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Efficiency of Commercial Banks in Bangladesh

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Efficiency of Commercial Banks in Bangladesh

By

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Efficiency of Commercial Banks in Bangladesh

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Certificate

I am pleased to certify that the thesis entitled "Efficiency of Commercial Banks in Bangladesh" by Mohammad Shamimul Haque is an original work. This research is done under my direct supervision and guidance. I have read the thesis and found it satisfactory for submission to the University of Rajshahi for degree of Doctor of Philosophy in Economics.

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Declaration

I do hereby declare that this thesis entitled "Efficiency of Commercial Banks in Bangladesh" submitted to the Institute of Bangladesh Studies, University of Rajshahi, Bangladesh for the degree of Doctor of Philosophy in Economics is completely my own and original work. No portion of this work referred to in this thesis in any form has been submitted to any university or any other institution of learning for any degree, diploma or any other similar purposes.

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To
My parents

Mohammad Zahirul Haque
And
Afia Khatun

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LIST OF ACRONYMS

ABBL	Arab Bangladesh Bank Limited
BASIC	Bank of Small Industries and Commerce (Bangladesh Limited)
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BCBL	Bangladesh Commerce Bank Limited
BIBM	Bangladesh Institute of Bank Management
BKB	Bangladesh Krishi Bank
BS	Balance Sheet
BSB	Bangladesh Shilpa Bank
BSRS	Bangladesh Shilpa Rin Shangstha
COLS	Corrected Ordinary Least Square
CRS	Constant Returns to Scale
crste	constant returns to scale technical efficiency
CV	Coefficient of Variation
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
EE	Economic Efficiency
EXIM	Export Import Bank of Bangladesh Limited
FCBs	Foreign Commercial Banks
FDH	Free Disposal Hull
FY	Fiscal Year
GDP	Gross Domestic Product
GNP	Gross National Product
GOB	Government of Bangladesh
IBBL	Islami Bank Bangladesh Limited
IPCBs	Islamic Private Commercial Banks (of Bangladesh)
IRS	Increasing Returns to scale
MLE	Maximum Likelihood Estimate
MOF	Ministry of Finance
NCBs	Nationalised Commercial Banks
NCCBL	National Credit and Commerce Bank Limited
NIRS	Non increasing returns to scale
NPL	Non-performing Loans
OLS	Ordinary Least Square
PCBs	Private Commercial Banks
rs	returns to scale
SCBs	Specialised Commercial Banks
SD	Standard Deviation
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
Tk.	Taka (About 69 Taka is Equal One US dollar)
UCBL	United Commercial Bank Limited
VRS	Variable Returns to Scale
vrste	variable returns to scale technical efficiency

Abstract

This study examines productive efficiency of each of the 49 commercial banks of Bangladesh for the period from 1999 to 2005 using two techniques, Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Pure technical, scale and overall technical efficiencies are derived from solving input-oriented and output-oriented DEA models. The two techniques, SFA and DEA are compared on the basis of technical efficiency estimates.

Based on the stochastic frontier, the average technical efficiency estimates of the commercial banks of Bangladesh for 1999, 2000, 2001, 2002, 2003, 2004 and 2005 are 75, 77, 82, 70, 76, 67 and 77 percent respectively. Based on input oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of these banks for 1999 are 83, 93, and 89 percent; for 2000 are 89, 94 and 95 percent; for 2001 are 88, 95 and 92 percent; for 2002 are 83, 90, and 93 percent; for 2003 are 65, 88, and 74 percent; for 2004 are 74, 94 and 79 percent; and for 2005 are 73, 88 and 84 percent respectively while based on output-oriented DEA, the corresponding values are 81, 91 and 89 percent for 1999; 93, 97, and 96 percent for 2000; 85, 93, and 93 percent for 2001; 84, 88, and 95 percent for 2002; 74, 90 and 81 percent for 2003; 79, 94, and 84 percent for 2004; and 86, 97, and 89 percent for 2005 respectively. The technical efficiency estimates obtained from the stochastic frontiers are significantly lower than those obtained from DEA. Stochastic frontier results show constant returns to scale, whereas DEA results show both constant and variable returns.

To facilitate intra-category comparison all the banks are grouped into five categories, for example, Nationalised Commercial Banks (NCBs), Private Commercial banks (PCBs), Specialised Commercial Banks (SCBs), Islamic Private Commercial Bank (IPCBs) and Foreign Commercial Banks (FCBs) according to ownership forms and objective principles. NCBs are found the most efficient and the 'best practice'

performer. SCBs are second best performer. Then appear the rank of FCBs. PCBs are found more efficient than IPCBs in case of private banking. However, their efficiency scores fluctuate over time and in their intra-category comparison. Given current output levels, NCBs would reduce 4-29 percent, PCBs 20-34 percent, SCBs 22-33 percent, IPCBs 17-38 percent and FCBs 15-36 percent of their input expenditures if they all achieved full efficiency according to SFA. If current resources were utilised at full efficiency, NCBs would increase their output by 25 percent, PCBs 41 percent, SCBs 38 percent IPCBs 39 percent, and FCBs 26 percent. According to output-oriented DEA, this study indicates that the banking sector of Bangladesh is potential for increasing banking output through improvement in efficiency.

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Chapter 1

Introduction to Commercial Banking Efficiency

1.1 Introduction

This study attempts to assess productive efficiency of the commercial banks of Bangladesh. We examine productive efficiency of 49 commercial banks grouped into 5 categories according to their ownership forms and objective principles. We compare the productive efficiency of all banks within their categories and over a period of time. We first examine efficiency of the banks based on stochastic production frontiers. We then use another methodology, on the same set of data, that is quite different from the stochastic frontiers to find estimates of efficiency. The study is designed to achieve a set of similar objectives from two distinct and methodologically different approaches. Econometric and linear programming techniques have been used to calculate production frontiers separately and to reveal unconnected individual efficiency scores of the commercial banks over the period from 1999 to 2005. To this purpose, we have used bank specific data.

1.2 Status of the Commercial Banks of Bangladesh

Commercial banks play important roles in the financial market of Bangladesh. The banking sector has been sheltered from competition under government regulatory controls until 1982. During the early 1990s, it has gone through a gradual deregulation and reform process. The banking sector alone captures 75 percent of the involvements of the total financial intermediations in the financial year 2004-2005. The net worth of the banking asset is Tk.2001.03 billion while the amount of loans and advances of the commercial banks stand at Tk. 1330.02 billion and the liability (deposit) stand at Tk.1609.87 billion. Contribution of total financial intermediation is Tk. 59.35 billion to the GDP against a total GDP of Tk. 3707.07 billion while contribution of the banking sector is Tk. 44.51 billion in financial year 2004-2005 at current prices (Bangladesh Economic Review, 2006:21). In terms of percentage share, the total financial intermediations occupy 1.60 percent of the GDP while the share of banking sector is 1.20 percent in the year 2004-2005. The growth rate of the banking activities is 9.86 percent in the same financial year (Bangladesh Bureau of Statistics, 2006).

There are 49 scheduled banks functioning in the banking sector of Bangladesh as on June 30, 2004 (Financial Sector Review, 2005). These are 4 Nationalised Commercial Banks (NCBs), 25 Private Commercial Banks (PCBs), 5 Specialised Banks (SCBs), 5 Islamic Private Commercial Banks (IPCBs) and 10 Foreign Commercial Banks (FCBs). We introduce Islamic Private Commercial Banks (IPCBs) as a separate category of bank. IPCBs are special type of PCBs. Because IPCBs abstain from interest charges on both deposits and loans, rather they replace interest charges for business profits that are calculated on as a variety of participation based financial activities and innovations as per Islamic principles. Hence, Islamic banks are put under a distinct category according to objective principles. However, the banking sector comprises a total number of 6404 branches in the year 2005. In the total banking assets, NCBs' share is 37.8 percent, PCBs' 35.88 percent, SCBs' 8.58 percent, IPCBs' 9.81 percent and FCBs' 7.30 percent in 2005. FCBs, PCBs and IPCBs show comparatively better performance according to the criteria of capital adequacy, quality of assets, and expenditure- income ratio but the banking activities of NCBs and SCBs are more open to common people because of easy access and better location of the branches. We find 63.44 percent branches of the NCBs and 88.76 percent branches of the SCBs are located in the sub-urban and rural areas while 26.15 percent branches of the PCBs are located outside the urban areas of Bangladesh. Foreign banks do not have a single branch in any rural area. 109 new branches of the NCBs were established and 2 existing branches were closed up to June 2006 (Bangladesh Economic Review, 2006:54).

Banks accumulate enormous non-performing loans (NPL) since 1972. One of the major reasons for high amount of NPL is weak legal framework. Prior to financial sector reforms of the early 90s, credit disbursement was mostly directed by the bank management, which was often politically motivated rather than based on any commercial grounds (Financial Sector Review, 2005:93). However, in 1999 the real total classified loans amounts to Tk.209 billion against real total loans outstanding of Tk.510 billion at constant prices of 1995-1996. In 2005 the amount of non-performing loans is reduced to 126 billion (Financial Sector Review, 2005:98).

The liberalisation policies for the commercial banks have been aimed at advancement towards a less regulated modern and free market economy. The implementation of reform policies of 90's is also politically motivated in the hope of accommodating the conditions of IMF and World Bank. The set of financial policies adopted was primarily aimed at increasing competition in the banking sector. The basic indicators of growth in the banking sector following inception of the liberalisation programs are remarkable. Between 1982 and 1999, the number of banks increased from 22 to 46, that of branches from 4,743 to 6,075 and employment by 29.3 percent (Banking Sector Survey data, 2006). Between the years 1999 to 2005, assets of the banks in terms of current prices, showed an increase from Tk.1019.93 billion to Tk.2001.03 billion. Non- interest expenses, particularly in machinery and equipment expenses for modern banking, rise by a substantial amount of value (Financial Sector Review, 2005:87). On the financial liabilities side, deposits rises from Tk.706.21 billion to Tk.1609.87 billion while employment has been increased from 104,399 to 111,132 at a relatively modest rate of 1.05 percent during 1999-2005 (Calculated from Financial Sector Survey data, 2006).

1.3 Problems of the Banking Sector of Bangladesh

In Bangladesh, deregulation measures have forced banks to pay higher cost of funds, which include competitive (high) interest rates on deposits, high salaries, wages and benefits to employees, and other overhead costs. These situations pressurise management authorities to be concerned to enhance the efficiency of their respective banks. In terms of resource allocation, scale and scope of economies, the use of resources by the commercial banks can narrowly be categorized as efficient by international standards.

Perhaps the causes are poor processing techniques of the inputs and lack of quality assets. High levels of poor quality and non-performing assets have been prevalent in the banking sector since 1972. For the majority of the NCBs and the PCBs, the principal and the interest losses emanating from these poor quality assets have precluded profitable operations and diminished reserves, and resulted in enormous capital deficiencies. These weaknesses preclude the banking sector from playing its essential role into supporting private sector growth and investment. Despite adoption of adequate reform measures by Bangladesh Bank (BB) such as, interest rate liberalisation, the introduction of various monetary policies, the discontinuation of directed credit and subsidized refinancing facilities, the imposition of more stringent measures in calculation of interest on bad debts, the establishment of Credit Information Bureau (CIB) and the financial loan courts, the inconsistency in the banking sector could not be abated remarkably and still suffers from limited competition, weak adherence to the regulatory framework and a selective but unsustainable exposures to NPL (Banking Sector Review, 2005).

Since banks play significant roles in the economic development (Fry, 1995) and efficiency of commercial bank is certainly related to the productivity of the economy (Herring and Santomero, 1991), it is important to evaluate the efficiency of banks.

1.4 Objectives

This study aims at estimating individual technical efficiency of the commercial banks in Bangladesh. The specific objectives are as follows:

(i) to find bank-specific technical efficiency score of the commercial banks in a single output and multiple-input framework using both parametric and nonparametric methodology for the period 1999 to 2005.

(ii) to compare category –specific technical efficiency scores of the NCBs, PCBs, SCBs, IPCBs and FCBs and overall banking sector technical efficiency.

(iii) to assess stochastic frontier SFA and DEA methods

(iv) to make comparison between stochastic frontier and DEA results

(v) to provide some policy conclusions to policy makers based on our results.

1.5 Contribution of the Study

The study seeks to inquire the basic characteristics of banking activities by examining productive efficiency estimates based on production frontier unlike those of financial ratio analysis, generally used to assess the performance of a banks' management. We provide a brief discussion how the study of efficiency and productivity can contribute to the banking sector as well as to the promising literature of its kind.

1.5.1 Contribution to Banking Sector

We know that productivity gains can be obtained through technological progress and efficiency improvement. Technological progress requires a considerable period of time and a large amount of budget to be introduced and implemented. Whereas efficiency improvement is relatively speedy and less expensive (Wadud, 2006), thus studies of efficiency improvement in the commercial banks will likely to add to productivity gains in the banking sector. This study examines the potentials of the banking sector of Bangladesh by determining technical efficiency and scale efficiency based on banks specific costs and returns from banking services and activities. Productive efficiency can be determined by estimating the 'best- practice' production frontier, and the discrepancy between the frontier and the observed output of individual bank that gives a measure of inefficiency. Inefficiency increases cost and reduces profitability. Efficiency is more important in the competitive environment since the inefficient institutions are less likely to survive. Hence, it is essential for the executives and policy makers to know inefficiency status of the banking sector and their causes.

In Bangladesh, commercial banks operate with relatively high spreads. Since high spreads affect intermediation and distort prices impairing the role of banking system in contributing to rapid economic growth, such high spreads should be narrowed. A basic benefit of the improved efficiency is a reduction in spreads between lending and deposit rates, which is likely to stimulate both greater loan demands for industrial investment and thus contribute to higher economic growth. Although, government policies and regulations are considered as the major causes of such high spreads, yet studies of banking efficiency is likely to contribute on exploring other possible sources of inefficiencies responsible for high spreads.

As this study attempts to find measures of potentialities of commercial banks providing technical efficiency with better understanding on the expenditure components, cost structures and income structures, which can be regarded as crucial factors to the banking sector; this study will likely to contribute to banking sector. It might be expected that banks would display low efficiency prior to failure and that management quality would be positively related to efficiency (Berger and Humphrey, 1997). Berger and Humphrey (1992a), Hermalin and Wallace (1994) and Cebenoyan et al. (1993a) have found in different studies that banks with low efficiency failed at greater rates than banks with higher efficiency levels. Thus, the study may contribute to the build up of an early warning mechanism for the banking sector.

As the entire economy of Bangladesh is currently passing through a period of rapid economic deregulation and liberalisation, the banking sector of the economy needs a scrutiny of on efficiency criteria regarding policy matters as it is moving towards a more open and less regulated market system for a competitive banking. Therefore, this study is likely to contribute to the effects of the policy measures since adopted.

Banking sector assets constitute a substantial proportion of total financial intermediations. Banks provide liquidity, payments and safekeeping for depositors and channel funds into investment and working capital. Commercial banks play a special role in funding all sorts of business and ensure a smoothly functioning payment system, which allows financial and real resources to flow freely to their highest-returns uses. This is why commercial banks today are under great pressure to perform and to meet the objectives of their shareholders, employees, depositors, and borrowing customers while keeping government regulators convinced that their policies, loans, and investments are sound. In order to keep everything all right the issue of efficiency comes first. In many cases, the growth of local deposits has simply been inadequate to fund the growing needs of the customer's loan and offer other services innovated. Bank's entry into the open market to raise funds means that their financial statements are increasingly being scrutinised by the potential investors, prospective clients and by the general people. In this connection, calculation of efficiency scores may give better understanding of the health of the banks. And that concerned people can make a prediction of individual commercial bank, they want to deal with.

In the process of continuous evaluation, banks necessitate the need for greater efficiency in their operations that usually mean reducing operating expenses and increasing the productivity of the employees through training and use of technology. Yearly efficiency scores calculated by central regulatory authority or security exchange commission or any other approved agencies could be helpful in this regard.

Again, different policy measures may have different, and often opposite, effects on operational efficiency and technological improvements of banking operation. Although tightening prudential requirements may limit banks profitability and reduce innovative ways to invest, but still it expands the production possibilities frontier. Again, regulations might also have the opposite effects of what was originally intended. It is, therefore, essential for a policy maker to be able to identify whether the policy instruments are effective in bringing about the desired changes. Productivity and efficiency analysis can be the focal point in this regard to know the change looking at the efficiency scores. And policy makers, thus, would be able to come up with the policy responses. This is of particular importance for the economy of Bangladesh where the choice of instruments for policy makers can be rather limited as well as costly.

1.5.2 Contribution to Literature

In the process of the study, this thesis is expected to contribute to the efficiency literature in three different ways. Firstly, despite numerous studies on efficiency analysis in commercial banks as well as wide variety of industries in the international perspective, hardly any study has examined productive efficiency of the commercial banks in

Bangladesh using both parametric and non-parametric frontier techniques. As such, this study is likely to contribute to the discussion of banking performance under a separate literature at national level.

Secondly, a few studies have compared the empirical performance of the econometric approach and the Data Envelopment Analysis (DEA) approach using a same set of data. This study is expected to bridge that gap. The application of DEA in banking is increasingly receiving attention through out the globe, while application of DEA in the context of commercial banks of Bangladesh is still virgin, hence the research is likely to provide a contribution to DEA literature concerning Bangladesh. Since this study is designed to show an empirical applicability of DEA in commercial banking of Bangladesh by analyzing productive efficiency. To our knowledge this is the first study to employ both SFA and DEA approaches to assess technical efficiency in the banking sector of Bangladesh. Thus, this study is likely to add to banking efficiency literature as regard regarding Bangladesh. This is because the need to extend frontier work to different countries has been emphasized by Berger and Humphrey (1997) on the grounds that "banking markets that are more national in scope with much higher level of concentration (relative to the U.S. market)" may be useful for research and policy purposes.

Thirdly, despite a huge literature in both theoretical and empirical work on frontier models, a number of issues in commercial banking still remain unresolved. The efficiency estimates may be highly sensitive to the choice of methodology, for example, econometric or mathematical methods. A number of studies, other than banking sector, have compared stochastic production frontier with the deterministic frontier and found that deterministic method tends to overestimate the average level of firm-specific technical inefficiency (Ekanayake and Jaysuriya, 1987; Taylor and Shonkwiler, 1986), and thus the application of SFA and DEA methodology with commercial banking data of Bangladesh is expected to add to a bit of comparison of the methodologies to efficiency literature. Since the efficiency of banks are directly linked to the productivity of its economy, it is expected that new research on efficiency will emerge in this area and will conducted frequently with different relevant variables (as there is no set rule for selection of variables).

1.6 Organisation of the Thesis

The chapters are structured to incorporate a systematic composition of theoretical issues, data and empirical findings that have been presented into the form of a thesis. The structure of the thesis is planned as follows.

Chapter 2 reviews literatures reflecting research studies on banking efficiency. Contemporary national level works on efficiency issues have been discussed. International works using frontier model that have been accomplished very recently around the globe are reviewed.

Chapter 3 gives a preliminary survey on the banking sector of Bangladesh based on collected data for the period of 1999-2005. This chapter describes observations on different characterization of the commercial banks with reference to categories of the banks over time. List of variables and data were given and justification of the variables has been discussed for further analysis under SFA and DEA.

Chapter 4 focuses on the relationship between production function and efficiency. This chapter explains some basic theoretical concepts of production function theory and related issues. Then the chapter describes the development of technical efficiency.

Chapter 5 describes the Stochastic Frontier Analysis (SFA) method of efficiency measurement.

Chapter 6 gives the SFA results obtained from collected data by applying SFA methodology. This chapter provides individual bank-specific efficiency scores by years under given categories of banks. Co-efficient of the variables and t-ratios are tabulated. Related statistics are described and mean and standard deviation of efficiency is shown in tabular form.

Chapter 7 describes in brief the Data Envelopment Analysis (DEA) as a full-fledged methodology of efficiency measurement. This chapter discusses basic differences between DEA and SFA methodologies and the usefulness of DEA efficiency scores and other related issues of DEA.

Chapter 8 provides results obtained from DEA methodology. Estimates of individual bank-specific efficiency scores by years are given under category of banks. Estimations are given in constant returns to scale and variable returns to scale under input and output oriented DEA. Scale efficiency scores and corresponding returns to scale and economies of operation of all the commercial banks have been given.

Chapter 9 gives conclusion and recommendations.

Finally, this thesis contains a bibliography.

Chapter 2

Literature Review

2.1 Introduction

Bank efficiency has been discussed for years. Recently, because of the rapid growth of financial markets and financial innovations, it has become more important to measure the efficiency of commercial banks. The dynamic changes in the financial sector for the last two decades have attracted research attention throughout the globe. Review of literature in this arena shows that the performance of the financial sector receives extensive scrutiny from the scholars. Since banking sector uses multiple inputs to produce multiple outputs, a consistent aggregation is really a problem (kim, 1986). To overcome such problems some attempts have been made to estimate average practice cost functions. While these approaches are successful in identifying the average practice productivity growth, they fail to account the productivity of the 'best practice' banks. These problems associated with the classical approach to productivity led to the emergence of other approaches, which incorporate multiple inputs and multiple outputs and take into account the relative performance of banks.

In an article, Farrell (1957) proposes two ways to estimate efficiency of firms in production. His article leads to the foundation for development of several approaches to efficiency analysis. Among several approaches, Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) are most popular and presently being used to measure efficiencies of production units. The stochastic frontier analysis is based on econometric production frontier. DEA called for identifying efficient production units and construction of piecewise linear efficiency frontier using efficient units. Non-parametric linear programming methods are used to identify the efficient units, according to the approach of DEA. Although the efficiency of financial institutions is being studied around the world, a little has been done in the banking sector of Bangladesh to develop understanding of efficiency of the commercial banks and the causes of inefficiency with such techniques. Since efficient operations of commercial banks are essential for the effective functioning of the financial system, some international researchers bring an interdisciplinary and international approach in developing a deep sense of understanding of the drivers of performance of commercial banks. Scholars from Economics, Finance, Operations Management, and Marketing have recently concentrated their expertise to look at differently towards appraising efficiency and stand on the issues- the definitions of efficiency of financial institutions and its measurement techniques, benchmarking of efficient institutions, identification of the factors of performance and their effects on efficiency and the impact of financial innovation and information technology on efficiency. In view of these points, the banking sector of Bangladesh requires a scrutiny on efficiency matters. This study is expected to furnish room for efficiency measurement opportunity. However, a number of books and articles on efficiency literature have been reviewed in this connection. The reviews are categorised into two sections. Section 2.2 presents national level works on efficiency issues and Section 2.3 provides reviews of international level works.

2.2 National Level Works

Saha et al. (1994) in their study attempt to measure cost efficiency in banking mainly to emphasise on the two facet challenges faced by bank management with regard to improvement of declining profitability and delivery of better services by the commercial banks of Bangladesh. The study chiefly sheds light on the relationship between cost and earnings of the banks and tries to identify the potential factors responsible for determining the level of cost efficiency existing among the banks and their branches. The study is conducted on a sample of 20 branches belonging to 3 NCBs and 3 PCBs. The study measures cost efficiency at the operational level. But the methodology used in the study is statistical averages, percentage differences and financial analysis techniques like ratios. Analysis of data is made by establishing relationship amongst various individual cost items to total expenditure, various individual earnings to total earnings, cost earnings relationship etc. The study period covers the year 1990-1992. The methodology applied to this study could not generate concept of efficiency based on production frontier technology. However, the major findings of the study are (i) NCBs are relatively less cost efficient compared to PCBs in respect to providing services to the customers.(ii) relatively higher productivity is observed in the PCBs as compared to the NCBs (iii) PCBs bear higher average rates of interest on deposit than the NCBs, and (iv) at branch level, NCBs show a declining or static trend regarding classified loan during the period under study. However, the study has made a modest attempt to address the key issues of cost efficiency in banking operations on the basis of analysis of cost and earnings performance of sample banks but suffers from providing a full-fledged picture of the commercial bank's cost efficiency with respect to individual bank ratings. The study did not use production frontier.

Choudhuri and Choudhury (1993) analyse the performance of private commercial banks vis-à-vis banking sector as a whole. The authors find that results of denationalisation and privatization in the banking sector of Bangladesh so far do not indicate clear–cut improvement in the efficiency of the banking system. The efficiency of the two denationalised banks, such as, Uttara Bank and Pubali Bank deteriorated in all respect during the last 10 years. The performance of PCBs is though better only in operational aspects compared to NCBs but lagging in allocative aspects in terms of putting less emphasis in socially more desirable sectors. The privatization and denationalisation process is inducing NCBs to gradually withdraw from socially desirable sectors in order to improve NCBs profitability. As a tool of methodology, the authors have used a thorough comparison of the denationalised banks for the pre (1973-1982) and post (1982-1992) denationalisation period in the characterisation of (i) deposit mobilisation, its growth rate and per branch deposit, (ii) branch expansion, its growth rate, population per branch, effective coverage per branch, rural-urban proportions (iii) deployment of credit, growth rate, per branch credit comparison of rural-urban proportions of credit (iv) size of accounts. This study can be judged as a comparative study of nationalisation and denationalisation debate of the banking sector. The study also analyse banking policy of the country regarding improvement of efficiency through denationalisation and privatization, which requires further investigation. The study can not generate idea about having any individual scores of performance of pre and post denationalisation period. The study do not use any frontier related methodology to explore their findings.

Choudhury (1988) attempts to examine how far the decisions of denationalisation have been instrumental in improving the profitability and productivity of the commercial banks in Bangladesh. The study covers the period from 1982-1986. The author has used a mixed methodology of different ratios to find absolute profitability and assumed that profit is the measuring rod of performance. For measuring profitability the author divide profit by volume of working fund of commercial banks. The author measures productivity in terms of total as well as manpower productivity. The author used two approaches to measure total productivity and manpower productivity (i) Total productivity is constructed as the amount of working fund per taka of the total expenditure and manpower productivity as the amount of working fund expenditure per taka on manpower. The second method shows total productivity as the amount of income per taka of the total expenditure and manpower productivity as the amount of income per taka of the manpower expenditure. The author examines the contribution of the commercial banks to the national exchequer after the denationalisation and privatisation process started in 1983. The study reveals that though absolute profit level of the commercial banks has increased after denationalisation and privatisation, but it could not help improve the profitability and productivity of the commercial banks. Rather, the profitability of the NCBs as well as the banking sector as a whole has gone down from the level existing before the process of denationalisation and privatisation started. Even the NCBs could not be able to improve the profitability and productivity of the commercial banking sector and slide down to a lower level in 1986 compared to the level of 1982. The author finds that the contribution of the commercial banks to the national exchequer as percentage of the volume of the working fund decreases remarkably though as percentage to the total profit, the working fund remains almost same.

Bhuiyan and Akhtaruddin (1989) attempt to find out average productivity performance of Uttara and Pubali Banks Ltd before and after denationalistion period. This paper analyses whether government's denationalisation decisions are correct or not. However, it uses combinations of methodologies in this connection. These methodologies are semi-logarithmic trend line equation and fitted Lau-Yotopoulos model to measure partial productivity and productivity growth rate. The basic character of Lau-Yotopoulos model is that the actual normalised restricted profit would be a decreasing function of the normalised prices of variable inputs while it would be an increasing function of the quantities of fixed inputs like capital and price of output. Technique of purposive sampling enable them to select the above two commercial banks for study and they have used time series data on some selective economic variables involved in the banking industry such as working funds per taka spent on employee, income –expenditure ratio, spread etc. The findings of the study reveal that both in general and individual bank case, the average productivity performance appeared to be lower in denationalised period relative to nationalised period. But productivity stability is found comparatively higher in the denationalised period. Further, productivity growth both in aggregate and particular bank tends to be declining during both nationalised and denationalised period. The author found that productivity in Uttara Bank is found better compared to Pubali Bank Ltd. Finally the authors have reported that the overall objectives of denationalisation of commercial banks are yet to be achieved.

Cookson (1989) in his seminal paper has used three different components of output for measurement of productivity, such as, (i) deposit services (ii) loan services and (iii) other financial services generally offered by the commercial banks. The author in this connection provides the concept of productivity measures as output per unit of input. For multi product firms the author indicates a number of ways to value the output, using a set of base year prices or to value inputs using appropriate base year input prices. To examine productivity trends over several years, the author suggests making necessary correction for the inflation in prices. The author has provided a formula for calculating the value of the each component. The estimated value is taken to be output and the operating cost involved in rendering services to the customers, including loan losses, is taken as inputs. The author has measured productivity as output per unit of output. Productivity calculated on this principle has been computed separately for the NCBs and the PCBs for the period 1979-1988. The major findings of the study are (i) productivity in the PCBs is much higher than in the NCBs. This is partly because of very high number of employees in the NCBs and partly due to the lower outputs in loan services (non-performing loans) and lower earning of fees income. (ii) The trend in NCBs productivity over 1979-1988 shows significant improvement since real product has doubled while staffing increased only 40 percent. But the improvement has stopped and the productivity is declining. (iii) Productivity of the total banking system is currently stagnant. The author noted that Bangladesh's present accounting practices in banking sector are inadequate to identify bad-debt cost. Bad-debt cost must be taken into account in computing total output of loan services, the author suggests. The problems associated with calculation of bad-debt cost make international comparison of banking productivity almost impossible. The author points out that labour is the main input as there has been only limited mechanisation of the system, capital is essentially complementary to labour inputs, and therefore, average labour productivity is the measure of banking productivity in Bangladesh. However, the author concludes that productivity in banking industry is actually very difficult to estimate using available data and conceptual differences limit comparisons among banks in Bangladesh as well as it makes global comparisons complicated.

Shakoor (1989) addresses a seminal paper wherein he tries to investigate the nature of productivity of the NCBs during 1972-1986. He selected five PCBs during 1983-1986. The author used data on spread, establishment expenses and other current expenses as per profit and loss account, other non-current expenses, profit, working funds (total expenditure excluding interest paid on deposits and borrowings), operating expenses and total expenditure. As regard to productivity indicator, the author used the following components such as (i) deposit per employee (ii) advances per employee (iii) spread per employee (iv) income per employee (v) expenditure per employee (vi) establishment expenses per employee (vii) expenditure per branch (viii) advances per branch (ix) deposit per branch (x) income per branch (xi) spread per branch (xii) ratio of working funds to establishment expenses (xiii) ratio of deposit to cash balances. The above-mentioned selected indicators of productivity with respect to special social objectives are (1) Proportion of the rural and semi-urban branches to the total branches (2) Ratio of rural and semi-urban branch deposit to total deposits (3) Ratio of savings and term deposits in rural and semi-urban areas to total savings and term deposits and (4) Ratio of number of accounts of savings and term deposits in rural and semi-urban areas to total number of accounts of savings and term deposits. In addition to the above, the sectoral objectives of productivity indicators are as follows:

(a) Ratio of advances to priority sectors to total advances

(b) Ratio of agricultural advances to total advances

(c) Ratio of advances to small scale industries to total advances

(d) Ratio of advances to other priority sectors to total advances

(e) Ratio of agricultural advances less than Tk.1000.00 to total agricultural advances

The author has selected indicators for profitability, which are

(i) Ratio of investment income to net income

(ii) Ratio of net profits to net income

(iii) Ratio of net income to working funds

(iv) Ratio of net income to establishment expenses

The author expresses that he has been unable to collect all required data due to shortage of time and in-depth analysis could not be done. Therefore, the study has been restricted to analysis of the selected indicators of productivity of commercial banks. However, the author's main findings of the paper are as follows:

Productivity in NCBs in Bangladesh has an increasing trend during 1972-1986. It declines a little during 1978-80 but improves during 1981-82 again deteriorates during 1983 to 1985 though there are improvements in 1986.

1. Available spread have also a great impact on the return on investment of the banks

1. PCBs show better productivity banking way of increasing earnings through working funds, deposit mobilisation and advances during 1983-1986.

2. NCBs have given greater emphasis on the social profitability of the working funds as per the policy of the government of Bangladesh.

3. There is ample scope to enhance productivity of the NCBs by identifying the sick projects, analyzing the causes of the same, preventing the same though proper feasibility study.

4. Steps can be taken to strengthen budgetary control practice for ensuring the application of the cost control mechanism at branch level which may be done through improving the existing reporting system of the banks and strengthening better communication between the branch and the Head office.

Huq (1989) examines productivity of a bank by the following two methods.

(a) The total productivity is construed as the amount of working fund per taka of the total expenditure. Productivity rate of the bank is arrived at by dividing the total working fund by total expenditure of the bank

(b) The second method shows total productivity as the amount of income per taka of the total expenditure. By this method productivity rate of the bank is arrived at by dividing the total expenditure of the bank.

The author has used total income as output and total expenditure as input. This conforms to the common definition of productivity as output per unit of input. The productivity ratio for the three banks is given in Table 2.1:

Table 2.1: Productivity Ratio of Banks

	1985	1986	1987	1988
Faisal Islamic Bank of Bahrain E.C.	1.60	1.82	1.88	1.79
Islami Bank Bangladesh Limited	1.16	1.10	1.13	1.17
Bank Islam Malaysia Berhad	1.05	1.08	1.11	1.15

The author's findings reveal that, compared to Bahrain Islamic Bank, the productivity of the two banks is quite low. Again, the productivity of IBBL is apparently similar to that of Bank Islam Malaysia Berhad but in realty it may not be so. The author finds significant differences in the accounting practices in the two banks. IBBL does its accounting on accrual basis whereas Bank Islam Malaysia Berhad follows the cash basis. If accounting system of the two banks is brought to a common form the two banks become comparable. However, the author attributes difference in the productivity primarily for the factors like size of transactions, technology, and legal environment. It is pertinent to mention here that Islamic principles of banking is different from conventional commercial banking to the principle that the objectives of Islamic banking possesses social orientation and profit sharing nature on commercial loans and advances. Therefore, the social impact of Islamic banks can be scaled to some financial form, then the recombined profitability (commercial and social) would be definitely be higher the productivity (profitability) of conventional interest-based commercial banks.

Abedin et al. (1989) proposes to use ratio analysis method for productivity measurement. The method is expressed by the formula, $Q = \frac{\Delta I/I}{\Delta E/E}$ where Q= productivity, I= income, E=expenditure Δ=change. The basic proposition behind the formula is that productivity of a bank is inversely related to changes in cost. The main objective of the study is to measure the productivity levels of the different types of commercial banks of Bangladesh. The authors have made a rough comparison among the level of productivity of different types of commercial banks. The authors convey that comparison among the levels of productivity of different types of commercial banks is no doubt 'rough' because these banks operate with different objectives. The productivity indexes have been calculated covering the year 1975-1988. However, the following issues regarding measurement of bank productivity have been discussed:

(i) The relationship between the inputs and outputs is generally called productivity, which in the case of banking industry can not be easily quantified because its input and outputs are of different nature than in the case of other types of industries.

(ii) In the absence of specific indicators of output and input of a bank, measurement of productivity is widely used so as to indicate the productivity of human and financial resources (working funds).

(iii) The ratio of incremental income and incremental expenditure measures the productivity of a bank i.e., percentage change in its earnings in relation to percentage change in its costs measures a bank's productivity.

(iv) The commercial banks categorised by the author are NCBs, PCBs and FCBs.

(v) The paper is based on the data collected from various reports published by the Bangladesh Bank and does not go into an in-depth study necessary for analysing the causes of lower or higher level of productivity in any of the three types of banks.

(vi) The cost control measures and improvement in earnings are essential for increasing the levels of productivity of the banks. Performance budgeting, manpower planning and development, certain degree of mechanisation and computerisation would enhance the efficiency of the employees and reduce cost per employee. Proper management of assets and liabilities will help reduce cost.

The authors have attempted to measure productivity of commercial banks of Bangladesh in terms of financial considerations. The study neither attempts an in-depth analysis of the causes of lower or higher productivity of the banks nor strongly suggests the measures for increasing the levels of bank productivity. The authors argue that cost control measures, prudent deployment of excess reserves and idle funds, better fund management and portfolio management, etc., are measures for increasing bank' earnings. The author does not apply Stochastic Frontier and DEA model to measure efficiency performance of banks.

2.3 International Level Works

Ferrier and Lovell (1990) estimate efficiencies of 575 banks that participated in the Federal Reserve System's functional cost analysis (FAC) program in the year 1984 using stochastic frontier and linear programming approaches. The paper compares two techniques for estimating production economies and efficiencies. One approach involves the econometric estimation of a cost frontier; the second is a series of linear programs, which calculate the production frontier. The study compares the ability of econometric and linear programming techniques to shed light on the structure of production technology and the nature and extent of cost inefficiency in U.S. banking. Stochastic cost frontier results explain that technical inefficiency raises cost nearly 9 percent on average; although this value fluctuates, it shows no pattern as bank size grows. Overall cost inefficiency fluctuates narrowly and without trend around a mean value of 26 percent Further major findings are (i) efficient cost frontier exhibits small but pervasive scale economies and (ii) the banks are operating at observed costs roughly 26 percent higher than frontier costs. This is due to mainly excessive labour utilisation. (iii) Potential cost advantages are conferred on large banks due to the structure of banking technology. The authors find that two approaches are in substantial agreement on several important issues. Relatively to their cost frontier, banks operate inefficiently with observed cost. Nonstochastic production frontier results show that increasing, constant, and decreasing returns to scale appear in each bank size class. The authors report that majority of banks experience increasing returns to scale, which is qualitatively consistent with the overall cost elasticity of 0.98 obtained for the stochastic cost frontier. The authors find 88 percent of all institutions exhibit IRS; only one bank experiences decreasing returns to scale. The results on economies of size is fairly consistent across size classes; except for smallest size class. Most of the banks in each size class exhibit IRS (85-90percent). They have found the inefficiency in U.S. banking with observed cost roughly 20-30 percent above minimum for all but the smallest size classes, and so the effects of scale economies are sustained as bank size increases. The empirical findings of these techniques show that they yield very similar results regarding cost economies, and dissimilar results regarding cost efficiencies. These are important findings to the extent that policy decisions and evaluation often rely on only one of the two types of approaches available. The agreement between the results of the two approaches are substantial while the authors expect that inefficiency would be greater relative to a non stochastic production frontier than to a stochastic frontier. The authors point out that two techniques are very different in principle, both possessing certain advantages and disadvantages. However, the authors concluded that the disagreements, and the areas in which neither approach is very informative, should encourage continued application of non-parametric series of linear programs and econometric estimation of cost frontier approaches to frontier analysis.

Raveh (2000) examines the traditional method of evaluation of banking performance based on financial statement analysis with help of ratio analysis method. Generally performance of banking institutions is measured by financial ratios dealing with asset quality, capital adequacy, earning quality, liquidity, and management efficiency under traditional method. In a recent study, Zopounidis et al. (1995) uses regression analysis to assess an additive quality model and to obtain final ranking of a representative sample of Greek commercial banks. Rabeh examines their data by means of multivariate analysis called Co-plot, a two-dimensional graphic display technique designed to analyse observations of 16 banks and 7 attributes simultaneously. The method produces three results (1) similarity among the banks by the composite of all attributes involved (2) the structure of correlations among the attributes and (3) the mutual relationship between the banks and the attributes. The author has mapped the banks in partial order according to their performance to obtain rating. The final ranking obtained by the Co-plot method differs from that obtained by Zopounidis et al. The Co-plot method introduces a greater degree of rigor to the analysis of the final ranking of performance using utility level.

Berger and Humphrey (1997) surveys 130 studies that applied frontier efficiency analysis to financial institutions in 21 countries. The primary goals of the study are to summarize and critically review empirical estimates of financial institution efficiency and to attempt to arrive at a consensus view. The authors find that various efficiency methods do not necessarily yield consistent results and suggest some ways that those methods might be improved to bring about findings that are more consistent, accurate, and useful. The authors focus in this article is on frontier efficiency i.e., how close financial institutions are to a 'best- practice' frontier. They emphasized that if those institutions operate more efficiently, they might expect improved profitability and a greater amount of funds to be utilized in various investment activities. As a result, the consumer might expect better prices and service quality and greater security of their funds and as well as soundness of the financial system as a whole. The academic research on the performance of financial institutions has increasingly concentrated on frontier efficiency that measures how close financial institutions are to a 'best- practice' frontier. Since engineering information on the technology of financial institutions is not available, studies of frontier rely on accounting measures of costs, outputs, inputs, revenues, profits, etc. to impute efficiency relative to the 'best- practice' within the available sample. There is a virtual consensus in the literature that differences in frontier efficiency among financial institutions 0attributable to incorrect scale or scope of output. However, there is really no consensus on the preferred method for determining the 'best-practice' frontier against which relative efficiencies are measured.

Berger and Mester (1997) use multiple efficiency concept to explain and examine the problems of (1) differences in the efficiency concept used (2) differences in measurement methods used to estimate efficiency within the context of efficiency concepts, and (3) potential correlates of efficiency such as bank, market, and regulatory characteristics that are at least partially exogenous and explain some of the efficiency differences that remain after controlling for efficiency concept and measurement method. They estimated the efficiency of almost 6,000 U.S. commercial banks that are in continuous existence over the six-year period from 1990-1995 with no missing or questionable data on the variables. Any differences in the data set to which the estimates of efficiency often vary substantially across different studies according to the authors is due to data sources. They include measures of bank size, organizational form and corporate governance and other bank characteristics, market characteristics, state geographic restrictions and government regulations.

Bhattacharyya, Lovell and Sahay (1998) have examined the productive efficiency of 70 Indian commercial banks during the early stages (1986-1991), the initial period of liberalisation. The objective of the study is to measure, and to explain measured variation in the performance of Indian commercial banks. The authors use DEA to calculate radial technical efficiency scores. The authors then use stochastic frontier analysis to attribute variation in the calculated efficiency scores to a set of temporal and government regulatory policy variables. The authors apply 419 banks per year observations to construct a grand frontier. Their measures of technical efficiency do not incorporate non-radial slacks. Therefore, chances remain to overstate the overall efficiency of banks. The overstatement is serious. The average ratios of the non-radial investments are 0.73 percent, 2.25 percent and 4.00 percent receptively. The average ratio for interest expense and operating expenses are 3.82 percent and 5.03 percent, respectively. SFA estimates show that on average, across all three ownership forms and throughout the sample period, 5.7 percent of the calculated efficiency variation remains unexplained by the temporal and ownership form interaction effects. For the foreign owned banks the mean random efficiency is found smallest for each sample year and declining steadily over time. The findings of the study are as follow: (i) Publicly owned banks are most efficient and privately owned banks are less efficient in utilising the resources at their disposal. (ii) Foreign banks are least efficient in the beginning of the sample period, but by the end of the period they are almost efficient as the publicly owned banks.

Harker and Zenios (2000) write about the driver of performance of the financial institution. They give us an idea about financial institution's efficiency which receives extensive scrutiny from scholars and industry thinkers, while the efficiency of the financial institutions have been studied and debated at length, less research has been arranged in understanding the performance of the financial institutions that operate in those markets. The authors emphasise that banking institutions face a dynamic, fast-paced, competitive environment at a global scale due to advanced services of the banking sector in multifarious dimensions and thus bringing about markets restructuring in the industry. The authors show that from 1979 to 1994 over the 15 years period the US banking industry undergone a drastic change mainly after collapse of Bretton-Woods agreements. The authors defined performance to mean economic performance as measured by a host of financial indicators that have a direct positive impact on financial measures, and that are actionable. Those are (i) quality of the services provided, and (ii) efficiency of risk management. The writers classify drivers of performance into three broad classes: (i) strategy, (ii) execution of strategy, and (iii) the environment. In the context of banking institutions, the selection of a strategy primarily involves the decision on how the global banking organization should restructure into the component of the "dis-aggregated" bank. Those are product mix, client mix, geographical location, distribution channels, and organizational form. The authors consider 'quality of services' as the actionable measure of performance. Execution of a strategy is required to achieve the strategic goals of the institution. However, they have not mentioned technical efficiency concept to measure performance based on production frontier.

