficiency (18.8%) score implies that private commercial banks were more cost-efficient and less profit efficient. These results show that the banks are 55.6% highest cost efficient in the year of 2008 and then it decreased gradually at 44% to 28.7% until 2012 and after then it increased 40.2% in 2013 and next year it fell and finally it rose at 50% on the last year. Contrarily, the profit efficiency scores were very low and the profit efficiency score had 20% below during the study period. The highest profit efficiency score was 31.1% in the last year. This study is supported by ( Gulati & Kumar; 2016) who found that Indian banking industry was less profit efficient rather than cost efficient.

Fig-5. 10: Year-wise Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis

### 5.2.5: Bank-wise VRS Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis

The cost and profit efficiency of state-owned commercial bank banks using Data Envelopment Analysis is presented in Figure-5.11. The bank-wise average cost and profit efficiency scores were 74.5% and 20.6%. These results show that Rupali bank was the most cost with the efficiency score of 91.6% where Sonali bank was the less cost efficient with the efficiency score of 59%. Conversely, Sonali bank was the most profit efficient bank with an efficiency score of 30.7% and Rupali bank was the less profit efficient with the efficiency score of 14.9% respectively.

Fig-5. 11: Bank-wise VRS Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis

### 5.2.6: Bank-wise VRS Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis

The cost and profit efficiency of private commercial banks using Data Envelopment Analysis is presented in Figure-5.12. The bank-wise average cost and profit efficiency scores were 41.4% and 18.2% respectively. These results show that prime bank was the most cost and profit efficient bank with an efficiency score of 71.3% and 53.7% respectively. Moreover, the mercantile bank was the second cost (64.5%) and profit efficient (35.8%). Besides DBBL bank was the less cost efficient (22.3%) and Al-arafah was the less profit efficient (2.6%) respectively. Furthermore, the IBBL and the premium bank had 50% above cost efficiency scores but the majority of the private commercial banks were around 20% to 40% regarding cost efficiency and around 10% to 20% in terms of profit efficiency.

Fig-5. 12: Bank-wise VRS Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis

## **5.3: Result of IT Determinant based on Tobbit Regression Model**

### 5.3.1: IT Determinant of Cost and Profit Efficiency of Stochastic Translog frontier

### Model for State-owned Commercial Banks by Estimating Tobit Regression Model

Table-5.12 represents the results of IT determinant of cost and profit efficiency of Stochastic Translog cost frontier model for state-owned commercial banks. As can be seen that there was no significant IT variable for the cost efficiency but The IT expenses ɸ1 (-0.0003), IT personnel expanses ɸ5 (-0.002), ATM expenses ɸ7 (-0.008) and credit card transaction ɸ8 (-0.0004) had a negative impact on the cost efficiency of state-owned commercial banks. Also, there were not found significant IT variable for the profit efficiency but The IT income ɸ2 (-0.0008), IT investment ɸ3 (-0.00009), IT personnel ɸ4 (-0.002), ATM transaction ɸ6 (-0.0003) had a negative impact on the profit efficiency of state-owned commercial banks. This finding contradicts the result of (Elena Beccalli; 2007).

Table-5. 12: IT Determinant of Cost and Profit Efficiency of Stochastic Translog Frontier Model for State-owned Commercial Banks by Estimating Tobit Regression Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Translog | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.623\* | 0.0000 | 0.948\*\*\* | 0.0000 |
| IT.Expenses | ɸ1 | -0.0003 | 0.676 | 0.0008 | 0.1178 |
| IT.Income | ɸ2 | 0.002 | 0.168 | -0.0008 | 0.3123 |
| IT.Investment | ɸ3 | 0.0002 | 0.3266 | -0.00009 | 0.3028 |
| IT.personnel | ɸ4 | 0.003 | 0.1857 | -0.002 | 0.0826 |
| IT personnel Expanses | ɸ5 | -0.002 | 0.0831 | 0.0006 | 0.2862 |
| ATM. Transaction | ɸ6 | 0.00003 | 0.9663 | -0.0003 | 0.254 |
| ATM. Expenses | ɸ7 | -0.008 | 0.4023 | 0.004 | 0.4681 |
| Credit Card Transaction | ɸ8 | -0.0004 | 0.9444 | 0.00003 | 0.9201 |
| Credit Card Expenses | ɸ9 | 0.005 | 0.7671 | 0.008 | 0.3954 |

### 5.3.2: IT Determinant of Cost and profit Efficiency of Stochastic Translog Frontier Model for Private Commercial Banks by Estimating Tobit Regression Model

Table-5.13 represents the results of IT determinant of cost and profit efficiency of Stochastic Translog cost and profit frontier model for private commercial banks. As presented the result, the IT personnel expenses ɸ5 (0.0006) and credit card transaction ɸ8 (0.000006) were positively significant but IT income ɸ2 (-0.0002 , ATM Transaction ɸ8 (-0.00005) and credit card expenses ɸ9 (-0.0001) are negatively significant for the cost efficiency of private commercial banks. Also, IT expenses ɸ1 (-0.00003) and IT investment ɸ3 (-0.000002) were insignificant but had a negative impact on the cost efficiency of private commercial banks. On the contrary, In IT determinant profit efficiency of Stochastic Translog profit frontier model, the IT investment ɸ3 (-0.000008), and credit card expenses ɸ9 (-0.0000007) were found negatively significant IT variable for the profit efficiency. IT Expenses ɸ1 (-0.00002), Credit Card Transaction ɸ8 (-0.0000007) had a negative impact on the profit efficiency of private commercial banks. This study supports the (Surulivel et. al.; 2013, Safari & Yu ; 2014) .

Table-5. 13: IT Determinant of Cost and profit Efficiency of Stochastic Translog Frontier Model for Private Commercial Banks by Estimating Tobit Regression Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Translog | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.619\*\*\* | 0.0000 | 0.42\*\*\* | 0.00000 |
| IT.Expenses | ɸ1 | -0.00003 | 0.416 | -0.00002 | 0.804 |
| IT.Income | ɸ2 | -0.0002\*\* | 0.006 | 0.00003 | 0.822 |
| IT.Investment | ɸ3 | -0.000002 | 0.263 | -0.000008\* | 0.031 |
| IT.Personnel | ɸ4 | 0.0003 | 0.11 | 0.0006 | 0.141 |
| IT Personnel Expanses | ɸ5 | 0.0006\* | 0.044 | 0.0009 | 0.096 |
| ATM.Transaction | ɸ6 | -0.00005\* | 0.029 | 0.00005 | 0.235 |
| ATM.Expenses | ɸ7 | 0.0002 | 0.139 | 0.00002 | 0.923 |
| Credit.Card.Transaction | ɸ8 | 0.000006\*\* | 0.001 | -0.0000007 | 0.863 |
| Credit.Card.Expenses | ɸ9 | -0.0001\* | 0.012 | -0.0002\*\*\* | 0.003 |

### 5.3.3: IT Determinant of Cost and Profit Efficiency of Stochastic Cobb-Douglas Cost and Profit Frontier Model for State-owned Commercial Banks by Estimating Tobit Regression Model

Table-5.14 represents the results of IT determinant of cost and profit efficiency of stochastic cobb-Douglas cost and profit frontier model for state-owned commercial banks. As can be observed that the IT personnel expanses ɸ5 (-0.002) was negatively significant for the cost efficiency of the state-owned commercial bank. Also, the IT expenses ɸ1 (-0.00002), IT income ɸ2 (-0.0001), ATM Expenses ɸ7 (-0.012) and credit card transaction ɸ8 (-0.0003) were an insignificant but negative impact on the cost efficiency of private commercial banks. On the other hand, In IT determinant profit efficiency of Stochastic Cobb-Douglas profit frontier model, the IT personnel expanses ɸ5 (0.0015) was positively significant and IT investment ɸ3 (-0.00009) and credit card expanses ɸ9 (-0.0003) had a negative impact on the profit efficiency of state-owned commercial banks.