Leong, Dollery and Coelli (2002) employed data on Singaporean banking for the period 1993 to 1999 to develop efficiency scores and rankings for Singaporean banks. The authors empirical approach may be described in two stages. First, relative technical efficiency scores from three alternate DEA model specifications have been used to rank a sample of 35 major banks. In the second stage, the implied rankings from the results have been tested under the five specific consistency conditions developed by Bour et al. (1997). Only commercial banks focus on the corporate lending markets are selected. The resulting sample accounted for over 60 per cent of total banking assets in 1999. Bank size in terms of total assets in authors sample ranged from S$1.9 billion to S$106.4 billion. This wide variance facilitates more accurate analysis of the correlation between observed efficiency and institution size. The author evaluated DEA efficiency scores for banks. The efficiency scores are reasonably consistent with competitive industry conditions, in identifying best practice banks. In terms of consistency over time, results reasonably explain policy conclusions.

Dogan and Fausten (2005) study the regulatory and technological change in Malaysian banking sector during the post crises decade. They examine the impact of deregulation and technological change on the productivity of Malaysian banks. The authors use Malmquist indices, which is constructed with non-parametric DEA techniques. The Malmquist indices are decomposed into pure efficiency, scale efficiency, and technological change components. The study suggests that productivity of Malaysian banks has deteriorated during the decade 1989-1998. Estimates of productivity decline range between 3.3 to 5.6 percent. The findings indicate as erosion of banking productivity that masks divergent tendencies among its components elements. These are dominated by adverse effects of technological change, which are associated with a reduction in the labour intensity of banking activity. The study further suggests that regulatory reform and liberalisation are not sufficient conditions for productivity improvement.

Mahesh and Meenakshi (2006) examine the changes in the productive efficiency of Indian commercial banks after the financial sector reforms initiated in 1992. They used stochastic frontier technique to estimate bank specific deposit, advance and investment efficiencies for the period 1985 to 2004. Their results show that deregulation has significant impacts on all the three types of efficiency measures. They found that while deposit and investment efficiencies have improved, advance efficiency has declined marginally over the study period. They also report that public sector banks as a group ranks first in all the efficiency measures showing that these banks are doing better than their private counterparts. They further remarks on the basis of their findings that private banks however have shown marked improvement during the post liberalisation period in terms of productive efficiency measures.

2.3 Conclusion

Several literatures are reviewed in this chapter. Reviews of literature reveal that there are several works done which used cost ratios and all of them refer to a particular aspect of banking activity at national level. Works on productivities, performances and efficiencies are accomplished frequently but none of them used frontier analysis. Productivity of banking sector has been evaluated on the basis of financial ratio analysis as seen at national level works. Reviews of literature at national level reveal that there are a number of efforts regarding measures of productivity, profitability and performance of the commercial banks of Bangladesh, which are based on various financial ratio analysis, but integrated work with all category of banks is quite rare. Although saha et al. (1994), Choudhuri and Choudhury (1993), Choudhury (1988), Bhuiyan and Akhtaruddin (1989), Cookson (1989), Shakoor (1989) have examine various issues relating to the performance of commercial banks of Bangladesh, none of these studies have examined the technical, overall, pure technical efficiency and scale efficiencies of commercial banks of Bangladesh using Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis have been popular since Aigner, Lovell and Schmidt (1977) and Charnes, Coopers and Rhodes (1978). In international level, we have found a number of works using frontier analysis Ferrier and Lovell (1990), Berger and Humphrey (1997), Berger and. Mester (1997), Bhattacharyya, Lovell and Sahay (1998) pioneer in using frontier analysis. Bhattacharyya et al. (1998) studies Indian Commercial banks using the econometric approach and the mathematical programming approach to find estimates of efficiency while many similar studies have evaluated the performance of banking sectors in the U.S. and other advanced countries. We believe this to be the first work, with such combination of DEA and SFA approaches, to evaluate efficiency of commercial banks in Bangladesh.

Chapter 3

Data Description of the Banking Sector in Bangladesh

3.1 Introduction

Throughout the last two decades, the banking sector of Bangladesh has experienced a phenomenal growth due to huge changes in government policies and regulatory reforms in the context of changing global economy. The extent of the financial sector reforms and privatisation of financial institutions have paved the way to analyse the banking sector performance in the perspective of financial liberalisation and deregulation.

In this chapter a through assessment has been made on the commercial banks of Bangladesh on the basis of collected data to show the significance and magnitude of the banking sector.

3.2 Magnitude of the Banking Sector to the Economy

For the matter of economic development, the financial system mobilises and pulls together the financial resources from various surplus units, and ultimately channelises all those resources for productive investments. The financial system influences the economic development through supporting an active payment mechanism. The major function of a financial system is to strengthen savings-investment process of the country. Thus, an efficient payment mechanism helps to achieve specialisation and economies of scale and scope in production and strengthen the development process of the country. Bangladesh's financial system can be characterized as bank-based rather than market based. Since, banks provide the major source of funding trade and business majority of the core financial services (Temple, 2000).

In Bangladesh, banking sector is one of the major sub-sectors of the financial intermediations. Financial intermediations consist of banking sub-sector, insurance and other non-banking financial intermediations (Economic Review, 2004). The magnitude of the banks can well be assessed from Table 3.1.

Table 3.1: Contribution of Financial Intermediations to GDP at Current Prices (Tk. in Million)

Sub-sectors	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Mean
Banking	26390	28280	29880	31790	35400	38890	44510	33591.43
Insurance	5650	6600	7610	8610	9990	11110	12590	8880
Others	1470	1600	1620	1670	1800	1980	2250	1770
Total Financial Intermediations	33510	36480	39110	42070	47190	51980	59350	44241.43
Total GDP	2196970	2370860	2535460	2732010	3005800	3329730	3707070	283970
Share* of financial sub-sectors to GDP at Current Prices (in percent)								
Banking	1.20	1.19	1.18	1.16	1.18	1.17	1.20	1.18
Insurance	0.26	0.28	0.30	0.32	0.33	0.33	0.34	0.31
Others	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06
Total Financial Intermediations	1.53	1.54	1.54	1.54	1.57	1.56	1.60	1.55
Growth rate** of financial intermediations by sub-sectors over the years 1998-99 to 2004-05 (in percent)								
Banking		7.16	5.66	6.39	11.36	9.86	14.45	9.15
Insurance		16.81	15.30	13.14	16.03	11.21	13.32	14.30
Others		8.84	1.25	3.09	7.78	10.00	13.64	7.43
Total Financial Intermediations		8.86	7.21	7.57	12.17	10.15	14.18	10.02
Involvement*** of banking sector to financial intermediations in terms of GDP (in percent)								
Banking	78.75	77.52	76.40	75.56	75.02	74.82	75.00	76.15
Insurance	16.86	18.09	19.46	20.47	21.17	21.37	21.21	19.80
Others	4.39	4.39	4.14	3.97	3.81	3.81	3.79	4.04
Total Financial Intermediations	100	100	100	100	100	100	100	100

Note 1: *Share is calculated by the formula, $(y/Y)\times 100$, where y = Amount of contribution by sub-sector and Y = Total GDP. **Growth rate indicates rate of increase (or decrease) over the year and is calculated by the formula $[(Y_t - Y_{t-1})/Y_{t-1}]\times 100$ where Y_t = Current year, Y_{t-1} = Previous year. *** Involvement indicates a ratio of banks contribution to total intermediations in percentage form and calculated same as share.

Note 2: we use the term 'banking sub-sector' as banking sector and continue to use it throughout the thesis in our discussion.

In Table 3.1 the picture of the financial intermediations of Bangladesh is revealed, where contribution of banking sub-sector to GDP is shown over the financial years 1998-1999 to 2004-2005. Moreover, the relative share of sub-sectors of financial intermediations is also shown. From Table 3.1, it can be instantly understood that the commercial banks of Bangladesh have got the maximum share in the total intermediations (78.75 percent in 1999) having 14.45 percent growth rate in 2005. It is evident from Table 3.1 that banking sector's contribution increases from Tk. 26390 million in 1998-1999 to Tk. 44510 million in 2004-2005. The relative share of the sub-sectors to the financial system is also shown in Table 3.1.

Table 3.2 shows banking sub-sector's contribution to total GDP at constant price. The share and growth rate of the sub-sector are shown at constant prices with the base year 1995-96. Table 3.2 shows that the rate of growth increases over years. It increases from 3.85 to 5.52 in 2001-02 and to 9.11 in 2004-05 continuously.

Table 3.2: Share of Financial Intermediations to GDP at Constant Prices (Base Year: 1995-96)

Sub-sectoral share	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Mean
Banking	1.24	1.22	1.20	1.22	1.22	1.23	1.27	1.23
Insurance	0.27	0.28	0.31	0.33	0.34	0.35	0.36	0.32
Others	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06
Total Financial Intermediations	1.58	1.57	1.57	1.61	1.63	1.65	1.69	1.61
Growth rate of financial intermediations to GDP								
Banking	3.85	3.87	4.01	5.52	5.91	6.73	9.11	5.57
Insurance	13.05	13.59	13.46	12.35	10.29	8.06	8.34	11.31
Others	6.20	5.54	-0.03	2.05	2.32	6.91	8.51	4.50
Total financial intermediations	5.4	5.5	5.54	6.7	6.67	7.02	8.92	6.54

Source: Economic Review, various issues, 1999-2005.

Table 3.3: Status of the Banking Sector of Bangladesh

Types of Banks	Number of Banks	No. of Branch	Net Asset [a]	Total Deposit [b]	Total Loans and Advances [c]
NCBs	4	3387	756.50 (37.81%)	643.87 (40.00%)	494.88 (37.21%)
PCBs	25	1357	718.03.8 (35.88%)	588.39 (36.55)	483.86 (36.38%)
SCBs	5	1333	171.77 (8.58%)	89.96 (5.59%)	110.04 (8.27%)
IPCBs	5	280	196.23 (9.81)	172.47 (10.71)	148.84 (11.19%)
FCBs	10	47	158.50 (7.3%)	115.17 (7.15%)	92.41 (6.95%)
Total	49	6404	2001.03 (100.00%)	1609.87 (100.00%)	1330.02 (100.00%)

Source: Calculated from cross-section data for the year 2005.
Note: a, b and c are in Billions taka, Figure in the parentheses indicate percent of industry asset, industry deposits, industry loan respectively. Figures in this table are calculated from 2005 data.

Table 3.3 provides a static snapshot of the banking sector in terms of number banks, branches, net assets, total liabilities and total assets which give us an idea about the status of the banking sector of Bangladesh in the year 2005. It shows that the net worth of the banking assets is Tk.2001.03 billion while the amount of loans and advances are Tk.1330.02 billion and banking liability is Tk.1609.87 billion in 2005.

We would like to mention in brief the status of the reform measures that have been implemented until 1999. Due to initiation of reforms and gradual deregulation polices private banks come into existence and competitions increase among the category of banks. We discuss the basic reforms and changes of the banking sector chronologically. Since reform means gradual rational change, hence it aims at up dating, adjusting to operating environment and progress. Therefore, reform is a continuous process. While further up dating on reform deregulation and liberalisation is being continued, we mention only the major and basic changes to understand banking sector's response and adjustment. In our analysis, impact of the initial reforms could have influence. Further measures of deregulation could well be perceived from behaviour of the variables during the study period 1999 to 2005.

Years	Reform Programmes
1972-82	Just after liberation, the whole banking system was restructured and nationalized. During this period, the banking system expanded very rapidly. This was a basic change in the banking sector both in objectives and operations.
1986	The government of Bangladesh constituted 'National Commission on Money, Banking and Credit'-NCMBC. The commission conducted a detail study on the banking sector, identified major problems, and suggested remedial measures. The commission submitted a large volume of report containing large number of recommendations on different aspects of money and banking. Clarification was made about deep-rooted malaise in the banking system and suggested to carry out further professional analysis leading to treatment under a reform programme. The government sought professional help from the World Bank in the formulation of a reform programme. In response, a strong World Bank team worked in Bangladesh for a long period of time and developed FSRP project which is known as the first planned banking reform project in Bangladesh.
1991	According to the opinion of the 'Task Force on Financial Sector' formed during the regime of interim caretaker government in 1991, restoration of financial disciplines" was adjudged as the most urgent requirement in the financial/ banking sector.
1991-96	It has been observed that the recommendations of NCMBC of 1986 was rather ignored while designing reform framework under FSAC, though all the FSAC related documents of the World Bank indicated that the financial sector reform agenda was determined in compliance with the economic and sector work by the bank and the recommendations of a GOB taskforce, NCMBC (Khaled, 2003).
1996	Banking Reform Committee (BRC) was constituted
1997	FSRP project was evaluated by USAID and in the month of May 1997, a Commercial Bank Restructuring Project –CBRP funded by the World Bank was undertaken.
1999	BRC submitted its report to the government in the month of December.

3.3 Structure of the Banking Sector of Bangladesh

The financial system of Bangladesh consists of Bangladesh Bank (BB) as the central bank, 4 (four) nationalised commercial banks (NCBs), 5 (five) government owned specialised banks (SCBs), 24 (twenty) domestic private banks (PCBs), 5 (five) Islamic private commercial banks (IPCBs), 10 (ten) foreign commercial banks and 20 (twenty) non-bank financial institutions. Number of the commercial banks varied slightly over the study period. The financial system also embraces a number of insurance companies, stock exchange, development financial institutions, various licensed NGOs having BB's permission to conduct financial business and co-operative banks.

Table 3.4 shows a comprehensive structure of the banking sector of Bangladesh. During the study period (1999-2005) the number of banks as specified in the corresponding column as per category or types have been studied for measuring technical efficiency. Notable that in the year 1999 and 2000 data on two commercial banks under PCBs category namely, The Jamuna Bank Ltd and BRAC Bank Ltd and data on one commercial bank under IPCBs category namely The Shahjalal bank are unavailable as they did not start functioning during 1999-2000. During the time period 2001- 2004 data on all the 49 banks are available. But in the year 2005 data on Bangladesh Shilpa Rin Shangstha (BSRS) and the Oriental Bank Ltd are unavailable till completion of the study and data on American Express Bank could not found, as it is acquisitioned by Standard Chartered Bank in November 2005.

Table 3.4: Banking Sector of Bangladesh

Type of Banks	Number
NCBs (Nationalised Banks)	4
PCBs (Private Commercial Banks)	25
SCBs Government Owned development Finance Institutions (DFIs) or Specialized Banks	5
IPCBs (Islamic Commercial Banks)	5
FCBs (Foreign Commercial Banks) (FCBs)	10
Total (All Banks)	49

Source: Bank o Arthik Prothistaner Karjabali-2004-2005

Table 3.5: Changes in the Number of Scheduled Banks by Years

YEAR	NCBs	PCBs	IPCBs	FCBs	SBs	Total Banks
1997-98	4	14	4	13	5	39
1998-99	4	15	4	13	5	41
1999-00	4	23	4	13	5	49
2000-01	4	25	4	13	5	51
2001-02	4	25	5	12	5	51
2002-03	4	25	5	10	5	49
2003-04	4	25	5	10	5	49
2004-05	4	25	5	9	5	48

Source: Financial Sector Review, 2005, Bangladesh Bank.

The number of total banks varied throughout the study period. In Table 3.5 increase and decrease of the number of banks are shown.

The name of the banks are given in Table 3.6 categorized under ownership form and objectives. From Table 3.6 it is clear that NCBs includes the government owned 4 commercial banks.

Table 3.6: Categories of Banks, 2005

Bank Type	Serial No.	Name of banks	Date of functioning	Experience in years
NCBs	1	Sonali Bank	26.03.1972	33
	2	Janata Bank	26.03.1972	33
	3	Agrani Bank	26.03.1972	33
	4	Rupali Bank	26.03.1972	33
PCBs	5	Pubali Bank Ltd.	26.03.1972	33
	6	Uttara Bank Ltd.	26.03.1972	33
	7	AB Bank Ltd.	12.04.1982	23
	8	National Bank Ltd.	23.03.1983	22
	9	The City Bank Ltd.	27.03.1983	22
	10	IFIC Bank Ltd.	24.06.1983	22
	11	UCBL	29.06.1983	22
	12	Eastern Bank Ltd.	16.08.1992	13
	13	NCCBL	17.05.1993	12
	14	Prime Bank Ltd.	17.04.1995	10
	15	South East Bank Ltd.	25.05.1995	10
	16	Dhaka Bank Ltd.	05.07.1995	10
	17	Dutch-Bangla Bank Ltd.	30.06.1996	9
	18	Mercantile Bank Ltd.	02.06.1999	6
	19	Standard Bank Ltd.	03.05.1999	6
	20	One Bank Ltd.	14.07.1999	6
	21	EXIM Bank of BD. Ltd.	03.08.1999	6
	22	BD. Commerce Bank Ltd.	16.09.1999	6
	23	Mutual Trust Bank Ltd.	24.10.1999	6
	24	First Security Bank Ltd.	25.10.1999	6
	25	The Premier Bank Ltd.	26.10.1999	6
	26	Bank-Asia Ltd.	27.11.1999	6
	27	The Trust Bank Ltd.	29.11.1999	6
	28	Jamuna Bank Ltd.	03.06.2001	4
	29	Brac Bank Ltd.	04.07.2001	4
SCBs	30	BD. Krishi Bank	P.O. of 1972	33
	31	Raj. Krishi Unnayan Bank	15.03.1987	18
	32	BD. Shilpa Bank	22.10.1972	33
	33	BD. Shilpa Rin Shangstha	04.05.1997	8
	34	BASIC Bank Ltd.	21.01.1989	16
IPCBs	35	Islami Bank of BD. Ltd.	30.03.1983	22
	36	Al- Arafa Islami Bank Ltd.	27.09.1995	10
	37	Social Investment Bank Ltd.	22.11.1995	10
	38	The Oriental Bank Ltd.	20.05.1987	18
	39	Shahjalal Bank Ltd.	10.05.2001	4
FCBs	40	American Express Bank	07.02.1966	39
	41	Standard Chart Bank U.K.	01.01.1948	57
	42	Habib Bank Ltd.	09.07.1976	29
	43	State Bank of India Ltd.	05.05.1975	30
	44	Credit Agricole Indosuez	06.11.2003	2
	45	National Bank of PAK. Ltd.	31.08.1994	11
	46	City Bank n.a.	24.06.1995	10
	47	HANVIT (Woori) Bank Ltd.	21.09.1996	9
	48	The HSBC Ltd.	17.12.1996	9
	49	Shamil Bank of Bahrain E E.C.	21.08.1997	8

3.4 Sources of Data

For conducting the study, various data on the entire banking sector of Bangladesh are collected mainly from secondary sources. The sources of secondary data are Ministry of Finance's (MOF) publications namely Resumes and Activities of financial Institutions, Bangladesh Economic Survey and BB's publications; Bangladesh Bank publications include mainly, Bangladesh Bank Bulletins, Economic Trends, Scheduled Bank Statistics, Financial Sector Review, BB circulars, Bangladesh Bank's Annual Reports. Bank specific Annual Reports of 49 commercial bank's various published banking manuals, audit reports, government and government gazettes, World Bank Study Reports, Working Papers, Research papers, BIBM's publications namely 'Bank Parikrama'.

Cross section data has been chosen for seven years from 1999 to 2005. Data has been collected accordingly. The reason for choosing 7 years cross-sectional data can be given to DeYoung's (1997) findings. Using U.S. banking data, DeYoung (1997) devised a test to determine how many years of separate cross-section data for regressions may be needed to have a random error likely average out close to zero and achieve a stable measure of efficiency. Six years are the result. Thus the research has been conducted on 7 years data instead of six years to make the study more meaningful and comprehensive. Positing estimated efficiency, on this timeline the study is expected to be able to interpret the findings of the study as an average indicator of efficiency over the time period so chosen. Another reason for the time border so chosen is because, a phenomenal growth of the commercial banks has been observed due to reform and liberalisation policies. In addition, a huge growth of PCBs has been observed during this period. For example, 10 new banks have come into operation in the year 1999 and in the year 2001 more 3 banks started functioning. Therefore, the time line 1999-2005 is important for watching the changes in efficiency and to record how efficiency changes over time due to changes in policies.

3.5 Lists of Variables

Seven years bank specific data have been collected for the study requirement. The following variables have been chosen to undertake a through survey of the banking sector of Bangladesh from which the essential data are modified to fit the model of the study. As the study aims at measuring of technical efficiency of the commercial banks, data on income components and expenditure components have been necessary. However, the collected data have been represented in the following characterisation.

1. Total income

(i) Interest Income

(ii) Income from investment

(iii) Income from commission, exchange and brokerage

(iv) Other operating income

2. Total Expenditure

(i) Interest expenditure

(ii) Expenditures on salaries and wages

(iii) Occupancy cost i.e., rent, electricity and insurance

(iv) Expenditures on postage, stamps and communications

(v) Expenditures on stationary, printing and advertisement

(vi) Expenditures on legal expenses

(vii) Depreciation and repairs of the bank assets.

(viii) Other operating expenses

Other variables are as follows:

1. Deposit situations of all banks
2. Disbursed loans and recovery of all banks

(i) Category wise loans outstanding

(ii) Category wise recovery and total recovery at the end of the years

The other Progress indicator Variables are as follows:

1. Capital structure of the banking sector
2. Investment of fund of banks with other financial institutions
3. Total assets of the banks
4. Reserve fund of the banks

5. Volume of foreign exchange and trade
6. Number of Officers
7. Number of non-Officers
8. Number of branches
9. Number foreign correspondent banks

Description of the collected data has been provided in tabular form and brief explanations of the behaviour of the variables are described in the following section 3.8.

3.6 Income of the Banks

As the main concern of this study is to measure technical efficiency of the commercial banks operating in Bangladesh with application of econometric stochastic production frontier (SFA) as well as with application of nonparametric Data Envelopment Analysis (DEA) approaches. The figures for the variables have been collected and after necessary calculations these are put under following sub-sections with required interpretations. Total income of a commercial bank includes (i) interest income that is interest earned by the bank from loans, advances and credit activities, interest earned from banks and other financial institutions, and interest received from foreign currency clearing accounts etc. (ii) income from investment by the bank that is interest received from Treasury bills, bonds etc. (iii) Commission, Exchange and Brokerage that is, income earned by commission received, exchange earnings, rental income godown and banks assets, receipts from services and other charges, rental income of lockers etc. and (iv) other operating income which includes recovery of charges such as, telex and fax, incidental charges, postage, legal charges, forward booking, and miscellaneous income etc.

3.6.1 Interest Income

Table 3.4 shows that in the year 1999 NCBs earned interest income amounting to Tk. 21876.81 million, PCBs Tk. 13974.12 million, SCBs Tk. 4893.84 million, IPCBs Tk. 3256.56 million and FCBs Tk. 2844.32 million which in the year 2005 increases to Tk. 30619.83 million for NCBs, Tk. 50823.45 million for PCBs, Tk. 7334.96 million for SCBs, Tk. 11472.04 million for IPCBs and Tk. 5559.93 million for FCBs respectively.

Share of interest income by types of bank shows that in the year 1999 NCBs held 46.70 percent of the interest income while according to the table, the interest income portion declines to 27.85 in 2005. It can be noted that at the same time PCBs share of interest income increases from 29.83 to 46.22 percent, which implies that the scenery nearly reversed for PCBs.

Table 3.7: Interest Income, Share, Growth and Portion of Interest Income to Total Income, 1999-2005

Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	21876.81	24544.5	26262	26409.54	27928.9	25290	30619.83	26133.07	2732.50
PCBs	13974.12	18119.7	24418.9	28135.7	34000.2	39326.2	50823.45	29828.33	12708.15
SCBs	4893.84	6281.54	7731.17	6864.74	7780.85	7628.96	7334.96	6930.866	1047.94
IPCBs	3256.555	4479.42	6070.26	7247.376	9914.834	11901	11472.041	7763.068	3409.10
FCBs	2844.32	3239.47	3282.31	4590.57	6874.34	8380.89	9707.57	5559.924	2762.09
All banks	46845.64	56664.63	67764.62	73247.92	86499.12	92527.05	109957.85	76215.26	21738.65
Share of interest income									
NCBs	46.70	43.32	38.75	36.06	32.29	27.33	27.85	36.04	7.43
PCBs	29.83	31.98	36.03	38.41	39.31	42.50	46.22	37.75	5.72
SCBs	10.45	11.09	11.41	9.37	9.00	8.25	6.67	9.46	1.68
IPCBs	6.95	7.91	8.96	9.89	11.46	12.86	10.43	9.78	2.04
FCBs	6.07	5.72	4.84	6.27	7.95	9.06	8.83	6.96	1.64
All banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of interest income									
NCBs		12.19	7.00	0.56	5.75	-9.45	21.07	6.19	10.34
PCBs		29.67	34.76	15.22	20.84	15.66	29.24	24.23	8.14
SCBs		28.36	23.08	-11.21	13.35	-1.95	-3.85	7.96	15.99
IPCBs		37.55	35.51	19.39	36.81	20.03	-3.60	24.28	15.99
FCBs		13.89	1.32	39.86	49.75	21.92	15.83	23.76	17.90
All banks		20.96	19.59	8.09	18.09	6.97	18.84	15.42	6.20
Portion of interest income to total income									
NCBs	68.06	66.68	67.72	64.48	67.05	61.53	63.31	65.55	2.48
PCBs	70.62	68.93	71.76	70.84	69.76	68.30	71.91	70.30	1.37
SCBs	88.40	91.63	83.67	89.71	89.17	87.68	86.60	88.12	2.53
IPCBs	77.99	81.32	82.97	83.57	84.13	83.80	78.67	81.78	2.53
FCBs	63.78	56.08	48.48	56.11	61.16	60.29	60.95	58.12	5.08
All banks	70.87	69.75	70.49	69.64	70.82	68.30	69.59	69.92	0.90

However, the case of FCBs is interesting because over the time fluctuation of interest income is almost stable which is indicated by mean interest income 6.96 percent and smallest standard deviation 1.64.

Growth of interest income segment shows that NCBs experiences a growth rate of 12.19 percent in 2000 which gradually declines to 0.56 percent in 2002 and -9.45 percent in 2004, but it recovered again in 2005 showing the growth rates of 21.07 percent. However, IPCBs growth rate is highest in 2000, which is 37.55 percent. However, the trend of the growth rate is declining over time.

3.6.2 Income from Commission and Exchange

Table 3.8 shows that Commission and Exchange Income earned by NCBs stand a Tk. 4763.79 million in 1999 which increases over the study period to Tk. 9612.80. Commission and Exchange Income increase in all categories of banks in 1999 the share of Commission and Exchange Income component by NCBs shows 44.41 percent while PCBs share is 34.11 percent, SCBs share is 2.60 percent, IPCBs share is 7.33 and FCBs share is 11.55 percent. Over the period NCBs and SCBs lose their share showing the figure 33.62 percent and 2.29 percent while PCBs and IPCBs increase their share showing the figure as 37.85 percent, 9.53 percent and 16.92 percent respectively in the year 2005. The explanation for such behaviour can be ascribed to providing modern facilities and good services to their clients compared to NCBs and SCBs.

Table 3.8: Commission and Exchange Income, Share and Growth of Banks, 1999-2005

Banks	1999	2000	2001	2002	2003	2004	2005	Mean	St.Dev
NCBs	4765.79	5718.71	5962.86	8051.37	6159.07	7526.02	9612.80	6828.09	1654.19
PCBs	3660.13	4976.38	5818.33	7257.43	8429.48	9308.94	10821.53	7181.74	2531.79
SCBs	278.95	289.28	397.71	370.43	445.86	601.571	593.65	425.35	131.36
IPCBs	786.168	886.26	1031.24	1255.23	1636.04	2063	2724.28	1483.17	706.90
FCBs	1239.53	1785.26	2023.45	2984.96	3237.70	4126.67	4838.40	2890.85	1300.70
All banks	10730.56	13655.89	15233.59	19919.43	19908.15	23626.17	28590.66	18809.21	6136.32
Share of commission and exchange income									
NCBs	44.41	41.88	39.14	40.42	30.94	31.85	33.62	37.47	5.29
PCBs	34.11	36.44	38.19	36.43	42.34	39.40	37.85	37.82	2.60
SCBs	2.60	2.12	2.61	1.86	2.24	2.55	2.08	2.29	0.30
IPCBs	7.33	6.49	6.77	6.30	8.22	8.73	9.53	7.62	1.23
FCBs	11.55	13.07	13.28	14.99	16.26	17.47	16.92	14.79	2.22
All banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of commission and exchange income									
NCBs		20.00	4.27	35.03	-23.50	22.19	27.73	14.28	21.14
PCBs		35.96	16.92	24.73	16.15	10.43	16.25	20.07	9.02
SCBs		3.70	37.48	-6.86	20.36	34.92	-1.32	14.72	18.99
IPCBs		12.73	16.36	21.72	30.34	26.10	32.05	23.22	7.70
FCBs		44.03	13.34	47.52	8.47	27.46	17.25	26.34	16.33
All banks		27.26	11.55	30.76	-0.06	18.68	21.01	18.20	11.18

However, growth rate of Commission and Exchange Income component shows declining growth trend of NCBs, PCBs, SCBs and FCBs while increasing growth rate for IPCBs. The overall growth rate trend over the year 1999-2005 is a bit declining.

3.6.3 Investment Income

Investment Income includes interest received from Treasury bills, bonds etc. Table 4.6 shows the income earned from Investment Income by the types of banks for period 1999-2005. This component shows increase for NCBs, PCBs, SCBs, IPCBs and FCBs.

Table 3.9: Volume of Investment Income, Share and Growth Rate of Banks 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	4877.09	6036.03	6134.45	5875.38	7077.16	6616.00	7135.51	6250.23	783.86
PCBs	1399.64	2210.60	2372.51	2850.06	4379.36	6050.83	5769.25	3576.04	1832.88
SCBs	108.95	168.68	212.91	236.60	234.60	255.50	268.60	212.26	55.84
IPCBs	0.18	0.22	57.78	0.48	1.00	0.38	151.13	30.17	57.46
FCBs	334.60	598.92	419.74	511.93	1035.79	1279.20	1227.29	772.50	397.31
All banks	6720.47	9014.45	9197.39	9474.44	12727.91	14201.91	14551.78	10841.19	2986.36
Share investment income									
NCBs	72.57	66.96	66.70	62.02	55.60	46.59	49.04	59.92	9.79
PCBs	20.83	24.52	25.80	30.08	34.41	42.61	39.65	31.13	8.11
SCBs	1.62	1.87	2.31	2.50	1.84	1.80	1.85	1.97	0.31
IPCBs	0.00	0.00	0.63	0.01	0.01	0.00	1.04	0.24	0.42
FCBs	4.98	6.64	4.56	5.40	8.14	9.01	8.43	6.74	1.81
All banks	100.00	100.00	100.00	100.01	100.00	100.00	100.00	100.00	0.00
Growth rate of investment income									
NCBs		23.76	1.63	-4.22	20.45	-6.52	7.85	7.16	12.65
PCBs		57.94	7.32	20.13	53.66	38.17	-4.65	28.76	25.34
SCBs		54.82	26.22	11.13	-0.85	8.91	5.13	17.56	20.36
IPCBs		20.33	26283.56	-99.17	108.33	-62.00	39670.00	10986.84	17551.6
FCBs		79.00	-29.92	21.96	102.33	23.50	-4.06	32.14	49.92
All banks		34.13	2.03	3.01	34.34	11.58	2.46	14.59	15.62
Portion of investment income to total income									
NCBs	15.17	16.40	15.82	14.34	16.99	16.10	14.75	15.65	0.94
PCBs	7.07	8.41	6.97	7.18	8.99	10.51	8.16	8.18	1.28
SCBs	1.97	2.46	2.30	3.09	2.69	2.94	3.17	2.66	0.44
IPCBs	0.00	0.00	0.79	0.01	0.01	0.00	1.04	0.26	0.45
FCBs	7.50	10.37	6.20	6.26	9.21	9.20	7.71	8.06	1.59
All banks	10.17	11.10	9.57	9.01	10.42	10.48	9.21	9.99	0.76

Segment of share of Investment Income component shows that NCBs held 72.57 percent income of the banking industry while Islamic bankers have no share in 1999. This is because in the initial stage of banking operation by the Islamic bankers, they are reluctant to invest in interest earning instruments. However, because of policy matters, they changed their mode of investment as per the decision of board, therefore, investment income increases very slowly and the shares for all banks stand at 1.04 percent. This shows abnormal growth rate for IPCBs in the year 2001.

Anyway from the segment of Portion of investment income to total income ratio (in percentage form), it is seen that the banking industry occupies only 10.17 percent of income from this component. For the NCBs the portion stands at 15.17 and for SCBs, the portion stands at 1.97 and comparatively stable over time (smallest standard deviation 0.44). Portion of the PCBs has been increased over the period and stand at 10.51 from the initial stage of 7.07 in 1999.

3.6.4 Other Operating Income

Table 3.10 shows that NCBs other operating income earning is Tk.622.82 million in 1999, which over the study period increases to Tk.995.48 million in 2005, at the same time PCBs experiences a huge increase from Tk.753.07 million to Tk.3258.70 million. NCBs and SCBs shares have been declines during the period from 34.51 percent to 20.24 percent and SCBs from 14.10 percent to 5.54 percent. While PCBs increases their income from this component from 41.73 percent to 66.27 percent.

Table 3.10 shows NCBs experiences a negative growth rate in 2000 at -18.06 and in the year 2001 at -17.26 and in the year 2004 it experiences an excellent leap of the growth rate at 242.43 but the growth rate again dropped to -40.28 percent in 2005. At the same time NCBs growth rate consistently (standard deviation smallest at 12.49) declines with fluctuations in the year 2003 and 2004 but experiences no negative growth rate.

Table 3.10: Other Operating Income, Share and Growth of Banks, 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	622.82	510.34	422.27	622.91	486.82	1667.00	995.48	761.09	440.97
PCBs	753.07	982.06	1205.40	1475.53	1931.31	2891.96	3258.70	1785.43	962.62
SCBs	254.48	116.08	898.47	180.46	264.56	214.84	272.58	314.50	263.36
IPCBs	132.86	142.19	157.06	169.47	233.44	237.00	235.54	186.79	46.82
FCBs	41.29	152.59	89.30	94.58	92.74	115.10	155.11	105.82	39.66
All banks	1804.52	1903.26	2772.50	2542.96	3008.86	5125.90	4917.41	3153.63	1349.29
Share of operating income									
NCBs	34.51	26.81	15.23	24.50	16.18	32.52	20.24	24.29	7.56
PCBs	41.73	51.60	43.48	58.02	64.19	56.42	66.27	54.53	9.50
SCBs	14.10	6.10	32.41	7.10	8.79	4.19	5.54	11.18	9.90
IPCBs	7.36	7.47	5.66	6.66	7.76	4.62	4.79	6.33	1.31
FCBs	2.29	8.02	3.22	3.72	3.08	2.25	3.15	3.68	1.99
All banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00		
Growth rate of income									
NCBs		-18.06	-17.26	47.52	-21.85	242.43	-40.28	32.08	107.31
PCBs		30.41	22.74	22.41	30.89	49.74	12.68	28.15	12.49
SCBs		-54.39	674.01	-79.91	46.60	-18.79	26.88	99.07	285.66
IPCBs		7.02	10.46	7.91	37.74	1.53	-0.62	10.67	13.89
FCBs		269.54	-41.47	5.91	-1.95	24.11	34.76	48.48	111.44
All banks		5.47	45.67	-8.28	18.32	70.36	-4.07	21.25	30.91
Portion of other operating income to total income									
NCBs	1.94	1.39	1.09	1.52	1.17	4.06	2.06	1.89	1.02
PCBs	3.81	3.74	3.54	3.71	3.96	5.02	4.61	4.06	0.55
SCBs	4.60	1.69	9.72	2.36	3.03	2.47	3.22	3.87	2.74
IPCBs	3.18	2.58	2.15	1.95	1.98	1.67	1.62	2.16	0.55
FCBs	0.93	2.64	1.32	1.16	0.83	0.83	0.97	1.24	0.64
All banks	2.73	2.34	2.88	2.42	2.46	3.78	3.11	2.82	0.51

From the segment of portion of other operating income to total income (in percentage form) shows that the overall of all banks total income is 2.73 percent while NCBs income from this component is 1.94 percent, PCBs income is 3.81 percent, SCBs income is 4.60 (highest) percent and IPCBs income is 3.18 percent and FCBs income is 0.93 percent (lowest). It implies that FCBs do not depend heavily on this income component.

Table 3.11: Total Income by Types of Banks 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	32142.50	36809.54	38781.55	40959.20	41651.95	41099.00	48363.62	39972.48	4970.00
PCBs	19786.96	26288.79	34029.15	39718.71	48740.34	57577.92	70672.93	42402.11	17879.73
SCBs	5536.22	6855.58	9240.26	7652.23	8725.87	8700.87	8469.79	7882.97	1302.69
IPCBs	4175.58	5508.08	7316.33	8672.08	11785.31	14201.08	14582.98	9463.06	4141.03
FCBs	4459.71	5776.24	6769.80	8182.04	11240.57	13901.85	15928.37	9465.51	4324.03
All Banks	66100.98	81238.23	96137.09	105184.27	122144.04	135480.72	158017.69	109186.14	31800.27
Share of total income by types of banks									
NCBs	48.63	45.31	40.34	38.94	34.10	30.34	30.61	38.32	7.08
PCBs	29.93	32.36	35.40	37.76	39.90	42.50	44.72	37.51	5.34
SCBs	8.38	8.44	9.61	7.28	7.14	6.42	5.36	7.52	1.42
IPCBs	6.32	6.78	7.61	8.24	9.65	10.48	9.23	8.33	1.54
FCBs	6.75	7.11	7.04	7.78	9.20	10.26	10.08	8.32	1.50
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth rate of total income by types of banks									
NCBs		14.52	5.36	5.62	1.69	-1.33	17.68	7.26	7.38
PCBs		32.86	29.44	16.72	22.71	18.13	22.74	23.77	6.30
SCBs		23.83	34.78	-17.19	14.03	-0.29	-2.66	8.75	19.07
IPCBs		31.91	32.83	18.53	35.90	20.50	2.69	23.73	12.47
FCBs		29.52	17.20	20.86	37.38	23.68	14.58	23.87	8.42
All Banks		22.90	18.34	9.41	16.12	10.92	16.63	15.72	4.95

3.7 Expenditures of Banks

Banks total expenditure has been splitted into the following components; (i) Expenditure made for various short term and long term deposits (interest paid on deposits- capital inputs) for collection of funds. (ii) Expenditure made on staffs (salaries and wages-labour input) (iii) expenditure for renting premises, electricity, insurance (occupancy expenditure-land inputs) (iv) expenditures on postage and telecommunications (v) expenditure on printing and materials (vii) provisions for classified loans (viii) miscellaneous expenditures.

3.7.1 Interest Expenditures

Banks accept deposits, against payment of interest on deposited amount. Interest expenditure component includes payment of interest on deposits, borrowing from other banks, discount paid to banks etc.

Table 3.12 shows that NCBs incur Tk. 23200.16 million as payment of interest while PCBs Tk. 10091.92 million, SCBs Tk. 5357.37 million, IPCBs Tk.2599.77 million and FCBs Tk.1650.32 million in the year 2005. Due to interest rate cut down policy in 2003 this component decreases in the year 2003 in the NCBs but the PCBs could not reduced the expenditure as is evident.

Table 3.12: Interest Expenses, Share, Growth and Portion of Interest Expenses to Total Expenditure, 1999-2005 (Tk. in Million)

TYPES OF BANK	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	23200.16	25758.64	28270.21	28578.15	16325.99	26416.00	25974.90	24932.01	4192.73
PCBs	10091.92	13112.92	16712.99	20528.88	24321.21	27119.29	35448.67	21047.98	8727.51
SCBs	5357.37	5325.66	5065.88	5677.06	5633.11	5641.44	2422.05	5017.51	1165.65
IPCBs	2599.77	3394.70	4200.48	5274.33	7326.00	8383.00	7379.68	5508.28	2227.18
FCBs	1650.32	1788.80	1515.20	2213.54	3343.59	3890.03	4066.25	2638.25	1098.70
All Banks	42899.54	49380.72	55764.76	62271.96	56949.90	71449.76	75291.55	59144.03	11528.20
Share of interest expenses									
NCBs	54.08	52.16	50.70	45.89	28.67	36.97	34.50	43.28	9.90
PCBs	23.52	26.55	29.97	32.97	42.71	37.96	47.08	34.39	8.60
SCBs	12.49	10.78	9.08	9.12	9.89	7.90	3.22	8.93	2.91
IPCBs	6.06	6.87	7.53	8.47	12.86	11.73	9.80	9.05	2.54
FCBs	3.85	3.62	2.72	3.55	5.87	5.44	5.40	4.35	1.20
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of interest expenses									
NCBs		11.03	9.75	1.09	-42.87	61.80	-1.67	6.52	33.54
PCBs		29.93	27.45	22.83	18.47	11.50	30.71	23.49	7.47
SCBs		-0.59	-4.88	12.06	-0.77	0.15	-57.07	-8.52	24.46
IPCBs		30.58	23.74	25.56	38.90	14.43	-11.97	20.21	17.70
FCBs		8.39	-15.30	46.09	51.05	16.34	4.53	18.52	25.55
All Banks		15.11	12.93	11.67	-8.55	25.46	5.38	10.33	11.32
Portion of interest expenses to total expenses									
NCBs	73.48	74.69	75.67	75.07	61.70	71.29	68.10	71.43	5.03
PCBs	69.08	68.57	70.14	69.00	69.47	68.33	70.65	69.32	0.83
SCBs	69.86	64.76	63.35	68.51	67.23	64.03	38.10	62.27	10.92
IPCBs	76.13	75.52	75.52	75.92	77.34	77.34	75.81	76.23	0.79
FCBs	56.95	56.96	50.85	51.66	51.47	55.78	53.93	53.94	2.66
All Banks	71.31	71.08	71.75	71.30	66.37	69.12	67.25	69.74	2.19

It can be seen that NCBs share in this component is 54.08 percent and over the years the share reduces to 34.50 percent, which implies that deposits flow towards PCBs from NCBs and SCBs. The case is same for IPCBs and FCBs also which incur increasing interest expenditure.

From the growth rate segment it can be clearly understood that NCBs experiences declining growth rate which in the year 2005 stands at -1.67 percent from initial stage of 11.03 in the year 1999. The growth rate of the overall interest expenditure component is declining over time.

Lower segment of the table (Portion of interest expenses to total expenses) indicates that out of total expenditures NCBs potion in interest expenditure component is 73.48 percent while PCBs portion is 69.08 percent, SCBs portion is 69.86 percent, IPCBs portion is 76.13 percent. This implies that in the total expenditures of bank, interest expenditure component occupy an overall portion of 71.31 percent which over the years slightly decline to 67.25 percent.

3.7.2 Expenditures on Salaries and Wages

From the Table 3.13, it can be seen that NCBs incur Tk. 6438 million in 1999 to pay their staffs while PCBs pay Tk. 2493.26 million, SCBs pay Tk. 1676.89 million, IPCBs pay Tk. 463.85 million, and FCBs pay Tk. 494.45 million. It is evident that over the years the figure increases due to overall price hike and subsequent increase in salaries. However, from the share segment of the table it is seen that NCBs share in this component is 55.66 percent, while PCBs only 21.55 percent, SCBs 14.50 percent, IPCBs 4.01 percent and FCBs 4.27 percent in 1999. Over the period, the share of NCBs has been reduced to 39.41 percent and the share of SCBs to 10.87 percent.

Table 3.13: Salary and Wage Expenses of Banks 1999-2005 (Tk. in Millions)

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	6438.60	6714.78	6835.14	7119.60	7494.61	7716.00	9094.22	7344.71	889.69
PCBs	2493.26	3429.75	4041.26	4811.07	5853.73	7054.60	8362.98	5149.52	2073.95
SCBs	1676.89	1872.60	1936.47	2032.53	2021.64	2250.51	2509.55	2042.88	269.48
IPCBs	463.85	650.16	791.57	949.51	1187.00	1533.00	1487.26	1008.91	410.64
FCBs	494.45	528.31	601.69	896.77	1087.69	1359.82	1624.37	941.87	437.94
All banks	11567.05	13195.60	14206.13	15809.48	17644.67	19913.93	23078.38	16487.89	4025.56
Share of year wise salary and wage expenses (in percent)									
NCBs	55.66	50.89	48.11	45.03	42.48	38.75	39.41	45.76	6.20
PCBs	21.55	25.99	28.45	30.43	33.18	35.43	36.24	30.18	5.29
SCBs	14.50	14.19	13.63	12.86	11.46	11.30	10.87	12.69	1.48
IPCBs	4.01	4.93	5.57	6.01	6.73	7.70	6.44	5.91	1.21
FCBs	4.27	4.00	4.24	5.67	6.16	6.83	7.04	5.46	1.29
All banks	100	100	100	100	100	100	100	100.00	0.00
Growth of salary and wage expenses (in percent)									
NCBs		4.29	1.79	4.16	5.27	2.95	17.86	6.05	5.91
PCBs		37.56	17.83	19.05	21.67	20.51	18.55	22.53	7.49
SCBs		11.67	3.41	4.96	-0.54	11.32	11.51	7.06	5.19
IPCBs		40.17	21.75	19.95	25.01	29.15	-2.98	22.17	14.27
FCBs		6.85	13.89	49.04	21.29	25.02	19.45	22.59	14.43
All banks		14.08	7.66	11.29	11.61	12.86	15.89	12.23	2.81
Portion of salary and wage expenses to total expenses (in percent)									
NCBs	20.39	19.47	18.30	18.70	28.33	20.82	23.84	21.41	3.56
PCBs	17.07	17.93	16.96	16.17	16.72	17.78	16.67	17.04	0.63
SCBs	21.87	22.77	24.22	24.53	24.13	25.54	39.47	26.08	6.03
IPCBs	13.58	14.46	14.23	13.67	12.53	14.14	15.28	13.99	0.85
FCBs	17.06	16.82	20.19	20.93	16.74	19.50	21.54	18.97	2.06
All banks	19.23	18.99	18.28	18.10	20.56	19.27	20.61	19.29	0.99

The share of PCBs increases and the same is experienced by IPCBs and FCBs. In the growth rate segment of the table, we see that NCBs experiences a substantial growth rate in the year 2005 but in the preceding years its salary expenditure growth is declining. This implies that NCBs do not immediately respond to enhancement of salaries as quickly as does the PCBs. This is evident in the year 2000 with 37.56 percent growth rate in the PCBs and the case is same for the IPCBs. The FCBs responds to price hike in the year 2003 with highest growth rate in salary expenses of 49.04 percent.

In the lower segment of the table, the portion to total expenditure shows that on an average all banks incur 19.23 percent outlay in salary and wages to the total expenditure. This figure increases in the year 2005, which shows 20.61 percent.

3.7.3 Occupancy Expenditure

We find bank's expenditure on rent electricity and insurance component and their relative shares, rate of growth and portion to total expenditure and respective changes over the years in Table 3.14.

Table 3.14: Rent, Electricity and Insurance Expenses of Banks, 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	634.89	621.23	759.97	805.42	850.88	935.00	936.46	791.98	128.99
PCBs	651.00	787.84	917.70	1147.56	1242.25	1578.91	1766.74	1156.00	409.62
SCBs	106.85	107.03	142.45	133.04	187.03	189.89	190.35	150.95	37.94
IPCBs	91.77	104.73	114.22	169.39	223.00	260.00	207.15	167.18	65.48
FCBs	117.59	128.24	129.25	156.30	211.52	269.12	342.42	193.49	85.39
All Banks	1602.10	1749.07	2063.59	2411.71	2714.68	3232.92	3443.12	2459.60	710.60
Share of rent electricity and insurance expenses									
NCBs	39.63	35.52	36.83	33.40	31.34	28.92	27.20	33.26	4.43
PCBs	40.63	45.04	44.47	47.58	45.76	48.84	51.31	46.23	3.43
SCBs	6.67	6.12	6.90	5.52	6.89	5.87	5.53	6.21	0.61
IPCBs	5.73	5.99	5.54	7.02	8.21	8.04	6.02	6.65	1.12
FCBs	7.34	7.33	6.26	6.48	7.79	8.32	9.95	7.64	1.24
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of rent electricity and insurance expenses									
NCBs		-2.15	22.33	5.98	5.64	9.89	0.16	6.97	8.68
PCBs		21.02	16.48	25.05	8.25	27.10	11.90	18.30	7.43
SCBs		0.17	33.09	-6.61	40.58	1.53	0.24	11.50	19.97
IPCBs		14.13	9.06	48.30	31.65	16.59	-20.33	16.57	23.06
FCBs		9.06	0.79	20.93	35.33	27.23	27.24	20.10	12.88
All Banks		9.17	17.98	16.87	12.56	19.09	6.50	13.70	5.12
Portion of rent electricity and insurance expenses									
NCBs	2.01	1.80	2.03	2.12	3.22	2.52	2.46	2.31	0.47
PCBs	4.46	4.12	3.85	3.86	3.55	3.98	3.52	3.90	0.33
SCBs	1.39	1.30	1.78	1.61	2.23	2.16	2.99	1.92	0.59
IPCBs	2.69	2.33	2.05	2.44	2.35	2.40	2.13	2.34	0.21
FCBs	4.06	4.08	4.34	3.65	3.26	3.86	4.54	3.97	0.43
All Banks	2.66	2.52	2.65	2.76	3.16	3.13	3.08	2.85	0.26

3.7.4 Expenditure on Postage, Stamp, Telecommunication

Table 3.15 shows that NCBs and SCBs expenditure on Postage, Stamp, Telecommunication components decrease over the time (27.54 percent in 1999 to 13.74 percent in 2005). Over the years all category of banks reduce portion of the expenses on this component while SCBs portion increases (0.43 percent in 1999 to 0.64 in 2005).

Table 3.15: Postage and Telecommunication Expenses of Banks 1999-2005

Bank type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	174.85	182.72	177.20	157.20	168.05	159.00	150.02	167.01	11.99
PCBs	268.55	316.47	382.66	420.34	459.83	510.10	600.25	422.60	113.43
SCBs	32.80	35.59	33.67	30.49	34.57	35.38	40.52	34.72	3.10
IPCBs	56.67	63.25	74.65	75.75	84.00	96.00	88.83	77.02	13.90
FCBs	101.99	103.81	93.85	114.34	155.31	164.73	212.24	135.18	43.67
All banks	634.86	701.84	762.03	798.12	901.76	965.21	1091.86	836.53	159.08
Share of postage and telecommunication expenses									
NCBs	27.54	26.03	23.25	19.70	18.64	16.47	13.74	20.77	5.06
PCBs	42.30	45.09	50.22	52.67	50.99	52.85	54.97	49.87	4.55
SCBs	5.17	5.07	4.42	3.82	3.83	3.67	3.71	4.24	0.65
IPCBs	8.93	9.01	9.80	9.49	9.32	9.95	8.14	9.23	0.61
FCBs	16.06	14.79	12.32	14.33	17.22	17.07	19.44	15.89	2.32
All banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of postage and telecommunication expenses									
NCBs		4.50	-3.02	-11.29	6.90	-5.39	-5.65	-2.32	6.83
PCBs		17.84	20.92	9.85	9.39	10.93	17.67	14.43	4.96
SCBs		8.51	-5.39	-9.44	13.38	2.34	14.53	3.99	9.91
IPCBs		11.61	18.03	1.47	10.89	14.29	-7.47	8.14	9.42
FCBs		1.79	-9.59	21.82	35.84	6.07	28.84	14.13	17.47
All banks		10.55	8.58	4.73	12.99	7.04	13.12	9.50	3.35
Portion of postage and telecommunication expenses to total expense									
NCBs	0.55	0.53	0.47	0.41	0.64	0.43	0.39	0.49	0.09
PCBs	1.84	1.65	1.61	1.41	1.31	1.29	1.20	1.47	0.23
SCBs	0.43	0.43	0.42	0.37	0.41	0.40	0.64	0.44	0.09
IPCBs	1.66	1.41	1.34	1.09	0.89	0.89	0.91	1.17	0.31
FCBs	3.52	3.31	3.15	2.67	2.39	2.36	2.81	2.89	0.45
All banks	1.06	1.01	0.98	0.91	1.05	0.93	0.98	0.99	0.05

3.7.5 Expenditures on Printing, Stamps, Stationery and Advertisement

Table 3.16 shows that NCBs expenditure on this component increases from Tk.207.72 million to Tk.276.11 while comparative share decreases from 39.24 in 1999 to 21.38 in 2004 growth rate of increases for all category banks in the year 2004.

Table 3.16: Stationary Expenses of Banks 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	207.72	218.4	234.3	242.83	249.84	273	276.11	243.17	25.72
PCBs	187.942	251.93	298.87	378.4	429.57	505.01	640.23	384.56	155.74
SCBs	40.74	40.67	45.73	46.11	47.03	59.1	56.47	47.98	7.20
IPCBs	27.974	33.738	41.81	56.76	58	72	66.06	50.91	16.65
FCBs	65.01	79.581	92.43	177.22	805.44	227.38	252.463	242.79	258.86
All Banks	529.386	624.319	713.14	901.32	1589.88	1136.49	1291.333	969.41	387.20
Share of stationary expenses									
NCBs	39.24	34.98	32.85	26.94	15.71	24.02	21.38	27.88	8.27
PCBs	35.50	40.35	41.91	41.98	27.02	44.44	49.58	40.11	7.16
SCBs	7.70	6.51	6.41	5.12	2.96	5.20	4.37	5.47	1.56
IPCBs	5.28	5.40	5.86	6.30	3.65	6.34	5.12	5.42	0.92
FCBs	12.28	12.75	12.96	19.66	50.66	20.01	19.55	21.12	13.50
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of stationary expenses									
NCBs		5.14	7.28	3.64	2.89	9.27	1.14	4.89	2.99
PCBs		34.05	18.63	26.61	13.52	17.56	26.78	22.86	7.59
SCBs		-0.17	12.44	0.83	2.00	25.66	-4.45	6.05	11.12
IPCBs		20.60	23.93	35.76	2.18	24.14	-8.25	16.39	16.24
FCBs		22.41	16.15	91.73	354.49	-71.77	11.03	70.67	148.42
All Banks		17.93	14.23	26.39	76.39	-28.52	13.62	20.01	33.63
Portion of stationary expenses to total expenses									
NCBs	0.66	0.63	0.63	0.64	0.94	0.74	0.72	0.71	0.11
PCBs	1.29	1.32	1.25	1.27	1.23	1.27	1.28	1.27	0.03
SCBs	0.53	0.49	0.57	0.56	0.56	0.67	0.89	0.61	0.13
IPCBs	0.82	0.75	0.75	0.82	0.61	0.66	0.68	0.73	0.08
FCBs	2.24	2.53	3.10	4.14	12.40	3.26	3.35	4.43	3.57
All Banks	0.88	0.90	0.92	1.03	1.85	1.10	1.15	1.12	0.34

3.7.6 Depreciation and Repair Expenditures of the Bank's Property

Depreciation means an amount charged to profit and loss account of a bank to represent wearing out or diminution in value of assets. The amount charged is normally based on a percentage of the value of the asset.

Table 3. 17: Depreciation of Banks, 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	233.79	238.71	252.91	270.28	301.24	393	432.32	303.18	78.88
PCBs	366.97	435.19	491.15	652.93	757.3	893.58	1099.5	670.95	265.00
SCBs	62.92	66.13	60.48	71.08	94.87	100.88	100.43	79.54	18.34
IPCBs	50.207	73.987	100.98	128.96	157	82	145.38	105.50	39.62
FCBs	149.05	166.35	179.22	285.63	369.88	418.84	460.68	289.95	128.81
All Banks	862.94	980.367	1084.7	1408.88	1680.3	1888.3	2238.4	1449.12	511.03
Share of depreciation expenses									
NCBs	27.09	24.35	23.32	19.18	17.93	20.81	19.31	21.71	3.31
PCBs	42.53	44.39	45.28	46.34	45.07	47.32	49.12	45.72	2.13
SCBs	7.29	6.75	5.58	5.05	5.65	5.34	4.49	5.73	0.97
IPCBs	5.82	7.55	9.31	9.15	9.34	4.34	6.49	7.43	1.97
FCBs	17.27	16.97	16.52	20.27	22.01	22.18	20.58	19.40	2.43
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of depreciation expenses									
NCBs		2.10	5.95	6.87	11.45	30.46	10.01	11.14	10.02
PCBs		18.59	12.86	32.94	15.98	18.00	23.05	20.24	7.06
SCBs		5.10	-8.54	17.53	33.47	6.33	-0.45	8.91	14.77
IPCBs		47.36	36.48	27.71	21.74	-47.77	77.29	27.14	41.60
FCBs		11.61	7.74	59.37	29.50	13.24	9.99	21.91	19.93
All Banks		13.61	10.65	29.88	19.26	12.38	18.54	17.39	7.01
Portion of depreciation expenses to total expenses									
NCBs	0.74	0.69	0.68	0.71	1.14	1.06	1.13	0.88	0.22
PCBs	2.51	2.28	2.06	2.19	2.16	2.25	2.19	2.24	0.14
SCBs	0.82	0.80	0.76	0.86	1.13	1.15	1.58	1.01	0.30
IPCBs	1.47	1.65	1.82	1.86	1.66	0.76	1.49	1.53	0.37
FCBs	5.14	5.30	6.02	6.67	5.69	6.01	6.11	5.85	0.52
All Banks	1.43	1.41	1.40	1.61	1.96	1.83	2.00	1.66	0.26

The bank assets include furniture and fixture, office appliance, electrical appliance, motor vehicles. In Table 3.17, it can be seen that over the study period, this expenditure component for the commercial banks increases about three times i.e., in the year 1999 the amount is Tk. 862.94 which increases to Tk. 2238.4 in 2005. Table 3.17 shows that this share of expenditure is highest for the PCBs at 45.72 percent on an average.

Table 3.17 supports the same fact which shows 20.24 percent growth rate on an average over the period. One of the reason for increase of this expenditure component is application of modern technology such as computer, air conditioners, vehicles and other electronic and decorative equipments in the PCBs. However, the NCBs are found conservative in disposing such expenditures which can be clearly understood from the lower segment table where portion of this expenditure is only 0.88 percent to total expenditure on an average during the period. This also implies that rate of introduction of new equipments in the NCBs is low.

3.7.7 Expenditure on Legal Affairs

This component of expenditure is mandatory for the financial institutions. We find that legal affairs expenditure occupies 0.23 to 0.29 percent to total expenditures.

Table 3.18: Legal Expenses of Bank, 1999-2005 (Tk. in Millions)

Bank Types	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	73.6	79.24	85.71	74.77	99.98	172.2	121.6	101.02	35.69
PCBs	25.84	24.745	27.54	45.65	97.54	218.4	121.3	80.15	71.99
SCBs	3.1	2.991	3.14	3.67	2.27	8.94	6.63	4.39	2.45
IPCBs	5.01	5.8	7.12	10.53	10.98	22.56	15.45	11.06	6.21
FCBs	6.274	6.69	7.25	9.57	21.63	13.53	19.64	12.08	6.36
All banks	113.824	119.47	130.76	144.194	232.4	435.7	284.6	208.71	119.05
Share expenses (in percent)									
NCBs	64.66	66.33	65.55	51.85	43.02	39.53	42.73	53.38	11.96
PCBs	22.70	20.71	21.06	31.66	41.97	50.14	42.61	32.98	12.03
SCBs	2.72	2.50	2.40	2.55	0.98	2.05	2.33	2.22	0.59
IPCBs	4.40	4.85	5.45	7.30	4.72	5.18	5.43	5.33	0.95
FCBs	5.51	5.60	5.55	6.64	9.31	3.11	6.90	6.09	1.87
All banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth expenses (in percent)									
NCBs		7.66	8.17	-12.76	33.72	72.23	-29.36	13.28	35.91
PCBs		-4.24	11.28	65.79	113.65	123.94	-44.48	44.33	67.74
SCBs		-3.52	4.98	16.88	-38.15	293.83	-25.84	41.37	125.31
IPCBs		15.77	22.76	47.89	4.27	105.46	-31.52	27.44	46.21
FCBs		6.63	8.43	31.93	126.02	-37.45	45.16	30.12	54.80
All banks		4.96	9.45	10.27	61.17	87.46	-34.67	23.11	43.84
Portion expenses (in percent)									
NCBs	0.23	0.23	0.23	0.20	0.38	0.46	0.32	0.29	0.10
PCBs	0.18	0.13	0.12	0.15	0.28	0.55	0.24	0.24	0.15
SCBs	0.04	0.04	0.04	0.04	0.03	0.10	0.10	0.06	0.03
IPCBs	0.15	0.13	0.13	0.15	0.12	0.21	0.16	0.15	0.03
FCBs	0.22	0.21	0.24	0.22	0.33	0.19	0.26	0.24	0.05
All banks	0.19	0.17	0.17	0.17	0.27	0.42	0.25	0.23	0.09

Note: Portion indicates a fraction of the component and is measured as the ratio of component value to total value of the variable and is calculated by the formula $(e/E)\times 100$ where e = value of the component E =total value of the variable.

3.7.8 Other Operating Expenses

Table 3.18 shows that operating expenses increase almost double from Tk. 608.92 in 1999 to Tk. 1156.48 in 2005 for NCBs while comparative share decrease over time. For the PCBs the expenses increase about four times 522.97 in 1999 to 2137.86 in 2005 and comparative share increases from 26.79 in 1999 to 40.85% in 2005.

Table 3.19: Other Expenses of Banks, 1999-2005 (Tk. in Millions)

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	608.92	675.13	742.85	821.87	967.9	989	1156.41	851.73	194.96
PCBs	522.97	764.42	956.42	1765.9	1846.53	1807.58	2137.86	1400.24	634.26
SCBs	387.63	772.63	708.26	292.34	357.93	524.03	1031.52	582.05	267.58
IPCBs	119.658	168.442	231.53	282.13	426	390	344.95	280.39	114.12
FCBs	313.14	338.55	360.59	431.82	500.9	630.32	562.19	448.22	120.52
All Banks	1952.32	2719.17	2999.65	3594.1	4099.26	4340.93	5232.93	3562.62	1103.49
Share of other expenses (in percent)									
NCBs	31.19	24.83	24.76	22.87	23.61	22.78	22.10	24.59	3.08
PCBs	26.79	28.11	31.88	49.13	45.05	41.64	40.85	37.64	8.71
SCBs	19.85	28.41	23.61	8.13	8.73	12.07	19.71	17.22	7.75
IPCBs	6.13	6.19	7.72	7.85	10.39	8.98	6.59	7.69	1.57
FCBs	16.04	12.45	12.02	12.01	12.22	14.52	10.74	12.86	1.80
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of other expenses (in percent)									
NCBs		10.87	10.03	10.64	17.77	2.18	16.93	11.40	5.64
PCBs		46.17	25.12	84.64	4.57	-2.11	18.27	29.44	31.89
SCBs		99.32	-8.33	-58.72	22.44	46.41	96.84	32.99	61.46
IPCBs		40.77	37.45	21.85	50.99	-8.45	-11.55	21.85	2 6.40
FCBs		8.11	6.51	19.75	16.00	25.84	-10.81	10.90	12.85
All Banks		39.28	10.31	19.82	14.06	5.90	20.55	18.32	11.69
Portion of other expenses to total expenses (in percent)									
NCBs	1.93	1.96	1.99	2.16	3.66	2.67	3.03	2.48	0.66
PCBs	3.58	4.00	4.01	5.94	5.27	4.55	4.26	4.52	0.82
SCBs	5.05	9.40	8.86	3.53	4.27	5.95	16.23	7.61	4.40
IPCBs	3.50	3.75	4.16	4.06	4.50	3.60	3.54	3.87	0.38
FCBs	10.81	10.78	12.10	10.08	7.71	9.04	7.46	9.71	1.72
All Banks	3.25	3.91	3.86	4.12	4.78	4.20	4.67	4.11	0.52

Note: Portion indicates a fraction of the component and is measured as the ratio of component value to total value of the variable and is calculated by the formula $(e/E)\times 100$ where e = value of the component E =total value of the variable.

3.7.9 Total Expenditure by Types of Banks

Table 3.20 shows that NCBs total expenditure in 1999 is 31572.53 and in 2005 is 38142.08. Total volume increases overtime but relative Share decreases overtime (52.48 percent in 1999 to 34.07 present in 2005).

Table 3.20: Total Expenditure of Banks 1999-2005

Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	31572.53	34488.85	37358.29	38070.12	26458.49	37053.20	38142.08	34734.79	4350.27
PCBs	14608.46	19123.27	23828.59	29750.73	35007.96	39687.51	50177.55	30312.01	12374.24
SCBs	7668.30	8223.30	7996.08	8286.32	8378.45	8810.17	6357.52	7960.02	788.25
IPCBs	3414.91	4494.80	5562.36	6947.36	9471.98	10838.56	9734.76	7209.25	2864.03
FCBs	2897.82	3140.34	2979.49	4285.19	6495.96	6973.77	7540.25	4901.83	2040.83
All Banks	60162.02	69470.55	77724.81	87339.72	85812.84	103363.21	111952.16	85117.90	18169.03
Share of total expenditure									
NCBs	52.48	49.65	48.06	43.59	30.83	35.85	34.07	42.08	8.49
PCBs	24.28	27.53	30.66	34.06	40.80	38.40	44.82	34.36	7.41
SCBs	12.75	11.84	10.29	9.49	9.76	8.52	5.68	9.76	2.30
IPCBs	5.68	6.47	7.16	7.95	11.04	10.49	8.70	8.21	2.00
FCBs	4.82	4.52	3.83	4.91	7.57	6.75	6.74	5.59	1.41
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of total expenditures									
NCBs		9.24	8.32	1.91	-30.50	40.04	2.94	5.32	22.50
PCBs		30.91	24.61	24.85	17.67	13.37	26.43	22.97	6.35
SCBs		7.24	-2.76	3.63	1.11	5.15	-27.84	-2.25	13.01
IPCBs		31.62	23.75	24.90	36.34	14.43	-10.18	20.14	16.63
FCBs		8.37	-5.12	43.82	51.59	7.36	8.12	19.02	22.92
All Banks		15.47	11.88	12.37	-1.75	20.45	8.31	11.12	7.51

3.8 Deposit Situation

Accepting deposit from savers is one of the important activities of the commercial banks. Deposits are deemed as liabilities of the banks. Loans and advances are created from deposit to finance business, industry and consumer. As banks accept deposits and makes loans, it transforms savings (deposits) into investment (loans). And this is how banks make profit. The Table 3.21 shows deposit liability portfolio of the banking sector in the form of deposit composition by types of banks, share and growth rate over the year 1999-2005. The average size of deposit over the years is Tk. 223214.3 million whereas the banking sector's total deposit is Tk. 706214 million in 1999 and it increases to Tk.1116071 million in 2005. The banking sector experiences a gradual decline in deposit growth rate where initial growth rate is 18.01 percent in 2000 and declines to the lowest of 10.23 in 2003 and thereafter improved to 15.57 percent in 2005. Further, the annual growth of deposits during the period from 1999 to 2005 has been higher (18.01 percent) than the growth of advances (16.96 percent) in 1999. Advances made from commercial banks have recorded an average growth of 14.92 percent during the period 1999 to 2005, whereas in the mean time average growth rate of deposit is 14.75 percent although the growth has been slower in the matter of advances. In the year 2003 growth rate of loans and advances came down to 6.82 compared to deposits growth rate of 10.23 percent. But in the next consecutive years growth rate of loans and advances has risen sharply (15.67 and 20.72 respectively). The rate of growth of deposits improved considerably after 2003.

Table 3.21: Deposit, Share and Growth Rate, 1999-2005 (Tk. in Millions)

Types of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	ST.DEV
NCBs	394984	452739	491458	528124	545829	592333	643867	521333.4	83928.02
PCBs	176627	224137	284565	335596	384710	476544	588394	352939	143978.2
SCBs	33830	42918	53628	60190	67286	76895	89968	60673.57	19368.08
IPCBs	44777	55020	75659	96935	124595	151152	172473	102944.4	48455.73
FCBs	55996	58562	63469	73760	84196	96111	115172	78180.86	21752.65
All Banks	706214	833376	968779	1094605	1206616	1393035	1609874	1116071	315912.4
Mean	141243	166675	193756	218921	241323	278607	321975	223214.3	63496.53
Share of deposits to total deposit in percentage									
NCBs	55.93	54.33	50.73	48.25	45.24	42.52	39.99	48.14	5.94
PCBs	25.01	26.90	29.37	30.66	31.88	34.21	36.55	30.65	4.01
SCBs	4.79	5.15	5.54	5.50	5.58	5.52	5.59	5.38	0.30
IPCBs	6.34	6.60	7.81	8.86	10.33	10.85	10.71	8.79	1.92
FCBs	7.93	7.03	6.55	6.74	6.98	6.90	7.15	7.04	0.44
All Banks	100	100	100	100	100	100	100	100	0
Growth rate									
NCBs		14.62	8.55	7.46	3.35	8.52	8.70	8.53	3.61
PCBs		26.90	26.96	17.93	14.63	23.87	23.47	22.29	4.99
SCBs		26.86	24.95	12.24	11.79	14.28	17.00	17.85	6.53
IPCBs		22.88	37.51	28.12	28.53	21.31	14.11	25.41	7.93
FCBs		4.58	8.38	16.21	14.15	14.15	19.83	12.88	5.51
All Banks		18.01	16.25	12.99	10.23	15.45	15.57	14.75	2.74
Ratio of deposits to GDP									
All Banks	0.31	0.33	0.35	0.37	0.36	0.39	0.42	0.37	0.03

Table 3.21 shows that deposit increases over the years in the NCBs starting from Tk. 394984 million in 1999 to Tk. 643867 million in 2005 but their market share gradually declines from 55.93 to 39.99 percent through the same period. And growth rate shows a vast decline in 2003, which is 3.35 percent. Whereas PCBs and IPCBs increases their deposit throughout years with PCBs increasing market share from 25.01 to 36.55 and IPCBs from 6.34 to 10.71 respectively over the same period. SCBs experiences a comparatively stable improvement in market share with declining growth rate (26.86 percent in 1999 to 17.00 percent in 2005). During this period SCBs slightly improved their market share of deposit and show as 4.79 in 1999 to 5.59 in 2005. FCBs market share is also stable and consistent with minimum standard deviation. Overall the banking sector experiences a decline in deposit growth rate, though in terms of currency the volume deposit increases substantially.

3.9 Loans and Advances

Banks accept deposits to create loans and advances to match between depositors and borrowers. Loans and advances are banks assets. In Table 3.22 volume of loans and advances, share and growth rate of loans and advances made by the types of banks has been shown over the years 1999-2005.

Table 3.22: Loans and Advances, Share, Growth rate, and Ratio of Loans and Advances to Deposits , 1999-2005 (Tk. in Million)

Bank type	1999	2000	2001	2002	2003	2004	2005	Mean	ST.DEV
NCBs	296205	324631	350003	386470	388082	417334	494881	379658	65428.05
PCBs	128483	165574	211241	254738	295314	372159	483862	273053	123400.7
SCBs	87711	105391	111281	113523	105784	111979	110035	106529	8845.519
IPCBs	33217	43448	54544	72779	96729	122259	148837	81687.6	42835.2
FCBs	34070	38944	43118	64199	66570	78045	92408	59622	21742.5
All Banks	579686	677988	770187	891709	952479	1101776	1330023	900550	257292.2
Mean	96948	113331	128698	148952	159080	183963	222005	150425	42882.4
Share in percentage									
NCBs	51.10	47.88	45.44	43.34	40.74	37.88	37.21	43.37	5.15
PCBs	22.16	24.42	27.43	28.57	31.00	33.78	36.38	29.11	5.03
SCBs	15.13	15.54	14.45	12.73	11.11	10.16	8.27	12.49	2.75
IPCBs	5.73	6.41	7.08	8.16	10.16	11.10	11.19	8.55	2.27
FCBs	5.88	5.74	5.60	7.20	6.99	7.08	6.95	6.49	0.71
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth rate									
NCBs		9.60	7.82	10.42	0.42	7.54	18.58	9.06	5.85
PCBs		28.87	27.58	20.59	15.93	26.02	30.01	24.83	5.47
SCBs		20.16	5.59	2.01	-6.82	5.86	-1.74	4.18	9.17
IPCBs		30.80	25.54	33.43	32.91	26.39	21.74	28.47	4.65
FCBs		14.31	10.72	48.89	3.69	17.24	18.40	18.87	15.63
All Banks		16.96	13.60	15.78	6.82	15.67	20.72	14.92	4.62

At the opening of 1999, NCBs advances are Tk.296205 million and it increases to Tk. 494881 million in 2005. Share table shows that NCBs dominance on the advances declines throughout the period 1999-2005 which is 51.10 in 1999 and came down to 37.21 in 2005. The growth rate table shows that NCBs experiences a declining rate (9.60

in 1999) and reaches a minimum in 2003 (0.42 percent) and thereafter improves sharply in 2004 (7.54 percent) and 2005 (18.58 percent).

Accordingly, the NCBs share in total loans and advances decreases from 51.10 to 37.21 in 2005. Total loans and advances of the banking sector rose to Tk. 1330023 million in 2005 from Tk. 579686 million in 1999 showing an average growth rate by 14.92 percent. However, loans and advances of the PCBs and IPCBs rose to Tk. 128483 million and Tk.33217 million (36.38 and 11.19 percent of the total industry loans and advances respectively) in 2005 from Tk. 483862 and Tk.148837 million (22.16 and 5.73 percent of the total industry loans and advances) respectively in 1999.

Table 3.23: Ratio of Loans and Advances to Total Deposits 1999-2005

Bank Type	1999	2000	2001	2002	2003	2004	2005	Mean	ST.DEV
NCBs	0.75	0.72	0.71	0.73	0.71	0.70	0.77	0.73	0.02
PCBs	0.73	0.74	0.74	0.76	0.77	0.78	0.82	0.76	0.03
SCBs	2.59	2.46	2.08	1.89	1.57	1.46	1.22	1.89	0.51
IPCBs	0.74	0.79	0.72	0.75	0.78	0.81	0.86	0.78	0.05
FCBs	0.61	0.67	0.68	0.87	0.79	0.81	0.80	0.75	0.10
All Banks	0.82	0.81	0.80	0.81	0.79	0.79	0.83	0.81	0.02

Table 3.23 shows that the activity of commercial banks in Bangladesh has been focused more on deposit accumulation rather than on credit expansion. It is noteworthy that, SCBs have supplied more loans and advances than their level of deposits. This is evident from the Table that it has higher exposure on advances (2.59 in 1999 and 1.22 in 2005) than its deposits and the mean ratio is 1.89 over the years. All banks average ratio shows the figure 0.81; this indicates that the banking sector contain 81 percent loans and advances out of its deposits. 19 percent of the deposits are being kept with the banks by which transaction demand or other demand requirement is met. The Table 3.24 has been prepared to look at the ratio of deposits and advances to GDP so that a quick impression can be made on deposits and advances situation of the banking sector of Bangladesh.

Table 3.24 illustrates that the total Deposits/GDP ratio is 0.31 in fiscal year 1999-200, which rose to 0.41 in the fiscal year 2005-2006. At the same time, the total loans and advances to GDP ratio is 0.24 in the fiscal year 1999-2000 and gradually increases to 0.34 in fiscal year 2005-2006. It is notable that in the over the years the Advances/GDP ratio remains below the Deposits/GDP ratio and Deposits/GDP ratio is higher than that of Total Loans and Advances/GDP ratio.

Table 3.24: Ratio of Total Deposits to GDP and Loans and Advances to GDP by Commercial Banks

Fiscal Year	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	Mean	SD
Deposits / GDP	0.31	0.33	0.35	0.37	0.36	0.39	0.40	0.37	0.03
Loans and advances / GDP	0.24	0.26	0.28	0.28	0.29	0.30	0.34	0.28	0.03

Source: Economic Trends, Issues from 1999-2006.

3.10 Disbursement of Loans and Recovery of Loans Situation

Table 3.25 shows disbursement of loans and recovery of loans situation.

Table 3.25: Disbursement and Recovery of Banks, 1999-2005.

Disbursement								
TYPES	1999	2000	2001	2002	2003	2004	2005	SD. Dev.
NCBs	142636	163230	172295	157577	151396	189115	268098	42557.78
PCBs	130754	169968	286713	320270	413957	547276	722036	209741.69
SCBs	23017	23418	24056	22590	25576	36897	37099	6543.09
IPCBs	72304	96069	111046	147111	199106	189541	360350	96989.68
FCBs	37194	34986	61074	53016	69320	70850	77790	16739.60
All Banks	405905	487671	655184	700564	859355	1033679	1465373	361607.76
Recovery								
NCBs	109761	156341	157361	137671	121360	157810	318085	69905.98
PCBs	105292.1	137090	229849	248570	332815	420489	560421	160633.18
SCBs	15143	20794	22883	24070	18266	28300	21120	4208.52
IPCBs	63011	88923	99974	115033	131672	103816	283453	72403.43
FCBs	32162	31534	56984	46167	58388	61428	63819	13629.29
All Banks	325369.1	434682	567051	571511	662501	771843	1246898	298872.86
Share of disbursement in percentage								
NCBs	35.14024	33.4713	26.29719	22.4929	17.6174	18.295332	18.29555	7.36
PCBs	32.21296	34.853	43.76068	45.716	48.17066	52.944483	49.27319	7.64
SCBs	5.670539	4.80201	3.67164	3.22454	2.976186	3.5694834	2.53171	1.09
IPCBs	17.81304	19.6996	16.94883	20.9989	23.16924	18.336544	24.59101	2.85
FCBs	9.163228	7.1741	9.321656	7.56762	8.066515	6.8541588	5.308546	1.39
All banks	100	100	100	100	100	100	100	0.00
Share of recovery in percentage								
NCBs	33.7343	35.9667	27.75077	24.089	18.31846	20.445868	25.51011	6.50
PCBs	32.36083	31.538	40.5341	43.4935	50.23615	54.478566	44.94522	8.54
SCBs	4.654099	4.78373	4.035439	4.21164	2.757128	3.6665488	1.693803	1.11
IPCBs	19.36601	20.457	17.63051	20.1279	19.87499	13.450404	22.73265	2.91
FCBs	9.884774	7.2545	10.04918	8.07806	8.81327	7.9586133	5.118221	1.69
All Banks	100	100	100	100	100	100	100	0.00
Growth of disbursement								
NCBs		14.44	5.55	-8.54	-3.92	24.91	41.76	18.84
PCBs		29.99	68.69	11.70	29.25	32.20	31.93	18.69
SCBs		1.74	2.72	-6.09	13.22	44.26	0.55	18.18
IPCBs		32.87	15.59	32.48	35.34	-4.80	90.12	31.62
FCBs		-5.94	74.57	-13.19	30.75	2.21	9.80	32.28
All Banks		20.14	34.35	6.93	22.67	20.28	41.76	12.20
Growth of recovery								
NCBs		42.44	0.65	-12.51	-11.85	30.04	101.56	43.70
PCBs		30.20	67.66	8.14	33.89	26.34	33.28	19.35
SCBs		37.32	10.05	5.19	-24.11	54.93	-25.37	32.26
IPCBs		41.12	12.43	15.06	14.46	-21.16	173.03	68.51
FCBs		-1.95	80.71	-18.98	26.47	5.21	3.89	34.94
All Banks		33.60	30.45	0.79	15.92	16.50	61.55	20.82

3.11 Investment of Fund with Other Financial Institutions

Table 3.26 indicates that total investment of the banks with other financial institutions institution increases over time. Total investment of the banking sector in 1999 is Tk.126, 657 million which rises over the period to Tk.185, 260.07 million in 2005. In fact, this is a sort of diversification of fund, which provide security of funds of banks rather putting the entire portfolio in disbursement of loans. In the year 2001 NCBs experiences a decline in the growth rate at -10.94 percent.

Table 3.26: Total Investment of Banks, 1999-2005

Bank Types	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	85377	102433	91223	119994	113810	127322	110037	107170.86	15135.76
PCBs	22905	29268	34117	53592	64658	78102	81792	52062.00	23856.08
SCBs	3622	4099	6235	6893	11767	11664	13396	8239.43	3980.29
IPCBs	31	34	34	38	38	3741	4240	1165.22	1935.42
FCBs	14722	12291	12039	15778	17234	20951	23343	16622.57	4249.91
All Banks	126657	148125	143648	196295	207507	241780	232808	185260.07	45856.46
Share									
NCBs	67.41	69.15	63.50	61.13	54.85	52.66	47.27	59.42	8.09
PCBs	18.08	19.76	23.75	27.30	31.16	32.30	35.13	26.78	6.50
SCBs	2.86	2.77	4.34	3.51	5.67	4.82	5.75	4.25	1.24
IPCBs	0.02	0.02	0.02	0.02	0.02	1.55	1.82	0.50	0.82
FCBs	11.62	8.30	8.38	8.04	8.31	8.67	10.03	9.05	1.31
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth rate									
NCBs		19.98	-10.94	31.54	-5.15	11.87	-13.58	5.62	18.31
PCBs		27.78	16.57	57.08	20.65	20.79	4.72	24.60	17.63
SCBs		13.17	52.11	10.55	70.71	-0.88	14.85	26.75	28.03
IPCBs		9.78	0.00	11.73	0.00	9719.06	13.34	1625.65	3964.95
FCBs		-16.51	-2.05	31.06	9.23	21.57	11.42	9.12	16.87
All Banks		16.95	-3.02	36.65	5.71	16.52	-3.71	11.52	15.25

Table 3.26 give us an idea about the picture of the commercial banks. PCBs are more interested to their funds in well secured portfolio like financial institutions. PCBs share increase while NCBs relative share decline over the year.

3.12 Total Capital Structures of the Bank

Table 3.27 shows that the capital structure of the NCBs is same over the years. The rest of the banks increase their capital base over the year. Growth rate of capital is highest in FCBs. The average growth rate of capital structure is 37.84 and IPCBs is 36.49 percent.

Table 3.27: Total Capital of Bank 1999-2005

Bank Types	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	9600	9600	9600	9600	9600	9600	9600	9600.00	0.00
PCBs	6696	6854	7928	8634	11865	13973	17404	10479.14	4071.20
SCBs	4240	4300	4400	4650	4950	6875	7410	5260.71	1316.59
IPCBs	1033	1093	1618	1618	3436	4462	5483	2677.57	1783.76
FCBs	1962	2390	3001	4733	5923	7067	12544	5374.29	3677.97
All Banks	23531	24237	26547	29235	35774	41977	52441	33391.71	10703.80
Share of total capital									
NCBs	40.80	39.61	36.16	32.84	26.84	22.87	18.31	31.06	8.61
PCBs	28.46	28.28	29.86	29.53	33.17	33.29	33.19	30.82	2.30
SCBs	18.02	17.74	16.57	15.91	13.84	16.38	14.13	16.08	1.62
IPCBs	4.39	4.51	6.09	5.53	9.60	10.63	10.46	7.32	2.80
FCBs	8.34	9.86	11.30	16.19	16.56	16.84	23.92	14.72	5.33
All Banks	100	100	100	100	100	100	100	100.00	0.00
Growth rate of total capital									
NCBs		0	0	0	0	0	0	0.00	0.00
PCBs		2.36	15.67	8.91	37.42	17.77	24.55	17.78	12.27
SCBs		1.42	2.33	5.68	6.45	38.89	7.78	10.42	14.16
IPCBs		5.81	48.03	0.00	112.36	29.86	22.88	36.49	40.97
FCBs		21.81	25.56	57.71	25.14	19.31	77.50	37.84	24.00
All Banks		3.00	9.53	10.13	22.37	17.34	24.93	14.55	8.42

3.13 Asset Base

Assets base of the commercial banks comprises of cash, balance with other banks and financial institution (including foreign currencies home and abroad), money at call and short notice, investment with government and others, loans and advances, fixed assets including premises, furniture and fixtures, other assets, non-banking assets etc. Table 3.28 has been constructed to look at the changes in the volume of banking sector's assets by types of banks over the years 1999-2005. Table also shows the share of assets by types of banks over time and growth rate of assets by different types of banks over time.

Table 3.28: Total Assets of Bank, 1999-2005

Total assets								(Tk. in Million)	
Types of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	ST.DEV
NCBs	446350	522603	590350	506389	631872	684168	756501	591176	108399
PCBs	234082	299764	369261	429435	497375	606333	718034	450612	170615
SCBs	116827	140257	150720	158774	154347	164225	171771	150989	18080
IPCBs	135942	143202	86445	109228	139970	170458	196230	140211	36357
FCBs	86734	94653	114338	129486	113742	133593	158498	118721	24378
All Banks	1019935	1200479	1311114	1333312	1537306	1758777	2001034	1451708	338306
Share of total assets in percentage									
NCBs	43.76	43.53	45.03	37.98	41.10	38.90	37.81	41.16	3.00
PCBs	22.95	24.97	28.16	32.21	32.35	34.47	35.88	30.14	4.89
SCBs	11.45	11.68	11.50	11.91	10.04	9.34	8.58	10.64	1.32
IPCBs	13.33	11.93	6.59	8.19	9.10	9.69	9.81	9.81	2.25
FCBs	8.50	7.88	8.72	9.71	7.40	7.60	7.92	8.25	0.80
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth rate of total assets									
NCBs		17.08	12.96	-14.22	24.78	8.28	10.57	9.91	13.17
PCBs		28.06	23.18	16.30	15.82	21.91	18.42	20.61	4.69
SCBs		20.06	7.46	5.34	-2.79	6.40	4.59	6.84	7.42
IPCBs		5.34	-39.63	26.36	28.14	21.78	15.12	9.52	25.48
FCBs		9.13	20.80	13.25	-12.16	17.45	18.64	11.19	12.17
All Banks		17.70	9.22	1.69	15.30	14.41	13.77	12.02	5.77

Source: Functions of Bank and Financial Institutions, Issues from 1999 to 2005

Table 3.28 points out that in 1999 NCBs' asset base is Tk. 446350 million and during the period it increases up to Tk. 756501 million, in the same time asset base of the PCBs rose from Tk. 234082 million to Tk. 718034 million which is significantly comparable to that of the NCBs. During the years markets share of NCBs declines from 43.76 percent in 1999 to 37.81 percent in 2005. IPCBs also lost their market share from 13.33 percent in 1999 to 6.59 percent in 2001, thereafter NCBs again recovered up to 9.81 in 2005. In the year 2001 IPCBs experienced highest negative growth rate of -39.63 in terms of assets.