Table-5. 14: IT Determinant of Cost and Profit Efficiency of Stochastic Cobb-Douglas Cost and Profit Frontier Model for State-owned Commercial Banks by Estimating Tobit Regression Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.555\*\*\* | 0.0000 | 0.38\*\*\* | 0.00000 |
| IT.Expenses | ɸ1 | -0.00002 | 0.974 | -0.0001 | 0.082 |
| IT.Income | ɸ2 | -0.0001 | 0.922 | 0.00004 | 0.732 |
| IT.Investment | ɸ3 | 0.0001 | 0.476 | -0.00009\*\* | 0.006 |
| IT.personnel | ɸ4 | 0.002 | 0.138 | 0.0008 | 0.072 |
| IT Personnel Expanses | ɸ5 | -0.002\* | 0.029 | 0.0015\*\* | 0.005 |
| ATM.Transaction | ɸ6 | 0.0002 | 0.703 | 0.00004 | 0.261 |
| ATM.Expesnes | ɸ7 | -0.012 | 0.145 | -0.0002 | 0.454 |
| Credit.Card.Transaction | ɸ8 | -0.0003 | 0.613 | 0.000001 | 0.662 |
| Credit.Card.Expenses | ɸ9 | 0.005 | 0.764 | -0.0003\*\*\* | 0.0002 |

### 5.3.4: IT Determinant of Cost and profit Efficiency of Stochastic Cobb-Douglas Frontier Model for Private Commercial Banks by Estimating Tobbit Regression Model

Table-5.15 represents the results of IT determinant of cost and profit efficiency of Stochastic Cobb-Douglas cost and profit frontier model for private commercial banks from. As can be seen that the IT income ɸ2 (-0.00018) and credit card expanses ɸ9 (-0.00013) were negatively significant for the cost efficiency. Besides IT personnel expanses ɸ5 (0.00087), ATM Expenses ɸ7 (0.00306) and credit card transaction ɸ8 (0.00008) had a positive impact on the cost efficiency of private commercial banks. In IT determinant profit efficiency of Stochastic Cobb-Douglas profit frontier model, the IT investment ɸ3 (-0.0003), IT income ɸ2(-0.0032), IT personnel ɸ4(-0.004), and ATM transaction ɸ6 (-0.0008) were found negatively significant for the profit efficiency but the IT personnel expenses ɸ5(0.0018) and Credit Card Transaction ɸ8 (0.0013) were positively significant on the profit efficiency of private commercial banks. Also, the ATM expenses ɸ7 (-0.009) and credit card expense ɸ9 (-0.0012) were an insignificant but negative impact on the profit efficiency for private commercial Bank.

Table-5. 15: IT Determinant of Cost and profit Efficiency of Stochastic Cobb-Douglas Frontier Model for Private Commercial Banks by Estimating Tobit Regression Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cobb-Douglas | | Cost model | | Profit model | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.580\*\*\* | 0.0000 | 0.304\*\*\* | 0.0000 |
| IT.Expenses | ɸ1 | 0.00002 | 0.617 | 0.0009 | 0.104 |
| IT.Income | ɸ2 | -0.00018\* | 0.028 | -0.0032\*\* | 0.001 |
| IT.Investment | ɸ3 | -0.0000009 | 0.697 | -0.0003\* | 0.016 |
| IT.Personnel | ɸ4 | 0.0002 | 0.489 | -0.004\*\* | 0.009 |
| IT Personnel Expenses | ɸ5 | 0.00087\* | 0.016 | 0.0018\*\* | 0.009 |
| ATM.Transaction | ɸ6 | -0.00004 | 0.139 | -0.0008\* | 0.021 |
| ATM.Expenses | ɸ7 | 0.00306\* | 0.039 | -0.009 | 0.118 |
| Credit.Card.Transaction | ɸ8 | 0.00005\* | 0.015 | 0.0013\*\*\* | 0.000 |
| Credit.Card.Expenses | ɸ9 | -0.00013\*\* | 0.006 | -0.0012 | 0.927 |

### 5.3.5: IT Determinant of Cost Efficiency of Data Envelopment Analysis for State-owned and Private Commercial Banks by Estimating Tobit Regression Model

Table-5.16 represents the results of IT determinant of cost and profit efficiency of Data Envelopment Analysis model for the state-owned and private commercial banks. As can be observed that the IT Investment ɸ3 (0.00032) and IT personnel expanses ɸ5 (0.00154) were positively significant for the cost efficiency of state-owned commercial bank. Also, the ATM Transaction ɸ6 (-0.0012) was negatively significant and credit card expenses ɸ9 (-0.002) was insignificant but had a negative impact on the cost efficiency of state-owned commercial banks. In IT determinant of profit efficiency of Data Envelopment Analysis, the IT personnel ɸ4 (-0.0009) was negatively significant and credit card transaction ɸ8 (0.000006) and credit card expenses ɸ9 (0.0002) were positively significant for the cost efficiency of the private commercial bank. Also, the IT expenses ɸ1 (-0.00007), IT income ɸ2 (-0.00003), IT Investment ɸ3 (0.000004) and ATM transaction ɸ6 (-0.00003) had a negative impact on the cost efficiency of private commercial banks. This result contradicts the (Syrinedhane ;2013).

Table-5. 16: IT Determinant of Cost Efficiency of Data Envelopment Analysis for State-owned and Private Commercial Banks by Estimating Ordinary Least Square Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cost efficiency | | State-owned commercial bank | | Private commercial banks | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.6\*\*\* | 0.0000 | 0.44\*\*\* | 0.0000 |
| IT.Expenses | ɸ1 | 0.00007 | 0.868 | -0.00007 | 0.189 |
| IT.Income | ɸ2 | 0.001 | 0.059 | -0.00003 | 0.684 |
| IT.Investment | ɸ3 | 0.00032\*\* | 0.001 | -0.000004 | 0.075 |
| IT Personnel | ɸ4 | 0.002 | 0.874 | -0.0009\*\* | 0.003 |
| IT Personnel Expenses | ɸ5 | 0.00154\*\* | 0.006 | 0.00056 | 0.183 |
| ATM.Transaction | ɸ6 | -0.0012\*\*\* | 0.0001 | -0.00003 | 0.232 |
| ATM.Expenses | ɸ7 | 0.008 | 0.092 | 0.00009 | 0.587 |
| Credit.Card.Transaction | ɸ8 | 0.002 | 0.508 | 0.000006\*\* | 0.004 |
| Credit.Card.Expenses | ɸ9 | -0.002 | 0.845 | 0.0002\*\*\* | 0.000 |

## **5.4: Result of IT Determinant based on Ordinary Least Square**

### 5.4.1: IT Determinant of Profit Efficiency of Data Envelopment Analysis for State-owned and Private Commercial Banks by Estimating Ordinary Least Square Model

Table-5.17 represents the results of IT determinant of profit efficiency of Data Envelopment Analysis model for state-owned commercial banks. As can be observed that there was no significant estimates for the profit efficiency of Data Envelopment Analysis model for the state-owned commercial banks. As can be seen that the IT income ɸ2 (-0.0004), IT Investment ɸ3 (-0.0002), IT personnel ɸ4 (-0.002), IT personnel expenses ɸ5 (-0.0005), ATM expenses ɸ7 (-0.019) and credit card expenses ɸ9 (-0.025) were negatively significant for the cost efficiency of state-owned commercial bank. Besides the IT personnel expenses ɸ5 (0.0015) and credit card transaction ɸ8 (0.00008) were positively significant and IT Investment ɸ3 (-0.00007) and IT personnel ɸ4 (0.0007) were negatively significant for the profit efficiency of the private commercial bank. Also, the IT expenses ɸ1 (-0.000002), ATM transaction ɸ6 (-0.00002) and ATM expenses ɸ7 (-0.0002) had a negative impact on the profit efficiency of private commercial banks.

Table-5. 17: IT Determinant of Profit Efficiency of Data Envelopment Analysis for State-owned and Private Commercial Banks by Estimating Ordinary Least Square Model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Profit efficiency | | State-owned commercial bank | | Private commercial bank | |
| Variable | Parameter | Coefficient | P-Value | Coefficient | P-Value |
| Intercept | ɸ0 | 0.220 | 0.026 | 0.078\*\* | 0.001 |
| IT.Expenses | ɸ1 | 0.0002 | 0.8568 | -0.000002 | 0.956 |
| IT.Income | ɸ2 | -0.0004 | 0.7735 | 0.00006 | 0.456 |
| IT.Investment | ɸ3 | -0.0002 | 0.2889 | -0.00007\*\* | 0.003 |
| IT personnel | ɸ4 | -0.002 | 0.3214 | -0.0007\* | 0.031 |
| IT Personnel Expenses | ɸ5 | -0.0005 | 0.6469 | 0.0015\*\*\* | 0.000 |
| ATM.Transaction | ɸ6 | 0.0010 | 0.116 | -0.00002 | 0.373 |
| ATM.Expenses | ɸ7 | -0.019 | 0.0645 | -0.0002 | 0.311 |
| Credit.Card.Transaction | ɸ8 | 0.000 | 0.3143 | 0.00008\*\*\* | 0.000 |
| Credit.Card.Expenses | ɸ9 | -0.025 | 0.2321 | -0.0001 | 0.049 |

## **5.5 Comparison: Bank-wise and Year wise Cost Efficiency and Profit Efficiency with DEA and SFA**

### 5.5.1: Bank-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for State-owned Commercial Bank

The average cost and profit efficiency scores of individual state-owned commercial banks by Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysisis reported in Table-5.18. In Cobb-Douglas Stochastic Frontier Analysis model confirms that throughout, state-owned banks were more cost efficient rather than profit efficiency. The Janata bank was the most cost & profit efficient among the other banks with an average efficiency score of 62.8% and 38.4% respectively. Besides Sonali bank was the second cost efficient (51.7%) and profit efficient (26.4%) and Rupali bank was the less cost and profit efficient with the score of 63.2% and 18.2% respectively. In Translog Stochastic Frontier Analysis model implies state-owned banks were 81.3% cost efficient and 84.4% profit efficient implies that with the same resources, these banks were able to more cost efficient to increase efficiency by 18.7% and 15.4% more profit efficient by choosing optimum quantities and input prices. The Janata bank was the most efficient among the other banks with an average cost and profit efficiency score of 90% and 89.5% respectively. Besides Rupali bank was the second cost inefficient (89%) and profit efficient (84%) and Sonali bank was the less cost and profit efficient with the score of 63.8% and 79.7% respectively. In the VRS- Data Envelopment Analysis model, the bank-wise average cost and profit efficiency scores were 74.5% and 20.6%. These results show that Rupali bank was the most cost with the efficiency score of 91.6% where Sonali bank was the less cost efficient with the efficiency score of 59%. Conversely, Sonali bank was the most profit efficient bank with an efficiency score of 30.7% and Rupali bank was the less profit efficient with the efficiency score of 14.9% respectively. These results are supported by (Aiello & Bonanno ; 2013 , Dong, et. al. ; 2013) and contradicted by the (Fiorentino, et al.; 2006)

Table-5. 18: Bank-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for State-owned Commercial Bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Banks Name | Cobb-Douglas | | Translog | | VRS-DEA | |
| Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency |
| Rupali | 0.632 | 0.182 | 0.89 | 0.84 | 0.916 | 0.149 |
| Sonali | 0.517 | 0.264 | 0.638 | 0.797 | 0.590 | 0.307 |
| Janata | 0.628 | 0.384 | 0.90 | 0.895 | 0.724 | 0.162 |
| Mean | 0.593 | 0.276 | 0.813 | 0.844 | 0.745 | 0.206 |

### 5.5.2: Bank-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for Private Commercial Bank

The average cost and profit efficiency scores of individual private commercial banks by Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis is reported in Table 5.19. As presented the result, In Cobb-Douglas SFA model, we had IBBL was the most profit efficient with an average efficiency score of 73.8% conversely and the Brac bank was the most cost efficient bank with an average efficiency score of 89.3% among the other banks. Besides DBBL was the less cost efficient (34.1%) and Al- arafah was the less profit efficient (37%) respectively. Furthermore, the southeast, Al-arafah, brace, and the prime bank has 60% above profit efficiency scores and the Mercantile, One, Southeast, Eastern, IBBL has cost efficiency scores more 70%. This result confirms that over the period of estimation, the majority of the private commercial banks were around 40% to 50% regarding profit efficiency and around 60% to 70% in terms of cost efficiency. In Translog SFA model, IBBL was the most cost-efficient with an average efficiency score of 82.4% and conversely, the southeast and eastern banks were the most profit efficient bank with an average efficiency score of 68% among the other banks. Besides Exim bank was the less cost efficient (31.1%) and Mercantile was the less profit efficient (33.3%) respectively. Furthermore, the IBBL and the Prime bank had 60% above profit efficiency scores and the Brac, Mercantile, One, Prime, premier, and Shahjalal banks had cost efficiency scores more 70%. This result confirms that over the period of estimation, the majority of the private commercial banks were around 40% to 50% regarding profit efficiency and around 60% to 70% in terms of cost efficiency. In the Data Envelopment Analysis model, the bank-wise average cost and profit efficiency scores were 41.4% and 18.2% respectively. These results show that prime bank was the most cost and profit efficient bank with an efficiency score of 71.3% and 53.7% respectively. Moreover, the Mercantile bank was the second cost (64.5%) and profit efficient (35.8%). Besides DBBL bank was the less cost efficient (22.3%) and Al-arafah was the less profit efficient (2.6%) respectively. Furthermore, the IBBL and the Premium bank had 50% above cost efficiency scores but the majority of the private commercial banks were around 20% to 40% regarding cost efficiency and around 10% to 20% in terms of profit efficiency. These results are supported by (Baten ; 2015) who showed that SFA result was better than DEA.

Table-5. 19: Bank-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for Private Commercial Bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Banks Name | Cobb-Douglas | | Translog | | VRS-DEA | |
| Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency |
| DBBL | 0.618 | 0.341 | 0.552 | 0.389 | 0.223 | 0.162 |
| Brack | 0.893 | 0.549 | 0.712 | 0.678 | 0.251 | 0.201 |
| City | 0.668 | 0.489 | 0.675 | 0.514 | 0.38 | 0.106 |
| Marchentile | 0.712 | 0.336 | 0.727 | 0.333 | 0.645 | 0.358 |
| Mutual | 0.473 | 0.398 | 0.527 | 0.397 | 0.357 | 0.199 |
| One | 0.746 | 0.425 | 0.714 | 0.477 | 0.425 | 0.101 |
| Premium | 0.678 | 0.463 | 0.703 | 0.406 | 0.513 | 0.108 |
| Prime | 0.694 | 0.591 | 0.721 | 0.628 | 0.713 | 0.537 |
| Southeast | 0.797 | 0.691 | 0.66 | 0.68 | 0.468 | 0.215 |
| Eastern | 0.738 | 0.717 | 0.779 | 0.68 | 0.378 | 0.212 |
| UCB Limited | 0.613 | 0.455 | 0.590 | 0.585 | 0.439 | 0.167 |
| IFIC | 0.588 | 0.449 | 0.663 | 0.482 | 0.314 | 0.162 |
| IBBL | 0.726 | 0.738 | 0.824 | 0.674 | 0.528 | 0.133 |
| Al-arafah | 0.374 | 0.608 | 0.461 | 0.566 | 0.318 | 0.026 |
| Social | 0.823 | 0.486 | 0.88 | 0.507 | 0.401 | 0.172 |
| Exim | 0.393 | 0.428 | 0.311 | 0.567 | 0.313 | 0.116 |
| Shahjalal | 0.658 | 0.426 | 0.761 | 0.595 | 0.374 | 0.111 |
| Mean | 0.658 | 0.505 | 0.662 | 0.539 | 0.414 | 0.182 |

### 5.5.3: Year-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for State-owned Commercial Bank

The average cost and profit efficiency scores of individual state-owned commercial banks by Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysisis reported in Table-5.20. As can be seen that the average profit efficiency was 27.6% less than the average cost efficiency of 59.2% in Cobb-Douglas Cost and Profit Frontier Analysis and it was fluctuated year by year in both cases of cost and profit. The profit efficiency of state banks was recorded 20% to 40% in the year 2008-2010, and then it attained the peak percentage amount of 60.6% in 2012. After that, it dramatically fell by 16.7% in 2013 which was the lowest percentage over the study period. Next year it has been slightly increased by 6%. Finally, it was observed that they again attained a slow upward trend of around 17%to20% until 2017. The cost efficiencies were around 53%to60% from 2007-2010, then it declined dramatically at the percentage of 38.4% of the year 2011 after then it increased over the period and the highest cost efficiency level was 71.5% in 2016. Besides, it is observed that the average cost efficiency of 81.3% was less than the average profit efficiency of 84.4% in Translog Stochastic Cost and Profit Frontier Analysis and they have fluctuated year by year in both cases of cost and profit. The profit efficiency of state banks was recorded 80% to 90% from 2007 to 2014, and then it fell dramatically at 63.7% in2015. After then again it went up at 80% in 2016 and last year of the study period it declined by 10%. Conversely, at the beginning of the study period, the cost efficiencies were 80.6% then it decreased slightly in the next two year at 76.4% to 68.4% respectively after then it rose just over 90% from 2013-2014, and again it has been slightly decreased by 88.4% in 2015. Finally, it has been an upward trend for the last three years and it attained the peak percentage amount of 98.4% in 2017. Moreover, the average cost efficiency (74.4) was higher than profit efficiency (20.6%) score implies that state-owned commercial banks were more cost-efficient and less profit efficient in data envelopment analysis model. These results show that the banks were 74% cost efficient in the year of 2008 and 2009 then it increased slightly at 1% to 5% until 2013 after then it fallen and steady at 65% on the next year. Finally, it increased dramatically at a percentage of 91.8% in the last year. On the other hand, the profit efficiency scores were very low during the study period. In these years 2010, 2014 and 2016, the profit efficiency score had 30% above. Otherwise the rest of the years, the bank had 10% to 20% profit efficiency score. This result supports (Ariff and Can ; 2008, Aiello & Bonanno; 2013) and contradicts (Kasman and Yildirim; 2006, Baten; 2013, Ara ;2016, Ngan,2014).