3.14 Total Reserve Funds Held by the Commercial Bank

Table 3.29 indicates that during the study period volume of reserve fund increases over the years in all types of banks. It grows on an average 16.10 percent for the NCBs, while 44.21 percent in PCBs, 14.49 in SCBs, 14.52 in IPCBs and 10.68 percent in FCBs over the year.

Table 3.29: Reserve Fund Held by Banks, 1999-2005 (Tk. in Million)

Types Bank	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	3074	3176	3835	4103	4673	5127	5581	4224.14	952.65
PCBs	5127	6897	9364	11779	14667	17872	24106	12830.36	6628.15
SCBs	2708	2827	3323	4095	4294	4527	4843	3802.43	847.95
IPCBs	2066	3130	2767	3710	4434	5760	6309	4025.14	1566.03
FCBs	1629	2914	2146	2820	2792	3642	3873	2830.86	781.67
All Banks	14604	18944	21435	26507	30860	36928	44712	27712.93	10593.92
Mean	2921	3789	4287	5301	6172	7386	8942	5542.59	2118.78
Share of reserve fund (in percent)									
NCBs	21.05	16.77	17.89	15.48	15.14	13.88	12.48	16.10	2.81
PCBs	35.11	36.41	43.69	44.44	47.53	48.40	53.91	44.21	6.67
SCBs	18.54	14.92	15.50	15.45	13.91	12.26	10.83	14.49	2.49
IPCBs	14.15	16.52	12.91	14.00	14.37	15.60	14.11	14.52	1.18
FCBs	11.15	15.38	10.01	10.64	9.05	9.86	8.66	10.68	2.24
All Banks	100	100	100	100	100	100	100	100	0
Growth rate of reserve fund									
NCBs		3.32	20.75	6.99	13.89	9.72	8.86	10.59	6.06
PCBs		34.51	35.77	25.79	24.52	21.85	34.88	29.55	6.17
SCBs		4.39	17.55	23.23	4.86	5.43	6.98	10.41	7.99
IPCBs		51.50	-11.60	34.08	19.51	29.91	9.53	22.16	21.77
FCBs		78.88	-26.36	31.41	-0.99	30.44	6.34	19.95	36.01
All Banks		29.71	13.15	23.66	16.42	19.66	21.08	20.61	5.77

3.15 Foreign Exchange Trade

The share of foreign exchange trade transaction increases in PCBs over the period while the share decreases in the NCBs. Table 3. 30 shows that NCBs share reduce to 22.24 in 2005 from 34.73 percent in 1999 while the reverse event occur in case of NCBs.

Table 3.30: Total Volume of Foreign Exchange Transactions (Tk. in Million)

Banks	1999	200	2001	2002	2003	2004	2005	Mean	SD
NCBs	301530	370500	361812	402862	420261	530286	599709	426708.6	103528
PCBs	265895	375126	417782	496341	645866	795515	1417029	630507.7	388907
SCBs	24676	18113	22426	23802	25414	31422	44057	27130	8450.1
IPCBs	58212	71207	75499	98590	138845	177085	218408	119692.3	60463
FCBs	217872	227925	271277	312547	300629	357437	417841	300789.7	70833
All Banks	868185	1062871	1148796	1334142	1531015	1891745	2697044	1504828	622937
Mean	145031	177179	191800	222691	255503	315625	449842	300965.7	126436
Share of foreign exchange transactions (in percent)									
NCBs	34.73	34.86	31.49	30.20	27.45	28.03	22.24	29.86	4.45
PCBs	30.63	35.29	36.37	37.20	42.19	42.05	52.54	39.47	7.02
SCBs	2.84	1.70	1.95	1.78	1.66	1.66	1.63	1.89	0.43
IPCBs	6.71	6.70	6.57	7.39	9.07	9.36	8.10	7.70	1.17
FCBs	25.10	21.44	23.61	23.43	19.64	18.89	15.49	21.09	3.32
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth of foreign exchange transactions (in percent)									
NCBs		22.87	-2.34	11.35	4.32	26.18	13.09	12.58	10.80
PCBs		41.08	11.37	18.80	30.13	23.17	78.13	33.78	23.97
SCBs		-26.60	23.81	6.14	6.77	23.64	40.21	12.33	22.90
IPCBs		22.32	6.03	30.58	40.83	27.54	23.34	25.11	11.47
FCBs		4.61	19.02	15.21	-3.81	18.90	16.90	11.81	9.33
All Banks		22.42	8.08	16.13	14.76	23.56	42.57	21.25	11.86

3.16 Number of Employees Working in the Commercial Bank

Numbers of employees have been splitted into two types. Usually more educated with high professional skilled human resources are recruited as officers who are generally expected to have better motivation towards their job assignment. The numbers of officers have been given in Table 3.31 and comparatively small salaried non-officers have been reported in Table 3.32.

3.16.1 Number of Officers in the Commercial Bank

The number of officers increases over the years of study 1999-2005. This is in fact a good sign for the banking sector. Table 3.31 shows that the number of officers stand at 66, 263 in 2005 from 55203 in 1999. The number of employment reduces in the NCBs while the same increases in other types of banks except SCBs.

Table 3.31: Total Number of Officers of Banks, 1999-2005

Bank Types	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	30673	31075	31667	30874	30471	30644	30007	30773.00	517.24
PCBs	13449	14670	15382	16509	18970	20423	22066	17352.71	3196.06
SCBs	7242	7145	7321	7295	7270	7113	7044	7204.29	104.19
IPCBs	3022	3446	3941	4350	4788	5361	5992	4414.29	1051.13
FCBs	817	849	923	994	1078	1114	1154	989.86	131.87
All Banks	55203	57185	59234	60022	62577	64655	66263	60734.14	3985.08
Share of total number of officers									
NCBs	55.56	54.34	53.46	51.44	48.69	47.40	45.28	50.88	3.85
PCBs	24.36	25.65	25.97	27.50	30.31	31.59	33.30	28.38	3.38
SCBs	13.12	12.49	12.36	12.15	11.62	11.00	10.63	11.91	0.88
IPCBs	5.47	6.03	6.65	7.25	7.65	8.29	9.04	7.20	1.25
FCBs	1.48	1.48	1.56	1.66	1.72	1.72	1.74	1.62	0.11
All Banks	100	100	100	100	100	100	100	100.00	0.00
Growth of total number of officers									
NCBs		1.31	1.91	-2.50	-1.31	0.57	-2.08	-0.35	1.86
PCBs		9.08	4.85	7.33	14.91	7.66	8.04	8.65	3.37
SCBs		-1.34	2.46	-0.36	-0.34	-2.16	-0.97	-0.45	1.58
IPCBs		14.03	14.36	10.38	10.07	11.97	11.77	12.10	1.79
FCBs		3.92	8.72	7.69	8.45	3.34	3.59	5.95	2.59
All Banks		3.59	3.58	1.33	4.26	3.32	2.49	3.09	1.04

Total number of non-officers declines over the years in the NCBs is given in Table 3.31.

Table 3.32: Total Number of Non Officers Employed of Banks, 1999-2005

Total Number of non -officers employed by types of bank									
Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	31674	30938	29660	29124	28163	26944	26193	28956.57	2006.28
PCBs	6819	6844	7476	7771	6995	7519	8112	7362.29	494.18
SCBs	9419	9374	9340	9265	9150	8764	8608	9131.43	319.43
IPCBs	838	857	861	923	1181	1315	1431	1058.00	247.03
FCBs	446	434	373	390	434	471	525	439.00	50.46
All Banks	49196	48447	47710	47473	45923	45013	44869	46947.29	1696.75
Share of non officers employed									
NCBs	64.38	63.86	62.17	61.35	61.33	59.86	58.38	61.62	2.11
PCBs	13.86	14.13	15.67	16.37	15.23	16.70	18.08	15.72	1.48
SCBs	19.15	19.35	19.58	19.52	19.92	19.47	19.18	19.45	0.26
IPCBs	1.70	1.77	1.80	1.94	2.57	2.92	3.19	2.27	0.61
FCBs	0.91	0.90	0.78	0.82	0.95	1.05	1.17	0.94	0.13
All Banks	100	100	100	100	100	100	100	100.00	0.00
Growth of non officers employed									
NCBs		-2.32	-4.13	-1.81	-3.30	-4.33	-2.79	-3.11	1.00
PCBs		0.37	9.23	3.95	-9.99	7.49	7.89	3.16	7.20
SCBs		-0.48	-0.36	-0.80	-1.24	-4.22	-1.78	-1.48	1.44
IPCBs		2.27	0.47	7.20	27.95	11.35	8.82	9.68	9.83
FCBs		-2.69	-14.06	4.56	11.28	8.53	11.46	3.18	9.96
All Banks		-1.52	-1.52	-0.50	-3.27	-1.98	-0.32	-1.52	1.07

3.16.2 Total Number of Employees

The overall impact of employment is reported in Table 3.33 where we find that total number of employment increases in banking sector (104,399 in 1999 to 111,132 in 2005) while employment reduces in NCBs (62, 347 in 1999 to 56,200 in 2005). SCBs are static in employment generation. The rest of the banks experiences increase in employment.

Table 3.33: Total Number of Employees of Banks, 1999-2005

Name Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	62347	62013	61327	59998	58634	57588	56200	59729.57	2342.84
PCBs	20268	21514	22858	24280	25965	27942	30178	24715.00	3546.84
SCBs	16661	16519	16661	16560	16420	15877	15652	16335.71	404.25
IPCBs	3860	4303	4802	5273	5969	6676	7423	5472.29	1288.19
FCBs	1263	1283	1296	1384	1512	1585	1679	1428.86	164.47
All banks	104399	105632	106944	107495	108500	109668	111132	107681.43	2312.14
Share total number of employees									
NCBs	59.72	58.71	57.34	55.81	54.04	52.51	50.57	55.53	3.34
PCBs	19.41	20.37	21.37	22.59	23.93	25.48	27.16	22.90	2.79
SCBs	15.96	15.64	15.58	15.41	15.13	14.48	14.08	15.18	0.67
IPCBs	3.70	4.07	4.49	4.91	5.50	6.09	6.68	5.06	1.08
FCBs	1.21	1.21	1.21	1.29	1.39	1.45	1.51	1.32	0.12
All banks	100	100	100	100	100	100	100	100.00	0.00
Growth total number of employees									
NCBs		-0.54	-1.11	-2.17	-2.27	-1.78	-2.41	-1.71	0.74
PCBs		6.15	6.25	6.22	6.94	7.61	8.00	6.86	0.80
SCBs		-0.85	0.86	-0.61	-0.85	-3.31	-1.42	-1.03	1.35
IPCBs		11.48	11.60	9.81	13.20	11.84	11.19	11.52	1.09
FCBs		1.58	1.01	6.79	9.25	4.83	5.93	4.90	3.15
All banks		1.18	1.24	0.52	0.93	1.08	1.33	1.05	0.30

3.17 Number of branches of the commercial Bank

Table 3.34 shows expansion of branches over study period. During this period branches in banking sector grow from 6075 in the year1999 to 6404 in 2005. It means total number of branches rationalised further and hence the number reduced. Table indicates that NCBs shut down their branches over the years, which declines to 3387 in 2005 from 3620 in 1999. NCBs relative share in branch expansion declines.

Table 3.34: Total Number of Branches, Share and Growth Rate of Branches of Banks, 1999-2005

Total Number of branches									
Types of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	ST.DEV
NCBs	3620	3606	3607	3494	3392	3393	3387	3499.86	110.30
PCBs	1028	1070	1118	1182	1237	1294	1357	1183.71	120.09
SCBs	1199	1200	1266	1314	1313	1322	1333	1278.14	57.66
IPCBs	191	201	212	229	249	258	280	231.43	32.45
FCBs	37	34	34	34	37	40	47	37.57	4.72
All Banks	6075	6111	6237	6253	6228	6307	6404	6230.71	111.78
Share of branches in percentage									
NCBs	59.59	59.01	57.83	55.88	54.46	53.80	52.89	56.21	2.64
PCBs	16.92	17.51	17.93	18.90	19.86	20.52	21.19	18.98	1.61
SCBs	19.74	19.64	20.30	21.01	21.08	20.96	20.82	20.51	0.62
IPCBs	3.14	3.29	3.40	3.66	4.00	4.09	4.37	3.71	0.46
FCBs	0.61	0.56	0.55	0.54	0.59	0.63	0.73	0.60	0.07
All Banks	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Growth rate of branches									
NCBs		-0.39	0.03	-3.13	-2.92	0.03	-0.18	-1.09	1.51
PCBs		4.09	4.49	5.72	4.65	4.61	4.87	4.74	0.55
SCBs		0.08	5.50	3.79	-0.08	0.69	0.83	1.80	2.29
IPCBs		5.24	5.47	8.02	8.73	3.61	8.53	6.60	2.11
FCBs		-8.11	0.00	0.00	8.82	8.11	17.50	4.39	8.95
All Banks		0.59	2.06	0.26	-0.40	1.27	1.54	0.89	0.90

Source: Functions of Banking activities and Financial Institutions, Issues from 1999 to 2005

On the other hand, PCBs and IPCBs raised their branches from 1028 to 1357 and 191 to 280 respectively over the same period. Also the SCBs increase from 1199 to 1333 and hence experiences growth throughout the same time. Table 3.34 shows that expansion of branches by FCBs is stable with zero growth in 2000 and 2001 where as PCBs showes a consistent growth rate of expansion branches over the time.

3.18 Disbursement and Recovery of Loans

Table 3.35 shows disbursement of loans and subsequent recovery by types of banks over time. NCBs records increase in disbursement. Average size of yearly disbursement for NCBs is 177764 million. While size of recovery is Tk. 165484 million.

Table 3.35: Disbursement and Recovery of Banks (Tk. in Million)

TYPES	1999	2000	2001	2002	2003	2004	2005	Mean	SD. Dev.
Disbursement									
NCBs	142636	163230	172295	157577	151396	189115	268098	177764	42557.77769
PCBs	130754	169968	286713	320270	413957	547276	722036	370139	209741.6882
SCBs	23017	23418	24056	22590	25576	36897	37099	27521.9	6543.089113
IPCBs	72304	96069	111046	147111	199106	189541	360350	167932	96989.68164
FCBs	37194	34986	61074	53016	69320	70850	77790	57747.1	16739.59879
All Banks	405905	487671	655184	700564	859355	1033679	1465373	801104	361607.7633
Recovery									
NCBs	109761	156341	157361	137671	121360	157810	318085	165484	69905.97987
PCBs	105292	137090	229849	248570	332815	420489	560421	290647	160633.1808
SCBs	15143	20794	22883	24070	18266	28300	21120	21510.9	4208.519234
IPCBs	63011	88923	99974	115033	131672	103816	283453	126555	72403.4318
FCBs	32162	31534	56984	46167	58388	61428	63819	50068.9	13629.28737
ALL BANKS	325369	434682	567051	571511	662501	771843	1246898	654265	298872.8641
Share of disbursement (in percent)									
NCBs	35.1402	33.471	26.297	22.493	17.6174	18.2953	18.2955	24.5157	7.363419642
PCBs	32.213	34.853	43.761	45.716	48.1707	52.9445	49.2732	43.8473	7.644664642
SCBs	5.67054	4.802	3.6716	3.2245	2.97619	3.56948	2.53171	3.77802	1.094497085
IPCBs	17.813	19.7	16.949	20.999	23.1692	18.3365	24.591	20.2224	2.84964179
FCBs	9.16323	7.1741	9.3217	7.5676	8.06652	6.85416	5.30855	7.63655	1.390776127
All Banks	100	100	100	100	100	100	100	100	0
Share of Recovery (in percent)									
NCBs	33.7343	35.967	27.751	24.089	18.3185	20.4459	25.5101	26.545	6.504969117
PCBs	32.3608	31.538	40.534	43.493	50.2362	54.4786	44.9452	42.5123	8.535531459
SCBs	4.6541	4.7837	4.0354	4.2116	2.75713	3.66655	1.6938	3.68606	1.108501607
IPCBs	19.366	20.457	17.631	20.128	19.875	13.4504	22.7327	19.0914	2.910966738
FCBs	9.88477	7.2545	10.049	8.0781	8.81327	7.95861	5.11822	8.16523	1.68770336
All Banks	100	100	100	100	100	100	100	100	4.92475E-06

NCBs disburse a total of Tk.142636 million and recover Tk.109761 million in 1999 which is 35.14 percent of the industry share of disbursement and 33.73 percent of the total industry recovery respectively. Over the study period disbursed amount declines a minimum in 2003 at 17.61 percent and recovery at 18.31 percent. Then it grows gradually up to 2005.

3.19 Classified Loans

Commercial banks of Bangladesh accumulates huge classified loans. Table 3.36 shows that the amount of classified loans is Tk.209 billion against outstanding real total loans of Tk.510 billion in 1999. Table 3.35 shows the changes of bank assets, outstanding loans, and amount of classified loans at constant prices. Ratio of classified loans to total loans are shown in percentage terms over the study period. We understand that total classified loans abated remarkably over the period.

Table 3.36: Structure of Total Bank Assets, Outstanding Loans and Classified Loans

Year	Total Bank Assets At constant prices.	Real total Loans Outstanding At constant prices	Real Total Classified Loans At constant prices	Total Classified Loans/Total Loan Ratio	Total Bank Assets at current prices
1999	950.96	510	209	41.18	1019.935
2000	1105.83	564	197	34.92	1200.479
2001	1280.31	635	200	31.49	1311.114
2002	1441.94	705	198	28.10	1333.312
2003	1510.41	723	160	22.13	1537.306
2004	1727.00	805	142	17.63	1758.777
2005	1727.08	930	126	13.55	2001.034

Note: Base year 1995-96.

Table shows classified loans decline from Tk. 209 billion in 1999 to Tk. 126 billion in 2005 and it shows total bank assets at constant prices and at current prices for a comparison.

3.20 Conclusion

This Chapter discusses the sources of data collection over the study period. The purpose of data collection is to facilitate application of SFA and DEA methodology in the study to find estimates of productive efficiencies for the commercial banks in Bangladesh. We describe a wide range of banking activities under a number of banking variables that determine performance of commercial banks. Fluctuations of the variables over the years of study provide important information about banking production activities in different years. We expect that behaviour of the banking variables are likely to be reflected in efficiency performance results of the banking sector. One of the main objectives of this Chapter is to generate an idea about the banking activities, rise and fall, over the study period. It is expected that the behaviour of the variables will be consistent to efficiency results. Since banking policies affect banking activities and banking data respond to the changes to the policy measures, data description is likely to give a hint of the changes in performance accordingly. The banking sector is dissected on the basis of the collected data arranged according to categories of banks and over the period 1999-2005. We have discussed major issues of reforms in brief chronologically. We expect that the reform measures have got positive effects in banking activities, which is reflected in the data. Data shows trends of fluctuations over time. Description of data reveals that all the variables show similar behaviour over time. Exogenous shocks affect the variable almost homogeneously. Behaviour of the specific variables has been described for particular components for continuous seven years. We construct principal table for amounts in volume (in million taka) from observed data to see the behaviour of the specific variable (increase or decrease) within the types of banks and over the period. We further modify the table to understand about relative shares of the variable by types of banks and growth rates of the variables over time. We, first, process the data and then represent data for cross-section years in dynamic form and in few cases static form. Mean and standard deviation of the variables help understanding overall size of the variable with variation over the years. We understand from tables, the behaviour of data, most of the variables show a tendency to increase over time. Relative share and growth rate increase and sometimes decrease. Growth rate of some variables in some table show negative value according to data nature. Over the years non performing loans abates remarkably over the study period. From most of the table it is evident that the value of variables starts fluctuations in the year 2000 and further drops in value in 2001, 2002 and 2003. By observing the tables it can be perceived that value of the variables starts to recover in the year 2004 and thereafter rises in 2005. Data reveals that NCBs relative share decreases over time while PCBs relative share increases which indicate persistence of competition in the banking sector and it deepens over time. IPCBs almost follow the PCBs in many cases while FCBs relative share and growth rates are comparatively stable and consistent. SCBs follow trends of NCBs in many cases and the standard deviation values are relatively small for SCBs, IPCBs and FCBs.

Chapter 4

Production Function and Efficiency

4.1 Introduction

This Chapter is designed to describe some related issues of efficiency that has been derived from the microeconomic study of production function. Neo-classical production function is the main basis of estimating efficiency of a production unit and the idea starts with Farrell (1957). To measure productive efficiency Farrell conducted an empirical study on U.S. agriculture and disclosed fundamental concept of technical efficiency wherein he argued that failure to produce the maximum output from a given input mix at minimum cost results in inefficiency. The cause of inefficiency may arise from the constraints of access to technology, lack of know-how, inaccurate scale of production and sub-optimal allocation of resources. Some important issues of production function and its essential properties in conjunction with related concepts are described in this Chapter.

The outline of this Chapter is as follows: Section 4.2 discusses the production function; Section 4.3 describes estimation of production function; Section 4.4 gives some important concepts related to production function; Section 4.5 describes cost minimising input combination; Section 4.6 discusses efficiency concepts and Section 4.7 gives summary and conclusions.

4.2 Production Function

A production function shows the maximum output that can be produced from any given combination of inputs. This means that a production function is defined in terms of the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms (Battese, 1998). In microeconomic theory, the production function explains the technical or physical relationship between outputs and inputs. A simple production function can be given as follows:

$$y = f(x_1, x_2)$$

Where

y = Units of output

x_1 = Units of labour inputs used

x_2 = Units of capital inputs employed

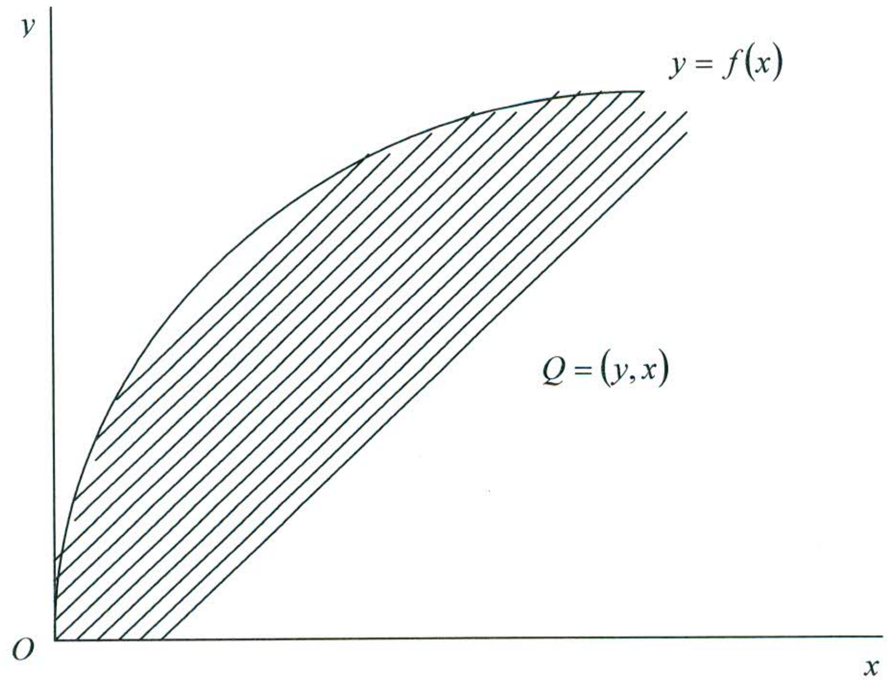
The reason why maximum output attainable has been assumed in the production function is that only technologically efficient methods are chosen by the production unit. This implies that using more of one input and either the same amount or more of the other input must increase output. A firm's option for combining inputs into outputs is given to its technology. The firm's technology can be summarized by its production function. Inputs are the rates of resources use and output is the rate of production over a particular time period.

Let $(x_1, x_2, ..., x_q)$ denote the inputs used in the production function for producing output y; the production function can be written as:

$$y_i = f(x_1, x_2, ..., x_q) \qquad (4.1)$$

This formulation ignores the possibility of technical inefficiency because the output y_i is assumed maximum for any level of inputs. The production function given in (4.1) shows the borderline of the production set. As shown in Figure 4.1, a two dimensional input output production technology is described for the sake of simplicity. One input x is used to produce a single output y. The production set Q, denotes the technically feasible production set (y, x), that is, $Q = (y, x)$. The shaded region in figure 4.1 shows the production set.

Figure 4.1: The production function



The production combinations which maximise y for a given x or minimize x for given y is technically efficient combination and constitute the boarder line to the production set $Q = (y, x)$. Therefore, the production function $y = f(x)$ is the set of technically efficient combinations, and all technically efficient combinations belong to the interior portion of the production set.

4.3 Estimation of Production Function

Production function can be estimated from sample data. This data may be of cross-sectional type, which involves observation on a number of firms in a particular time period say one year. Or the data may be of time-series type which involves aggregate industry-level data observed over a number of time periods. Or the data may be of panel type which involves observation on a number of firms in a number of time periods.

To estimate a production function, information on output and input quantities is essential. Production function can be estimated either by using econometric methods which is often referred to as parametric function or this can be estimated using mathematical programming method, which is suggested by Farrell (1957). According to mathematical programming method, the production function can be estimated from sample data using a nonparametric piece-wise-linear technology often called as non-parametric function. This research involves application of both parametric and nonparametric approaches to analyse of banking sector efficiency of Bangladesh on the same set of data.

4.4 Some Important Concepts Related to Production Function

Production function recognises some fundamental characteristics, such as marginal productivity of the factor of production, output elasticity, marginal rate of technical substitution, the elasticity of substitution and the return to scale. These are described below.

The marginal productivity of a factor of production can be defined as the change in output for an infinitesimal change in a factor, holding all other factors constant. In mathematical citation, it can be derived by partial derivative of the production function with respect to the input being considered. If the production function is given as in (5.1), the marginal productivity of x_i can be written as:

$$f_i = \frac{\partial f}{\partial x_i} \qquad (i = 1,2,3,\ldots,q)$$

The prime focus of the production theory centers around the range of output over which the marginal productivity is positive and diminishing, that:

$$f_i > 0 \quad \text{and} \quad f_{ii} = \frac{\partial^2 f}{\partial x_i^2} < 0 \qquad (4.2)$$

Where f_{ii} denotes the second order derivative.

In economics, elasticity is the ratio of proportional change in one variable with respect to proportional change in another variable. Elasticity is a negative number but shown as a positive value. Output elasticity can be measured as the percentage change of output (revenue for a single firm) divided by the percentage change in an input, all other inputs remaining constant. Considering the production function in (5.1), this is defined as:

$$E_i = \frac{\partial f_i}{\partial x_i} \times \frac{x_i}{y_i}$$

This is a unit free measure. Important features of output elasticity can be attributed as follows:

When, $E_i = 1$, it indicates that proportional increase in input x results in the same proportional increase in output;

When, $E_i > 1$, a proportional increase in output is larger than the proportional increase in input x;

When, $E_i < 1$, the proportional increase in output is less than the proportional increase in the input x, and when $E_i = \infty$, then the output elasticity shows perfectly elastic situation.

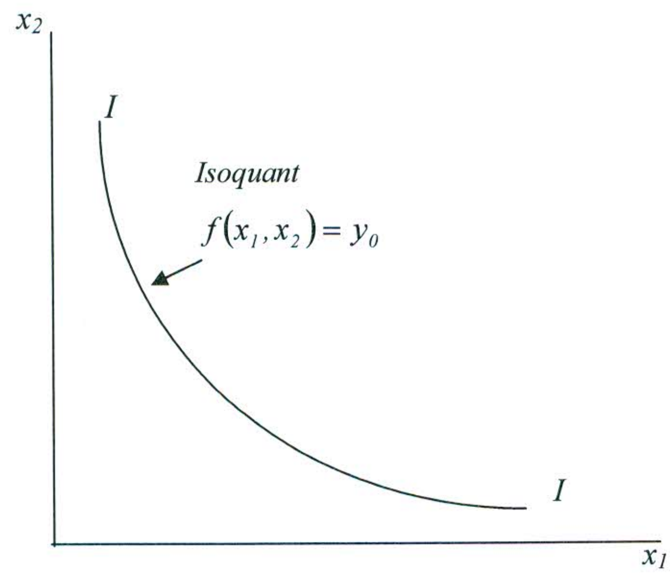
An isoquant or production indifference curve can be defined as a curve which represents combinations of factors of production that give equal amount of output. A point on the isoquant curve is technically efficient. This displays the rate at which inputs are substituted in production keeping output constant. Let the production function be:

$$y = f(x_1, x_2) \qquad (4.3)$$

The equation of an isoquant can be obtained by the production function (4.3) when output is held constant say y_0,

$$y_0 = f(x_1, x_2) \qquad (4.4)$$

Figure 4.2: Isoquant Curve



This represents the isoquant, which exhibits all combinations of inputs that can be employed to produce output y_0. This can be explained by the curve II in Figure 4.2. To get the slope of the isoquant at any point, it requires to differentiate equation (4.4) with respect to an input say, x_1. Accordingly, it can be written as:

$$f_1 + f_2 = \frac{dx_2}{dx_1} = 0$$

or $$\frac{dx_1}{dx_2} = -\frac{f_1}{f_2}$$

The negative sign of the slope of an isoquant is the Marginal Rate of Technical Substitution (MRTS), which measures the rate at which inputs can be substituted, holding output constant. The marginal rate of technical substitution (MRTS) or the Technical Rate of Substitution (TRS) is the amount by which the quantity of one input can be reduced $(-dx_2)$ when one extra unit of another input is used (dx_1), so that output remains constant $(y = y_0)$

$$MRTS(x_1, x_2) = \frac{dx_1}{dx_2} = -\frac{f_1}{f_2} = -\frac{MP_1}{MP_2}$$

Where MP_1 and MP_2 are the marginal products of input x_1 and input x_2, respectively.

Along an isoquant, the MRTS shows the rate at which one input (e.g. capital or labor) may be substituted for another, while maintaining the same level of output. The MRTS can also be seen as the slope of an isoquant at a point. Since the isoquant is generally downward sloping and marginal products are generally positive, the MRTS is negative. The MRTS is not independent of units of measurement.

The elasticity of factor substitution is a better measure of factor substitution since it does not depend on the units of measurement. It can be defined as the proportional rate in change of the input ratio divided by the proportional rate of change in MRTS.

$$\sigma = \frac{d(f_1 / f_2)/(f_1 / f_2)}{d(MRTS)/(MRTS)}$$

The larger the value of σ, exhibits greater the degree of substitutability between the two factors of production. It is commonly expected that variable elasticity of substitution exists in the production function. However, constant elasticity of substitution may exist in some production functions. For example, Cobb-Douglas production function has been characterized by an unitary elasticity of substitution and this substitution does not depend upon the assumption of $\alpha + \beta = 1$. The elasticity of substitution of the production function $Q = AL^{\alpha} K^{\beta}$ is unitary even if $\alpha + \beta \neq 1$.

Returns to scale refers to a technical property of production function that examines changes in output resulting from a proportional changes in all inputs. If output increases by the same proportional change as the inputs change then there exists a constant return to scale (CRTS). If output increases by less than that proportional change, there are decreasing returns to scale (DRS). If output increases by more than that proportion, there are increasing returns to scale (IRS). This can be shown mathematically as:

$$\varepsilon = \sum_{i=1}^{q} \frac{\partial y}{\partial x_i} \times \frac{x_i}{y} \qquad (4.5)$$

Important three characterization of return to scale are as follows:

When $\varepsilon = 1$, then the production function shows constant returns to scale (CRS).

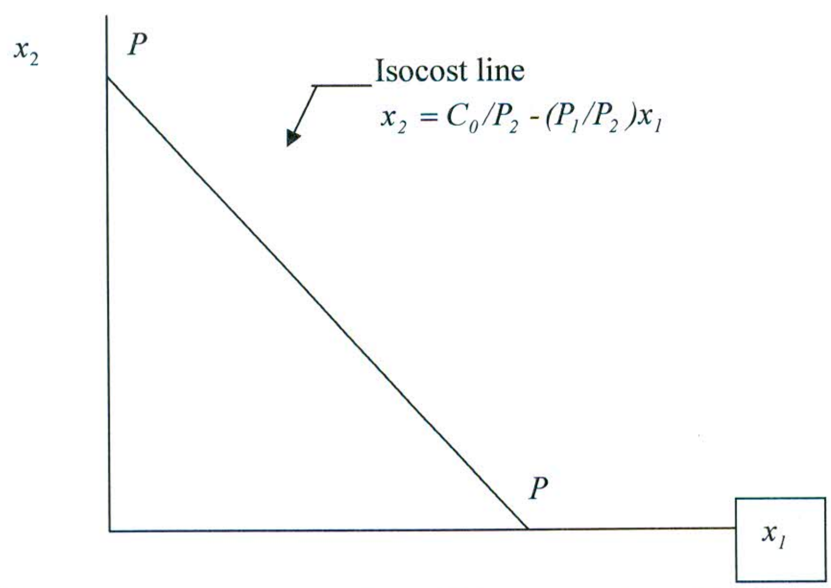
When $\varepsilon < 1$, then the production function displays decreasing returns to scale (DRS).

When $\varepsilon > 1$, then the production function exhibits increasing returns to scale (IRS).

Isocost line shows all the combinations of inputs that have the same total cost. The line shows the rate at which inputs are exchanged in the market. The isocost line is shown in Figure 4.3. It is the locus of all combination of inputs that can be bought with a given cost expenditure say C_0:

$$C_0 = p_1x_1 + p_2x_2 \tag{4.6}$$

Figure 4.3: Isocost line



Where p_1 and p_2 are the prices of input x_1 and x_2. This can be explained by the curve PP` in Figure 4.3. The slope of isocost line can be obtained by differentiating equation (4.6):

$$\frac{dx_2}{dx_1} = -\frac{p_1}{p_2}$$

This is the negative ratio of the input prices. It tells us how many units of x_2 have to be given up to purchase one more units of x_1.

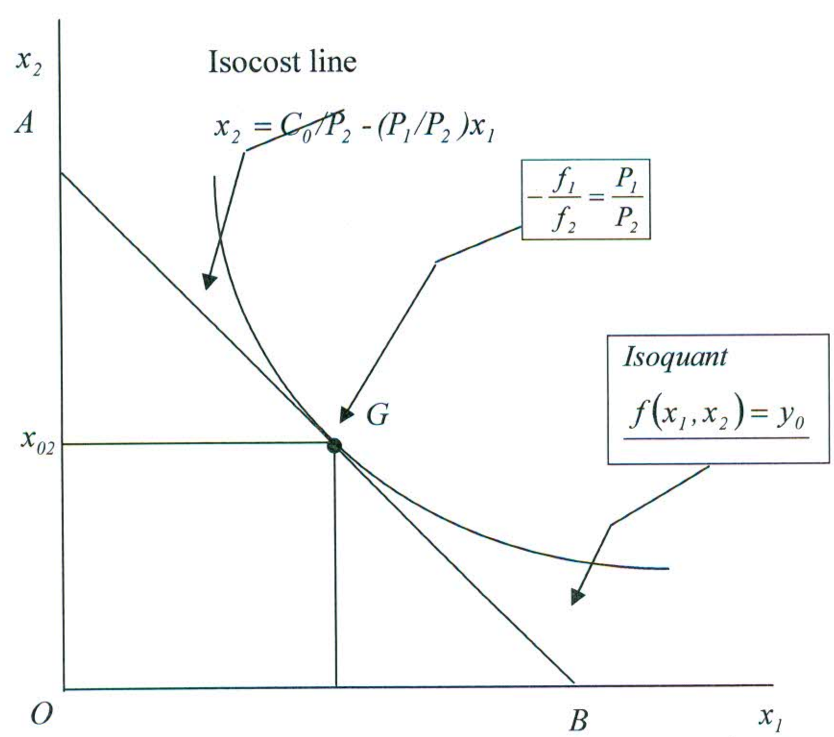
4.5 Cost Minimizing Input Combination

The choice of least cost input mix is described under graphical presentation and mathematical presentation.

4.5.1 Graphical Presentation

The cost-minimization problem of a firm is to choose an input bundle feasible x_1 and x_2 for a specific output y_0 that costs as little as possible. In terms of the figure, a cost-minimizing input bundle is a point on the isoquant that lies on the lowest possible isocost line. Putting differently, a cost-minimizing input bundle must require the tangency of the given isoquant with the lowest possible isocost line. This is shown in Figure 4.3.

Figure 4.4: Isoquant, Isocost and Cost-Minimization



The firm minimizes its costs by using input combination (x_{01}, x_{02}) determined by the tangency point of the given isoquant y_0 with the isocost line AB.

The isocost line touches the isoquant at point G and hence the cost minimizing input mix is obtained at this point. The second order condition for cost minimization is fulfilled as well at this point as the isoquant is convex to the origin.

4.5.2 Mathematical presentation

The conditions for least-cost combination of inputs can be derived by formulating a minimization problem. This can be done by minimizing the cost in (4.6) subject to the output constraint in (4.4) Hence the Lagrangian function is:

$$Z = p_1 x_1 + p_2 x_2 + \lambda[y_0 - f(x_1, x_2)]$$

Where λ is the Lagrangian multiplier. The input points are required to satisfy the following simultaneous first-order condition for a minimum cost:

$$p_1 - \lambda f_1 = 0 \qquad (4.7)$$

$$p_2 - \lambda f_2 = 0 \qquad (4.8)$$

$$y_0 - f(x_1, x_2) \qquad (4.9)$$

Equations (4.7) and (4.8) provide conditions which ensure the least-cost combination:

$$\frac{p_1}{f_1} = \frac{p_2}{f_2} = \lambda$$

That is, the input prices to marginal productivity ratio must be the same for each input. Then again, this can be written as:

$$\frac{p_1}{p_2} = \frac{f_1}{f_2} \qquad (4.10)$$

This displays that the cost-minimizing input combination can be attained at a point where the slopes of the isoquant and the is cost line are equal.

Equation (4.10) gives the first-order condition for cost minimization. To ensure this minimum cost, the following second-order condition must hold for the negative bordered Hessian:

$$|H| = \begin{vmatrix} 0 & f_1 & f_2 \\ f_1 & \lambda f_{11} & \lambda f_{12} \\ f_2 & \lambda f_{21} & \lambda f_{22} \end{vmatrix} = \lambda(f_{11} f_2^2 - 2 f_{12} f_1 f_2 + f_{22} f_1^2) < 0$$

Here the optimal value of λ is positive. Therefore, the expression shown in the bracket must be negative when the production function is strictly quasi concave.

4.6 Efficiency

Banks efficiency denotes whether a bank is cost minimizing that is consuming fewer inputs for the same level of outputs or a bank is output maximizing that is producing more of outputs for the same amount of inputs (Beccalli et al., 2001).

The term efficiency involves the success with which a firm best utilises its available resources to produce maximum levels of potential outputs (Dine et all., 1998)

Neoclassical theory of production function gives the notion of such efficiency that can be derived from obtaining maximum possible output for a given amount of inputs. It is not sensible to identify this 'maximum' output merely by observing the actual amount of output except the observed output is assumed to be a maximum. Whereas different firms produce different output levels even if they use the same input vector (Kumbhakar, 1994)

Variations in producing output among firms can be explained through differences in efficiency. The commonly perceived efficiency refers to technical efficiency.

4.6.1. Technical efficiency

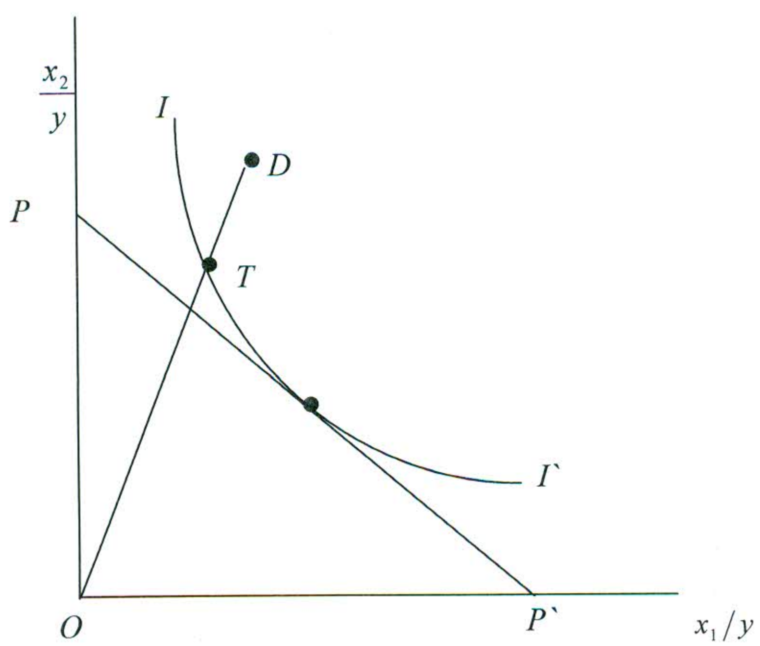
A firm is said to be technically efficient if it produces a maximum output, given the amount of input and technology. Therefore, the production frontier is associated with the maximum attainable level of output, given a level of inputs, or the minimum level of inputs required to produce a given output. Technical efficiency reveals the capability to produce maximum output with a given input mix utilizing the available technologies. In microeconomic theory, technical efficiency can be defined as a situation in which it is impossible for a given firm, with given knowledge of technology, to produce a larger output from a given set of inputs or it is impossible to produce a given output with less of one or more inputs without increasing the amount of other inputs. Technical efficiency is associated with the process of conversion of physical inputs such as the services of employees, machines and raw materials into outputs relative to 'best- practice'. The technical efficiency is determined by the difference between the observed ratio of combined quantities of a firm's output to input and the ratio achieved by 'best practice'. It can be expressed as the potential to increase quantities of outputs from given quantities of inputs, or the potential to reduce the quantities of inputs used in producing given quantities of outputs. In other words, given current technology, there is no wastage of inputs whatsoever in producing the given quantity of output. A firm operating at 'best-practice' is said to be 100 percent technically efficient. If operating below 'best- practice' levels, then the firm's technical efficiency is expressed as percentage of the 'best-practice'. Managerial practices (non-scale technical efficiency) and the scale or size of operations (scale efficiency) affect technical efficiency, which is based on engineering relationships but not on prices and costs. Technical efficiency of a firm depends on its level of productivity.

4.6.2 Graphical representation

Farrell (1957) explained the concept of technical efficiency. This can be explained using a simple example involving a firm that use two inputs, i.e., x_1 and x_2 to produce a single output, y under the assumptions of constant returns to scale. The constant returns to scale assumption allows one to represent the technology using a unit isoquant. As Farrell originally initiated his ideas under input/output space with input reduction strategy, it is termed as 'input-oriented' measures. This case may be better illustrated by the following figure that permits the measurement of technical efficiency. To explain diagrammatically the concept of technical efficiency, it is required to reflect on the production activity of an firm, succeeding to Kopp and Diewert (1982).

In Figure 4.5, it is assumed that the production technology is abridged by a linearly homogeneous production function as given by Farrell. The frontier unit isoquant for this technology and an inefficient production activity are depicted by II' and B respectively. The unit isoquant of the fully efficient firm permits the measurement of technical efficiency.