Table-5. 20: Year-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for State-owned Commercial Bank

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Cobb-Douglas | | | Translog | | VRS-DEA | |
| Cost Efficiency | | Profit Efficiency | Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency |
| 2008 | 0.594 | 0.207 | | 0.806 | 0.881 | 0.749 | 0.106 |
| 2009 | 0.607 | 0.285 | | 0.764 | 0.954 | 0.743 | 0.179 |
| 2010 | 0.533 | 0.356 | | 0.619 | 0.886 | 0.752 | 0.301 |
| 2011 | 0.384 | 0.384 | | 0.543 | 0.938 | 0.767 | 0.177 |
| 2012 | 0.472 | 0.606 | | 0.684 | 0.928 | 0.757 | 0.179 |
| 2013 | 0.571 | 0.167 | | 0.938 | 0.778 | 0.793 | 0.087 |
| 2014 | 0.711 | 0.236 | | 0.928 | 0.918 | 0.658 | 0.344 |
| 2015 | 0.707 | 0.178 | | 0.884 | 0.636 | 0.654 | 0.156 |
| 2016 | 0.715 | 0.142 | | 0.974 | 0.810 | 0.67 | 0.376 |
| 2017 | 0.630 | 0.202 | | 0.984 | 0.708 | 0.918 | 0.159 |
| Mean | 0.592 | 0.276 | | 0.813 | 0.844 | 0.744 | 0.206 |

### 5.5.4: Year-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for Private Commercial Bank

The average cost and profit efficiency scores of individual private commercial banks by Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysisis reported in Table-5.21. It is observed that the average cost efficiency of 65.8% was greater than the average profit efficiency of 50.5% in Cobb-Douglas Frontier Analysis. Also, it may be viewed that they were varied year by year in both cases of cost and profit. The profit efficiency of private commercial banks was recorded 40% in the year of 2008, and then slightly decreased at 31.7% in the next year. After then it remained constant at 47% in 2011 and 2012. Again it declined slowly and after 2014 it was gradually increasing and reaches the highest value at 66.7% in the last year of 2017. Conversely, the cost efficiencies were around 49.9 %-74.4% from 2007-2014, and it attained the peak percentage amount of 74.8% in 2013. After that, it has been a little drop of 71.5% in 2015 and 2016. In the last year of the study period, it has been slightly increased by 73.1% over the study period. Besides, the average cost efficiency of 66.3% was much than the average profit efficiency of 53.9% in Translog Stochastic Frontier Analysis. In 2007, the profit efficiency score of private commercial banks were 50%, and then it decreased moderately at 32.8% in the next year. After then it remained 50% in 2011 and 2012. Again it declined slowly at 407% and finally, it was an upward trend and reaches the highest value at 66.7% in the last year of 2017. On the other hand, the cost efficiencies were around 51.1 % to 72.1% from 2008 -2013, and then it has been slightly decreased by 71.2 %. After then, it remained steady at 70.1% in 2015 and 2016. In the last year of the study period, it was a little drop of 69.8% . Moreover, the average cost efficiency (41.4%) was higher than profit efficiency (18.8%) score implies that state-owned commercial banks were more cost-efficient and less profit efficient in Data Envelopment Analysis. . These results show that the banks are 55.6% highest cost efficient in the year of 2008 and then it decreased gradually at 44% to 28.7% until 2012, and after then it increased 40.2% in 2013 and next year it fell and finally it rose at 50% on the last year. Contrarily, the profit efficiency scores were very low and the profit efficiency score had 20% below during the study period. The highest profit efficiency score was 31.1% in the last year. This study is supported by (Casu and Girardone ; 2004, Gulati & Kumar ; 2016 , Baten ; 2013, Ara; 2016, Hasan & Hasan ; 2018 ).

Table-5. 21: Year-wise Cost and Profit Efficiency of Cobb-Douglas, Translog Stochastic Frontier Analysis and VRS- Data Envelopment Analysis for Private Commercial Bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | Cobb-Douglas | | Translog | | VRS-DEA | |
| Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency | Cost Efficiency | Profit Efficiency |
| 2008 | 0.499 | 0.454 | 0.518 | 0.503 | 0.556 | 0.144 |
| 2009 | 0.530 | 0.319 | 0.559 | 0.328 | 0.440 | 0.135 |
| 2010 | 0.567 | 0.470 | 0.643 | 0.545 | 0.450 | 0.167 |
| 2011 | 0.643 | 0.471 | 0.676 | 0.512 | 0.329 | 0.18 |
| 2012 | 0.690 | 0.468 | 0.694 | 0.510 | 0.287 | 0.164 |
| 2013 | 0.748 | 0.444 | 0.721 | 0.473 | 0.402 | 0.145 |
| 2014 | 0.744 | 0.566 | 0.712 | 0.600 | 0.374 | 0.154 |
| 2015 | 0.715 | 0.578 | 0.701 | 0.620 | 0.383 | 0.177 |
| 2016 | 0.715 | 0.615 | 0.704 | 0.631 | 0.414 | 0.223 |
| 2017 | 0.731 | 0.667 | 0.698 | 0.664 | 0.505 | 0.311 |
| Mean | 0.658 | 0.505 | 0.663 | 0.539 | 0.414 | 0.18 |

## **5.6 Conclusion**

This study concentrated on banking efficiency measurement by two methods such as Stochastic Frontier Analysis for parametric method and data envelopment analysis for non-parametric method. Also, Tobbit regression and OLS model are used for analyzing the impact of ICT factor on cost and profit efficiency of banks in Bangladesh. The empirical result depict that state-owned commercial banks were more cost and profit efficient rather than private commercial banks. Besides Translog stochastic frontier model were more preferable than cobb-Douglas stochastic frontier model. Further stochastic frontier analysis given better result than data envelopment analysis. Finally, the ICT component had great impact on the private commercial banks.

# CHAPTER SIX

# SUMMARY OF FINDINGS

# 6.0 Introduction

In the context of this research, the cost and profit efficiency are examined for the state-owned commercial banks and private commercial banks in Bangladesh employing a panel set of data. This study includes 3 state-owned commercial banks and 17 private commercial banks during 2008-2017. Both parametric (stochastic frontier analysis) and nonparametric (data envelopment analysis) techniques are applied to examine the efficiency of banks. For stochastic frontier analysis, the Cobb-Douglas and Translog model are used uniquely for estimating cost and profit efficiency. Also, the VRS cost and profit model are used for data envelopment analysis. Then the IT components are assessed using a Tobit regression model for stochastic Cobb-Douglas and Trans-log function. Also, the Tobit regression model is used for finding the IT determinant of VRS cost model in data envelopment analysis. But the Tobit regression model could not apply for estimating the IT determinant of VRS profit model for data envelopment analysis because the Tobit model is used when the dependent variable was bounded [ 0,1]. So the ordinary least square method is employed for VRS profit data envelopment analysis model to determine the IT factor. The most important results are summarized as follows: Section 6.1 illustrates the findings of Cobb-Douglas Stochastic Cost and Profit Frontier Model, Section 6.2 discusses the findings of SFA Translog Cost and Profit Frontier Model, Section 6.3 demonstrates the findings of VRS DEA Cost and Profit Model, Section 6.4 explains the findings of Tobit Regression Model, Section 6.5 illustrates the findings of OLS Model in case of profit efficiency of VRS-DEA Model, Research Contribution and Recommendationare described in Section 6.6 and the final section explains concluding remarks.

## **6.1 Findings of Cobb-Douglas Stochastic Cost and Profit Frontier Models**

* The maximum likelihood estimates were found for efficiency and inefficiency part using Cobb-Douglas stochastic frontier analysis.
* In the state-owned commercial banks, the average cost efficiency was 59.2% whereas the average profit efficiency was 27.6% during the study period. In 2016, the cost efficiency level was high at 71.5% and the highest profit efficiency was 60.6% in 2012.
* In the state-owned commercial banks, the Janata bank was the most cost & profit efficient with an average efficiency score of 62.8% and 38.4% respectively and Rupali bank was the less cost and profit efficient with the score of 63.2% and 18.2% respectively.
* In the private commercial banks, the average cost efficiency score was 65.8% and the average profit efficiency score was 50.5%.
* In the private commercial banks, IBBL was the most profit efficient with an average efficiency score of 73.8% and the Brac bank was the most cost efficient bank with an average efficiency score of 89.3%, Al-arafah was the less cost efficient (37.4%) and mercantile bank was the less profit efficient (33.6%) respectively.

## **6.2 Findings of SFA Translog Cost and Profit Model**

* The maximum likelihood estimates were found for efficiency and inefficiency part using Cobb-Douglas stochastic frontier analysis.
* The average cost efficiency was 81.3% and the average profit efficiency was 84.4% for state-owned banks. The highest level of profit efficiency was in 2009 by 95.4% and in 2017, the banks were the most cost efficient at the score of 98.4%.
* For state-owned banks, the Janata bank was the most cost and profit efficient bank with an average cost and profit efficiency score of 90% and 89.5% respectively. Sonali bank was the less cost and profit efficient with a score of 63.8% and 79.7% respectively.
* In the private commercial bank, the average cost efficiency score was 66.3% and the average profit efficiency score was 53.9%.
* Social Islami bank was the most cost-efficient with an average efficiency score of 88% and the southeast and eastern banks were the most profit efficient bank with an average efficiency score of 68%. Exim bank was the less cost efficient (31.1%) and Mercantile bank was the less profit efficient (33.3%) respectively.
* Translog Stochastic Frontier model was found more preferable than the Cobb-Douglas Stochastic Frontier model.

## **6.3 Findings of VRS DEA Cost and Profit Model**

* Among state-owned banks, the average technical, allocative and cost efficiency scores were 81.4%, 91.8%, and 74.4% respectively.
* The average cost efficiency score (41.4%) was higher than profit efficiency (18.8%) score for state-owned commercial banks.
* Rupali bank was the most cost efficient with the efficiency score of 91.6% where Sonali bank was the less cost efficient with the efficiency score of 59%. Sonali bank was the most profit efficient bank with an efficiency score of 30.7% and Rupali bank was the less profit efficient with the efficiency score of 14.9% respectively.
* On the private commercial banks, the average technical, allocative and cost efficiency scores were 41.4%, 59.5%, and 92% respectively.
* In the Private Commercial Banks, the average cost efficiency score (41.4%) was higher than profit efficiency (18.8%) score.
* Prime bank was the most cost and profit efficient bank with an efficiency score of 71.3% and 53.7% respectively. Besides DBBL bank was the less cost efficient (16.2%) and Al-arafah was the less profit efficient (2.6%) respectively.

## **6.4 Findings of Tobitt Regression Model**

* The ICT factors had a more positive impact on the private commercial bank rather than the state-owned commercial banks.
* There were no significant IT variable for the cost and profit efficiency of Stochastic Translog frontier Model for State-owned Commercial Banks but The IT expenses ɸ1 (-0.0003), IT personnel expanses ɸ5 (-0.002), ATM expenses ɸ7 (-0.008) and credit card transaction ɸ8 (-0.0004) had a negative impact on the cost efficiency of state-owned commercial banks. Also, the IT income ɸ2 (-0.0008), IT investment ɸ3 (-0.00009), IT personnel ɸ4 (-0.002), ATM transaction ɸ6 (-0.0003) had a negative impact on the profit efficiency of state-owned commercial banks.
* In IT determinant of cost and profit efficiency of Stochastic Translog cost and profit frontier model for private commercial banks, the IT personnel expenses ɸ5 (0.0006) and credit card transaction ɸ8 (0.000006) were positively significant but IT income ɸ2(-0.0002) and credit card expenses ɸ9(-0.0001) are negatively significant for the cost efficiency of private commercial banks. On the contrary, the IT investment ɸ3 (-0.000008), and credit card expenses ɸ9 (-0.0000007) were found negatively significant IT variable for the profit efficiency of Stochastic Translog profit frontier model.
* The IT personnel expanses ɸ5 (-0.002) was negatively significant for the cost efficiency of stochastic Cobb-Douglas cost frontier model of the state-owned commercial bank. On the other hand, the IT personnel expanses ɸ5 (-0.0015) was positively significant on the profit efficiency of Stochastic Cobb-Douglas profit frontier model for state-owned commercial banks.
* The IT income ɸ2 (-0.00018) and credit card expanses ɸ9 (-0.00013) were negatively significant for the cost efficiency of the Stochastic Cobb-Douglas cost frontier model. In IT determinant profit efficiency of Stochastic Cobb-Douglas profit frontier model, the IT investment ɸ3 (-0.0003), IT income ɸ2 (-0.0032), IT personnel ɸ4(-0.004), and ATM transaction ɸ6 (-0.0008) were negatively significant for the profit efficiency but the IT personnel expenses ɸ5(0.0018) and Credit Card Transaction ɸ8 (0.0013) were positively significant.
* In IT determinant of cost and profit efficiency of Data Envelopment Analysis model for state-owned and private commercial banks, the IT Investment ɸ3 (0.00032) and IT personnel expanses ɸ5 (-0.00154) have found positively significant for the cost efficiency of state-owned commercial bank. Also, the ATM transaction ɸ6 (-0.0012) was negatively significant on the cost efficiency of the state-owned commercial banks. In IT determinant of profit efficiency of Data Envelopment Analysis, the IT personnel ɸ4 (-0.0009) was negatively significant and credit card transaction ɸ8 (0.000006) and credit card expenses ɸ9 (0.0002) were positively significant for the cost efficiency of the private commercial bank.

## **6.5 Findings of OLS Model in Case of Profit Efficiency of VRS-DEA**

Since the profit efficiency score is negative so in case of profit efficiency of VRS data envelopment analysis we analyzed the impact of ICT factor by the ordinary least square method. The IT factors are found more significant for the private commercial bank rather than the state owned banks. On the other hand, this study has not found any significant estimates for the profit efficiency of Data Envelopment Analysis model for state-owned commercial banks but the IT personnel expenses ɸ5 (0.0015) and credit card transaction ɸ8 (0.00008) were positively significant and IT Investment ɸ3 (-0.00007) and IT personnel ɸ4 (0.00007) were found negatively significant for the profit efficiency of private commercial bank.

## **6.6 Research Contribution and Recommendation**

This study identified the most efficient method to observe the cost and profit efficiency methods of banks in Bangladesh. Also, this research builds a new measure of efficiency because this study employs the huge ICT data for measuring the impact of ICT component on cost and profit efficiency of Bangladesh banking industry using Tobit Regression Model which is different from other studies. This research emphasized a unique data set for the different part of DEA, SFA, Tobit Regression and OLS method analysis. Therefore, in an advance study, the cost and profit efficiency will be analyzed with two methods combination as if (DEA and SFA). However, to do this research, the private commercial banking system has to be internally efficient and technologically advanced. The information obtained from efficiency studies can be used to help government, regulators, and investors to remove the hindrance of progress in economy of Bangladesh.

## **6.7 Conclusion**

The main aim of this study was to determine the impact of ICT factor on cost and profit efficiency of Bangladesh banks. For this purpose, we concentrated on two methods, SFA and DEA and to identify the most efficient method to measure cost and profit efficiency on sample data of Bangladesh banks .Then the Tobit Regression Model was used for Cobb-Douglas, Translog stochastic frontier analysis, and VRS cost minimization data envelopment analysis. OLS method was used for only profit DEA model. This type of empirical analysis could be applied to another sector of the economic market.

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# APENDIX

**Table –1: Year-wise Average Cost and Profit Efficiency of State-owned Bank using Cobb-Douglas Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.594 | 0.207 |
| 2009 | 0.607 | 0.285 |
| 2010 | 0.533 | 0.356 |
| 2011 | 0.384 | 0.384 |
| 2012 | 0.472 | 0.606 |
| 2013 | 0.571 | 0.167 |
| 2014 | 0.711 | 0.236 |
| 2015 | 0.707 | 0.178 |
| 2016 | 0.715 | 0.142 |
| 2017 | 0.630 | 0.202 |
| Mean | 0.592 | 0.276 |

**Table-2: Year-wise Average Cost and Profit Efficiency of Private Commercial Bank for Stochastic Cobb-Douglas Frontier Model**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.499 | 0.454 |
| 2009 | 0.530 | 0.319 |
| 2010 | 0.567 | 0.470 |
| 2011 | 0.643 | 0.471 |
| 2012 | 0.690 | 0.468 |
| 2013 | 0.748 | 0.444 |
| 2014 | 0.744 | 0.566 |
| 2015 | 0.715 | 0.578 |
| 2016 | 0.715 | 0.615 |
| 2017 | 0.731 | 0.667 |
| Mean | 0.658 | 0.505 |

**Table- 3: Bank-wise Average Cost and Profit Efficiency of State-owned Banks using Cobb-Douglas Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Bank Name | Cost Efficiency | Profit Efficiency |
| Rupali | 0.632 | 0.182 |
| Sonali | 0.517 | 0.264 |
| Janata | 0.628 | 0.384 |
| Mean | 0.593 | 0.276 |