Figure 4.5: Measures of Technical Efficiency



Along the ray OD, the production activity, as indicated by T and defined by the intersection of line segment OD with the isoquant II', represents a technically efficient input combination as it lies on the frontier isoquant. The technical inefficiency of the firm producing at point D is represented by the distance TD.

Since this is the amount by which all inputs could be proportionally reduced producing the same level of output. In percentage terms, this can be written as the ratio TD/OD by which use of all inputs might possibly be reduced.

The technical efficiency of the firm running at point D can be expressed as:

$$TE = \frac{OT}{OD} = 1 - \frac{TD}{OD} = 1 \text{ - Technical inefficiency} \qquad (0 \le TE \le 1).$$

This ratio takes the value between 0 and 1 and gives a measure of technical efficiency of the firm. If the firm is operating at point T it can be said that the firm is fully technically efficient firm because it is located on the efficient isoquant where $TE = 1$.

The above efficiency measures assume the production function of the fully efficient firm is known. In practice the case is different, whereas the efficient isoquant is required to be estimated from the sample data. For practical purpose Farrell proposed either (i) to use a nonparametric piecewise-linear convex isoquant built such that no observed point should lie to the left or below it.

4.7 Summary and Conclusions

This Chapter describes some important concepts of production function, which accommodate the basics to measuring efficiency. We discuss production function, marginal productivity, output elasticity, marginal rate of technical substitution and return to scale. The production function deals with the technical relationship between outputs and inputs. The marginal productivity of an input implies the change of output for an infinitesimal change in that input, keeping all other input constant. The output elasticity is a unit free measure of marginal productivity and it explains the percentage change in output resulting from a percentage change in an input, holding all other input fixed. Marginal rate of technical substitution (MRTS) measures the rate at which inputs are substituted, assuming the output constant. The elasticity of substitution is a unit free measure, which estimates the degree of substitution between inputs. Returns to scale indicates the proportional change in output derived from proportional changes in all inputs and is given as the sum of the output elasticities. The firm attains least-cost combination of input at the point where ratio of input prices and the marginal rate of technical substitutions are equal.

We discuss the concept of efficiency. Efficiency means the success with which a production firm produces maximum output using its existing inputs given technology. This implies that a production function expresses the maximum potential output from a given input mix. But failure to achieve this maximum potential output with minimum cost causes inefficiency.

Chapter 5

Empirical Methodology of Efficiency Measurement: the Stochastic Econometric Frontier

5.1 Introduction

The objective of this chapter is to provide an introduction to the basics of Stochastic Frontier Analysis (SFA). This empirical methodology captures the efficiency scores for each individual commercial bank. The efficiency measurement complexity based on production frontier has led to development of several approaches to efficiency measurement analysis. SFA and DEA are two different methods for estimating frontier functions that permit estimation of efficiency scores for firms in production.

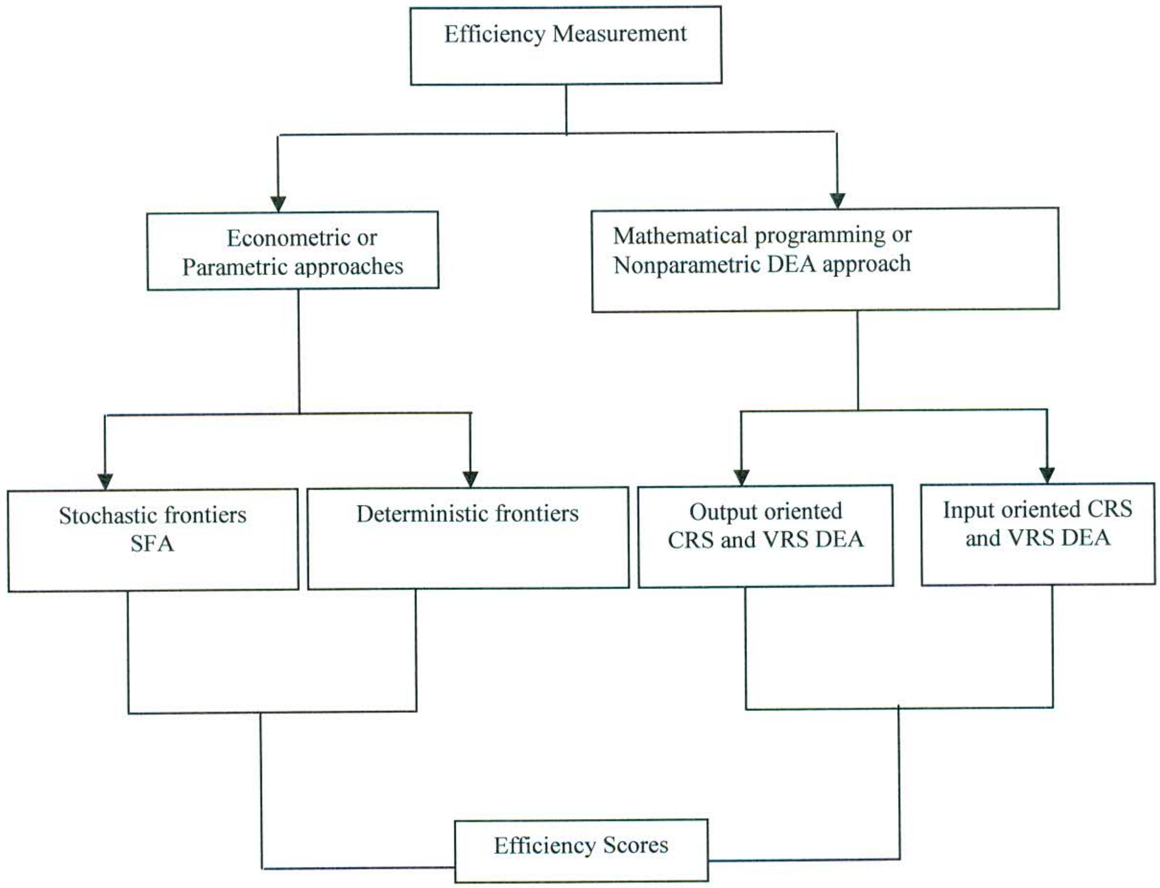
The analytical foundation for the definition and measurement of efficiency has been put down by Farrell (1957). Detailed reviews of the concepts and models regarding evolution and development of econometric approaches towards measurement and estimation of productive efficiency are found in Christensen and Greene (1976), Førsund and Jensen (1977), Schmidt and Lovell (1979, 1980), Schmidt (1986), Bour (1990b), Greene (1993, 1997), and Cornwell and Schmidt (1996). Modeling and estimation of frontier production function have been an important and potential area of econometric research.

The major econometric approaches to estimation of frontier efficiency consist of two techniques. The first is the deterministic frontier model and the second is the stochastic econometric frontier model. The prime difference between deterministic frontier and stochastic frontier model is that the deterministic frontier approach does not permit for a stochastic random error term while the later allows for the same. Therefore, deterministic frontier approach has been subject to a severe criticism on the ground that all deviations of the observed outputs from the frontier output are ascribed to inefficiency (Wadud, 2006).

Stochastic Frontier Analysis is able to construct efficiency estimates (efficiency scores) for individual firms. As a result, it is easy to identify those firms who need intervention and corrective measures for their relatively poor performances. Since efficiency scores vary across firms, the scores can be related to certain characteristics like size, ownership, and location etc., of firms to draw distinction among them for any changes in the characteristics. Therefore, SFA can help identifying sources of inefficiency attributable to inside or outside the firms. This can be a very powerful investigative tool for explaining the effects of internal resources alignments (input combinations) or external interventions, such as whether efficiency scores of banks change after reform or deregulation or across the ownership structure (Kumbhakar and Lovell, 2000). The core advantage of SFA approach is that it can deal with stochastic noise. SFA posits a composed error model where inefficiencies are assumed to follow an asymmetric distribution, generally the half-normal, while random error follows a symmetric distribution usually the standard normal. The estimated inefficiency for individual firm is taken as the conditional mean or mode of the distribution of the inefficiency term, given the observation of the composed error term (Berger and Humphrey, 1997). The disadvantages of econometric SFA approach are the need to impose an explicit functional form for the underlying technology, the explicit distributional assumption for the inefficiency term, and its inability to deal with multiple outputs (Khem, 1996).

Figure 5.1 shows the evolvement of different efficiency measurement approaches. Farrell's (1957) article on efficiency measurement originated from production function provides technical efficiency. Technical efficiency reflects the ability of a firm to obtain maximum output from a given set of input. The main focus of the study has been centered on the fundamentals of the technical efficiency since this efficiency is the core of Farrell's (1957) productive efficiency.

Figure 5.1: Measures of Efficiency



5.2 Deterministic Frontier Model

Aigner and Chu (1968) specifies a homogeneous Cobb-Daughlas production frontier. It has been accepted that the parameters of this production frontier could be estimated either by linear programming or quadratic programming technique. This imposition may lead, somehow, to inappropriate structure on the frontier and restricts the number of observations that can be technically efficient. For example, in the homogeneous Cobb-Douglas case, the number of technically efficient firm is equal to the number of parameters to be estimated. Since the number of technically efficient firm are required to be equal to the number of parameters to be estimated if the linear programming technique is to be solved and as the estimated frontier is required to be supported by the sub set of data, the technical efficiency estimates become extremely sensitive to outliers.

To overcome this sort of problem Timmer (1971) introduces estimation a 'probabilistic frontier' permitting a definite and pre-specified proportion of observations to lie above the estimated frontier. But due to lack of assumptions about the error terms, the efficiency estimates cannot contain statistical properties and thus tests of hypothesis become difficult on Timmers' (1971) 'probabilistic frontier'. Aigner et al.(1977) review the disadvantages of such parametric and probabilistic frontiers. Belbase and Grabowski, (1985) and Bravo-Ureta (1986) note that regardless of limitations, the probabilistic frontiers can be used in measuring productive efficiency. Ali and Chaudhry (1990) notice that 'probabilistic frontiers are still being used to measure efficiency. However, a common formulation of the deterministic frontier can be given by:

$$Y_i = f(x_i, \beta)\exp(-U_i) \qquad i = 1, 2, ..., n \qquad (5.1)$$

Where Y_i = Actual output, x_i = Input vector of the *i-th* firm. β = Unknown parameter to be estimated, U_i = Non-negative random variable associated with firm specific factors that cause *i-th* firm for not achieving maximum efficiency of production, and n = Number of firms.

The existence of non-negative random variable, U_i in the equation (5.1) implies that the term causes technical inefficiency of the firms and the value of $\exp(-U_i)$, ranges between 0 and 1. Therefore, this can be said that the possible production, Y_i, is bounded above by the non-stochastic (i.e., deterministic) quantity, $f(x_i;\beta)$. Thus the model in (6.1) is referred to as a deterministic frontier production function. The models of Aigner and Chu (1968), Afriat (1972) and Schmidt (1976) are examples of deterministic frontiers. Aigner and Chu (1968) establish an inequality relationship in production frontier, which can be given by the following expression:

$$Y_i \le f(x_i;\beta) \qquad i = 1, 2, ..., n \qquad (5.2)$$

Aigner and Chu (1968) suggest that the parameters of the model can be estimated by application of linear or quadratic programming algorithm and argued that chanceconstrained programming can also be applied to the inequality restrictions in (5.2) so that some observations can be permitted to lie above the estimated frontier.

Schmidt (1976) has mentioned that the maximum likelihood estimates for the β parameters of the model can be obtained by linear and quadratic programming techniques if the random variables hold exponential or half-normal distributions, respectively. For the β parameters in the model, (5.1), can be further added that β parameters are expressible as a linear function when logarithms are taken in both sides with U_i's having exponential or half-normal distribution. It follows that the maximum-likelihood estimates for the β parameters are obtained by minimizing the absolute sum or the sum of squares of the deviations of the logarithms of production from the corresponding frontier values, subject to the linear constraints obtained by applying logarithms to (5.1). The non-negativity restrictions on the parameter estimates, which are normally associated with linear and quadratic programming problems, are not required. Non-negative estimates for the partial elasticities in Cobb-Douglas models are generally reasonable.

However, the technical efficiency of a given firm can be obtained by the factors by which the level of production for the firm is less than its frontier output. Given the deterministic frontier model in equation (5.1), the frontier output for the *i-th* firm can be expressed as:

$$Y^* = f(x_i;\beta)$$

Thus, the technical efficiency for the *i-th* firm can be given as:

$$TE_i = \frac{Y_i}{Y^*}$$

$$= f(x_i;\beta)\exp(-U_i)/f(x_i;\beta)$$

$$= \exp(-U_i) \qquad (5.3)$$

In other words, from the deterministic production frontier model given in equation (5.1), technical efficiency for individual *i-th* firm can be estimated by obtaining the ratio of the observed production values to the corresponding estimated frontier values:

$$\widehat{TE}_i = \frac{Y_i}{f(x_i;\hat{\beta})}$$

where $\hat{\beta}$ can be either maximum-likelihood estimator or the corrected ordinary least-squares estimators (COLS) for β. Greene (1980) has proved that the corrected ordinary least-squares estimators for β is consistent, given the assumption that the U_i's are independently and identically distributed random variables.

It is worth-mentioning that the deterministic production frontier model as given in equation (5.1) has the form of a linear model with an intercept. The corrected ordinary least-squares estimators (COLS) for β can be defined by the ordinary least-square (OLS) estimators for the coefficients of β, except the intercept, and the OLS estimator for the intercept plus the largest residual required to make all deviations of the production observations (from the estimated frontier non-positive). When U_i of the deterministic production frontier model as given in equation (5.1), have exponential or half-normal distribution, inference about the β parameters cannot be found from the maximum-likelihood estimators, as some of the common regularity conditions are not satisfied. Detailed of this can be reviewed in Theil (1971). Greene (1980) has explained that if U_i's are independent and identically distributed as gamma random variables, with parameters $r > 2$ and $\lambda > 0$, then the required regularity conditions are fulfilled.

5.3 Stochastic Frontier Production Function and Efficiency Estimation

In deterministic frontiers, the effects of measurement error, exogenous shocks, and inefficiency are combined together into a single one-sided error as a measure of inefficiency. Further, deterministic frontiers approach counts all deviations from the production frontier as attributable to inefficiency disregarding the fact that firm's performance can also depend on some other factors that are beyond the control of the firm itself. For example, poor machine performance, strikes, bad weather and so on. Greene (1990) has pointed out that measurement error on the dependant variable causes detrimental effects on the analysis, and any single wrongful observation can dominate the estimation, even for a large sample. To correct and make necessary adjustment for the above weaknesses of the deterministic frontiers, Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Boreck (1977) have independently and separately introduced the stochastic production frontier or 'composed error' model. The stochastic frontier model permits the estimation of standard errors and tests of hypothesis using traditional maximum likelihood method, which has been impossible under the earlier deterministic production frontier model since violation of certain maximum likelihood regularity conditions occur. This is reviewed in Schmidt (1976). Stochastic frontier model allow for technical inefficiency and acknowledges the fact that random shocks outside the control of firms can affect the outputs. The model is such that the possible production Y_i, is bounded above by the stochastic quantity, $f(x_i;\beta)\exp(V_i)$ and that's why the term is named as stochastic frontier. The great virtue of stochastic production frontier model is that the impact on output due to internal or external shocks, in principle, can be separated from the contribution of variation in technical efficiency, in which an additional random error V_i, is added to the non-negative random variable, U_i. Where V_i is the two-sided "noise" component, and U_i is the non-negative technical inefficiency component, of the error term. Since the error term has two components, the stochastic production frontier model is often referred to as a "composed error" model.

The stochastic frontier production function can be defined by:

$$Y_i = f(x_i;\beta)\exp(V_i - U_i) \qquad (5.4)$$

$$u_i = V_i - U_i;\ i = 1,2,\dots,n$$

$$-\infty \le V_i \le \infty \text{ and } U_i \ge 0$$

Where Y_i = Observed output of the *i-th* firm

x_i = Input vectors of the *i-th* firm.

β = Unknown parameter to be estimated,

U_i = Non-negative random variable associated with firm specific factors that cause *ith* firm for not achieving maximum efficiency of production,

n = Number of firms.

V_i = Random error with mean zero and variance σ^2

u_i = Error term which analyzes a stochastic random disturbance and an asymptotic non-negative error term.

Random error V_i, is associated with random factors for example, measurement errors in production, weather, industrial actions, variations in labour and machinery performance, vagaries of the peripheral conditions, etc. which are not under the control of a firm. Random error V_i, is positive. When added to the deterministic frontier, $f(x_i;\beta)$, generates stochastic frontier. U_i is the asymmetric non-negative random error and is called technical inefficiency effects. When $U_i = 0$, the production function shows a best practice frontier and when $U_i > 0$, it expresses that the observed output is less than the expected maximum for existence of technical inefficiency. The greater is the value of actual output falls short of the stochastic frontier output, the higher the level of technical inefficiency. The observed variations in output occur either because of stochastic disturbances or technical inefficiency or both. A model without the random component, V_i turns into a deterministic or full frontier model and hence can be estimated by linear programming techniques. A model with U_i gives a response function or an average frontier model and is disapproved by Farrell (1957).

Under the assumptions of a probability density function for both V_i and U_i, equation (5.4) can be estimated by maximum- likelihood method. This approach yields a measure, which can be used to examine statistically the sources of differences between the firm's output and frontier output by computing the variance parameters, which relate the variance of V_i to the composed variance of u_i (Kaliranjan, 1981).

The random errors, V_i, $i = 1,2,...,n$, are assumed to be independently and identically distributed as $N(0,\sigma_V^2)$ and independent of the U_i's, which are assumed to be non-negative truncations of the $N(0,\sigma^2)$ distribution. The variance parameters are expressed as:

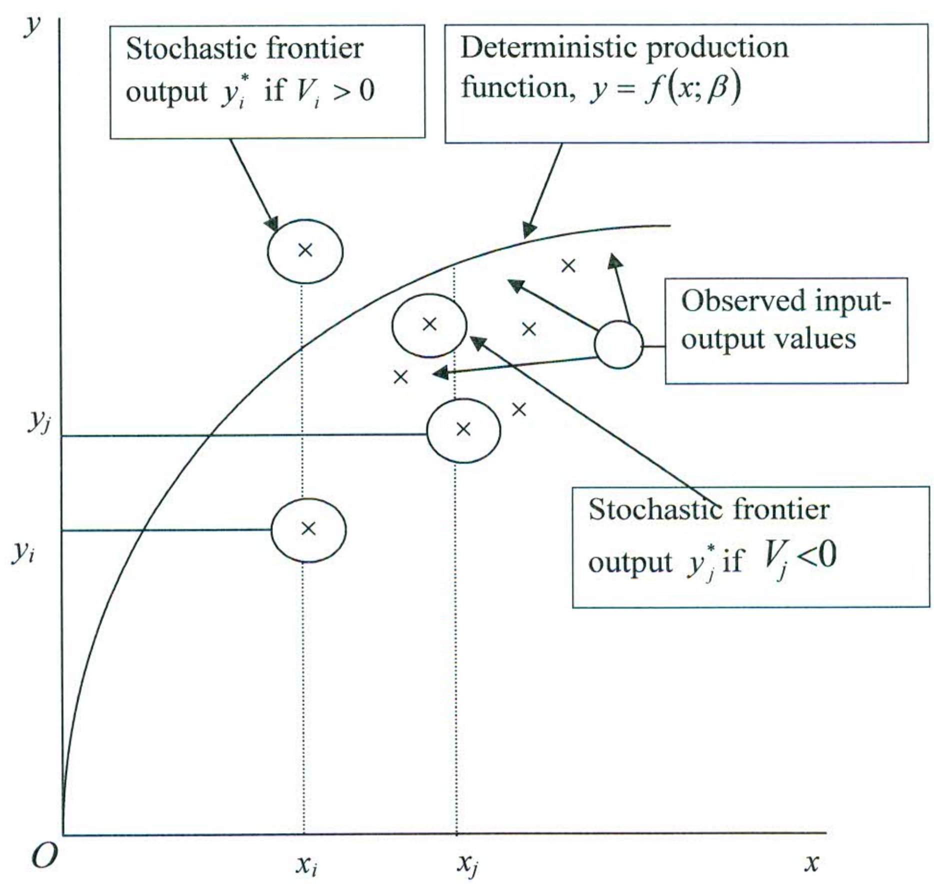
$$\sigma_u^2 = \sigma_V^2 + \sigma_U^2 \tag{5.5}$$

$$\gamma = \sigma_U^2 / \sigma_u^2 \text{ and } 0 \le \gamma \le 1$$

Battese and Corra (1977) defined γ as the total variation of output from the production frontier which might be attributed to technical inefficiency. When $\gamma \to 0$, then $\sigma_U^2 \to 0$ and $\sigma_V^2 \to \sigma_u^2$ which indicate that the symmetric error term V_i dominates the composed error term and output differs from the frontier output mainly because of measurement errors and other external factors on production. If $\gamma \to 1$ then $\sigma_V^2 \to 0$ and $\sigma_U^2 \to \sigma_u^2$ which implies that the symmetric non-negative error term U_i dominates the composed error and the differences between observed and frontier output can be attributed to differences in technical inefficiency.

The basic features of the stochastic frontier model are illustrated in Figure 5.2. Inputs are represented on the horizontal axis while outputs are measured on the vertical axis. The deterministic component of the frontier production model $y = f(x;\beta)$ is drawn assuming that diminishing return to scale applies. The observed output and inputs for two firms are presented. The productive activities of two firms are represented by i and j. Firm i uses inputs with values given by vector x_i and obtains the output Y_i, which exceeds the value on the deterministic production frontier $f(x_i;\beta)$. The frontier output is shown as Y_i^*. It is because of the fact that the productive activity of the *i-th* firm is accompanied by 'favourable' conditions for which the random error V_i, is positive. Similarly, the *j-th* firm uses the level of inputs, x_j, and produce output Y_j, which is less than the value on the deterministic production function $f(x_j;\beta)$, because its productive activity is associated with 'unfavourable' conditions for which the random error, V_j, is negative. In both cases the observed production values are less than the corresponding frontier values, but non-observable frontier production values would lie around the deterministic production function related with the firms involved.

Figure 5.2: Frontier Production Function and Technical Efficiency



The stochastic frontier outputs are, obviously, not observed since the random errors are not observed. The observed output may be higher than the deterministic part of the frontier function if the random errors are higher than inefficiency term. The observed input-output value is indicated by the point marked with '×' above the value of x_i. The value of the stochastic frontier output, $Y_i^* \equiv f(x_i;\beta)\exp(V_i - U_i)$, is marked by the point (×) above the production function because the random error V_i is positive. The frontier output $Y_j^* \equiv f(x_j;\beta)\exp(V_j)$, is below the production function because the random error, V_j, negative. The stochastic frontier outputs Y_i^* and Y_j^* are not observed because the random errors, V_i and V_j are not observable. Technical efficiency of the ith firm can be defined in terms of the ratio of the observed output to the corresponding frontier output, conditional upon the level of inputs used by that firm. The firm specific technical efficiency can be measured as:

$$TE_i = Y_i / Y_i^*$$

$$= \frac{f(x_i;\beta)exp(V_i - U_i)}{f(x_i;\beta)exp(V_i)}$$

$$= exp(-U_i) \qquad (5.6)$$

It is the expression as for the deterministic frontier model, given in equation (5.3). It is important to note that although the technical efficiency of a firm under deterministic and stochastic frontier models shows the same i.e., $\exp(-U_i)$, yet they have different values for the two models.

The reason for different efficiency value can be explained by the above Figure 5.2, wherein it is obvious that the technical efficiency of firm j is greater under the stochastic frontier model than for the deterministic frontier, i.e., $Y_j / Y_j^* > [Y_j / f(x_j;\beta)]$. That is, firm j is evaluated as technically more efficient relative to the 'unfavourable' conditions associated with its productive activity (i.e., $V_j < 0$) than if firm j's production is judged relative to the maximum under deterministic function, $f(x_j;\beta)$. Whereas firm i is evaluated technically less efficient relative to its 'favourable' conditions than if its production is calculated relative to the maximum associated with the value of the deterministic function $f(x_i;\beta)$. However, Battese (1998) suggests that for a given set of data, the estimated technical efficiencies obtained by fitting a deterministic frontier might be less than those obtained by fitting a stochastic frontier. This is because the deterministic frontier is estimated so that no output values exceed the frontier.

Aigner and Schmidt (1980) contain several other important papers dealing with the deterministic and stochastic frontier models. The prediction of the technical efficiency of an individual firm associated with the stochastic frontier production function in (5.4), defined by $TE_i = exp(-U_i)$, $i = 1, 2, ..., n$, was considered impossible until the appearance of Jondrow, Lovell, Materov and Schmidt (1982). This paper shed light on the conditional distribution of the non-negative random variable U_i, given that the random variable $u_i \equiv V_i - U_i$ was observable. Jondrow et al. (1982) recommended that U_i be predicted by the conditional expectation of U_i, given the value of the random variable, $u_i \equiv V_i - U_i$. This expectation was derived for the cases that the non-negative random variable U_i's had half normal and exponential distributions. Jondrow et al. (1982) use $1 - E(U_i / V_i - U_i)$ to predict the technical inefficiency of the *i-th* firm. But it has been pointed out by Battese and Coelli (1988) that the technical efficiency of the *i-th* firm $TE_i = exp(-U_i)$, is best predited by using the conditional expectation of $exp(-U_i)$ given the value of the random variable, $u_i \equiv V_i - U_i$.

Alternatively, TE_i can be defined as the ratio of the mean of production (given x_i and U_i) to the corresponding mean of production if there is no technical inefficiency (Battese and Coelli 1988):

$$TE_i = \frac{E(y_i | x_i, U_i)}{E(y_i | x_i, U_i = 0)}$$

Again the systematic random error, V_i, is assumed to be independently and identically distributed with mean zero and variance, σ_V^2; and U_i are non-negative truncations of the $N(\mu, \sigma_U^2)$ distribution, where:

$$\mu = z_i \delta_i \tag{5.7}$$

where z_i is a $(k \times 1)$ vector of variables which may influence efficiency and δ_i is an $(1 \times k)$ vector of parameters. Furthermore V_i and U_i are assumed to be independent of each other, i.e., $E(V_i, U_i) = 0$ and also independent of the input vector x_i, i.e., $E(V_i, x_i) = E(U_i, x_i) = 0$. The probability density function of the symmetric random error, V_i, is defined as:

$$f(V_i) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2\sigma^2}V_i^2}$$

The probability density function of the truncated normal distribution of technical inefficiency effects term is can be given as follow:

$$f(U_i \mid U_i \geq 0) = \frac{f(U_i)}{\Pr(U_i \geq 0)} \qquad U_i \geq 0$$

$$= \frac{\left(2\pi\sigma^2\right)^{-1/2} e^{-(U_i - \mu)/(2\sigma^2)}}{\{1 - \Pr(U_i \leq 0)\}}$$

$$= \frac{1}{\left(\sqrt{2\pi}\right)\sigma_U [1 - \Phi(-\mu/\sigma_U)]} e^{-\frac{1}{2\sigma_U{}^2}(U_i - \mu)^2}$$

$$= \frac{\frac{1}{\sigma_{Ui}} \phi\left(\frac{U_i - \mu}{\sigma_{Ui}}\right)}{1 - \Phi(-\mu/\sigma_{Ui})} \qquad (5.8)$$

where $\phi(\cdot)$ stands for the standard normal probability density function (pdf) and $\Phi(\cdot)$ denotes the cumulative distribution function (cdf) for the standard normal random variable.

The mean and variance of the truncated normal distribution of U_i can be written as:

$$E(U_i) = \mu + \frac{\sigma_U \phi(-\mu/\sigma_U)}{1 - \Phi(-\mu/\sigma_U)} \quad \text{and}$$

$$Var(U_i) = \sigma_U^2 \left[1 - \frac{\phi(-\mu/\sigma_U)}{1 - \Phi(-\mu/\sigma_U)} \left\{\frac{\mu}{\sigma_U} - \frac{\phi(-\mu/\sigma_{U_i})}{1 - \Phi(-\mu/\sigma_{U_i})}\right\}\right]$$

Measures of the firm-specific efficiency, e^{-U_i}, depends on the decomposition of u_i, which can be derived from the conditional expectation of e^{-U_i} provided u_i, is known that is:

$$\therefore \qquad TE_i = \left[\frac{1-\Phi\left\{\sigma_i^* - \left(\mu_i^* / \sigma_{U_i}^*\right)\right\}}{1-\Phi\left(-\mu_i^* / \sigma_{U_i}^*\right)} \right] e^{\left(-\mu_i^* + \frac{1}{2}\sigma_{U_i}^{*2}\right)} \tag{5.9}$$

This produces the measures of technical efficiency given the specification of the frontier production function model and the inefficiency effects model. According to Jondrow et al. (1982), technical inefficiency can be estimated by $1 - E\left\{e^{-U_i|u_i}\right\}$.

The mean technical efficiency of all firms in the sample, $\overline{TE}$, can be expressed as:

$$\overline{TE} = \left[\frac{1-\Phi\left\{\sigma^* - \left(\mu^* / \sigma^*\right)\right\}}{1-\Phi\left(-\mu^* / \sigma^*\right)} \right] e^{\left(-\mu^* + \frac{1}{2}\sigma^{*2}\right)}.$$

Instead of using the truncated normal distribution defined in (5.8), we can assume that the technical inefficiency term is half-normally distributed, a special case of the truncated normal distribution, so that:

$$f(U_i) = \frac{1}{\sigma_U \sqrt{\frac{1}{2}\pi}} e^{-\frac{1}{2\sigma_U^2} U_i^2} \tag{5.10}$$

The firm-specific technical efficiencies and mean technical efficiency are obtained respectively as:

$$TE_i = E\left[e^{-U_i|u_i}\right] = 1 - \Phi\left(\sigma_i^*\right) e^{\frac{1}{2}\sigma_i^{*2}} \tag{5.11}$$

and

$$\bar{TE}_i = 1 - \Phi\left(\sigma^*\right) e^{\frac{1}{2}\sigma^{*2}}$$

(Jondrow et al., 1982), which is equivalent to substituting $\mu = 0$.

The Frontier 4.1 program (Coelli, 1996) computes the maximum likelihood estimator of the predictor for the technical efficiency that is based on the conditional expectation of e^{-U_i} given the composed error term of the stochastic frontier production model (Battese and Coelli, 1988). The parameters of the coefficients of stochastic frontier model, β, and the technical inefficiency effects model, δ_i, along with the variance parameters can also be estimated. The log-likelihood function for the sample observations, can be given as:

$$L(\Omega^*, y) = \sum_{i=1}^{n} \ln\left[1 - \Phi\left(-\mu_i^* / \sigma_{iU}^*\right)\right] - \frac{1}{2}\sum_{i=1}^{n}\left[\{y_i - f(x_i;\beta)\}'\{y_i - f(x_i;\beta)\}/\sigma_V^2\right]^2$$

$$-\frac{1}{2}n(\mu/\sigma_U) + \frac{1}{2}\sum_{i=1}^{n}\left(\mu_i^*/\sigma_{Ui}^*\right)^2 - \frac{1}{2}n\ln(2\pi) - \frac{1}{2}n\ln\left(\sigma_U^2 + \sigma_V^2\right)$$

$$-n\ln\left[1 - \Phi\left(-\mu/\sigma_U\right)\right]$$

where $\Omega^* \equiv \left(\beta', \sigma_V^2, \sigma_U^2, \mu\right)'$

The foremost disadvantages of this approach are assumptions about the distributions of technical inefficiency and the random term and the nonexistence of an *a priori* explanation of choosing the distributional form of the random noise (Coelli, 1992).

The calculation of technical efficiencies of individual firm under stochastic frontier production function as given in equation (5.4) has been made possible by the contribution of Jondrow, Lovell, Materov and Schmidt (1982). Also Aigner and Schmidt (1980) contributed important papers dealing with the deterministic and stochastic frontier models.

The stochastic frontier model as given in equation (5.4) having the inference about the parameters of the model, is based on the maximum-likelihood estimators. It has been argued that maximum likelihood estimators satisfy the standard regularity conditions (Battese, 1998). Richmond (1974) has suggested applying of the corrected least-square

(COLS) methods to estimate the parameters. Battese (1998) noted that the ML estimator is asymptotically more efficient than the COLS estimator, but the properties of the two estimators in finite samples cannot be analytically ascertained.

5.4 Functional Forms of Production Function

One of the general assumptions in the study of productive efficiency is that the production function of a fully efficient firm is supposed to be known. But in practice, production function for efficient firm is never known. In such a situation, Farrell (1957) has suggested that the production function be estimated from sample data using either a non-parametric piece-wise-linear technology or a parametric function, such as the Cobb-Douglas functional form. However, Aigner and Chu (1968) consider the estimation of a parametric production function of Cobb-Douglas form. Cobb-Douglas production function is widely used in econometrics.

5.5 Functional Forms

Cobb-Douglas Production Function: The Cobb-Douglas production function can be given as follows:

$$\ln y_i = \beta_0 + \sum_{i=1}^{n} \beta_i \ln x_i \qquad (5.12)$$

where y_i = Output, β_0 = "efficiency parameter", i.e., an indicator of the state of technology, x_i = Inputs of production, ln = Natural logarithm, β_i $(i = 1,2,3,\ldots,n)$ are the output elasticities with respect each input and the production function is homogeneous of degree $\sum_{i=1}^{n} \beta_i$. Differentiating (5.12) yields the marginal product for input of *i-th* firm, for example:

$$\frac{\partial y}{\partial x_i} = \frac{\beta_i y_i}{x_i}$$

which is strictly positive for $x_i > 0$. The marginal rate of technical substitution is:

$$MRTS_{i,j} = \frac{\partial y_i / \partial x_i}{\partial y_i / \partial x_j} = \frac{\beta_i}{\beta_j} \frac{x_j}{x_i}$$

The elasticity of substitution is $\sigma = 1$ for any input combination and all levels of output, which restricts the flexibility of this functional form. The returns to scale can be given by $\sum_{i=1}^{n} \beta_i$.

5.6 Summary and Conclusion

This chapter describes econometric approach to estimate technical efficiency. Neo-classical production function is the basis of the stochastic frontier. Hence functional form of production function is a pre-requisite to find efficiency measurement. Production function provides the foundation for econometric approach to estimate technical efficiency, which includes deterministic frontier and stochastic frontier. We discuss recent evolution, progress and development of parametric models as empirical methodology of estimating productive efficiency. SFA fulfils necessary criteria for estimating technical efficiency on the basis of a suitable production function. The stochastic frontier model permits the estimation of standard errors and tests of hypothesis using traditional maximum likelihood methods, which has been impossible under the earlier deterministic production frontier model since violation of certain regularity conditions occurs. Stochastic frontier model allow for technical inefficiency, but they also acknowledge the fact that random shocks outside the control of firms can affect the output. Since the error term has two components, the stochastic production frontier model is often referred to as a "composed error" model.

Cobb-Douglas production functional form is very popular and widely used in econometric analysis. Although it is restricted by unitary elasticity of substitution. Statistical test of selecting the representative frontier production technology for firm efficiency is described. We have discussed Cobb-Douglas functional form to find measures of technical efficiency. Under stochastic frontier approach, we have used Cobb-Douglas production frontier to estimate the technical efficiency of individual commercial banks of Bangladesh. We have applied in our study the Cobb-Douglas stochastic frontier model to estimate efficiency.

Chapter 6

Stochastic Frontier Analysis: Empirical Results

6.1 Introduction

This chapter discusses results obtained from the stochastic econometric frontier model. The methodology has been analysed in chapter 5. The focus of the chapter is to present the technical efficiency scores of individual banks. We measure technical efficiency of 49 banks for each year from 1999 to 2005 using stochastic frontier model in a single stage estimation technique by maximum likelihood method.

We organise this Chapter as follows: Section 6.2 Summary Statistics and Explanation of the Variables; Section 6.3 presents Stochastic Production Frontier Function and Technical Efficiency Score; Section 6.4 discusses Maximum Likelihood Estimates of Cobb-Douglas Stochastic Frontier Production Function; Section 6.5 Summary Results of Efficiency Estimates; Section 6.6 Comparison among Efficiency Performance of Category of Banks; Section 6.7 Conclusion.

6.2 Summary Statistics and Explanation of the Variables

Year wise cross-section data are collected from each of the individual bank's annual reports for the years 1999-2005. Bank specific data has been used to find SF results. Summary statistics of variables are presented in Table 6.1. Table 6.2 gives the summary of income total and share of its components by types of banks over the year. Table 6.3 gives the summary of the expenditure variables.

Aggregate banking sector's expenditure in 1999 is Tk. 60162.02 million, which registeres an overall increase over the study period 1999-2005, and the amount of stands at Tk. 111952.16 in 2005. The average of the aggregate expenditure during the period shows Tk. 85117.90 million of which NCBs incurred Tk. 34734.79 million, PCBs Tk. 30312.01, SCBs Tk. 7960.02 million, IPCBs Tk. 7209.25 and FCBs Tk. 4901.83 million.

Table 6.1: Description of the Data

Year	Total Income	Interest	Salary	Printing and Stationary	Legal and Other Expenses	Depreciation	Total Expenditure
1999	66100.98	42899.54	11567.05	1164.246	2066.142	862.937	60162.02
2000	81238.23	49380.72	13195.6	1326.159	2838.638	980.367	69470.55
2001	96137.09	55764.76	14206.13	1475.17	3130.411	1084.74	77724.81
2002	105184.27	62271.96	15809.48	1699.44	3738.254	1408.88	87339.72
2003	122144.04	56949.9	17644.67	2491.64	4331.662	1680.29	85812.84
2004	135480.72	71449.76	19913.93	2101.7	4776.6	1888.3	103363.21
2005	158017.69	75291.55	23078.38	2383.193	5517.57	2238.35	111952.16
Mean	109186.15	59144.027	16487.891	1805.9354	3771.3253	1449.1234	85117.9
SD	31800.267	11528.202	4025.5633	524.97485	1194.6649	511.03401	18169.03
Maximum value	158017.69	75291.55	23078.38	2491.64	5517.57	2238.35	111952.16
Minimum value	66100.98	42899.54	11567.05	1164.246	2066.142	862.937	60162.02

Our data shows that aggregate banking sector's income in 1999 is Tk. 66100.98 million, which records a general increase during the study period 1999-2005, and the amount reaches at Tk. 158016.69 million in 2005. The average figure of the aggregate income during the period stands to be Tk. 109186.14 million of which NCBs share is Tk. 39972.48 million, PCBs Tk. 42402.11, SCBs Tk. 7882.97 million, IPCBs Tk. 9463.06 and FCBs Tk. 9465.51 million (Banking Sector Survey Data, 1999-2005). We understand that total income increases more than double during the study period.

6.2.1 Income Variable and share of its Components

Before we describe stochastic production frontier results, we would like to look at the summary of the year wise cross-section. Table 6.1 shows relative share of various income components by types of banks over time the year 1999-2005.From Table 6.1 we find that interest income is one of the major income earning sources of the commercial banks which occupies 65.55 percent of NCBs total income on an average. During the study period average interest income for PCBs shows a figure of 70.30 percent, for SCBs 88.12 percent, for IPCBs 81.78 percent (IPCBs call it a profit income instead of interest income), for FCBs 58.12 percent. However, the banking sector average is 69.92 percent over the study period. In 1999 NCBs interest income is 68.06 percent while income from investment is 15.17 percent, operating income is 1.94 percent, fees and commissions is 14.83 percent. Over the study period, relative contribution of the components fluctuates significantly. The contribution of interest income component for all banks starts to decline partly due to competition with the increasing number PCBs and government directed reduction in interest rates during 2001 to 2004.

Table 6.2: Share of Income Components to Total Income

	Income components	1999	2000	2001	2002	2003	2004	2005	Mean
NCBs	Interest income	68.06	66.68	67.72	64.48	67.05	61.53	63.31	65.55
	Investment income	15.17	16.40	15.82	14.34	16.99	16.10	14.75	15.65
	Operating income	1.94	1.39	1.09	1.52	1.17	4.06	2.06	1.89
	Fees and Comm. Income	14.83	15.54	15.38	19.66	14.79	18.31	19.88	16.91
	Total income	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PCBs	Interest income	70.62	68.93	71.76	70.84	69.76	68.30	71.91	70.30
	Investment income	7.07	8.41	6.97	7.18	8.99	10.51	8.16	8.18
	Operating income	3.81	3.74	3.54	3.71	3.96	5.02	4.61	4.06
	Fees and Comm. Income	18.50	18.93	17.10	18.27	17.29	16.17	15.31	17.37
	Total income	100.00	100.00	99.37	100.00	100.00	100.00	100.00	99.91
SCBs	Interest income	88.40	91.63	83.67	89.71	89.17	87.68	86.60	88.12
	Investment income	1.97	2.46	2.30	3.09	2.69	2.94	3.17	2.66
	Operating income	4.60	1.69	9.72	2.36	3.03	2.47	3.22	3.87
	Fees and Comm. Income	5.04	4.22	4.30	4.84	5.11	6.91	7.01	5.35
	Total income	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
IPCBs	Interest income	77.99	81.32	82.97	83.57	84.13	83.80	78.67	81.78
	Investment income	0.00	0.00	0.79	0.01	0.01	0.00	1.04	0.26
	Operating income	3.18	2.58	2.15	1.95	1.98	1.67	1.62	2.16
	Fees and Comm. Income	18.83	16.09	14.09	14.47	13.88	14.53	18.68	15.80
	Total	100.00	100.00	100.00	100.01	100.00	100.00	100.00	100.00
FCBs	Interest income	63.78	56.08	48.48	56.11	61.16	60.29	60.95	58.12
	Investment income	7.50	10.37	6.20	6.26	9.21	9.20	7.71	8.06
	Operating income	0.93	2.64	1.32	1.16	0.83	0.83	0.97	1.24
	Fees and Comm. Income	27.79	30.91	29.89	36.48	28.80	29.68	30.38	30.56
	Total income	100.00	100.00	85.89	100.00	100.00	100.00	100.00	97.98
All Banks	Interest income	70.87	69.75	70.49	69.64	70.82	68.30	69.59	69.92
	Investment income	10.17	11.10	9.57	9.01	10.42	10.48	9.21	9.99
	Operating income	2.73	2.34	2.88	2.42	2.46	3.78	3.11	2.82
	Fees and Comm. Income	16.23	16.81	15.85	18.94	16.30	17.44	18.09	30.56
	Total income	100.00	100.00	98.78	100.00	100.00	100.00	100.00	113.29

Source: Annual Reports of 49 Banks 1999-2005

For all banks the rest of the components fluctuated progressively showing somewhat growth in their shares. Fee and Commission component and operating income component have experienced a rise in their relative shares. Though declining PCBs shows almost stable in their comparative share in interest income components and shows a little decline in 2003 and 2004 at 69.76 percent and 68.30 percent respectively whereas in the year 1999, interest income is 70.62 percent. Mentionable that share of profit (in replacement of the concept interest) of IPCBs has not abated rather experienced a slight increase. FCBs' interest income is stable over the time though it is slightly declining, which comprises the sector lowest share in interest income component (on an average 58.12 percent). The percentage share of SCBs is comparatively better because it has experienced increase in both investment component and commission and exchange component. All banks share of interest income component to total income on an average stands at 69.92 percent.