**Table 4: Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Cobb-Douglas Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Bank Name | Cost Efficiency | Profit Efficiency |
| DBBL | 0.618 | 0.341 |
| Brac | 0.893 | 0.549 |
| City | 0.668 | 0.489 |
| Mercantile | 0.712 | 0.336 |
| Mutual | 0.473 | 0.398 |
| One | 0.746 | 0.425 |
| Premium | 0.678 | 0.463 |
| Prime | 0.694 | 0.591 |
| Southeast | 0.797 | 0.691 |
| Eastern | 0.738 | 0.717 |
| UCB Limited | 0.613 | 0.455 |
| IFIC | 0.588 | 0.449 |
| IBBL | 0.726 | 0.738 |
| Al-arafah | 0.374 | 0.608 |
| Social | 0.823 | 0.486 |
| Exim | 0.393 | 0.428 |
| Shahjalal | 0.658 | 0.426 |
| Mean | 0.658 | 0.505 |

**Table-5: Cost Efficiency Estimates of State-owned Commercial Banks over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 0.922 | 0.952 | 0.845 | 0.589 | 0.591 | 0.531 | 0.451 | 0.451 | 0.480 | 0.509 |
| Sonali | 0.282 | 0.318 | 0.302 | 0.176 | 0.162 | 0.719 | 0.801 | 0.844 | 0.878 | 0.692 |
| Janata | 0.579 | 0.55 | 0.453 | 0.387 | 0.661 | 0.463 | 0.879 | 0.826 | 0.787 | 0.691 |

**Table-6: Cost Efficiency Estimates of Private Commercial Banks over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | 0.368 | 0.414 | 0.467 | 0.629 | 0.778 | 0.829 | 0.825 | 0.558 | 0.613 | 0.653 |
| Brac | 0.666 | 0.719 | 0.723 | 0.793 | 0.811 | 0.848 | 0.854 | 0.886 | 0.874 | 0.913 |
| City | 0.443 | 0.445 | 0.502 | 0.627 | 0.766 | 0.886 | 0.702 | 0.688 | 0.698 | 0.765 |
| Mercantile | 0.877 | 0.924 | 0.922 | 0.638 | 0.563 | 0.812 | 0.815 | 0.608 | 0.492 | 0.365 |
| Mutual | 0.230 | 0.265 | 0.339 | 0.461 | 0.501 | 0.552 | 0.551 | 0.576 | 0.573 | 0.547 |
| One | 0.712 | 0.701 | 0.770 | 0.774 | 0.779 | 0.787 | 0.665 | 0.635 | 0.773 | 0.744 |
| Premium | 0.525 | 0.531 | 0.198 | 0.878 | 0.819 | 0.848 | 0.717 | 0.643 | 0.615 | 0.808 |
| Prime | 0.362 | 0.490 | 0.578 | 0.604 | 0.704 | 0.792 | 0.827 | 0.853 | 0.825 | 0.831 |
| Southeast | 0.706 | 0.772 | 0.846 | 0.794 | 0.795 | 0.804 | 0.794 | 0.779 | 0.713 | 0.780 |
| Eastern | 0.621 | 0.613 | 0.651 | 0.601 | 0.754 | 0.691 | 0.769 | 0.799 | 0.843 | 0.841 |
| UCB Limited | 0.357 | 0.387 | 0.469 | 0.542 | 0.602 | 0.808 | 0.689 | 0.707 | 0.698 | 0.706 |
| IFIC | 0.426 | 0.408 | 0.518 | 0.571 | 0.642 | 0.596 | 0.646 | 0.608 | 0.647 | 0.594 |
| IBBL | 0.469 | 0.484 | 0.570 | 0.662 | 0.730 | 0.792 | 0.782 | 0.803 | 0.864 | 0.861 |
| Al-arafah | 0.192 | 0.230 | 0.276 | 0.283 | 0.369 | 0.404 | 0.439 | 0.461 | 0.439 | 0.502 |
| Social | 0.898 | 0.875 | 0.855 | 0.864 | 0.909 | 0.798 | 0.934 | 0.924 | 0.909 | 0.918 |
| Exim | 0.213 | 0.219 | 0.278 | 0.368 | 0.319 | 0.436 | 0.476 | 0.519 | 0.494 | 0.469 |
| Shahjalal | 0.263 | 0.389 | 0.474 | 0.601 | 0.609 | 0.807 | 0.908 | 0.858 | 0.853 | 0.892 |

**Table-7: Profit Efficiency Estimates of State-owned Commercial Banks Over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 0.157 | 0.282 | 0.336 | 0.416 | 0.345 | 0.162 | 0.165 | 0.154 | 0.045 | 0.087 |
| Sonali | 0.194 | 0.117 | 0.227 | 0.372 | 0.998 | 0.092 | 0.208 | 0.079 | 0.113 | 0.271 |
| Janata | 0.297 | 0.516 | 0.596 | 0.453 | 0.494 | 0.221 | 0.341 | 0.311 | 0.274 | 0.268 |

**Table-8: Profit Efficiency Estimates of Private Commercial Banks Over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | 0.908 | 0.043 | 0.252 | 0.299 | 0.352 | 0.240 | 0.303 | 0.486 | 0.171 | 0.348 |
| Brac | 0.285 | 0.325 | 0.406 | 0.162 | 0.688 | 0.508 | 0.641 | 0.689 | 0.839 | 0.940 |
| City | 0.022 | 0.098 | 0.496 | 0.636 | 0.205 | 0.240 | 0.666 | 0.785 | 0.883 | 0.851 |
| Mercantile | 0.888 | 0.947 | 0.006 | 0.018 | 0.102 | 0.265 | 0.055 | 0.121 | 0.381 | 0.573 |
| Mutual | 0.792 | 0.152 | 0.247 | 0.058 | 0.090 | 0.305 | 0.455 | 0.506 | 0.651 | 0.724 |
| One | 0.621 | 0.837 | 0.221 | 0.119 | 0.029 | 0.207 | 0.586 | 0.443 | 0.527 | 0.656 |
| Premium | 0.074 | 0.108 | 0.469 | 0.961 | 0.991 | 0.136 | 0.221 | 0.254 | 0.607 | 0.802 |
| Prime | 0.068 | 0.464 | 0.553 | 0.705 | 0.731 | 0.691 | 0.827 | 0.625 | 0.644 | 0.601 |
| Southeast | 0.409 | 0.498 | 0.705 | 0.514 | 0.515 | 0.905 | 0.921 | 0.864 | 0.845 | 0.731 |
| Eastern | 0.124 | 0.136 | 0.656 | 0.788 | 0.726 | 0.941 | 0.979 | 0.994 | 0.898 | 0.927 |
| UCB Limited | 0.968 | 0.012 | 0.425 | 0.467 | 0.406 | 0.489 | 0.357 | 0.397 | 0.526 | 0.493 |
| IFIC | 0.786 | 0.154 | 0.949 | 0.932 | 0.041 | 0.094 | 0.147 | 0.999 | 0.067 | 0.318 |
| IBBL | 0.401 | 0.715 | 0.820 | 0.748 | 0.855 | 0.825 | 0.734 | 0.623 | 0.807 | 0.846 |
| Al-arafah | 0.069 | 0.144 | 0.435 | 0.656 | 0.679 | 0.741 | 0.770 | 0.792 | 0.911 | 0.882 |
| Social | 0.852 | 0.034 | 0.169 | 0.243 | 0.476 | 0.304 | 0.624 | 0.689 | 0.766 | 0.699 |
| Exim | 0.368 | 0.518 | 0.593 | 0.269 | 0.315 | 0.254 | 0.428 | 0.366 | 0.546 | 0.633 |
| Shahjalal | 0.074 | 0.242 | 0.586 | 0.425 | 0.741 | 0.406 | 0.902 | 0.194 | 0.377 | 0.313 |

**Table 9: Year-wise Average Cost and Profit Efficiency of State-owned Commercial Bank using Trans-Log Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.806 | 0.881 |
| 2009 | 0.764 | 0.954 |
| 2010 | 0.619 | 0.886 |
| 2011 | 0.543 | 0.938 |
| 2012 | 0.684 | 0.928 |
| 2013 | 0.938 | 0.778 |
| 2014 | 0.928 | 0.918 |
| 2015 | 0.884 | 0.636 |
| 2016 | 0.974 | 0.810 |
| 2017 | 0.984 | 0.708 |
| Mean | 0.813 | 0.844 |

**Table 10: Year-wise Average Cost and Profit Efficiency of Private Commercial Bank using Trans-Log Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.518 | 0.503 |
| 2009 | 0.559 | 0.328 |
| 2010 | 0.643 | 0.545 |
| 2011 | 0.676 | 0.512 |
| 2012 | 0.694 | 0.510 |
| 2013 | 0.721 | 0.473 |
| 2014 | 0.712 | 0.600 |
| 2015 | 0.701 | 0.620 |
| 2016 | 0.704 | 0.631 |
| 2017 | 0.698 | 0.664 |
| Mean | 0.663 | 0.539 |

**Table -11 Bank-wise Average Cost and Profit Efficiency of State-owned Commercial Banks for Translog Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Bank Name | Cost Efficiency | Profit Efficiency |
| Rupali | 0.89 | 0.84 |
| Sonali | 0.638 | 0.797 |
| Janata | 0.90 | 0.895 |
| Mean | 0.813 | 0.844 |

**Table-12: Bank-wise Average Cost and Profit Efficiency of Private Commercial Banks using Trans-Log Stochastic Frontier Model**

|  |  |  |
| --- | --- | --- |
| Bank Name | Cost Efficiency | Profit Efficiency |
| DBBL | 0.552 | 0.389 |
| Brac | 0.712 | 0.678 |
| City | 0.675 | 0.514 |
| Mercantile | 0.727 | 0.333 |
| Mutual | 0.527 | 0.397 |
| One | 0.714 | 0.477 |
| Premium | 0.703 | 0.406 |
| Prime | 0.721 | 0.628 |
| Southeast | 0.66 | 0.68 |
| Eastern | 0.779 | 0.68 |
| UCB Limited | 0.590 | 0.585 |
| IFIC | 0.663 | 0.482 |
| IBBL | 0.824 | 0.674 |
| Al-arafah | 0.461 | 0.566 |
| Social | 0.88 | 0.507 |
| Exim | 0.311 | 0.567 |
| Shahjalal | 0.761 | 0.595 |
| Mean | 0.662 | 0.539 |

**Table-13: Cost Efficiency Estimates of State-owned Commercial Banks over Time using Translog Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 0.975 | 0.999 | 0.888 | 0.785 | 0.999 | 0.925 | 0.789 | 0.692 | 0.943 | 0.998 |
| Sonali | 0.470 | 0.348 | 0.387 | 0.188 | 0.144 | 0.888 | 0.994 | 0.982 | 0.990 | 0.978 |
| Janata | 0.972 | 0.944 | 0.583 | 0.654 | 0.906 | 0.999 | 0.999 | 0.977 | 0.988 | 0.974 |

**Table-14: Cost Efficiency Estimates of Private Commercial Banks over Time using Translog Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | 0.396 | 0.431 | 0.556 | 0.643 | 0.748 | 0.784 | 0.605 | 0.413 | 0.472 | 0.472 |
| Brac | 0.467 | 0.545 | 0.600 | 0.856 | 0.717 | 0.630 | 0.694 | 0.840 | 0.866 | 0.917 |
| City | 0.546 | 0.592 | 0.642 | 0.757 | 0.790 | 0.868 | 0.650 | 0.638 | 0.615 | 0.648 |
| Mercantile | 0.822 | 0.900 | 0.920 | 0.653 | 0.595 | 0.782 | 0.804 | 0.641 | 0.662 | 0.491 |
| Mutual | 0.317 | 0.380 | 0.469 | 0.515 | 0.530 | 0.583 | 0.620 | 0.616 | 0.645 | 0.588 |
| One | 0.566 | 0.616 | 0.788 | 0.759 | 0.804 | 0.747 | 0.635 | 0.638 | 0.802 | 0.781 |
| Premium | 0.493 | 0.503 | 0.484 | 0.856 | 0.785 | 0.831 | 0.776 | 0.772 | 0.729 | 0.796 |
| Prime | 0.455 | 0.530 | 0.637 | 0.641 | 0.727 | 0.801 | 0.865 | 0.889 | 0.862 | 0.801 |
| Southeast | 0.441 | 0.550 | 0.662 | 0.706 | 0.675 | 0.697 | 0.704 | 0.740 | 0.673 | 0.744 |
| Eastern | 0.701 | 0.755 | 0.856 | 0.719 | 0.739 | 0.662 | 0.806 | 0.801 | 0.875 | 0.865 |
| UCB Limited | 0.402 | 0.459 | 0.535 | 0.620 | 0.635 | 0.771 | 0.654 | 0.721 | 0.534 | 0.567 |
| IFIC | 0.474 | 0.520 | 0.734 | 0.681 | 0.722 | 0.685 | 0.751 | 0.706 | 0.715637 | 0.642 |
| IBBL | 0.811 | 0.837 | 0.754 | 0.814 | 0.847 | 0.815 | 0.847 | 0.843 | 0.82934 | 0.838 |
| Al-arafah | 0.289 | 0.323 | 0.356 | 0.424 | 0.503 | 0.497 | 0.545 | 0.534 | 0.547785 | 0.591 |
| Social | 0.842 | 0.806 | 0.891 | 0.788 | 0.878 | 0.859 | 0.937 | 0.916 | 0.937 | 0.942 |
| Exim | 0.190 | 0.200 | 0.264 | 0.280 | 0.241 | 0.376 | 0.435 | 0.406 | 0.360 | 0.353 |
| Shahjalal | 0.590 | 0.552 | 0.769 | 0.766 | 0.857 | 0.858 | 0.769 | 0.789 | 0.836 | 0.823 |

**Table-15: Profit Efficiency Estimates of State-owned Commercial Banks over Time using Translog Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 0.84 | 0.927 | 0.867 | 0.945 | 0.908 | 0.837 | 0.903 | 0.654 | 0.798 | 0.708 |
| Sonali | 0.939 | 0.958 | 0.924 | 0.914 | 0.957 | 0.552 | 0.967 | 0.325 | 0.669 | 0.756 |
| Janata | 0.854 | 0.977 | 0.867 | 0.953 | 0.919 | 0.944 | 0.884 | 0.931 | 0.962 | 0.658 |

**Table-16: Profit Efficiency Estimates of Private Commercial Banks over Time using Translog Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | 0.988 | 0.051 | 0.283 | 0.379 | 0.438 | 0.111 | 0.384 | 0.613 | 0.210 | 0.425 |
| Brack | 0.232 | 0.321 | 0.957 | 0.229 | 0.804 | 0.751 | 0.846 | 0.892 | 0.878 | 0.868 |
| City | 0.020 | 0.097 | 0.533 | 0.844 | 0.225 | 0.201 | 0.680 | 0.739 | 0.866 | 0.933 |
| Marchentile | 0.813 | 0.969 | 0.006 | 0.021 | 0.114 | 0.263 | 0.073 | 0.140 | 0.387 | 0.537 |
| Mutual | 0.704 | 0.143 | 0.251 | 0.057 | 0.096 | 0.318 | 0.488 | 0.591 | 0.658 | 0.662 |
| One | 0.657 | 0.920 | 0.231 | 0.135 | 0.032 | 0.261 | 0.769 | 0.658 | 0.497 | 0.603 |
| Premium | 0.070 | 0.100 | 0.475 | 0.966 | 0.995 | 0.158 | 0.269 | 0.454 | 0.352 | 0.218 |
| Prime | 0.074 | 0.510 | 0.972 | 0.705 | 0.720 | 0.711 | 0.857 | 0.634 | 0.593 | 0.502 |
| Southeast | 0.423 | 0.533 | 0.748 | 0.572 | 0.512 | 0.914 | 0.888 | 0.815 | 0.767 | 0.622 |
| Eastern | 0.127 | 0.149 | 0.738 | 0.699 | 0.727 | 0.983 | 0.925 | 0.916 | 0.769 | 0.759 |
| UCB Limited | 0.932 | 0.012 | 0.518 | 0.533 | 0.467 | 0.789 | 0.485 | 0.445 | 0.863 | 0.792 |
| IFIC | 0.954 | 0.174 | 0.956 | 0.988 | 0.044 | 0.103 | 0.326 | 0.891 | 0.061 | 0.308 |
| IBBL | 0.342 | 0.611 | 0.679 | 0.644 | 0.785 | 0.842 | 0.781 | 0.631 | 0.667 | 0.754 |
| Al-arafah | 0.059 | 0.139 | 0.468 | 0.746 | 0.576 | 0.588 | 0.653 | 0.720 | 0.863 | 0.846 |
| Social | 0.685 | 0.035 | 0.193 | 0.388 | 0.684 | 0.302 | 0.590 | 0.736 | 0.751 | 0.701 |
| Exim | 0.512 | 0.735 | 0.892 | 0.440 | 0.492 | 0.248 | 0.418 | 0.428 | 0.725 | 0.772 |
| Shahjalal | 0.946 | 0.071 | 0.363 | 0.341 | 0.956 | 0.492 | 0.766 | 0.225 | 0.807 | 0.978 |

**Table-17: Year-wise Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.749 | 0.106 |
| 2009 | 0.743 | 0.179 |
| 2010 | 0.752 | 0.301 |
| 2011 | 0.767 | 0.177 |
| 2012 | 0.757 | 0.179 |
| 2013 | 0.793 | 0.087 |
| 2014 | 0.658 | 0.344 |
| 2015 | 0.654 | 0.156 |
| 2016 | 0.67 | 0.376 |
| 2017 | 0.918 | 0.159 |
| Mean | 0.744 | 0.206 |