6.2.2 Summary of Expenditure Components

Interest expense is the major expenditure component in banking sector. From Table 6.3, we find that 73.48 percent expenditure of NCBs goes for interest expenses purpose. FCBs make least amount of expenditure for interest component that is 56.95 percent in 1999, and 53.93 in 2005

The maximum expenditure in this component is made by IPCBs whose share in this is 76.13 in 1999, and 75.81 in 2005. The second major expenditure component is salary and wage (labour). The IPCBs expense on this component is relatively low at 13.58 percent where NCBs and SCBs share relatively high at 20.39 percent and 21.87 percent. One of the possible reasons for such higher share can be explained as excess manpower in the NCBs and SCBs.

Table 6.3: Share of Expenditure of Components to Total Expenditure (in percent)

	Component	1999	2000	2001	2002	2003	2004	2005	Mean
NCBs	Interest	73.48	74.69	75.67	75.07	61.70	71.29	68.10	71.43
	Salary and wage	20.39	19.47	18.30	18.70	28.33	20.82	23.84	21.41
	R L and Insurance	2.01	1.80	2.03	2.12	3.22	2.52	2.46	2.31
	Postage and tele	0.55	0.53	0.47	0.41	0.64	0.43	0.39	0.49
	Stationary	0.66	0.63	0.63	0.64	0.94	0.74	0.72	0.71
	Depreciation	0.74	0.69	0.68	0.71	1.14	1.06	1.13	0.88
	Other expense	1.93	1.96	1.99	2.16	3.66	2.67	3.03	2.48
	Legal expenses	0.23	0.23	0.23	0.20	0.38	0.46	0.32	0.29
	Total expenses	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PCBs	Interest	69.08	68.57	70.14	69.00	69.47	68.33	70.65	69.32
	Salary and wage	17.07	17.93	16.96	16.17	16.72	17.78	16.67	17.04
	R L and Insurance	4.46	4.12	3.85	3.86	3.55	3.98	3.52	3.90
	Postage and tele	1.84	1.65	1.61	1.41	1.31	1.29	1.20	1.47
	Stationary	1.29	1.32	1.25	1.27	1.23	1.27	1.28	1.27
	Depreciation	2.51	2.28	2.06	2.19	2.16	2.25	2.19	2.24
	Other expense	3.58	4.00	4.01	5.94	5.27	4.55	4.26	4.52
	Legal expenses	0.18	0.13	0.12	0.15	0.28	0.55	0.24	0.24
	Total cost	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SCBs	Interest	69.86	64.76	63.35	68.51	67.23	64.03	38.10	62.27
	Salary and wage	21.87	22.77	24.22	24.53	24.13	25.54	39.47	26.08
	R L and Insurance	1.39	1.30	1.78	1.61	2.23	2.16	2.99	1.92
	Postage and tele	0.43	0.43	0.42	0.37	0.41	0.40	0.64	0.44
	Stationary	0.53	0.49	0.57	0.56	0.56	0.67	0.89	0.61
	Depreciation	0.82	0.80	0.76	0.86	1.13	1.15	1.58	1.01
	Other expense	5.05	9.40	8.86	3.53	4.27	5.95	16.23	7.61
	Legal expenses	0.04	0.04	0.04	0.04	0.03	0.10	0.10	0.06
	Total cost	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
IPCBs	Interest	76.13	75.52	75.52	75.92	77.34	77.34	75.81	76.23
	Salary and wage	13.58	14.46	14.23	13.67	12.53	14.14	15.28	13.99
	R L and Insurance	2.69	2.33	2.05	2.44	2.35	2.40	2.13	2.34
	Postage and tele	1.66	1.41	1.34	1.09	0.89	0.89	0.91	1.17
	Stationary	0.82	0.75	0.75	0.82	0.61	0.66	0.68	0.73
	Depreciation	1.47	1.65	1.82	1.86	1.66	0.76	1.49	1.53
	Other expense	3.50	3.75	4.16	4.06	4.50	3.60	3.54	3.87
	Legal expenses	0.15	0.13	0.13	0.15	0.12	0.21	0.16	0.15
	Total cost	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
FCBs	Interest	56.95	56.96	50.85	51.66	51.47	55.78	53.93	53.94
	Salary and wage	17.06	16.82	20.19	20.93	16.74	19.50	21.54	18.97
	R L and Insurance	4.06	4.08	4.34	3.65	3.26	3.86	4.54	3.97
	Postage and tele	3.52	3.31	3.15	2.67	2.39	2.36	2.81	2.89
	Stationary	2.24	2.53	3.10	4.14	12.40	3.26	3.35	4.43
	Depreciation	5.14	5.30	6.02	6.67	5.69	6.01	6.11	5.85
	Other expense	10.81	10.78	12.10	10.08	7.71	9.04	7.46	9.71
	Legal expenses	0.22	0.21	0.24	0.22	0.33	0.19	0.26	0.24
	Total cost	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
All Banks	Interest	71.31	71.08	71.75	71.30	66.37	69.12	67.25	69.74
	Salary and wage	19.23	18.99	18.28	18.10	20.56	19.27	20.61	19.29
	R L and Insurance	2.66	2.52	2.65	2.76	3.16	3.13	3.08	2.85
	Postage and tele	1.06	1.01	0.98	0.91	1.05	0.93	0.98	0.99
	Stationary	0.88	0.90	0.92	1.03	1.85	1.10	1.15	1.12
	Depreciation	1.43	1.41	1.40	1.61	1.96	1.83	2.00	1.66
	Other expense	3.25	3.91	3.86	4.12	4.78	4.20	4.67	4.11
	Legal expenses	0.19	0.17	0.17	0.17	0.27	0.42	0.25	0.23
	Total cost	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.0

Rent lighting and insurance (occupancy expense) is 2.66 percent for the whole banking sector while NCBs incurs 2.01 percent, PCBs 4.46 percent (relatively high), SCBs 1.39 percent, IPCBs 2.69 percent, FCBs 4.06 percent (that can be compared almost equal to that of PCBs) in 1999. Postage and tele communication expenses occupy 1.06 percent for the whole banking sector where NCBs and SCBs relative shares to total cost are comparatively low at 0.55 percent and 0.43 percent respectively, PCBs share within their category is 1.84 percent, IPCBs is 1.66 percent, FCBs 3.52 percent (significantly high) in 1995.

However, the share of other components can well be perceived from Table 6.3. It is pertinent to mention here that expenditure on legal affairs is very scanty in the whole banking sector, 0.19 percent, while expenses on the same component for NCBs and SCBs are at 0.23 percent and 0.04 percent respectively, PCBs 0.18 percent IPCBs 0.18 percent and FCBs 0.22 percent (relatively high). It appears that increase in legal affairs expenditure may increase efficiency.

6.3 Stochastic Production Frontier Function and Technical Efficiency Score

The stochastic frontier production model is specified by the Cobb-Douglas production model. *A priori*, the Cobb-Douglas production model is restricted on the flexibility of functional form of production technology by imposing elasticity of scale to be constant and elasticity of input substitution to be unity. However, to estimate technical efficiency of each bank we need to select a representative functional form. We specify a Cobb-Douglas production function as given in equation (5.12) in chapter 5. Reviews of the literature on Cobb-Douglas stochastic production frontier and its use in measuring efficiency can be found, for instance, in Schmidt and Lovell (1979), Førsund et al. (1980), Schmidt (1986), Greene (1993), Battese and Coelli (1995) and Gstach (1998). For practical purpose we put the empirical Cobb-Douglas stochastic production function as follows:

$$ln\, y_i = \beta_0 + \sum_{j=1}^{6} \beta_{ij}\, ln\, x_{ij} + ln\, u_i \qquad i = 1, 2, ..., 49 \qquad (6.1)$$

where

y_i = Income of *i-th* bank,

x_{i1} = Interest expenses by the *i-th* bank,

x_{i2} = Salaries and wages expenses of *i-th* bank. Salary and wage include the following expenditure sub-components (a) Salaries and wage of all employees (b) Remuneration paid to CEO (c) Fees paid to the directors (d) Meeting expenses (e) Audit fees

x_{i3} = Occupancy expenses which include rent, taxes, lighting and insurance premiums paid for bank premises,

x_{i4} = Expenses of material used and communications which include (a) expenditure for stationery, printing and advertisement (b) Postage, stamp, telegram and telephone,

x_{i5} = Depreciation and repairs,

x_{i6} = Legal and all sorts of other expenses,

All of those values are presented in the natural logarithm and the error term is decomposed as follows:

$$ln\, u_i = V_i - U_i \qquad i = 1, 2, ..., 49$$

where U_i = Non-negative random variable (symmetric error component) associated with bank specific factors that cause *i-th* bank for not achieving maximum efficiency in production, U_i, are assumed to be independently and identically distributed random error having normal distribution with mean zero and variance σ_U^2, that is, $U_i \sim N(0,\sigma_U^2)$ and the technical inefficiency effects U_i are non-negative truncations of the $N(\mu,\sigma_U^2)$ distribution. $V_i =$ Random error with mean zero. The term V_i, is associated with random factors for example, measurement errors in production such as weather, industrial actions, variation in labour and machinery performance, vagaries of the peripheral conditions, unusual external shocks, political instability etc., which are not under the control of the term. V_i may capture positive value. The systematic random error, V_i, are assumed to be independently and identically distributed with mean zero and variance, σ_V^2.

In estimation process, the variances of the error terms in the model (6.1) reparameterised and expressed in terms of $\sigma_u^2 = \sigma_V^2 + \sigma_U^2$ and $\gamma = \sigma_U^2 / \sigma_u^2$ where, $0 \le \gamma \le 1$ as stated in equation (5.5).

We run the above stochastic frontier model with each year's cross-section data, for chronological seven years from 1999-2005. Estimates of the coefficients of the input variable parameters have been computed by maximum likelihood method. The model (6.1) generates TE score as well as estimates for the parameters. In this connection we have used FRONTIER Version 4.1, Computer Program (Coelli, 1996). We represent efficiency estimates in Table 6.5 to 6.6.

6.4 Maximum likelihood Estimates of Cobb-Douglas Stochastic Frontier Production Function for 1999-2005

We first introduce maximum likelihood estimates of parameters of Cobb-Douglas stochastic production function in Table 6.4. Parameters estimates for the stochastic Cobb-Douglas production frontier appear in Table 6.4. We examine the coefficients of the parameters estimates obtained from model (6.1) reported in Table 6.4 for 1999-2005. Table 6.4 shows that all the estimates of parameters of the stochastic Cobb-Douglas production function are holding positive signs as expected except for parameter β_2 in the year 1999, β_3 in 2001, 2003, 2004, and 2005, β_5 in 2002. The negative sign implies that variable is saturated in the banking sector and additional increase in the respective variable is likely to generate negative effects on banking output.

Table 6.4 Maximum Likelihood Estimates of the Cobb-Douglas Frontier Model, 1999-2005

Stochastic Frontier		Coefficients						
Name of the Variables	Parameters	1999	2000	2001	2002	2003	2004	2005
Constants	β_0	2.83*	2.7*	0.24	0.84*	3.44*	0.36*	3.42*
Interest Expenditures	β_1	0.33*	0.52*	0.55**	0.57	0.53**	0.44*	0.41*
Salaries and Wages	β_2	-0.04	0.10	0.12	0.27*	0.08	0.11*	0.29
Occupancy Expenditures	β_3	0.32*	0.21*	-0.09	0.02	-0.06	-0.08	-0.06
Communications and Stationeries Expenditures	β_4	0.18*	0.09	0.09	0.17	0.14	0.03	0.07
Depreciation and Repairs	β_5	0.02	0.07	0.12	-0.05	0.05	0.15	0.27*
Legal and Other Expenditures	β_6	0.23*	0.18	0.25**	0.18	0.01	0.11	0.13
Variance Parameters	σ^2	0.83*	0.05	0.04	0.24	0.14	0.04	0.18*
	γ	0.97*	0.83	0.39	0.99	0.94	1.00*	0.75*
Log Likelihood Function		-0.10	0.14	0.13	-0.49	0.13	0.18	-10.10

Note: * Indicates significance at five percent level, ** Indicates significance at ten percent level.

The statistically significant coefficients imply that the concerned variables are significantly important in the stochastic frontier production function of banks. The statistically insignificant coefficients indicate that the parameters have got influence on banking output but the influence is not high enough to affect output significantly. Appendix 6.1 to 6.7 in the appendix provides information on individual technical efficiency (TE) scores for each bank for seven years. We investigate SFA TE scores for each category of banks in Table 6.5 to obtain information about efficiency performance by category of banks. Findings are given according to the category of banks for 1999-2005.

6.5 Summary Results of Efficiency Estimates

We describe technical efficiency results and compare the results with in the groups and over time 1999-2005. Table 6.5 provides information of the mean technical efficiency scores of the various category of banks while Table 6.6 shows individual banks technical efficiency scores over the study period.

Table 6.5: Summary Statistics of SFA TE Estimates by types of Banks 1999-2005

Bank Type	Parameters	1999	2000	2001	2002	2003	2004	2005	Mean
	Mean	0.870	0.960	0.863	0.868	0.853	0.843	0.858	0.873
	SD	0.018	0.014	0.036	0.088	0.076	0.121	0.034	
	Max.	0.890	0.970	0.890	0.940	0.920	0.980	0.890	
	Min.	0.850	0.940	0.810	0.740	0.760	0.710	0.810	
PCBs	Mean	0.707	0.728	0.807	0.671	0.759	0.660	0.766	0.728
	SD	0.171	0.174	0.147	0.172	0.149	0.107	0.091	
	Max.	0.900	0.950	0.940	0.920	0.950	0.810	0.930	
	Min.	0.290	0.400	0.220	0.230	0.340	0.404	0.440	
SCBs	Mean	0.770	0.704	0.782	0.782	0.762	0.765	0.744	0.744
	SD	0.151	0.076	0.163	0.200	0.141	0.164	0.085	
	Max.	0.880	0.800	0.960	0.910	0.940	0.936	0.840	
	Min.	0.510	0.590	0.590	0.510	0.600	0.535	0.640	
IPCBs	Mean	0.830	0.748	0.779	0.664	0.702	0.619	0.619	0.709
	SD	0.082	0.118	0.123	0.241	0.141	0.154	0.154	
	Max.	0.910	0.920	0.886	0.970	0.940	0.860	0.860	
	Min.	0.720	0.660	0.610	0.420	0.580	0.465	0.465	
FCBs	Mean	0.778	0.812	0.850	0.744	0.730	0.642	0.642	0.742
	SD	0.178	0.135	0.104	0.181	0.200	0.213	0.213	
	Max.	0.950	0.970	0.985	0.960	0.930	0.939	0.939	
	Min.	0.330	0.620	0.700	0.430	0.410	0.310	0.310	
All Banks	Mean	0.754	0.766	0.815	0.703	0.755	0.669	0.740	0.743
	SD	0.162	0.158	0.131	0.181	0.153	0.149	0.137	
	Max.	0.950	0.970	0.985	0.970	0.950	0.980	0.939	
	Min.	0.290	0.400	0.220	0.230	0.340	0.310	0.310	

6.5.1 Nationalised Commercial Banks 1999-2005

Table 6.5 shows that the mean technical efficiency estimates for NCBs are 0.87, 0.960, 0.863, 0.868, 0.853, 0.843, and 0.858 in 1999, 2000, 2001, 2002, 2003, 2004 and 2005 respectively. Over the study period we find that average technical efficiency score of NCBs is 0.873.

Table 6.6: Summary of SFA Technical Efficiency Estimates 1999-2005

Type		Name of Banks	`99	`00	`01	`02	03	04	05	Mean	SD
NCBs	1	Sonali Bank	0.89	0.97	0.87	0.91	0.91	0.98	0.890	0.917	0.042
	2	Janata Bank	0.86	0.96	0.88	0.94	0.92	0.90	0.870	0.904	0.037
	3	Agrani Bank	0.88	0.97	0.89	0.88	0.76	0.78	0.860	0.860	0.071
	4	Rupali Bank	0.85	0.94	0.81	0.74	0.82	0.71	0.810	0.811	0.075
PCBs	5	Pubali Bank Ltd	0.76	0.93	0.84	0.75	0.75	0.63	0.800	0.780	0.092
	6	Uttara Bank Ltd	0.82	0.95	0.92	0.78	0.78	0.77	0.820	0.834	0.072
	7	AB Bank Ltd	0.62	0.79	0.92	0.54	0.67	0.59	0.440	0.653	0.160
	8	National Bank Ltd	0.84	0.91	0.91	0.75	0.80	0.78	0.740	0.818	0.070
	9	The City Bank Ltd	0.81	0.75	0.91	0.74	0.76	0.72	0.810	0.784	0.064
	10	IFIC Bank Ltd	0.85	0.88	0.94	0.71	0.69	0.70	0.720	0.784	0.103
	11	UCBL	0.72	0.79	0.86	0.64	0.84	0.70	0.800	0.764	0.080
	12	Eastern Bank Ltd	0.87	0.91	0.90	0.89	0.85	0.75	0.740	0.844	0.071
	13	NCCBL	0.89	0.94	0.89	0.92	0.66	0.63	0.770	0.814	0.128
	14	Prime Bank Ltd	0.81	0.91	0.87	0.75	0.50	0.73	0.790	0.766	0.133
	15	South East Bank Ltd	0.74	0.82	0.89	0.53	0.93	0.75	0.770	0.776	0.130
	16	Dhaka Bank Ltd	0.87	0.82	0.84	0.77	0.76	0.69	0.900	0.807	0.072
	17	Dutch-Bangla Bank Ltd	0.78	0.74	0.87	0.79	0.66	0.58	0.690	0.730	0.096
	18	Mercantile Bank Ltd	0.65	0.76	0.89	0.85	0.87	0.78	0.820	0.803	0.082
	19	Standard Bank Ltd	0.73	0.57	0.81	0.51	0.85	0.68	0.820	0.709	0.129
	20	One Bank Ltd	0.76	0.51	0.76	0.83	0.69	0.62	0.690	0.694	0.105
	21	EXIM Bank of BD. Ltd	0.58	0.65	0.79	0.77	0.91	0.81	0.870	0.769	0.117
	22	BD. Commerce Bank Ltd	0.57	0.40	0.22	0.43	0.48	0.42	0.710	0.461	0.152
	23	Mutual Trust Bank Ltd	0.61	0.68	0.81	0.79	0.89	0.62	0.790	0.741	0.106
	24	First Security Bank Ltd	0.43	0.49	0.70	0.65	0.80	0.60	0.730	0.629	0.132
	25	The Premier Bank Ltd	0.29	0.54	0.79	0.71	0.95	0.79	0.820	0.699	0.219
	26	Bank-Asia Ltd	0.35	0.56	0.77	0.59	0.84	0.64	0.750	0.643	0.164
	27	The Trust Bank Ltd	0.90	0.45	0.71	0.33	0.34	0.40	0.930	0.581	0.261
	28	Jamuna Bank Ltd	Na	Na	0.76	0.54	0.78	0.59	0.720	0.678	0.107
	29	BRAC Bank Ltd	Na	Na	0.61	0.23	0.92	0.54	0.720	0.605	0.254
SCBSs	30	BD. Krishi Bank	0.86	0.59	0.59	0.54	0.60	0.54	0.640	0.622	0.111
	31	Raj. Krishi Unnayan Bank	0.51	0.73	0.64	0.51	0.65	0.54	0.670	0.607	0.087
	32	BD. Shilpa Bank	0.77	0.69	0.96	0.91	0.94	0.94	0.780	0.855	0.106
	33	BD. Shilpa Rin Shangstha	0.83	0.71	0.81	0.56	0.86	0.66	Na	0.745	0.108
	34	BASIC Bank Ltd	0.88	0.80	0.91	0.89	0.76	0.71	0.800	0.827	0.074
IPCBs	35	Islami Bank of BD. Ltd	0.82	0.92	0.83	0.87	0.94	0.86	0.840	0.871	0.044
	36	Al- Arafa Islami Bank Ltd	0.87	0.66	0.69	0.55	0.66	0.58	0.340	0.655	0.109
	37	Social Investment Bank Ltd	0.91	0.69	0.89	0.97	0.71	0.67	0.710	0.786	0.130
	38	The Oriental Bank Ltd	0.72	0.72	0.88	0.42	0.58	0.52	Na	0.624	0.157
	39	Shahjalal Bank Ltd.	Na	Na	0.61	0.51	0.62	0.47	0.790	0.534	0.076
FCBs	40	American Express Bank	0.66	0.97	0.98	0.68	0.49	0.44	Na	0.666	0.233
	41	Standard Chart Bank U.K.	0.81	0.96	0.99	0.90	0.90	0.94	0. 910	0.918	0.057
	42	Habib Bank Ltd	0.89	0.77	0.77	0.43	0.56	0.37	0.690	0.593	0.216
	43	State Bank of India Ltd	0.95	0.91	0.96	0.90	0.83	0.78	0.730	0.872	0.077
	44	Credit Agricole Indosuez	0.79	0.88	0.82	0.94	0.57	0.54	0.770	0.726	0.171
	45	National Bank of PAK. Ltd	0.87	0.71	0.70	0.79	0.93	0.76	0. 780	0.787	0.085
	46	City Bank n.a.	0.83	0.65	0.79	0.66	0.80	0.74	0.880	0.744	0.069
	47	HANVIT Bank Ltd	0.90	0.94	0.92	0.96	0.91	0.84	0.880	0.901	0.046
	48	The HSBC Ltd	0.33	0.62	0.82	0.55	0.90	0.71	0.800	0.662	0.187
	49	Shamil Bank of (Bah) E.C.	0.75	0.71	0.75	0.63	0.41	0.31	0.530	0.553	0.203
		Mean Efficiency	0.75	0.77	0.81	0.70	0.76	0.67	0.768	0.742	0.047
		Standard Deviation	0.16	0.16	0.13	0.18	0.15	0.15	0.111	0.154	0.016
		Maximum	0.95	0.97	0.99	0.97	0.95	0.98	0.932	0.963	0.017
		Minimum	0.29	0.40	0.22	0.23	0.34	0.31	0.349	0.300	0.062

Table 6.6 shows that within the category of NCBs, Sonali Bank attains the highest TE score, 0.890 in 1999, 0.89 in 2004 and 0.89 in 2005, Rupali Bank 0.94 in 2000, Agrani Bank 0.89 in 2001 and Janata Bank 0.94 in 2002 and 0.92 in 2003.

6.5.2 Private Commercial Banks, 1999-2005

From Table 6.5 now we look at the TE scores of PCBs. The average technical efficiency estimates for PCBs are 0.707, 0.728, 0.807, 0.671, 0.759, 0.660, and 0.766 in 1999, 2000, 2001, 2002, 2003, 2004 and 2005 respectively. By observing the mean TE scores for PCBs, we find that PCBs experiences highest average TE score at 0.807 in 2001 and then TE score declines to 0.660 in 2004 with fluctuations.

Table 6.6 shows that among the banks under PCBs category, The Trust Bank Ltd attains the highest TE score 0.90 in 1999 and 0.930 in 2005. Uttara Bank Ltd achieves the highest TE score 0.950 in 2000, IFIC Bank Ltd 0.940 in 2001, The Premier Bank 0.950 in 2001, NCCBL 0.920 in 2002 and EXIM Bank (BD) Ltd 0.81 in 2004

6.5.3 Specialised Commercial Banks, 1999-2005

Table 6.5 shows based on the stochastic frontier, the average technical efficiency estimates of the SCBs for 1999, 2000, 2001, 2002, 2003, 2004 and 2005 are 0.770, 0.704, 0.782, 0.682, 0.762, 0.675 and 0.733 respectively.

Table 6.6 shows that within the SCBs category, BASIC Bank Ltd obtains the highest TE score 0.880, 0.800 and 0.840 in 1999, 2000 and 2005, Bangladesh Shilpa Bank 0.960, 0.910, 0.940 and 0.940 in 2001, 2002, 2003 and 2004 respectively.

6.5.4 Islamic Private Commercial Banks 1999-2005

Table 6.5 shows that the average technical efficiency scores of the IPCBs for 1999, 2000, 2001, 2002, 2003, 2004 and 2005 are 0.830, 0.748, 0.779, 0.664, 0.702, 0.619 and 0.670 respectively.

Table 6.6 shows that among IPCBs Social Investment Bank Ltd achieve the highest scores 0.910 in 1999, 0.886 in 2001, 0.97 in 2002, Islamic Bank Bangladesh Ltd 0.920 in 2000, 0.86 in 2004 and 0.840 in 2005.

6.5.5 Foreign Commercial Banks 1999-2005

Table 6.5 shows that the average technical efficiency estimates for FCBs are 0.778, 0.812, 0.850, 0.744, 0.730, 0.642, and 0.664 in 1999, 2000, 2001, 2002, 2003, 2004 and 2005 respectively. By observing the mean TE scores for FCBs, we find that FCBs highest average is at 0.850 in 2001 and then TE score declines gradually to 0.642 in 2004.

Table 6.6 shows that within the category of FCBs state Bank of India Ltd achieves the highest score 0.950 in 1999, American Express Bank 0.970 in 2000, Standard Chartered banks 0.985 in 2001, 0.939 in 2004 and 0.939 Hanvit Bank Ltd 0.960 in 2003 Ltd 0.920 in 2000, 0.86 in 2004 and 0.880 in 2005.

6.6 Comparison among Efficiency Performance of Category of Banks

We would like to make an intra category comparison of the banks over the study period. We make a closer look to Table 6.5 and find that average TE scores for NCBs are highest among the all categories of banks over the whole of the study period. It implies that NCBs are the most efficient banks among the categories of PCBs, SCBs, IPCBs and FCBs. This finding is similar to that of Bhattacharyya, Lovell and Shay (1998). Bhattacharyya et al. (1998) find that publicly-owned banks to have been the most efficient, and privately owned banks the least efficient, in utilising the resources at their disposal to deliver financial services, in case of Indian commercial banks. In another study Mahesh and Meenakshi (2006) establish the same conclusion in Indian commercial banks where they concluded public sector banks as a group ranks first in all the efficiency measures showing that these banks are doing better than their private counterparts.

By observing Table 6.4 we find that SCBs average TE scores follow the banking sector's average scores as appear in all banks performance. According to average TE score as shown in table 6.4, we find FCBs are the second best performer in the banking sector of Bangladesh. In 1999 (0.830) and 2000 (0.748) performance of IPCBs are better than that of PCBs but after 2000 and onward PCBs performance are found surpassing the IPCBs. Overall analysis leads to the conclusion that government owned banks are on average most efficient, and that SCBs are on the second position, FCBs are third performer in terms of technical efficiency scores In the beginning of the study period, IPCBs performance has been better than those of PCBs but after 2000 IPCBs performance gradually declined.

From Figure 6.1 it is evident that trend of the average technical efficiency of NCBs is relatively less fluctuating and clings between 80-90 percent efficiency. Figure 6.2 shows SCBs' harmonious swinging of average technical efficiency between the ranges of from 70 to 80 percent. Figure 6.3 shows FCBs high rise and subsequent down trend over year. Figure 6.4 shows PCBs average technical efficiency ranging around 70-80 percent. Figure 6.5 is sketched for IPCBs which shows gradual decline in efficiency with fluctuation. Figure 6.6 shows average technical efficiency performance of the banks sector of Bangladesh. Finally we put efficiency curve lines in terms of all categories of banks on the basis of same scale to see their simultaneous trends and fluctuations.

Figure 6.1: Mean Efficiency of NCBs

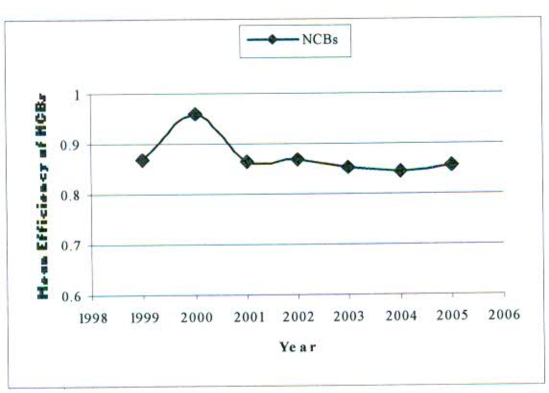
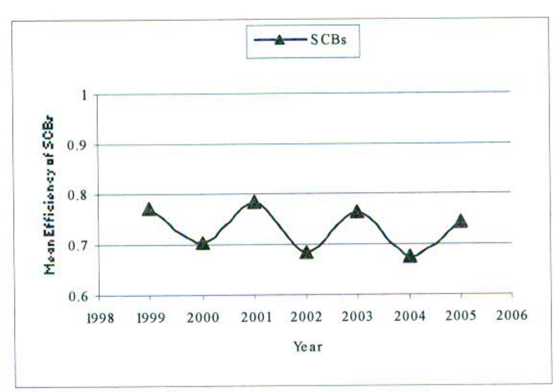


Figure 6.2: Mean Efficiency of SCBs



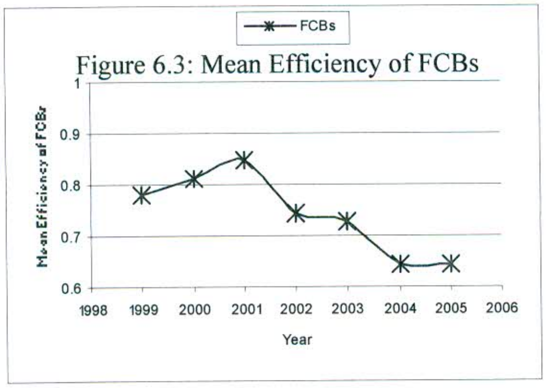


Figure 6.3: Mean Efficiency of FCBs

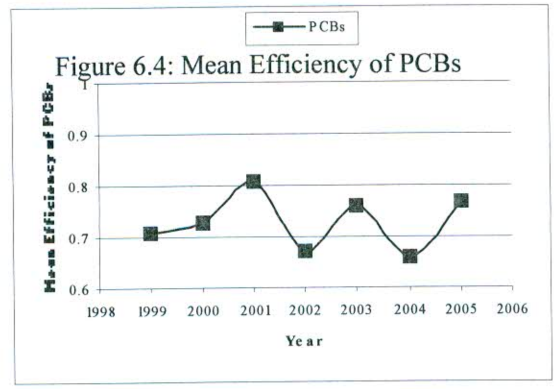


Figure 6.4: Mean Efficiency of PCBs

Figure 6.5: Mean Efficiency of IPCs

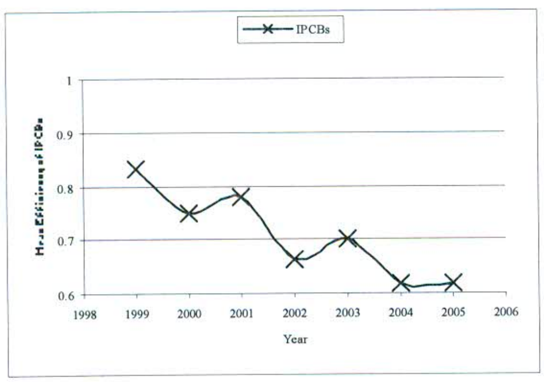


Figure 6.6: Mean Efficiency of All Banks

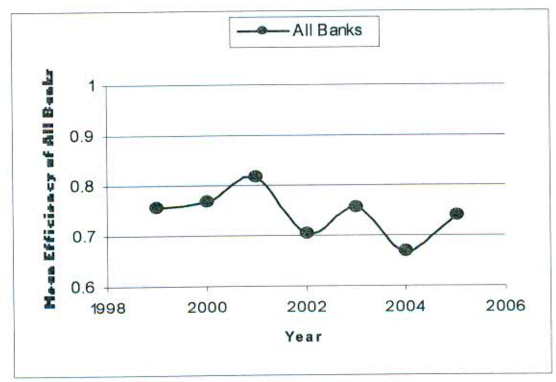
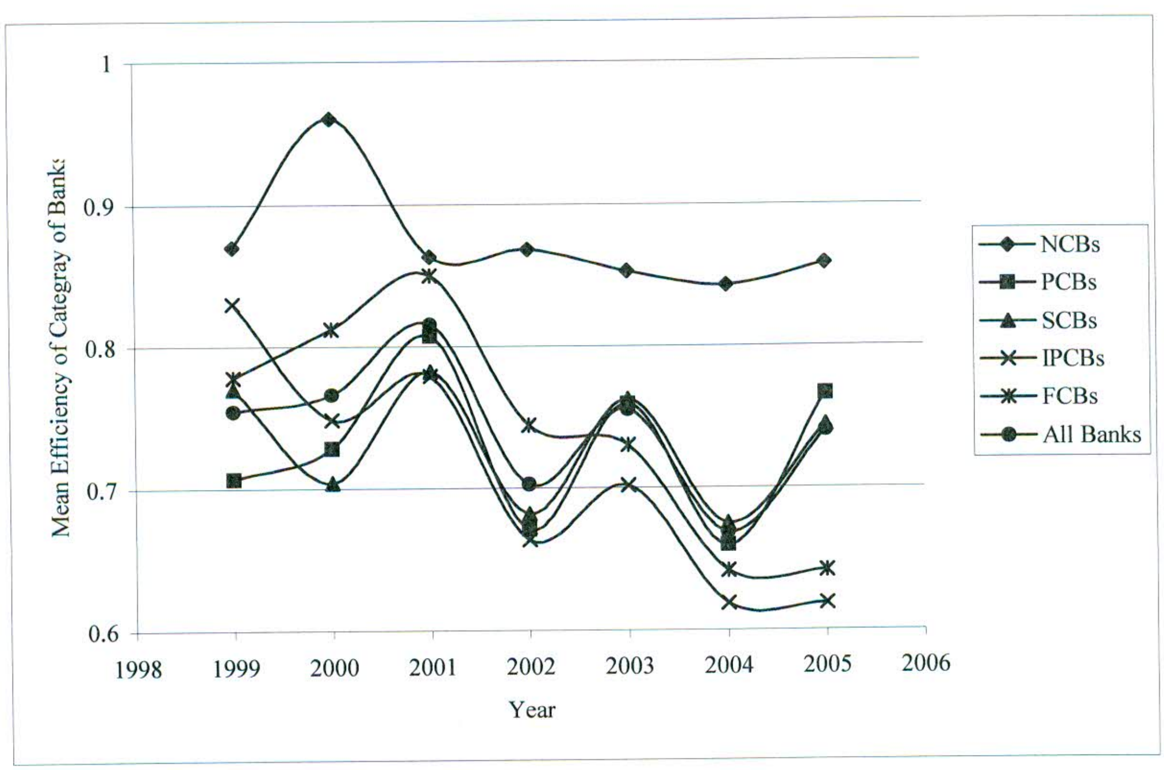


Figure 6.7: Mean Efficiency of all Category of Banks



6.7 Conclusion

This chapter exercises with the results obtained from Stochastic Frontier Analysis. We have applied SFA to calculate technical efficiency of the commercial Banks of Bangladesh. We have estimated technical efficiency scores for each individual bank using cross section data for the period 1999 to 2005. We first introduce parameters estimates and then describe technical efficiency results. After that we compare the results within the groups and over time 1999-2005. In this study we have examined each bank for continuous 7 years with technical efficiency. We have estimated technical efficiency scores of all the 49 individual banks in terms of expenditures for income. Expenditure input data with respect to income output data have been used to search out the technical efficiency scores of the banks for successive years. General assessments on the overall technical efficiency of the banks have been obtained over the period and within the group of banks as well as among each of the individual banks. Possibly the reform programs during early 1990's and deregulations afterward may have influence on efficiency scores, but this could not be commented as there is no data before reforms. We find that year 2002, 2003 and 2004 have been crucial for the banking sector. We recognize that the analysis have been able to examine efficiency changes that have got impact across categories of banks. Our results indicate the presence of inefficiency in the commercial banks of Bangladesh is persistent to the extent of. 18.5 to 33.10 percent during the study period. But there is a tendency for inefficiency to decline and thereafter increase over time. The results also indicate that efficiency of banks has increased in year 1999 to 2001 and then reduced with fluctuations in the year 2002, 2003, 2004 again efficiency started to rise in 2005. We expect that early 90's reforms have produced congenial atmosphere for the banking sector until 2001, thereafter further deregulation measures produced negative effects till 2004 when efficiency started to rise. We observe that though the reduction in inefficiency over time continues albeit at a slower rate compared to those observed in the year 1999, 2000 and 2001. Technical efficiency scores indicate that NCBs are generally more efficient than PCBs, but there are little significant differences among the groups on the efficiency over the time. At the individual level, we have found marked differences in the efficiency behavior of different banks with private banks exhibiting much more intra-group volatility in relative decency changes between the period 1999-2001 and the period 2002-2005 compared to those of NCBs and SCBs.

Chapter 7

Empirical Methodology: Data Envelopment Analysis

7.1 Introduction

The purpose of this chapter is to introduce Data Envelopment Analysis (DEA) as a methodology that has been used to find estimates of technical efficiency of the commercial banks of Bangladesh. Application of any analytical approach is to the art of reckoning. As such, the application of DEA, as a methodology, in a particular study requires knowledge about formulation of DEA models, choice of variables as well as underlying assumptions, data representations, interpretation of results, and knowledge of limitations, as it is required equally in any study with application of a particular methodology. This chapter provides some fundamental concepts, methods, related techniques and essential issues of DEA.

DEA is a nonparametric mathematical programming approach to estimating efficiencies of firms in production. To estimate frontier functions and to measure efficiencies of firms, two different methods such as, DEA and SFA have been applied since the seminal work of Farrell (1957). Subsequent to him, publication on DEA by Charnes, Coopers and Rhodes (1978) and efforts made towards SFA by Aigner, Lovell and Schmidt (1977) and Meeusen and ven den Broeck (1977) have specified a new paradigm towards production frontier based analysis of efficiency measurement technique. Detailed reviews of the DEA are presented by Seiford and Thrall (1990), Lovell (1993), Ali and Saiford (1993), Lovell (1994), Charnes et al. (1995) and Seiford (1996). In chapter 6, stochastic frontier model (SFA) and efficiency measurement have been discussed as an econometric method of estimating technical efficiency.

DEA is a performance measurement technique, which can be applied for evaluating the relative efficiency of decision-making units (DMUs). In DEA literature, a producer, a firm, or a production unit is usually referred to as a decision-making unit (DMU). In this study, each individual commercial bank of Bangladesh has been deemed as a DMU. For the sake of simplicity, we use the word 'firm' instead of the expression DMU.

DEA provide a means of calculating apparent efficiency levels within a group of firms. The efficiency of a firm is calculated relative to the group's observed best practice. To be more specific, using linear programming, DEA calculates the efficiency of a firm of an industry relative to observed 'best practice' or within the group. DEA can be said as an extreme point method and compares each firm with only the "best" firms. Extreme point methods are not always considered as right tools for measuring efficiency of firms wich operate under some extent of uncertainty, for example, firms exposed to natural conditions associated with vagaries of peripheral environments, such as, agricultural farming or livestock farming etc., but are appropriate in certain cases, for instance, services of financial institutions, banks, hospitals, post-office, etc.

Since DEA is an extreme point technique, stochastic noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems in a study. Being a deterministic rather than based on statistical technique, DEA produces results that are particularly sensitive to measurement error. If one firm's inputs are understated or its outputs overstated, then that firm can become an outlier that significantly distorts the shape of the frontier and reduces the efficiency scores of nearby firms. In regression-based studies, the presence of error terms in the estimation tends to discount the impact of outliers, but in DEA they are given equal weight to that of all other firms. Hence, it is important to screen for potential outliers when assembling the data. One useful check is to scrutinize those firms whose output to input ratios lie more than about two-and-a-half standard deviations from the sample mean. As DEA is a nonparametric technique, statistical hypothesis tests are difficult to apply and as such they are to be foregone in a research.

When choosing whether to apply DEA an analyst is required to think over the drawbacks of the methodology as stated above. However, some of the characteristics as discussed above prove that DEA is an authoritative tool for examining the efficiency of firms. But, it should be applied in appropriate and meaningful manners.

To describe DEA methodology systematically we produce different aspects of DEA in precise form. Therefore, this Chapter is segmented into several Sections. We organise this Chapter as stated. Section 7.2 discusses foundation of DEA; Section 7.3 DEA Frontiers; Section 7.4 Basic DEA Models; Section 7.5 DEA Formulation; Section 7.6 Parametric SFA versus Non-parametric Method of DEA; Section 7.7 Some Advantages of DEA; Section 7.8. Application of DEA in Banking; Section 7.9 Returns to Scale and Orientations in DEA; Section 7.10 Input-oriented Measures; Section 7.11 Output-oriented Measures Section 7.12 Input Oriented Constant Returns to scale DEA Model; Section 7.13 Input-oriented VRS model; Section 7.14 Output-oriented CRS DEA Model; Section 7.15 Output-oriented VRS DEA Model; Section 7.16 Computation of Scale Efficiencies; Section 7.17 Efficiency Measurement and Slacks. Finally we discuss the Chapter Summary in Section 7.18.

7.2 Foundation of DEA

In microeconomic theory, the specification of a production function (e.g., Cobb-Douglas or any other forms) determines the description of input-output relationship in a firm. The underlying assumptions of such a specification is the existence of transformation technology that determines what maximum amount of outputs can be produced from a combination of various inputs. However, Seiford and Tharl (1990) observed that this description of the production technology would be provided by the production function, *if it were known*. But in realty, the production function is never known. The analyst has only data- observation about various inputs and their magnitudes and various achieved outputs and their magnitudes. Therefore, the point of departure for DEA is the construction, from the observed data, of a piecewise empirical production frontier (Charnes *et al.* 1994). While production function for a fully efficient firm is not known, in practice, Farrell's (1957) suggestion to obtain an efficient production function has been on the point that the production frontier can be estimated from sample data using a nonparametric piece-wise-linear technology (Battese et al, 1998). Originally, Farrell's approach to estimating efficient unit isoquant has been centered on constructing a free disposal convex hull of the observed input-output ratios by linear programming technique with a subset of sample observations lying on it and rest of the sample lying above it. The production frontier attained in this way provides the boundary of the free disposal convex cone of the data set (Førsund *et al*., 1980). Since this procedure involves linear programming model and the process does not include any disturbance term or residual, it can, therefore, be said as 'nonparametric'. Thereafter, the idea of efficiency by Farrell (1957), caught up by Charnes, Coopers, Rhodes (1977) ultimately found its course into development of a self-sufficient separate methodology which for the first time coined the term DEA approach and the methodology has been put forward as CCR (Charnes, Coopers and Rhodes, 1978) ratio form of DEA.

Charnes, Coopers and Rhodes (1978) extended Farrell's (1957) idea by connecting the estimation of technical efficiency and production frontiers. The CCR model generalized the single output/input ratio measures of efficiency for a single firm in terms of fractional linear programming formulation transforming the multiple output/input characterization of each firm to that of a single 'virtual' output and virtual input. The relative technical efficiency of any firm is calculated by forming the ratio of a weighted sum of outputs to a weighted sum of inputs, where the weights (multipliers) for both outputs and inputs are to be selected in a manner that calculates the Pareto efficiency measure of each firm subject to the constraint that no firm can achieve a relative efficiency score greater than unity. DEA makes it possible for the data to 'speak for themselves' rather than speak in the idiom of some imposed functional form (such as Cobb-Douglas or Translog or any other functional form). In DEA 'data speak for themselves' means the analysis is focused on maximizing each individual observation, in contrast to fitting a single regression in a plane that is assumed to describe the behaviour of each observation on an average (Charnes *et al.* 1994). DEA model is applied to estimate technical efficiency on the basis of the type of data and variables specified in a firm under the industry. Technical efficiency is calculated from quantity data or value data for inputs and outputs. The DEA model expresses either the maximum output for a given level of input or uses minimum input for a given level of output.