**Table -18: Year-wise Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| 2008 | 0.556 | 0.144 |
| 2009 | 0.440 | 0.135 |
| 2010 | 0.450 | 0.167 |
| 2011 | 0.329 | 0.18 |
| 2012 | 0.287 | 0.164 |
| 2013 | 0.402 | 0.145 |
| 2014 | 0.374 | 0.154 |
| 2015 | 0.383 | 0.177 |
| 2016 | 0.414 | 0.223 |
| 2017 | 0.505 | 0.311 |
| Mean | 0.414 | 0.18 |

**Table-19: Bank-wise VRS Cost and Profit Efficiency of State-owned Commercial Bank using Data Envelopment Analysis**

|  |  |  |
| --- | --- | --- |
| Year | Cost Efficiency | Profit Efficiency |
| Rupali | 0.916 | 0.149 |
| Sonali | 0.590 | 0.307 |
| Janata | 0.724 | 0.162 |
| Mean | 0.745 | 0.206 |

**Table -20: Bank-wise VRS Cost and Profit Efficiency of Private Commercial Bank using Data Envelopment Analysis**

|  |  |  |
| --- | --- | --- |
| Bank | Cost Efficiency | Profit Efficiency |
| DBBL | 0.223 | 0.162 |
| Brac | 0.251 | 0.201 |
| City | 0.38 | 0.106 |
| Mercantile | 0.645 | 0.358 |
| Mutual | 0.357 | 0.199 |
| One | 0.425 | 0.101 |
| Premium | 0.513 | 0.108 |
| Prime | 0.713 | 0.537 |
| Southeast | 0.468 | 0.215 |
| Eastern | 0.378 | 0.212 |
| UCB Limited | 0.439 | 0.167 |
| IFIC | 0.314 | 0.162 |
| IBBL | 0.528 | 0.133 |
| Al-Arafah | 0.318 | 0.026 |
| Social | 0.401 | 0.172 |
| Exim | 0.313 | 0.116 |
| Shahjalal | 0.374 | 0.111 |
| Mean | 0.414 | 0.182 |

**Table- 21: Cost Efficiency Estimates of State-owned Commercial Banks over Time using Data Envelopment Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 1 | 0.922 | 0.860 | 0.870 | 0.887 | 0.885 | 0.891 | 0.905 | 0.946 | 1 |
| Sonali | 0.593 | 0.637 | 0.622 | 0.657 | 0.647 | 0.492 | 0.439 | 0.413 | 0.396 | 1 |
| Janata | 0.653 | 0.668 | 0.773 | 0.698 | 0.736 | 1 | 0.643 | 0.644 | 0.668 | 0.752 |

**Table-22: Cost Efficiency Estimates of Private Commercial Banks over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | 0.386 | 0.309 | 0.203 | 0.187 | 0.151 | 0.17 | 0.164 | 0.2 | 0.223 | 0.239 |
| Brac | 0.467 | 0.354 | 0.3 | 0.231 | 0.188 | 0.148 | 0.171 | 0.203 | 0.21 | 0.234 |
| City | 0.436 | 0.33 | 0.318 | 0.257 | 0.258 | 1 | 0.244 | 0.246 | 0.274 | 0.433 |
| Mercantile | 0.486 | 0.417 | 0.333 | 0.267 | 0.229 | 0.881 | 0.928 | 0.922 | 0.983 | 1 |
| Mutual | 0.688 | 0.462 | 0.372 | 0.399 | 0.323 | 0.299 | 0.271 | 0.225 | 0.227 | 0.299 |
| One | 0.786 | 0.584 | 0.474 | 0.432 | 0.349 | 0.312 | 0.292 | 0.313 | 0.339 | 0.368 |
| Premium | 0.722 | 0.628 | 1 | 0.42 | 0.353 | 0.321 | 0.265 | 0.223 | 0.194 | 1 |
| Prime | 0.303 | 0.259 | 0.823 | 0.473 | 0.461 | 0.917 | 0.945 | 0.97 | 0.981 | 1 |
| Southeast | 0.738 | 0.638 | 0.771 | 0.298 | 0.334 | 0.341 | 0.37 | 0.333 | 0.404 | 0.452 |
| Eastern | 0.398 | 0.295 | 0.23 | 0.198 | 0.217 | 0.262 | 0.524 | 0.534 | 0.536 | 0.587 |
| UCB Limited | 0.584 | 0.49 | 0.444 | 0.474 | 0.413 | 0.373 | 0.357 | 0.365 | 0.392 | 0.494 |
| IFIC | 0.548 | 0.429 | 0.411 | 0.33 | 0.272 | 0.238 | 0.222 | 0.216 | 0.233 | 0.24 |
| IBBL | 0.19 | 0.192 | 0.301 | 0.274 | 0.256 | 0.535 | 0.681 | 0.855 | 1 | 1 |
| Al-arafah | 0.712 | 0.568 | 0.432 | 0.296 | 0.21 | 0.189 | 0.175 | 0.184 | 0.193 | 0.217 |
| Social | 0.915 | 0.693 | 0.5 | 0.361 | 0.272 | 0.311 | 0.22 | 0.213 | 0.262 | 0.266 |
| Exim | 0.423 | 0.349 | 0.358 | 0.325 | 0.32 | 0.271 | 0.268 | 0.263 | 0.255 | 0.296 |
| Shahjalal | 0.674 | 0.486 | 0.389 | 0.312 | 0.276 | 0.276 | 0.265 | 0.247 | 0.348 | 0.465 |

**Table-22: Profit Efficiency Estimates of State-owned Commercial Banks Over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Rupali | 0.104 | 0.145 | 0.258 | 0.392 | 0.134 | 0.097 | -0.047 | 0.091 | 0.176 | 0.136 |
| Sonali | 0.105 | 0.176 | 0.294 | 0.062 | 0.176 | 0.092 | 1 | 0.164 | 0.868 | 0.132 |
| Janata | 0.108 | 0.215 | 0.351 | 0.076 | 0.225 | 0.071 | 0.080 | 0.196 | 0.084 | 0.206 |

**Table-23: Profit Efficiency Estimates of Private Commercial Banks over Time using Cobb- Douglas Stochastic Frontier Analysis**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Banks Name | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| DBBL | -0.048 | 0.017 | -0.013 | -0.088 | 0.012 | 0.005 | 0.103 | 0.105 | 0.110 |
| Brac | 0.022 | 0.102 | 0.039 | 0.013 | -0.163 | -0.009 | 0.030 | 0.039 | 0.082 |
| City | -0.047 | 0.016 | -0.022 | 0.057 | 0.358 | 0.112 | 0.117 | 0.150 | 0.336 |
| Mercantile | 0.033 | 0.049 | 0.061 | 0.042 | 0.478 | 0.578 | 0.619 | 0.738 | 0.935 |
| Mutual | -0.024 | -0.032 | -0.001 | -0.018 | -0.010 | 0.025 | 0.024 | 0.069 | 0.149 |
| One | 0.023 | 0.044 | 0.073 | 0.064 | 0.112 | 0.129 | 0.129 | 0.163 | 0.244 |
| Premium | 0.038 | 1 | 0.057 | -0.022 | -0.075 | -0.077 | -0.091 | -0.084 | 0.293 |
| Prime | 0.086 | 0.485 | 0.280 | 0.297 | 0.755 | 0.778 | 0.799 | 0.857 | 0.958 |
| Southeast | 0.264 | 0.379 | 0.104 | 0.133 | 0.125 | 0.162 | 0.137 | 0.239 | 0.345 |
| Eastern | 0.007 | 0.057 | 0.025 | 0.030 | 0.068 | 0.382 | 0.433 | 0.478 | 0.619 |
| UCB Limited | 0.035 | 0.080 | 0.202 | 0.194 | 0.158 | 0.173 | 0.190 | 0.234 | 0.353 |
| IFIC | 0.030 | 0.083 | 0.083 | 0.058 | 0.048 | 0.057 | 0.056 | 0.070 | 0.079 |
| IBBL | 0.024 | 0.216 | 0.172 | 0.063 | 0.149 | 0.105 | 0.187 | 0.266 | 0.094 |
| Al-arafah | 0.023 | 0.066 | 0.031 | -0.008 | -0.006 | -0.018 | 0.024 | 0.061 | 0.076 |
| Social | 0.013 | 0.012 | 0.022 | 0.011 | 0.242 | 0.047 | 0.074 | 0.129 | 0.137 |
| Exim | 0.074 | 0.177 | 0.155 | 0.145 | 0.107 | 0.111 | 0.091 | 0.087 | 0.147 |
| Shahjalal | 0.034 | 0.072 | 0.086 | 0.122 | 0.102 | 0.070 | 0.083 | 0.184 | 0.314 |
| Shahjalal | 0.034 | 0.166 | 0.079 | 0.064 | 0.145 | 0.154 | 0.177 | 0.223 | 0.310 |