7.3 DEA Frontier

Since DEA is a linear programming technique that identifies the apparent best 'production unit' of outputs or services (DMUs or firms) by their ability to produce the highest level of outputs or services with a given set of inputs or to produce given outputs or services with the least amount of inputs, therefore it is possible to draw a frontier of the best production units relative to other production units of outputs or services.

Suppose that there are n firms engaged in operation and every firm utilizes q inputs to produce r outputs. The *i-th* firm uses $x_i = \{x_{ki}\}$ of inputs ($k = 1,2,3,...,q$) and produces $y_i = \{y_{mi}\}$ of outputs ($m = 1,2,3,...,r$). Suppose that $x_{ki} > 0$ and $y_{mi} > 0$. The $(k \times n)$ input matrix is denoted by X and the $(m \times n)$ output matrix is denoted by Y for all n firms. The column vector x_i and y_i represent inputs and outputs for the *i-th* firm respectively. Therefore, the DEA frontier can be written as:

$$F(y_1, y_2, y_3,..., y_r) = \{(x_1, x_2, x_3,...., x_q)$$

$$y_{mi} \leq \sum_{i=1}^{n} \varpi_i Y_{mi}$$

$$x_{ki} \geq \sum_{i=1}^{n} \varpi_i x_{ki}$$

$$\varpi_i \geq 0; \qquad \sum_{i=1}^{n} \varpi_i = 1\}$$

Where $\varpi = (\varpi_1, \varpi_2, \varpi_3, ..., \varpi_n)$ is an intensity vector that forms convex combinations of observed input and output vectors and represents the percentage of other firms used to construct the virtual efficient firms. For example, if the efficient firm A is competent of producing output $y_{(A)}$ using input $x_{(A)}$, then other firms should as well be competent of producing in the same production schedule. Likewise, if the efficient firm B produces output $y_{(B)}$ using input $x_{(B)}$, then the other firm should again be able to produce in the same production schedule if the firms were to produce efficiently.

7.4 Basic DEA Models

Charnes et al. (1978) proposes a model on the basis of input orientation under constant returns to scale (CRS) assumption. This model is popularly known as CCR ratio model (1978). The model yields an objective evaluation of overall efficiency. Subsequent developments in DEA consider alternative sets of assumptions, such as variable returns to scale (VRS) model which have been initiated by Bankers *et al.* (1984). This model is known as BCC model (1984). The model distinguishes between technical and scale inefficiencies by estimating pure technical efficiency at the given scale of operation and identify whether the operation is on increasing or decreasing, or constant returns to scale.

7.5 DEA Formulation

There are several different ways to present the linear programming problem for DEA. The simplest common presentation where assumptions include constant returns to scale, and an objective of minimizing inputs, in an input oriented version of DEA, proceeds by solving a sequence of linear programming problems for a given level of output:

Minimise $\quad E_n$ with respect to $w_{1,......} w_N$, Subject to:

$$\sum_{J=1}^{N} w_j y_{ij} - y_{in} \geq 0 \qquad i = 1,....,I$$

$$\sum_{j=1}^{N} w_j x_{kj} - E_n x_{kn} \leq 0 \qquad k = 1,....,K$$

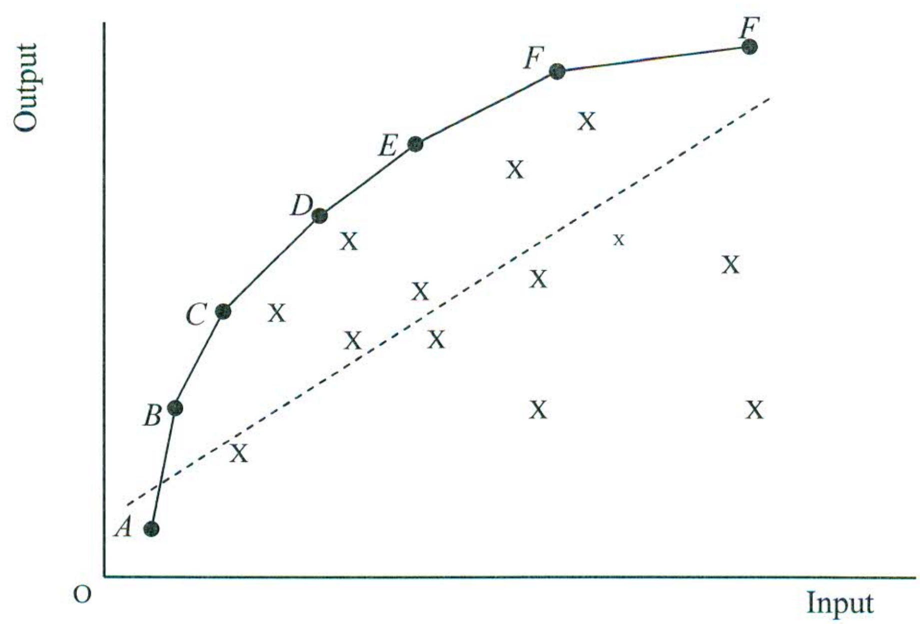
$$w_j \geq 0 \qquad j = 1,....,N$$

where n firms in the sample producing i different outputs (y_{in} denotes the observed amount of output i for firm n) and using k different inputs (x_{kn} denotes the observed amount of input k for firm n). The w_j are weights applied across the n firms. When the nth linear program is solved, these weights allow the most efficient method of producing firm $n's$ outputs to be determined. The efficiency score for the nth firm, E_n*, is the smallest number of E_n which satisfies three sets of constraints. For a full set of efficiency scores, this problem has to solve n times- for each firm in the sample. And the above formula is one of the simpler ways of presenting DEA methodology. The formulations for CRS DEA and VRS DEA under input orientation as well as for output orientation have been given separately in Section 7.11 – 7.15.

7.6 Parametric SFA versus Nonparametric Method of DEA –a Comparison

DEA requires minimum assumptions and no specific functional form unlike the functional form of production functions and the essential statistical properties of a production function in parametric analysis. It requires less focus on individual observed data and no implication of comparative or peer group indications of desired changes in single output. These are some of the reasons why DEA has become a popular nonparametric approach for applied research in many fields (Charnes *et al.* 1985). Whereas, parametric approach requires the imposition of a specific functional form (e.g., a regression equation, a production function, etc.) relating the independent variables to dependent variable(s). The functional form also requires specific assumptions about the distribution of error term (such as whether independently, identically or normally distributed) and many other restrictions, such as factor earning the value of their marginal product etc. In contrast, DEA does not require any assumption about the functional form. DEA computes a maximal performance measurement for each firm relative to all other firms in the observed population (Charnes *et al.*,1994). Coelli (1995) gives a critical review of DEA methods. DEA is non-stochastic model as it does not attribute any *a priori* parametric restrictions on the underlying frontier technology and it does not necessitate any distributional assumptions for the technical inefficiency term. Therefore, DEA model ignores imposition of uncertain structure on both the frontier technology and the inefficiency components. DEA computes efficiency more closely to Pareto-efficient frontier, which may be attributed to as Pareto optimal (Murthi *et al.*1997).

Figure 7.1: Parametric Regression Line and Nonparametric DEA



DEA possess an alternative principle for extracting information about a population of observations such as those shown in Figure 7.1. Parametric approach, whose objective is to optimize a single regression plane through the data, DEA optimizes on each individual observation with an objective of calculating a discrete piecewise frontier determined by the set of Pareto-efficient firms. Both the parametric and nonparametric approaches use all the information contained in the data. In parametric analysis, the single optimized regression equation is assumed to apply to each firm. DEA, on the contrary, optimizes the performance measures of each firm. Simply speaking, the focal point of DEA is on the individual observations as represented by the n optimizations, that is, one for each firm is required in the DEA analysis. Anyway, under econometrics approach analyst usually, focus on the average of regression line and care for estimation of parameters that is associated with a single optimization. The solid line in the Figure 7.1 represents a frontier derived by DEA data on population of firms, each utilizing different amounts of a single output. It is pertinent to note that the DEA calculations produce only relative efficiency measures since DEA points are generated from actual observed data for each firm. The relative efficiency of each firm is calculated in relation to the other entire firm, using the actual observed values for the outputs and inputs of each firm. The DEA calculations are devised to maximize the relative efficiency score of each firm, subject to the condition that the set of weights obtained in this manner for each firms, essentially be feasible for all the other firms included in the calculation. More precisely, DEA produces a piecewise empirical external production surface (solid line in the Figure 7.1 drawn by the points A, B, C, D, E, F), which in economic terms represents the revealed best practice production frontier. The maximum output empirically obtainable from any firm in the observed population, given its level of inputs.

It is to note that, the foremost shortcoming of DEA is that it is deterministic and assumes a zero value for the stochastic random error component. Hence, technical efficiency measure is liable for reflection of all unexplained variations of production and the inefficiency of the observed producer is biased upward (Wadud, 2006).

7.7 Some Advantages of DEA

DEA can handle multiple inputs and multiple outputs model while it doesn't require an assumption of a functional form relating to inputs and outputs to calculate technical efficiency. DEA methodology only requires information on output and input quantities (not prices). This makes DEA particularly suitable for analysing the efficiency of firms where it is difficult to assign prices to inputs.

Under DEA methods firms are directly compared against a peer or combination of peers. Inputs and outputs can have very different units but it is not a problem for DEA. For example, X_1 could be in units of lives saved and X_2 could be in units of dollars without requiring an *a priori* tradeoff between the two. DEA focuses on individual observations in contrast to population averages. It produces a single aggregate measure for each firm in terms of its utilisation of input factors as independent variables to produce desired outputs as dependent variables. DEA can simultaneously utilize multiple outputs and multiple inputs with each being stated in different units of measurement. It can be fine-tuned for exogenous variables and can incorporate categorical or dummy variables. Thus DEA calculations do not require specification or knowledge of a *priori* weights or prices for the inputs or outputs or about units. DEA can accommodate judgment when desired. This can produce specific estimates for desired changes in inputs and/ or outputs for projecting firms below the efficient frontier onto the efficient frontier. It allows technical inefficiency to be decomposed into scale effects, the effects of unwanted inputs, which the firm cannot dispose of.

Moreover, DEA calculations are considered as Pareto optimal. DEA calculation focuses on revealed 'best- practice' frontiers rather than on central tendency properties, and DEA computation satisfies strict equity criteria in the relative evaluation of each DMU.

7.8 Application of DEA in Banking

The application of Data Envelopment Analysis (DEA) to financial analysis is a recent extension. The process involves using selected groups of financial figures as inputs to evaluate the overall financial performance of firms (banks or other financial institutions) in a single DEA score, a process which can not be achieved through observing individual financial ratios calculated from financial statements. Data Envelopment Analysis provides a means of calculating comparative efficiency within a group of firms. The efficiency of a firm is calculated relative to the group's observed 'best- practice'. DEA has been widely used in the management science, applications to services industries such as banks and financial institutions, health care, NGOs for specific programmes, educational institutions, manufacturing firms, management evaluation, state service departments such as, Hospitals, Police Station, Post Office, Railway, Airway etc., and restaurants and retail stores etc.

The heart of the DEA analysis lies in finding the "best" virtual firm for each real firm. If the virtual firm is better than the original firm by either making more output with the same input or making the same output with less input then the original firm is *inefficient*. So, scores of DEA can help individual bank to achieving latent potentials.

7.9 Returns to Scale and Orientations in DEA

The choice of DEA model depends on two basic issues. The first is whether the problem formulations justify an assumption of constant returns to scale (CRS) or variable returns to scale (VRS) in production. And the second is whether the problem formulation is oriented towards output maximization or input minimization, or on equal emphasis on outputs and inputs. For details in both input minimization and output maximization models reviews can be made in Ali and Seiford chapter in Fried, Lovell, and Schmidt (1993).

7.9.1 CCR Model

The CCR (ratio) model is probably the most widely used and best-known DEA model. This DEA model is used when a constant returns to scale relationship is assumed between inputs and outputs. This model calculates the overall efficiency for each unit, where both pure technical efficiency and scale efficiency are aggregated in one value. As the model assumes constant returns to scale (CRS) it is referred to as CRS DEA model. It can be noted that the CCR model yields the same efficiency score regardless of whether it is input or output-oriented.

7.9.2 BCC Model

When a variable returns to scale relationship is assumed between inputs and outputs the BCC DEA (ratio) model is used. It is named after Banker, Charnes and Cooper (1984:1078-1092) who fist introduced it. The BCC model measures technical efficiency. The convexity constraint in the model formulation ensures that the composite unit is of similar scale size as the unit being measured. The efficiency score obtained from this model gives a score, which is at least equal to the score obtained using the CCR model. As the model relaxes the assumption of CRS to variable returns to scale (VRS) hence it is referred to as VRS DEA model. VRS DEA model is different from CRS DEA model in that the VRS DEA envelopes data more strongly, thus producing technical efficiency estimates greater than or equal to that obtained from the CRS DEA.

Table 7.1: DEA Model

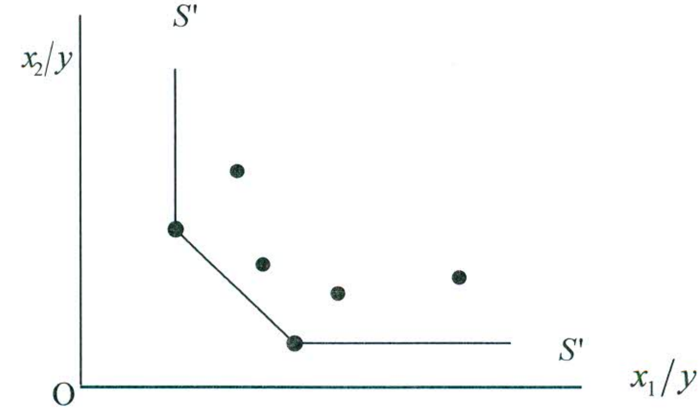
Assumptions of returns to scale	Orientations	
Constant Returns to Scale CRS	Output	Input
Variable Returns to Scale VRS	Output	Input

Sources: Charnes *et al.* 1994

7.10 Input-oriented Measures

Input-oriented CRS DEA model has been described here first because this model is applied in the preliminary stage of DEA initiation.

Figure 7.2: Piecewise Linear Convex Unit Isoquant

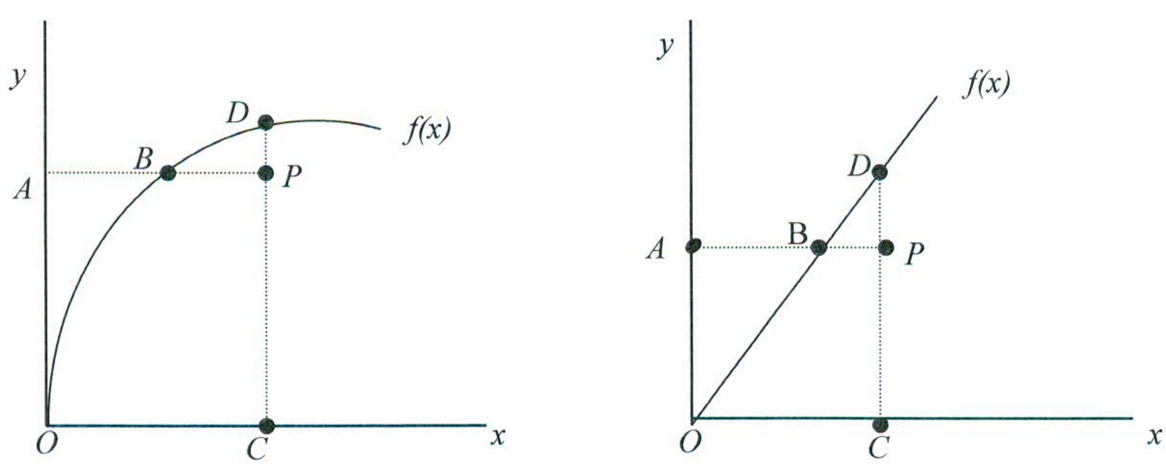


The efficiency measure only assumes the production function of the fully efficient firm is known whereas the fully efficient production frontier of a firm is never known (Coeilli, 98). Instead, for obtaining an efficient isoquant, according to Farrell (1957), a non-parametric piece-wise-linear convex isoquant could help construct production frontier from sample data so that no observed point should lie to the left or below it as shown in Figure 2. Farrell (1957) has also made an illustration of the method using agricultural data for the 48 continental states of US. The above mentioned efficiency measures have been defined in the context of the assumptions of constant returns to scale technology. The measures of technical efficiency can be equivalently defined for the non-constant returns to scale case. To explain technical efficiency under non-constant returns case, the Figure shown in 7.3 can be adjusted by changing the axes labels x_1 and x_2 with the assumptions that the isoquant represents the lower bound of the input set related with the production of a particular level of output. The efficiency measures are then defined comparably to the previous measures as in Chapter 5 Figure 5.5. The above input-oriented technical efficiency measure deal with the question that by how much input quantities can be proportionally reduced without changing the output quantities produced. Ultimately solution of this question gives rise to input- oriented technical efficiency measures.

7.11 Output-oriented Measures

The above input oriented production efficiency can be put forward by a different question. That is, one can ask, "By how much can output quantities be proportionally expanded without altering the input quantities used?" This question gives rise to the issues of output-oriented measure as against the input oriented measure. The difference between input and output orientation measures can be explained using a simple graph with an example of one input and one output where a decreasing returns to scale technology has been shown by f(x), and an inefficient firm operating at point P. This is shown in Figure 7.3. According to Figure Farrell's (1957) input oriented technical efficiency measure would be equal to ratio AB/AP, while the output orientation measure of technical efficiency would be CP/CD. The output-oriented and input- oriented measure will only provide equivalent measures of technical efficiency when constant returns to scale is present, but would be unequal when increasing or decreasing returns to scale are present (Fare and Lovell, 1978). The case of constant returns to scale is depicted in Figure 7.4 where it is observed that AB/AP=CP/CD, for any inefficient point P.

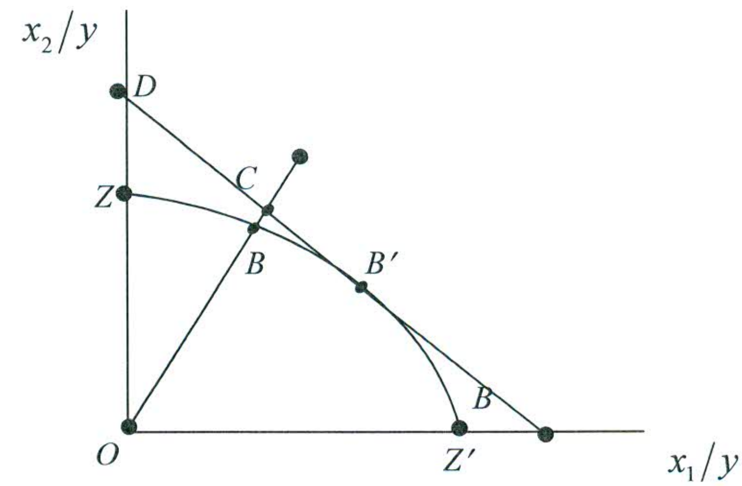
Figure 7.3: Input-Output Oriented Technical Efficiency Measures and Returns to Scale



It can further be considered with output-oriented measure where production involves two outputs (say, y_1 and y_2) and a single input (say, x_1). This illustration is portrayed in

Figure 7.4 where the line ZZ' is the unit production possibility curve and the point A corresponds to an inefficient firm. It can be noted that, the inefficient point, A, lies below the curve in this case because ZZ' represents the upper bound of production possibilities.

Figure 7.4: Technical Efficiency from an Output-orientation



Farrell's (1957) output-oriented efficiency measures (Färe, Grosskopf and Lovell, 1985, 1994) would be defined as follows: In Figure 7.4, distance AB represents technical inefficiency. That is the amount by which outputs could be increased without requiring extra input. Hence a measure output-oriented technical efficiency is the ratio

$$TE_0=OA/OB \qquad (7.1)$$

It can be noted that the technical efficiency measure is bounded by zero and one. It can also be observed that the output-oriented technical efficiency measure is exactly equal to the output distance functions (Shepherd, 1970). Details can be found in Lovell (1993) and Färe, and Primont (1995). Further, it can be mentioned here that technical efficiency has been measured along the ray from the origin to the observed production point. Therefore, it holds the relative proportions of inputs (or outputs) constant. One advantage of the radial efficiency measure is that it is unit invariant. That is, changing the units of measurement does not change the value of the efficiency measure. For example, one can measure quantity of labor in person hours instead of person years.

7.12 Input-oriented Constant Returns to Scale DEA Model

Suppose there are data on k inputs and m outputs for each of n firms. For the *i-th* firm these are represented by the column vectors x_i and y_i, respectively. The $k \times n$ input matrix, X, and the $m \times n$ output matrix, Y, represents the data for all n firms.

A way to introduce DEA is via the ratio form. For each firm, to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an m×1 vector of output weights and v is a k×1 vector of input weights obtained by solving the mathematical programming problem:

$$\max_{u,v}\left(u'y_i/v'x_i\right) \qquad (7.2)$$

$$\text{Subject to} \quad u'y_j/v'x_j \leq 1, \qquad j = 1, 2, \ldots, N,$$

$$u, v \geq 0$$

This involves finding values for u and v, such that the efficiency measures for the i-th firm is maximized, subject to the constraints that all efficiency measures must be less than or equal to one. One problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this, one can impose the constraint $v'x_i = 1$, which provides:

$$\max_{\mu,\nu}\left(\mu'y_i\right), \qquad (7.3)$$

$$\text{Subject to} \quad \nu'x_i = 1$$

$$\mu'y_j - \nu'x_j \leq 0, \; j = 1, 2, \ldots, N,$$

$$\mu, \nu \geq 0$$

Where, the change of notation from u and v to μ and ν used to stress that this is a different linear programming problem. The form in equation (7.1) is known as the multiplier form of the DEA linear programming problem.

Using the duality in linear programming, an equivalent envelopment form of this problem can be derived:

$$\min_{\theta,\lambda} \theta \qquad (7.4)$$

Subject to $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$\lambda \geq 0$,

Where, θ is a scalar constant and λ is a n×1 vector constant. This envelopment form involves fewer constraints than the multiplier form (k+m<n+1) and thus is generally the preferred form to solve. However, the multiplier form has been used in a number of studies. The value of θ obtained would be efficiency score for the *i-th* firm. It satisfies $\theta \leq 1$, with the value of 1 indicating a point on the frontier and thus a technically efficient firm according to Farrell's definition. It should be noted that the linear programming problems must be solved *n* times, once for each firm in the sample. A value of θ is then obtained for each firm.

The DEA problem given in equation (7.2) takes the *i-th* firm and then seeks to radially contract the input vector, x_i, as much as possible, whilst still remaining within the feasible input set. The radial contraction of the input vector, x_i, produces a projected point, (Xλ, Yλ), on the surface of this technology. This projected point is a linear combination of these observed data points. The constraints in equation (7.2) ensure that this projected point cannot lie outside the feasible set.

7.13 Input-oriented VRS Model

Imperfect competition, constraints on financial support, etc. may cause a firm to be not operating at optimal scale whereas in CRS DEA model firms are assumed to be operating at optimal scale. In such a circumstances, Banker, Charnes, and cooper (1984) have put forward an extension of CRS DEA model to explain variable returns to scale situation. Since the measures of technical efficiency under CRS specification is likely to generate scale efficiency if firms are not operating at optimal scale. The introduction of VRS specification permits technical efficiency to be free from scale efficiency effects. This has been done in the following way:

The CRS linear programming problems have been modified to explain for VRS by adding convexity constraint: $NI'\lambda=1$ to equation (7.2) to provide:

$$\min_{\theta,\lambda} \theta, \qquad (7.5)$$

Subject to

$$-y_i + Y\lambda \geq 0$$

$$\theta x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

Where, NI stands for an $n\times 1$ vector of one's of the model. This method gives a convex hull of intersecting planes which envelope the data point more tightly than the CRS conical hull. This gives technical efficiency scores which are greater than or equal to those obtained by using the CRS model.

Calculation of scale efficiency measures are, naturally, only relevant when specifying variable returns to scale frontier. Specifically, scale inefficiency is due to either decreasing or increasing returns to scale. Since no assumptions are made about the technologies of the observations, it is important to ask what the scale properties of the observations are. Rather, it is important to ask about scale properties of points on the frontier (Førsund and Hernaes, 1995).

7.14 Output-oriented CRS DEA Model

In the input oriented models, the method seeks to identify technical inefficiency as a proportional reduction in input usage with output level held un-changed. In the following sub-section we seek to measure technical efficiency as a proportional increase in output, with input level held fixed.

"By how much can output quantities be proportionally expanded without changing the input quantities used?" This question gives rise to the issues of output-oriented measure as against the input oriented measure described in the earlier section 7.5 and 7.6. The CRS output oriented linear programming problem can be given in ratio form by taking into consideration of the ratio of virtual input and virtual output in the following expression:

Minimize $\left(\sum \mu_k x_{ki} \Big/ \sum \lambda_m y_{mi} \right)$

Subject to $\left(\sum_{k}^{q} \mu_k x_{kj} \Big/ \sum_{m=1}^{r} \lambda_m y_{mi} \right) \geq 0$

$\lambda_m \geq 0$ for $m = 1,2,3,\ldots,r$ and $\mu_k \geq 0$ for $k = 1,2,3,\ldots,q$

Scaling down the denominator to unity (a constant) of the objective function, the linear programming problems can be written as follows:

Minimize $\left(\sum_{k=1}^{q} \mu_k x_{ki} \right)$

Subject to $\sum \lambda_m y_{mi} = 1$

$$\sum_{k=i}^{q} \mu_k x_{kj} - \sum_{m=1}^{r} \lambda_m y_{mj} \geq 1$$

To make discussion easy, the problems can be written in the matrix notation as:

$Minimize_{\theta' \lambda}$ θx_i

Subject to $\lambda y_i = I$

$$\theta_i' x_j - \lambda y_i \geq 0$$

$$\lambda \geq 0 \text{ and } \theta_i' \geq 0$$

The corresponding dual can be written as:

$$Maximize_{\varphi_i}^{output,CRS}, \varpi \quad \varphi_i^{output,CRS} \tag{7.6}$$

$$-\varphi_i^{output,CRS} y_i + Y\varpi \geq 0$$

$$\varpi \geq 0$$

Where $\varphi_i^{outout,CRS}$ is a scalar which measures firm specific efficiency under the output-oriented CRS method. $\varphi_i^{output\ CRS}=1$ suggests that the firm is efficient and is positioned on the frontier and $\varphi_i^{output,CRS}<1$ implies that the firm is inefficient lies outside the frontier. The first constraint affirms that the efficiency corrected amount of output may be less than or equal to the quantity of output produced by the reference firm. The second constraint states that the quantity of input consumed by *i-th* firm must at least equal the quantity of input used by the reference firm. The output oriented DEA frontier maximizes the proportional increase in the output vector while remaining within the efficient frontier.

7.15 Output-oriented VRS DEA Model

The output oriented VRS approach yields efficiency score forming a convex hull of intersecting planes and envelopes the data more closely than the CRS conical hull. Therefore VRS gives technical efficiency scores greater than or equal to those obtained from the CRS DEA model.

One point that should be stressed here that the output-oriented DEA models are very similar to their input- oriented counterparts. The following is an instance of output-oriented VRS model:

$$Max_{\phi,\lambda}\phi, \tag{7.7}$$

Subject to

$$-\phi y_i + Y\lambda \geq 0$$

$$x_i - X\lambda \geq 0$$

$$NI'\lambda = 1$$

$$\lambda \geq 0$$

Where $1 \leq \phi \leq \infty$, and $\phi - 1$ is the proportional increase in outputs that could be achieved by the *i-th* firm, with input quantities held fixed. It can be noted that $\frac{1}{\phi}$ defines a technical efficiency score which varies between zero and one. In this study, the above mentioned output orientation of DEA technical efficiency scores have been reported in the DEA estimates of banks efficiency as output oriented VRS in Chapter-9.

7.16 Computation of Scale Efficiencies

Many studies have decomposed the TE scores obtained from a CRS DEA into two components, the first is scale inefficiency and the other is 'pure' technical inefficiency.

When firms are operating at optimal scale, under the assumptions of CRS DEA, there exists no concept of scale inefficiency. But when the production technology is VRS, it is possible to obtain a scale efficiency measure for each firm. The measure of scale efficiency can be obtained by carrying out operations for both a CRS DEA TE score and a VRS DEA TE score. If there is a difference between the two TE scores for a particular firm, then it indicates that the firm has scale inefficiency. This scale inefficiency can be derived from the difference between the VRS TE score and the CRS TE score. Measures of scale efficiency for each bank can be obtained by solving both the CRS and VRS DEA. Technical inefficiency scores from the CRS DEA (CRS TI) thus, can be decomposed into pure technical inefficiency (VRS TI) and scale inefficiency. The CRS TI is greater than that of VRS TI the difference in the CRS and VRS technical inefficiency scores for a particular bank provides a measure of scale inefficiency.

This scale efficiency measure itself does not indicate whether the bank is operating at increasing or decreasing returns to scale. The presence of potential economies of scale at any input can only be determined by solving a DEA problem with imposition of additional constraint on non-increasing returns to scale (NIRS) condition. Therefore, finding efficiency scores for the CRS, VRS and NIRS frontiers are very important.

The scale efficiency score obtained for each bank from the three DEA frontiers (CRS, VRS and NIRS) can be ordered relative to each other and this ordering provides information regarding existence of the types of scale economies at any observed output. The CRS, VRS and NIRS technologies are explained in Figure 7.6. In an input–oriented framework, the CRS approach measures the input–oriented technical inefficiency of the bank operating at point *D* by the distance *BD*. However, the VRS approach estimates technical inefficiency as *CD*, which is smaller than the technical inefficiency *BD* from the CRS approach since the VRS approach envelops the data more closely. The difference, BC, measures scale inefficiency $\left(SE_i^{input,CRS}\right)$. These notions can be expressed as:

$$TE_i^{input,CRS} = \frac{AB}{AD} \qquad \left(0 \le TE_i^{input,CRS} \le 1\right)$$

$$TE_i^{input,VRS} = \frac{AC}{AD} \qquad \left(0 \le TE_i^{input,VRS} \le 1\right)$$

and

$$SE_i^{input} = \frac{AB}{AC} \qquad \left(0 \le SE_i \le 1\right)$$

Again it can be shown that,

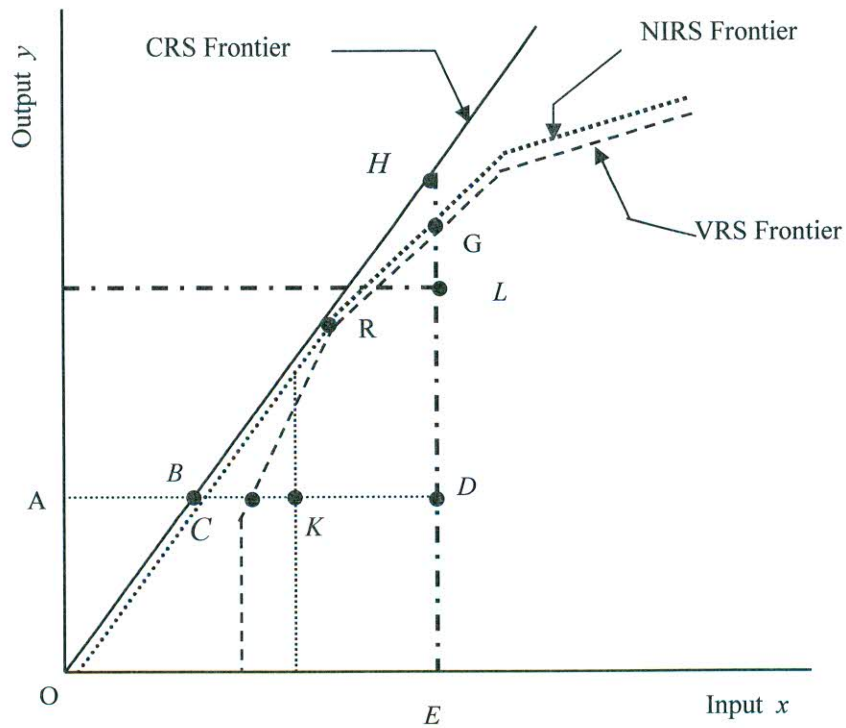
$$TE_i^{input,VRS} \times SE_i^{input} = \frac{AC}{AD} \times \frac{AB}{AC} = \frac{AB}{AD} = TE_i^{input,CRS}$$

$$\therefore \; TE_i^{input,CRS} = TE_i^{input,VRS} \times SE_i$$

That is, the CRS TE measure is decomposed into 'pure' technical efficiency and scale efficiency. Therefore,

$$SE^{input}{}_i = \frac{TE_i^{input\,CRS}}{TE_i^{input\,VRS}} \tag{7.8}$$

Figure 7.5: Estimation of Scale Economies in DEA



For the banks at point *D*, the CRS and NIRS technologies provide the same measure of efficiency scores but the VRS technology yields a higher level indicating that the VRS technology envelops the data more closely than the CRS and NIRS technologies at output vector Y. So increasing returns to scale (IRS) prevails. If we consider the bank at point L, the efficiency measures are equal relative to both the VRS and NIRS technologies, but lower for the CRS technology, which implies that the CRS technology does not envelop the data as closely as the other two predicting decreasing returns to scale (DRS) at output vector $L_{(Y)}$ at point L..

In an output-oriented framework, the CRS DEA estimates technical inefficiency of the bank operating at *D* by the distance *DH* and the VRS by the distance *DG*. The distance *GH* is due to scale inefficiency SE_i^{out}.

Therefore the measures of efficiency are:

$$TE_i^{output,CRS} = \frac{ED}{EH}$$

or $$TE_i^{output,VRS} = \frac{ED}{EG}$$

$$SE_i^{output} = \frac{EG}{EH}$$

Again in supplement:

$$TE_i^{output,VRS} \times SE_i^{output} = \frac{ED}{EG} \times \frac{EG}{EH} = \frac{ED}{EH} = TE_i^{output,CRS}$$

$$\therefore \quad TE_i^{output,CRS} = TE_i^{output,VRS} \times SE_i^{output}$$

or $$SE_i^{output} = \frac{TE_i^{output,CRS}}{TE_i^{output,VRS}} \tag{7.9}$$

Consider the bank at point *D* in Figure 7.6 where measures of efficiency are equivalent for both the VRS and NIRS technologies, but less for CRS technology. That show that the CRS technology does not envelop the data as closely as the other two technologies at input x and hence DRS exist. Now consider the bank at point K, where the efficiency measures are equivalent for both the CRS and NIRS technologies, but greater relative to the VRS technology. This implies that the VRS technology envelops the data more closely than the other two technologies at input vector $K_{(Y)}$ and thus IRS exist. To summarize:

Input orientation: $TE_i^{input,CRS} \leq TE_i^{input,NIRS} \leq TE_i^{input,VRS}$

Output orientation: $TE_i^{output,CRS} \leq TE_i^{output,NIRS} \leq TE_i^{output,VRS}$

For both orientations: $TE_i^{NIRS} < TE_i^{VRS}$ implies IRS

$TE_i^{CRS} < TE_i^{NIRS}$ implies DRS

and $TE_i^{CRS} = TE_i^{NIRS} = TE_i^{VRS}$ entails the restrictive property of NIRS.

Alternatively, scale economies arises due to either increasing or decreasing return to scale and can be determined by inspecting the sum of the weights $S = \sum_{j=1}^{n} \lambda_i$ with the CRS technology (Banker, 1984). Therefore, $S = 1$ implies constant returns to scale (optimal scale), $S > 1$ indicates decreasing returns to scale (super-optimal scale) and $S < 1$ implies increasing returns to scale (sub-optimal) (Löthgren and Tambour, 1996; Banker and Thrall, 1992; and Fǿrsund and Hernaes, 1994).

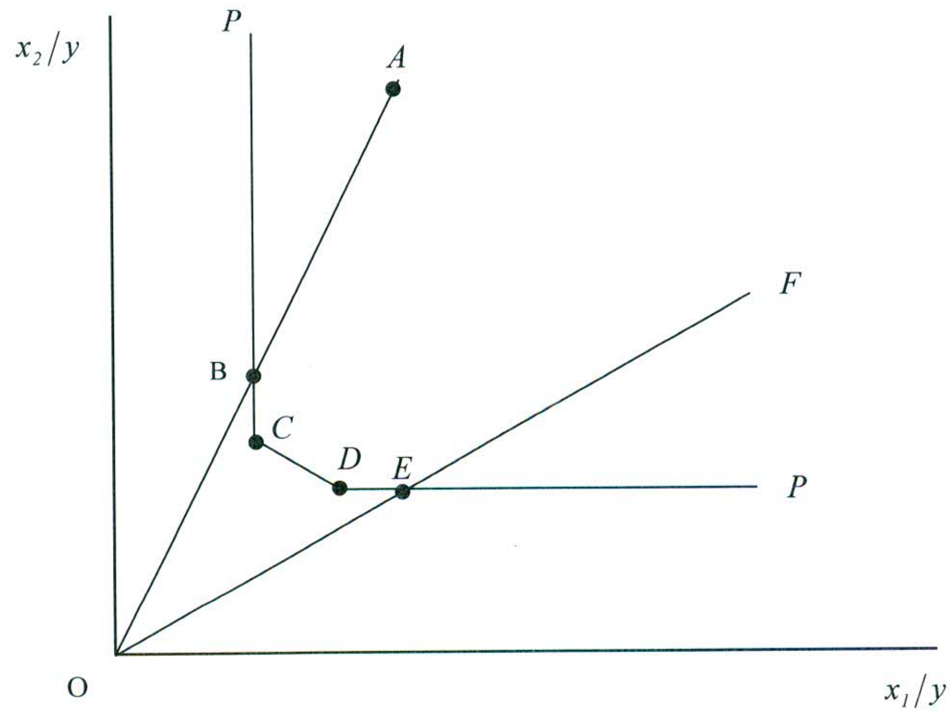
7. 17 Efficiency Measurement and Slacks

The nonparametric DEA frontier constructed by combining piecewise linear conical hull and piecewise linear frontiers parallel to the axes causes some problems in measuring technical efficiency. The problems happens because piecewise linear frontier generates some pieces that run sometimes parallel to the axes. In such a situation, it is difficult to find the nearest efficient point since more than one efficient point exists on both the parallel axes where scopes remains to reduce the use of inputs holding the same level of output or vice versa.

The problems can be better illustrated considering the Figure 7., where a firm is using input mix *C* and *D* can be said efficient while the frontier is *PP* and when the firm is applying input combinations *B* and *E* , it can be said inefficient.

Farrell's definition of the technical efficiency provides the efficiency of firms operating at point *A* and *F* with input mix *B* and *E* as *OB/OA* and *OE/OF* respectively. However, the firm producing at point *A* with input combination *B* can reduce input x_2 by the amount *BC* and the firm operating at point *F* with input mix *E* can decrease input x_1 by the amount *DE* and both firms remain capable of producing the same output; the amount *BC* is input slack of firm operating at point *A*, and the amount *DE* is input slack of firm operating at point *F* and hence these firms are inefficient. Thus the amount of inputs which can be reduced while remaining on the same level of output are called "input slacks".

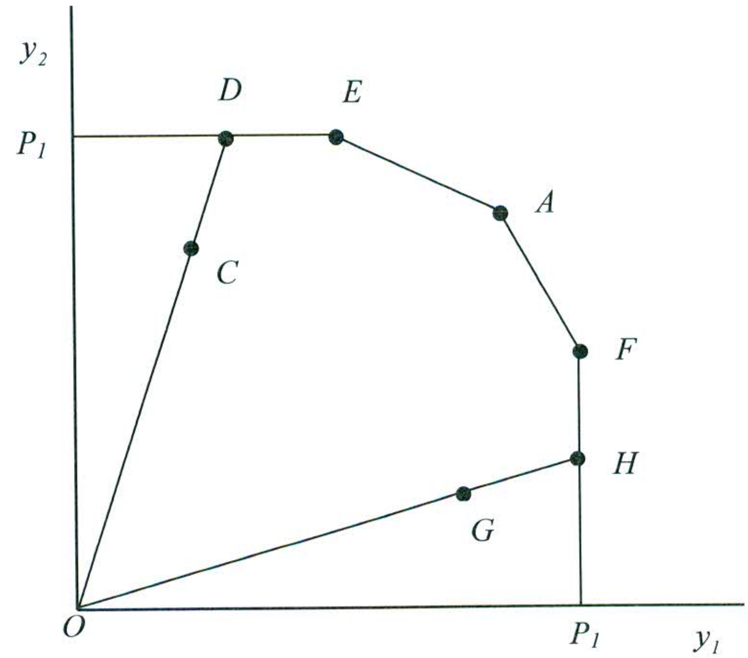
Figure 7.6: Input Slacks and Efficiency Measurement



Similarly, consider the analogous "output slack". An output-oriented DEA approach with two outputs is shown in Figure 7.6. The piecewise linear production possibility curve is $P_1DEAFHP_1$. An output slack takes place for the firm, which lies below the production possibility curve and remains at a right angle of the section of the curve to the axes when a redial expansion in output projects the firm onto those parts of the curve. Consider the firm with production point *C*.

The production point C can be projected to the point *D*, which lies on the frontier but not on the efficient frontier, because without reducing the output y_2 and applying any more inputs, the production of output y_1 could be increased by the amount *DE*. In the same manner, for the firm at G, production of y_2 could be increased by the amount *HF* without increasing the amount of inputs and decreasing the level of output of y_1. Therefore, the output slack of the firm with the production point C is DE in output y_1, and that of G is HF in output y_2.

Figure 7.7 Output Slack and output-oriented DEA



Note that both the output- and input-oriented DEA models estimate the same frontier and therefore, by definition, determine the same set of firms as being efficient, but the efficiency measures associated with the inefficient firms may vary between the two models (Coelli et al., 1998). So an appropriate direction of technical efficiency could be provided by reporting the Farrell measure of technical efficiency and any non-zero input or output slacks. The VRS DEA models can again be articulated with slacks as follows:

Input-oriented

$$\underset{\theta_i^{input\ VRS},\lambda}{Min} \quad \theta_i^{input,VRS}$$

Subject to $y_i + Y\lambda - S_{input} = 0,$

$$\theta_i^{input\ VRS} x_i - X\lambda - S_{input} = 0$$

$$NI'\lambda = 1$$

$$\lambda \geq 0$$

Output- oriented

$$\underset{\phi_i^{output,VRS},\lambda}{Max} \quad \phi_i^{output,VRS}$$

subject to $\phi_i^{output,VRS} y_i + Y\lambda - S_{output} = 0$

$$x_i - X\lambda - S_{output} = 0$$

$$NI'\lambda = 1$$

$$\lambda \geq 0$$

where S_{input} and S_{output} are $(k \times 1)$ and $(m \times 1)$ vectors of inputs and output slacks respectively.

The linear programming may not always allow identification of all efficiency slacks. Hence, identification of nearest efficient frontier point and the estimation of slacks are not straightforward if there are multiple inputs and outputs. A second-stage LP problem can be formulated to identify the nearest efficient point which maximizes the sum of slacks required to shift from the first stage projected point (inefficient point, such as point *B* in Figure 7.6) to a second- stage efficient point (such as point, *C* in Figure 7.6). This second-stage LP problem is formulated as:

$$\underset{\lambda_{input}, S_{output}, S_{input}}{Min} \quad -\left(MI' S_{output} + KI' S_{input}\right) \tag{7.10}$$

$$\text{Subject to} \quad -y_i + Y\lambda - S_{output} = 0$$

$$\theta x_i - X\lambda - S_{input} = 0,$$

$$\lambda \geq 0, \; S_{output} \geq 0, \quad S_{input} \geq 0,$$

where *M* and *K* are $(m \times 1)$ and $(k \times 1)$ unit vectors respectively. In this second stage LPs are solved for each firm where the first step gives the value of θ which is used in the second stage. However, one of the major problem with this second-stage approach is that it is not invariant to units of measurement (Lovell and Pastor, 1995); changing the units measurement, say for a capital input from Dollars to Taka, *ceteris paribus*, might results in identification of different efficient boundary points and thus different output slacks and different values of λ and slacks. As a result, many studies solve the first-stage, which does not explicitly include slacks, for the measure of Farrell technical efficiency for each firm and report the values of technical efficiency and the residual slacks as $S_{output} = -y_i + Y\lambda$ and $S_{input} = \theta x_i - X\lambda$. This removes the problem relating to the units of measurement and involves less programming. Again, this obviously does solve the immediate problem, but does another, in that there is no clear rationale for the slacks to give weights in this fashion (Coelli, 1998). However, these two issues are not problem in simple cases, as there is only two points to choose from the vertical facet but if slacks occurs in two or more dimensions (which is frequently the case) then the above-mentioned problems are relevant. To overcome such a problem Coelli (1997) suggests using a multi-stage DEA method to avoid the problems inherent in the two-stage method. This multi-stage methods involves a sequence of a radial DEA models and therefore more computationally demanding than the other two methods. The benefits of the approach are that it identifies efficient projected points which have input and output mixes as similar as similar as possible to those of the inefficient points, and that is also invariant to unit measurement. For details on multi-stage methods can be found in Coelli (1997).

7.18 Summary

A brief introduction to the basics of DEA has been discussed in this chapter. DEA has been defined as a nonparametric mathematical programming methodology to estimating efficiencies of firms in production. DEA can handle multiple input and multiple output models while it doesn't require an assumption of a functional form relating inputs to outputs. Inputs and outputs can have extremely dissimilar units but it not at al a problems for DEA. DEA is formulated for two types of orientations such as input orientation and output orientation.

In the input orientation models, the technique seeks to identify technical efficiency as a proportional reduction in input usage with output level held constant. And in the output orientation models, the method identifies technical efficiency as a proportional increase of output in production, while input levels are held fixed. The output-oriented DEA models yields alike estimates to their input- oriented counterparts. The CCR DEA model (1978) is the first DEA formulation. The BCC model (1984) is the later development in DEA model. When a variable returns to scale relationship is assumed between inputs and outputs the BCC DEA (ratio) model is used to measure technical efficiency. Notably, the VRS DEA model is different from CRS DEA model in that the VRS DEA envelopes data more robustly, producing TE estimates greater than or equal to that obtained from the CRS DEA. The input and a output oriented CRS and VRS models have been described and pointed out as to how these models can be used to measure technical and scale efficiencies. Scale efficiency measures can be obtained by conducting both a CRS DEA and a VRS DEA upon the same data. A through discussion has been made as to how scale efficiency can be used to NIRS DEA to help identify the nature of scale economies. The piecewise linear form of the non-parametric frontier in DEA can give rise to some difficulties in efficiency measurement which has been termed as 'slacks'. The problems arises because of the piecewise linear frontier that run parallel to the axes provide more than one efficient point. It has been discussed that the linear programs may not always allow identification of all efficiency slacks thus it requires treatment.

Chapter 8

DEA Frontier Results

8.1 Introduction

In this Chapter we discuss results obtained from the non-parametric approach to measuring efficiency of 49 commercial banks in Bangladesh with the application of Data Envelopment Analysis (DEA). Here we estimate constant returns to scale (CRS) and variable returns to scale (VRS) input oriented and output-oriented DEA frontiers. The CRS frontier produces the measures of overall technical efficiency and the VRS frontier produces estimates of pure technical efficiency. We compute scale efficiency as the ratio of CRS TE and VRS TE. We compare efficiency scores obtained from CRS TE, VRS TE and NIRS technologies to find commercial bank's operation levels- optimal, sub-optimal and super optimal.

8.2 DEA Frontier Results and TE Scores

To obtain DEA frontier results we have used the same set of data that has been used to find SFA technical efficiency results reported in Chapter 6. Data of each individual commercial Bank of Bangladesh have been arranged for the year 1999-2005 to conduct year-by-year cross-section analysis. The DEA results have been calculated using input orientations first and then output orientations.

A series of 49 linear programs, one for each bank is run for each CRS and VRS input-oriented frontiers in equation (7.2) for CRS and in (7.5) for VRS. Then we again run the same series for output-oriented frontiers. We use equation (7.6) for output-oriented CRS DEA frontier results and equation (7.7) for output-oriented VRS DEA results. We obtain measures of input oriented scale efficiency as a ratio of input oriented CRS DEA to input oriented VRS DEA and at the same time we obtain operation level of returns to scale as in equation (7.8). We further obtain output-oriented scale efficiency measures are as a ratio of output-oriented CRS DEA to output-oriented VRS DEA and obtain each of the commercial bank's corresponding returns to scale of operation as given in equation (7.9). In this connection we used application software computer program DEAP Version 2.1 (Coelli, 1996).

8.3 DEA Frontier Results for Technical Efficiency Estimates

The empirical study has been conducted in two DEA orientations. First we solve input oriented DEA on 49 banks for each of the year from 1999 to 2005. Then we solve output-oriented DEA problems for each of the banks.

8.3.1 Input-Oriented DEA Results, 1999-2005

Based on input oriented DEA, the overall technical efficiency (crste), pure technical efficiency (vrste) and scale efficiency of the commercial banks are estimated results of which appear in Appendix 8.1.1 to Appendix 8.1.11. We begin by discribeing input oriented summary results.

The average overall efficiency score for the banking sector in the year 1999 is 83 percent, for 2000 is 89 percent, for 2001 is 88 percent, for 2002 is 83 percent, for 2003 is 65 percent, for 2004 is 74 percent and for 2005 is 73 percent indicating 17 percent, 11 percent, 12 percent, 17 percent, 35 percent and 26 percent average potential reduction in inputs utilisation respectively.

From average overall efficiency scores, we understand that inefficiency declined in the 2000 and 2001 but after 2001 inefficiency increases gradually up to 2003 and thereafter inefficiency decreases in 2004 and 2005. The result is vey interesting. The results show that year 1999 and 2000 are very niece for banking activities but in year 2001 inefficiency starts to increase and further deteriorates in the subsequent years 2002 and 2003. Year 2003 is critical for banking sector performance since scores reach to its minimum value. However, the situation improved in 2004 and 2005. We can term the period 2004 and 2005 as restoration period for banking performance in Bangladesh. It can be commented that the banking policies around the year 2000-2002 could not sustain the competitiveness of the banking activities that appear in the year 1999, 2000 and 2001. The findings are important. Because we find similar behaviour of the banking variables for year 2003. However, we further portray category specific average crste, vrste and scale efficiency scores for further clarification.

From the year specific cross-section result Tables we find that the highest average overall efficiency score is enjoyed by several individual banks under NCBs, PCBs, SCBs, IPCBs and FCBs with crste scores 1.00 in each year 1999-2005 but the number banks varies over the period within the category.

Table 8.1 shows that based on input oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of NCBs for 1999 are 0.981, 1.00, and 0.981; for 2000 1.00, 1.00 and 1.00; for 2001 0.917, 1.00 and 0.917; for 2002 0.987, 1.00, and 0.987; for 2003 0.687, 1.00, and 0.687; for 2004 0.703, 1.00 and 0.703; and for 2005 0.755, 0.986 and 0.765 respectively

The average overall technical efficiency, average pure technical efficiency and average scale efficiency of PCBs for 1999 are 0.789, 0.953, and 0.824; for 2000 0.835, 0.902 and 0.96; for 2001 0.861, 9.44 and 0.912; for 2002 0.795, 0.893, and 0.893; for 2003 0.595, 0.854, and 0.698; for 2004 0.707, 0.932 and 0.764; and for 2005 0.696, 0.855 and 0.820 respectively.

The average overall technical efficiency, average pure technical efficiency and average scale efficiency of SCBs for 1999 are 0.851, 0.852, and 0.998; for 2000 0.960, 0.971 and 0.989; for 2001 0.959, 1.00 and 0.959; for 2002 0.996, 1.00, and 0.996; for 2003 0.721, 0.921, and 0.773; for 2004 0.852, 0.987 and 0.861; and for 2005 0.766, 0.864 and 0.872 respectively.

Table 8.1: Mean Efficiency Estimates of Banks obtained from Input-Oriented DEA, 1999-2005

Bank Type		1999			2000			2001			2002			2003			2004			2005		
		crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale
NCBs	Mean	0.981	1.000	0.981	1.000	1.000	1.000	0.917	1.000	0.917	0.987	1.000	0.987	0.687	1.000	0.687	0.703	1.000	0.703	0.755	0.986	0.765
	SD	0.039	0.000	0.039	0.000	0.000	0.000	0.058	0.000	0.058	0.018	0.000	0.018	0.222	0.000	0.222	0.048	0.000	0.047	0.070	0.028	0.057
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.742	1.000	0.742	0.847	1.000	0.847
	Min.	0.923	1.000	0.923	1.000	1.000	1.000	0.875	1.000	0.875	0.962	1.000	0.962	0.485	1.000	0.485	0.636	0.999	0.637	0.678	0.945	0.717
PCBs	Mean	0.789	0.953	0.824	0.835	0.902	0.926	0.861	0.944	0.912	0.795	0.893	0.893	0.595	0.854	0.698	0.707	0.932	0.764	0.696	0.855	0.820
	SD	0.166	0.100	0.141	0.149	0.137	0.080	0.136	0.098	0.106	0.142	0.140	0.096	0.173	0.175	0.140	0.117	0.114	0.120	0.165	0.173	0.122
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.900	1.000	0.970	0.918	1.000	0.969	1.000	1.000	1.000
	Min.	0.354	0.637	0.530	0.566	0.598	0.724	0.583	0.610	0.605	0.390	0.420	0.571	0.298	0.438	0.469	0.420	0.619	0.529	0.250	0.295	0.538
SCBs	Mean	0.851	0.852	0.998	0.960	0.971	0.989	0.959	1.000	0.959	0.996	1.000	0.996	0.721	0.921	0.773	0.852	0.987	0.861	0.766	0.864	0.872
	SD	0.203	0.202	0.002	0.055	0.041	0.022	0.066	0.000	0.066	0.010	0.000	0.010	0.260	0.086	0.227	0.179	0.028	0.166	0.219	0.113	0.154
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.613	0.937	0.658	0.890	0.937	0.658	0.848	0.937	0.658	0.978	0.937	0.658	0.474	0.937	0.658	0.617	0.937	0.658	0.471	0.937	0.658
IPCBs	Mean	0.958	0.999	0.959	0.922	0.947	0.973	0.869	0.973	0.885	0.710	0.773	0.925	0.632	0.842	0.748	0.747	0.912	0.811	0.615	0.734	0.855
	SD	0.054	0.002	0.053	0.103	0.100	0.022	0.207	0.060	0.173	0.210	0.229	0.079	0.216	0.214	0.136	0.198	0.123	0.134	0.294	0.353	0.080
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.950	1.000	0.950	1.000	1.000	1.000	0.903	1.000	0.937
	Min.	0.888	0.996	0.888	0.771	0.797	0.947	0.523	0.865	0.605	0.461	0.462	0.831	0.415	0.599	0.576	0.528	0.746	0.693	0.206	0.219	0.760
FCBs	Mean	0.806	0.879	0.914	0.835	0.902	0.926	0.861	0.944	0.912	0.586	0.811	0.723	0.737	0.890	0.827	0.790	0.926	0.852	0.857	0.968	0.888
	SD	0.235	0.203	0.148	0.120	0.069	0.074	0.128	0.107	0.107	0.198	0.189	0.056	0.216	0.194	0.137	0.195	0.149	0.144	0.145	0.097	0.135
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.377	0.497	0.561	0.682	0.825	0.818	0.660	0.695	0.660	0.375	0.375	0.834	0.433	0.484	0.638	0.474	0.564	0.643	0.644	0.708	0.644
All Banks	Mean	0.831	0.934	0.888	0.891	0.935	0.951	0.876	0.954	0.918	0.831	0.895	0.929	0.648	0.879	0.736	0.743	0.940	0.792	0.732	0.879	0.836
	SD	0.182	0.110	0.140	0.135	0.111	0.070	0.131	0.082	0.107	0.768	0.848	0.906	0.204	0.171	0.161	0.150	0.115	0.133	0.181	0.178	0.121
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.354	0.497	0.530	0.566	0.598	0.724	0.523	0.610	0.605	0.375	0.375	0.571	0.298	0.438	0.469	0.420	0.564	0.529	0.206	0.219	0.538

The average overall technical efficiency, average pure technical efficiency and average scale efficiency of IPCBs for 1999 are 0.958, 0.999, and 0.959; for 2000 are 0.922, 0.947 and 0.973; for 2001 are 0.869, 0.973 and 0.885; for 2002 are 0.710, 0.773, and 0.925; for 2003 are 0.632, 0.842, and 0.748; for 2004 are 0.747, 0.912 and 0.811; and for 2005 are 0.615, 0.734 and 0.855 respectively.

The average overall technical efficiency, average pure technical efficiency and average scale efficiency of FCBs for 1999 are 0.806, 0.879, and 0.914; for 2000 0.835, 0.902 and 0.926; for 2001 0.861, 0.944 and 0.912; for 2002 0.586, 0.811, and 0.723; for 2003 0.737, 0.890, and 0.827; for 2004 0.790, 0.926 and 0.852; and for 2005 0.857, 0.968 and 0.888 respectively.

Based on input oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of all Banks for 1999 are 0.831, 0.934, and 0.888; for 2000 0.891, 0.935 and 0.951; for 2001 0.876, 0.954 and 0.918; for 2002 0.831, 0.895, and 0.929; for 2003 0.648, 0.879, and 0.736; for 2004 0.743, 0.940 and 0.972; and for 2005 0.932, 0.879 and 0.836 respectively.

8.4 Summary of Economies of Operation obtained from Input-oriented DEA

Table 8.2 shows input-oriented economies of operation of the commercial banks. In 1999, there are 46 commercial banks operating in the banking sector. We find 11 banks showing increasing returns to scale, 17 constant returns to scale and 18 decreasing decreasing returns to scale.

We find over the time there is a tendency to diminish increasing returns to scale. The number of banks operating under constant returns to scale increases to 19 in the year 2000. After 2000 and onward, the number banks operating under constant returns to scale decline. We find that number of banks operating under decreasing returns to scale rises over time. The trend of rising number of drs shows that economies of operation is declining.

Table 8.2: Input-Oriented Returns to Scale

rs	1999	2000	2001	2002	2003	2004	2005
irs	11	8	8	4	3	2	6
crs	17	19	15	13	6	6	6
drs	18	19	26	32	40	41	34
Total	46	46	49	49	49	49	46

Note: rs indicates returns to scale, irs indicates increasing returns to scale, crs indicates constant returns to scale and drs indicates decreasing returns to scale.

8.5 Output-oriented DEA Results, 1999-2005

From the Table 8.3 we find that based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of NCBs for 1999 are 0.981, 1.00, and 0.981; for 2000 1.00, 1.00 and 1.00; for 2001 0.917, 1.00 and 0.917; for 2002 0.987, 1.00, and 0.987; for 2003 0.687, 1.00, and 0.687; for 2004 0.703, 1.00 and 0.703; and for 2005 0.755, 0.986 and 0.765 respectively.

Based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of PCBs for 1999 are 0.789, 0.943, and 0.836; for 2000 0.835, 0.899 and 0.931; for 2001 0.861, 0.947 and 0.909; for 2002 0.795, 0.897, and 0.890; for 2003 0.595, 0.891, and 0.665; for 2004 0.707, 0.941 and 0.755; and for 2005 0.696, 0.873 and 0.799 respectively. (see appendix 8.1.1 to 8.1.7 for details)

Based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of SCBs for 1999 are 0.851, 0.887, and 0.953; for 2000 0.960, 0.971 and 0.989; for 2001 0.959, 1.00 and 0.959; for 2002 0.996, 1.00, and 0.996; for 2003 0.721, 0.927, and 0.769; for 2004 0.852, 0.988 and 0.860; and for 2005 0.766, 0.875 and 0.862 respectively.

Based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of IPCBs for 1999 are 0.958, 0.999, and 0.959; for 2000 0.922, 0.951 and 0.968; for 2001 0.869, 0.936 and 0.918; for 2002 0.710, 0.786, and 0.903; for 2003 0.632, 0.855, and 0.732; for 2004 0.747, 0.923 and 0.801; and for 2005 0.615, 0.755 and 0.803 respectively.

Based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of FCBs for 1999 are 0.806, 0.900, and 0.886; for 2000 0.835, 0.965 and 0.865; for 2001 0.861, 0.944 and 0.912; for 2002 0.586, 0.876, and 0.669; for 2003 0.737, 0.904, and 0.808; for 2004 0.790, 0.937 and 0.839; and for 2005 0.857, 0.970 and 0.885 respectively.

Based on output oriented DEA, the average overall technical efficiency, average pure technical efficiency and average scale efficiency of all Banks for 1999 are 0.831, 0.937, and 0.883; for 2000 0.891, 0.934 and 0.953; for 2001 0.876, 0.952 and 0.919; for 2002 0.831, 0.901, and 0.922; for 2003 0.648, 0.930, and 0.713; for 2004 0.743, 0.948 and 0.783; and for 2005 0.932, 0.892 and 0.819 respectively.

Table 8.3: Mean Efficiency Estimates of Banks obtained from Output -oriented DEA, 1999-2005

Bank Type		1999			2000			2001			2002			2003			2004			2005		
		crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale
NCBs	Mean	0.981	1.000	0.981	1.000	1.000	1.000	0.917	1.000	0.917	0.987	1.000	0.987	0.687	1.000	0.687	0.703	1.000	0.703	0.755	0.987	0.765
	SD	0.039	0.000	0.039	0.000	0.000	0.000	0.058	0.000	0.058	0.018	0.000	0.018	0.222	0.000	0.222	0.048	0.000	0.047	0.070	0.026	0.057
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.742	1.000	0.742	0.847	1.000	0.847
	Min.	0.923	1.000	0.923	1.000	1.000	1.000	0.875	1.000	0.875	0.962	1.000	0.962	0.485	1.000	0.485	0.636	0.999	0.637	0.678	0.947	0.716
PCBs	Mean	0.789	0.943	0.836	0.835	0.899	0.931	0.861	0.947	0.909	0.795	0.897	0.890	0.595	0.891	0.665	0.707	0.941	0.755	0.696	0.873	0.799
	SD	0.166	0.132	0.129	0.149	0.143	0.082	0.136	0.095	0.108	0.142	0.143	0.099	0.173	0.142	0.143	0.117	0.099	0.113	0.165	0.158	0.125
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.900	1.000	0.900	0.918	1.000	0.918	1.000	1.000	1.000
	Min.	0.354	0.481	0.585	0.566	0.580	0.724	0.583	0.638	0.605	0.390	0.391	0.548	0.298	0.495	0.442	0.420	0.673	0.516	0.250	0.345	0.538
SCBs	Mean	0.851	0.887	0.953	0.960	0.971	0.989	0.959	1.000	0.959	0.996	1.000	0.996	0.721	0.927	0.769	0.852	0.988	0.860	0.766	0.875	0.862
	SD	0.203	0.161	0.095	0.055	0.041	0.023	0.066	0.000	0.066	0.010	0.000	0.010	0.260	0.079	0.228	0.179	0.027	0.166	0.219	0.105	0.159
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.613	0.937	0.658	0.890	0.937	0.658	0.848	0.937	0.658	0.978	0.937	0.658	0.474	0.937	0.658	0.617	0.937	0.658	0.471	0.937	0.658
IPCBs	Mean	0.958	0.999	0.959	0.922	0.951	0.968	0.869	0.936	0.918	0.710	0.786	0.903	0.632	0.855	0.732	0.747	0.923	0.801	0.615	0.755	0.803
	SD	0.054	0.002	0.053	0.103	0.092	0.026	0.207	0.143	0.111	0.210	0.216	0.075	0.216	0.196	0.140	0.198	0.107	0.143	0.294	0.333	0.070
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.950	1.000	0.950	1.000	1.000	1.000	0.903	1.000	0.903
	Min.	0.888	0.996	0.888	0.771	0.814	0.947	0.523	0.680	0.769	0.461	0.494	0.823	0.415	0.633	0.575	0.528	0.780	0.676	0.206	0.269	0.748
FCBs	Mean	0.806	0.900	0.886	0.929	0.965	0.960	0.858	0.929	0.926	0.836	0.876	0.950	0.737	0.904	0.808	0.790	0.937	0.839	0.857	0.970	0.885
	SD	0.235	0.165	0.170	0.120	0.063	0.081	0.128	0.102	0.106	0.198	0.180	0.063	0.216	0.167	0.140	0.195	0.126	0.148	0.145	0.090	0.133
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.377	0.609	0.561	0.682	0.842	0.799	0.660	0.710	0.660	0.375	0.402	0.817	0.433	0.573	0.638	0.474	0.634	0.643	0.644	0.730	0.644
All Banks	Mean	0.831	0.937	0.883	0.891	0.934	0.953	0.876	0.952	0.919	0.831	0.901	0.922	0.648	0.903	0.713	0.743	0.948	0.783	0.732	0.892	0.819
	SD	0.182	0.116	0.130	0.135	0.115	0.071	0.132	0.088	0.101	0.171	0.156	0.090	0.200	0.144	0.166	0.150	0.099	0.131	0.181	0.166	0.123
	Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Min.	0.354	0.481	0.561	0.566	0.580	0.724	0.523	0.638	0.605	0.375	0.391	0.548	0.298	0.495	0.442	0.420	0.634	0.516	0.206	0.269	0.538

8.6 Economies of Operation from Output-oriented DEA

Table 8.4 shows output-oriented economies of operation of the commercial banks. In 1999, we find 9 banks showing increasing returns to scale, 16 constant returns to scale scale and 21 decreasing decreasing returns to scale.

Table 8.4: Output -Oriented Returns to Scale

rs	1999	2000	2001	2002	2003	2004	2005
irs	9	5	8	3	2	2	3
crs	16	20	15	13	6	6	9
drs	21	21	26	33	41	41	35
Total	46	46	49	49	49	49	46

Note: rs indicates returns to scale, irs indicates increasing returns to scale, crs indicates constant returns to scale and drs indicates decreasing returns to scale.

After 1999 and onward, the number banks enjoying increasing returns to scale declines gradually but in the year 2005 it again starts to rise. We examine the behaviour of economies of operation over the years and find that there is a tendency to raise the number of banks under decreasing returns to scale. Similar event is found in input-oriented DEA returns to scale summary Table 8.2. Banks operating under constant returns to scale decreases gradually after 2000 to 6 in 2003. The trend of rising drs shows that economies of operation in banking sector is declining but with a clear indication to improve further after 2004.

8.7 Comparison of Efficiency Results Between SFA and DEA

The two approaches measure the efficiency of commercial banks relative to different frontiers, a stochastic parametric production frontier, and a non-stochastic non-parametric production frontier. For this reason differences in efficiency scores are to be expected, although overall consistency between the two methodologies is to be preferred.

Table 8.5: Stochastic Frontier and DEA Results

	1999	2000	2001	2002	2003	2004	2005
Stochastic Frontier Results Average TE score	0.754	0.766	0.815	0.703	0.755	0.669	0.768
DEA average overall efficiency results (crste)	0.831	0.891	0.876	0.743	0.648	0.743	0.732
Input-oriented DEA average pure technical efficiency results (vrste)	0.934	0.935	0.954	0.794	0.879	0.940	0.879
Output-oriented DEA average pure technical efficiency results (vrste)	0.937	0.934	0.952	0.901	0.903	0.948	0.892
Input-oriented DEA scale efficiency results	0.888	0.951	0.918	0.936	0.736	0.792	0.836
Output-oriented DEA scale efficiency	0.883	0.953	0.919	0.922	0.713	0.783	0.819

As Table 8.5 shows there are differences in magnitudes of calculated technical efficiency between SFA and DEA. Since the linear programming model is nonstochastic, noise is not reported as inefficiency, therefore, efficiency will be greater relative to a non-stochastic production frontier than to a stochastic production frontier. This expectation is fulfilled in our study.

It would appear that the linear programming production frontier is sufficiently flexible to envelop data more closely while stochastic Cobb-Douglas production frontier appropriately allows for measurement errors.

The consistency between the two sets of efficiency results are justified because fluctuations over time follows the same trend that appears in Table 8.5 under SFA TE scores and DEA effeciency scores. Consistency crieteria can be adjudged as follows

(i) Linear programming approach does not allow for any measurement error, as such it calculates high efficiency results.

(ii) The econometric approach imposes parametric structure on technology of production and therefore specification error may cause higher inefficiency.

However, Sometimes disagreements between the two results are found when the two results do not conform consistency. For example, for the average overall banking sector technical efficiency in Table 8.5, the DEA score declines in 2001(0.879) compared to year 2000 (0.891) while SFA score increases in 2001(0.815) to year 2000 (0.766). Such disagreement is sometimes ignorable as is observed in our results in Table 8.4.

8.8 Summary and Conclusion

In this chapter we have described input-oriented and output-oriented DEA results. We obtained the measures of overall technical efficiency, pure technical efficiency and scale efficiency. We have examined the economies of operation under increasing, constant and decreasing returns to scale.

In this chapter we have compared the ability of parametric econometric and non-parametric linear programming techniques to shed light on the structure of production technology and the nature and efficiencies of commercial banks of Bangladesh.we now summarise our findings as follows:

The two approaches are in substantial agreement on several important issues. Modest scale economies confer a potential reduction of inputs to the commercial banks of Bangladesh. Relative to the banks production frontier, the banking sector of Bangladesh operate with inefficiency ranging from 11-35 percent. The experienced banks are mostly on decreasing returns to scale operation of economies. Comparatively banks with medium experience enjoy increasing returns to scale operation economies. Two approaches generate technical efficiency while DEA generates overall, pure and scale efficiency with indication to economies of operation.

The stochastic Cobb-Douglas production frontier model is employed in this study. The model is fully stochastic and include a likage relationship while DEA model involves exogenously fixed variables. The two models differ in structure and implementation. The differences in technical efficiency scores are due to different unconnected methodologies. The DEA method is nonstochastic. Thus it yields relatively higher value in efficiency scores. The reason for comparatively higher efficiency values are that DEA does not allow for any noise, measurement error and other uncertainty. The accuracy of DEA results highly depend on the accuracy of data under consideration as stated earlier in methodology. Further, DEA can be applied for a large number of exogeneously fixed and categorical variables. We used bank specific data on income and expenditure variables and the variables are frequently used in similar studies.

The stochastic frontier approaches is parametric and allows for noise and uncertainty. The consistency between the results of the two approaches are substantial. Both the results show same behaviour over time. Some disagreements to a little extent is observed in our results.

Appendix 8.1.1 Input Oriented DEA Efficiency Score for the Year 1999

Bank		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.98	1.00	0.98
NCBs	2	Janata Bank	1.000	1.000	1.000	-	SD	0.039	0.000	0.039
	3	Agrani Bank	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	4	Rupali Bank	0.923	1.000	0.923	drs	Min.	0.92	1.00	0.92
	5	Pubali Bank Ltd.	0.665	1.000	0.665	drs				
	6	Uttara Bank Ltd.	0.826	0.989	0.835	drs				
	7	AB Bank Ltd.	0.609	0.932	0.654	drs				
	8	National Bank Ltd.	0.864	1.000	0.864	drs				
	9	The City Bank Ltd.	0.876	0.916	0.957	drs				
	10	IFIC Bank Ltd.	1.000	1.000	1.000	-				
	11	UCBL	0.787	1.000	0.787	drs				
	12	Eastern Bank Ltd.	0.902	1.000	0.902	drs				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.759	1.000	0.759	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.726	1.000	0.726	drs	Mean	0.79	0.95	0.82
	16	Dhaka Bank Ltd.	1.000	1.000	1.000	-	SD	0.17	0.10	0.14
PCBs	17	Dutch-Bangla Bank Ltd.	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.591	0.637	0.928	irs	Min.	0.35	0.64	0.53
	19	Standard Bank Ltd.	0.793	0.935	0.849	irs				
	20	One Bank Ltd.	0.657	0.920	0.714	irs				
	21	EXIM Bank of BD. Ltd.	0.769	1.000	0.769	irs				
	22	BD. Commerce Bank Ltd.	0.752	0.923	0.815	drs				
	23	Mutual Trust Bank Ltd.	0.901	1.000	0.901	irs				
	24	First Security Bank Ltd.	0.585	1.000	0.585	irs				
	25	The Premier Bank Ltd.	0.354	0.667	0.530	irs				
	26	Bank-Asia Ltd.	0.720	1.000	0.720	irs				
	27	The Trust Bank Ltd.	1.000	1.000	1.000	-				
	28	Jamuna Bank Ltd.	na	na	na	na				
	29	Brac Bank Ltd.	na	na	na	na				
	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.645	0.647	0.996	drs	Mean	0.85	0.85	1.00
SCBs	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.20	0.20	0.00
	33	BD. Shilpa Rin Shangstha	0.613	0.615	0.997	irs	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.997	1.000	0.997	drs	Min.	0.61	0.94	0.658
	35	Islami Bank of BD. Ltd.	0.945	0.996	0.948	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	1.000	1.000	1.000	-	Mean	0.96	1.00	0.96
IPCBs	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.05	0.00	0.05
	38	The Oriental Bank Ltd.	0.888	1.000	0.888	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	na	na	na	na	Min.	0.89	1.00	0.89
	40	American Express Bank	0.561	1.000	0.561	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.729	0.729	0.999	-				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
FCBs	44	Credit Agricole Indosuez	0.983	1.000	0.983	drs				
	45	National Bank of PAK. Ltd.	0.856	1.000	0.856	irs		crste	vrste	scale
	46	City Bank n.a.	1.000	1.000	1.000	-	Mean	0.806	0.879	0.914
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.24	0.20	0.15
	48	The HSBC Ltd.	0.377	0.497	0.759	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain	0.555	0.564	0.984	irs	Min.	0.377	0.497	0.561
		Mean Efficiency	0.831	0.934	0.888					
		Standard Deviation	0.182	0.110	0.140					
		Maximum	1.000	1.000	1.000					
		Minimum	0.354	0.497	0.530					

Appendix 8.1.2 Input Oriented DEA Efficiency Score for the Year 2000

Bank		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	1.000	1.000	1.000	-	Mean	1.00	1.00	1.00
	2	Janata Bank	1.000	1.000	1.000	-	SD	0.000	0.000	0.000
	3	Agrani Bank	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	1.00	1.00	1.00
PCBs	5	Pubali Bank Ltd.	0.807	1.000	0.807	drs				
	6	Uttara Bank Ltd.	0.988	1.000	0.988	drs				
	7	AB Bank Ltd.	0.635	0.845	0.751	drs				
	8	National Bank Ltd.	0.878	1.000	0.878	drs				
	9	The City Bank Ltd.	0.771	0.786	0.982	drs				
	10	IFIC Bank Ltd.	0.987	1.000	0.987	drs				
	11	UCBL	0.800	0.956	0.837	drs				
	12	Eastern Bank Ltd.	1.000	1.000	1.000	-				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.969	1.000	0.969	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.910	1.000	0.910	drs	Mean	0.84	0.90	0.93
	16	Dhaka Bank Ltd.	0.974	1.000	0.974	drs	SD	0.15	0.14	0.08
	17	Dutch-Bangla Bank Ltd.	0.853	0.892	0.957	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.903	0.925	0.976	drs	Min.	0.57	0.60	0.72
	19	Standard Bank Ltd.	0.866	0.959	0.903	irs				
	20	One Bank Ltd.	0.649	0.720	0.902	irs				
	21	EXIM Bank of BD. Ltd.	0.667	0.715	0.933	drs				
	22	BD. Commerce Bank Ltd.	0.566	0.608	0.930	irs				
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	-				
	24	First Security Bank Ltd.	0.578	0.598	0.967	drs				
	25	The Premier Bank Ltd.	0.686	0.741	0.926	irs				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.724	1.000	0.724	irs				
	28	Jamuna Bank Ltd.	na	na	na	na				
	29	Brac Bank Ltd.	na	na	na	na				
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	1.000	1.000	1.000	-	Mean	0.96	0.97	0.99
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.05	0.04	0.02
	33	BD. Shilpa Rin Shangstha	0.912	0.916	0.996	irs	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.890	0.937	0.950	drs	Min.	0.89	0.94	0.658
IPCBs	35	Islami Bank of BD. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.771	0.797	0.967	drs	Mean	0.92	0.95	0.97
	37	Social Investment Bank Ltd.	0.947	1.000	0.947	irs	SD	0.10	0.10	0.02
	38	The Oriental Bank Ltd.	0.969	0.991	0.978	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	na	na	na	na	Min.	0.77	0.80	0.95
FCBs	40	American Express Bank	0.776	0.948	0.818	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	1.000	1.000	1.000	-				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	1.000	1.000	1.000	-				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.830	0.846	0.981	irs	Mean	0.835	0.902	0.926
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.12	0.07	0.07
	48	The HSBC Ltd.	0.682	0.825	0.826	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	1.000	1.000	1.000	-	Min.	0.682	0.825	0.818
		Mean Efficiency	0.891	0.935	0.951					
		Standard Deviation	0.135	0.111	0.070					
		Maximum	1.000	1.000	1.000					
		Minimum	0.566	0.598	0.724					

Appendix 8.1.3 Input Oriented DEA Efficiency Score for the Year 2001

Bank	Sl	Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.92	1.00	0.92
NCBs	2	Janata Bank	0.875	1.000	0.875	drs	SD	0.058	0.000	0.058
	3	Agrani Bank	0.916	1.000	0.916	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	0.877	1.000	0.877	drs	Min.	0.88	1.00	0.88
	5	Pubali Bank Ltd.	0.683	1.000	0.683	drs				
	6	Uttara Bank Ltd.	0.889	1.000	0.889	drs				
	7	AB Bank Ltd.	0.662	0.924	0.717	drs				
	8	National Bank Ltd.	0.847	0.950	0.891	drs				
	9	The City Bank Ltd.	0.814	0.875	0.930	drs				
	10	IFIC Bank Ltd.	0.963	1.000	0.963	drs				
	11	UCBL	0.745	0.829	0.899	drs				
	12	Eastern Bank Ltd.	0.911	1.000	0.911	drs				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.847	1.000	0.847	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.924	1.000	0.924	drs	Mean	0.86	0.94	0.91
	16	Dhaka Bank Ltd.	0.776	0.939	0.826	drs	SD	0.14	0.10	0.11
PCBs	17	Dutch-Bangla Bank Ltd.	0.936	0.983	0.952	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.987	1.000	0.987	drs	Min.	0.58	0.61	0.61
	19	Standard Bank Ltd.	1.000	1.000	1.000	-				
	20	One Bank Ltd.	1.000	1.000	1.000	-				
	21	EXIM Bank of BD. Ltd.	0.783	0.865	0.906	drs				
	22	BD. Commerce Bank Ltd.	0.695	0.728	0.955	irs				
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	-				
	24	First Security Bank Ltd.	0.583	0.610	0.956	drs				
	25	The Premier Bank Ltd.	0.902	0.909	0.992	irs				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.975	1.000	0.975	irs				
	28	Jamuna Bank Ltd.	1.000	1.000	1.000	-				
	29	Brac Bank Ltd.	0.605	1.000	0.605	irs				
	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.848	1.000	0.848	drs	Mean	0.96	1.00	0.96
SCBs	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.07	0.00	0.07
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.945	1.000	0.945	drs	Min.	0.85	0.94	0.66
	35	Islami Bank of BD. Ltd.	0.992	1.000	0.992	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	1.000	1.000	1.000	-	Mean	0.87	0.97	0.89
IPCBs	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.21	0.06	0.17
	38	The Oriental Bank Ltd.	0.830	1.000	0.830	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.523	0.865	0.605	irs	Min.	0.52	0.87	0.61
	40	American Express Bank	0.827	0.995	0.832	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.857	0.882	0.972	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
FCBs	44	Credit Agricole Indosuez	0.945	1.000	0.945	drs				
	45	National Bank of PAK. Ltd.	0.660	1.000	0.660	irs		crste	vrste	scale
	46	City Bank n.a.	0.775	0.798	0.972	drs	Mean	0.861	0.944	0.912
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.13	0.11	0.11
	48	The HSBC Ltd.	0.682	0.695	0.981	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.835	0.915	0.912	irs	Min.	0.66	0.70	0.66
		Mean Efficiency	0.876	0.954	0.918					
		Standard Deviation	0.131	0.082	0.107					
		Maximum	1.000	1.000	1.000					
		Minimum	0.523	0.610	0.605					

Appendix 8.1.4 Input Oriented DEA Efficiency Score for the Year 2002

Bank Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.99	1.00	0.99
NCBs	2	Janata Bank	0.985	1.000	0.985	drs	SD	0.018	0.000	0.01
	3	Agrani Bank	0.962	1.000	0.962	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	0.96	1.00	0.96
	5	Pubali Bank Ltd.	0.760	1.000	0.760	drs				
	6	Uttara Bank Ltd.	0.849	1.000	0.849	drs				
	7	AB Bank Ltd.	0.485	0.850	0.571	drs				
	8	National Bank Ltd.	0.796	0.935	0.852	drs				
	9	The City Bank Ltd.	0.826	0.946	0.873	drs				
	10	IFIC Bank Ltd.	0.993	1.000	0.993	drs				
	11	UCBL	0.768	0.912	0.842	drs				
	12	Eastern Bank Ltd.	0.866	1.000	0.866	drs				
	13	NCCBL	0.869	1.000	0.869	drs				
	14	Prime Bank Ltd.	0.767	0.936	0.819	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.708	0.731	0.968	drs	Mean	0.80	0.89	0.89
	16	Dhaka Bank Ltd.	0.962	1.000	0.962	drs	SD	0.14	0.14	0.10
PCBs	17	Dutch-Bangla Bank Ltd.	0.775	1.000	0.775	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.938	0.996	0.942	drs	Min.	0.39	0.42	0.57
	19	Standard Bank Ltd.	0.801	0.805	0.996	irs				
	20	One Bank Ltd.	0.869	1.000	0.869	drs				
	21	EXIM Bank of BD. Ltd.	0.817	0.904	0.904	drs				
	22	BD. Commerce Bank Ltd.	0.712	0.756	0.942	drs				
	23	Mutual Trust Bank Ltd.	0.870	0.888	0.980	drs				
	24	First Security Bank Ltd.	0.830	0.878	0.945	drs				
	25	The Premier Bank Ltd.	0.902	0.936	0.964	drs				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.668	0.755	0.884	irs				
	28	Jamuna Bank Ltd.	0.656	0.676	0.969	drs				
	29	Brac Bank Ltd.	0.390	0.420	0.931	irs				
	30	BD. Krishi Bank	0.978	1.000	0.978	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	1.000	1.000	1.000	-	Mean	1.00	1.00	1.00
SCBs	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.01	0.00	0.01
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	1.000	1.000	1.000	-	Min.	0.98	0.94	0.66
	35	Islami Bank of BD. Ltd.	0.831	1.000	0.831	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.591	0.693	0.853	drs	Mean	0.71	0.77	0.92
IPCBs	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.21	0.23	0.08
	38	The Oriental Bank Ltd.	0.461	0.462	0.996	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.669	0.709	0.943	drs	Min.	0.46	0.46	0.83
	40	American Express Bank	0.714	0.856	0.834	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.867	0.884	0.981	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.375	0.375	1.000	-				
FCBs	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.894	0.917	0.976	drs	Mean	0.586	0.811	0.72
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.20	0.19	0.06
	48	The HSBC Ltd.	0.743	0.794	0.936	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.768	0.848	0.906	drs	Min.	0.38	0.38	0.83
		Mean Efficiency	0.831	0.895	0.929					
		Standard Deviation	0.768	0.848	0.906					
		Maximum	1.000	1.000	1.000					
		Minimum	0.375	0.375	0.571					

Appendix 8.1.5 Input Oriented DEA Efficiency Score for the Year 2003

Bank		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	0.670	1.000	0.670	drs	Mean	0.69	1.00	0.69
	2	Janata Bank	0.593	1.000	0.593	drs	SD	0.222	0.000	0.222
	3	Agrani Bank	0.485	1.000	0.485	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	0.49	1.00	0.49
PCBs	5	Pubali Bank Ltd.	0.411	0.801	0.513	drs				
	6	Uttara Bank Ltd.	0.405	0.863	0.469	drs				
	7	AB Bank Ltd.	0.298	0.576	0.517	drs				
	8	National Bank Ltd.	0.470	0.893	0.526	drs				
	9	The City Bank Ltd.	0.401	0.710	0.564	drs				
	10	IFIC Bank Ltd.	0.397	0.829	0.479	drs				
	11	UCBL	0.509	0.832	0.612	drs				
	12	Eastern Bank Ltd.	0.635	0.869	0.731	drs				
	13	NCCBL	0.565	0.718	0.786	drs				
	14	Prime Bank Ltd.	0.503	0.875	0.575	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.652	1.000	0.652	drs	Mean	0.59	0.85	0.70
	16	Dhaka Bank Ltd.	0.816	1.000	0.816	drs	SD	0.17	0.17	0.14
	17	Dutch-Bangla Bank Ltd.	0.464	0.631	0.735	drs	Max.	0.90	1.00	0.97
	18	Mercantile Bank Ltd.	0.702	1.000	0.702	drs	Min.	0.30	0.44	0.47
	19	Standard Bank Ltd.	0.730	1.000	0.730	drs				
	20	One Bank Ltd.	0.814	0.910	0.894	drs				
	21	EXIM Bank of BD. Ltd.	0.729	1.000	0.729	drs				
	22	BD. Commerce Bank Ltd.	0.383	0.450	0.851	drs				
	23	Mutual Trust Bank Ltd.	0.900	1.000	0.900	drs				
	24	First Security Bank Ltd.	0.653	0.974	0.671	drs				
	25	The Premier Bank Ltd.	0.714	1.000	0.714	drs				
	26	Bank-Asia Ltd.	0.750	1.000	0.750	drs				
	27	The Trust Bank Ltd.	0.425	0.438	0.970	irs				
	28	Jamuna Bank Ltd.	0.707	0.970	0.729	drs				
	29	Brac Bank Ltd.	0.840	1.000	0.840	drs				
SCBs	30	BD. Krishi Bank	0.510	0.936	0.545	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.474	0.863	0.549	drs	Mean	0.72	0.92	0.77
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.26	0.09	0.23
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.623	0.806	0.772	drs	Min.	0.47	0.94	0.66
IPCBs	35	Islami Bank of BD. Ltd.	0.743	1.000	0.743	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.415	0.599	0.693	drs	Mean	0.63	0.84	0.75
	37	Social Investment Bank Ltd.	0.950	1.000	0.950	drs	SD	0.22	0.21	0.14
	38	The Oriental Bank Ltd.	0.572	0.994	0.576	drs	Max.	0.95	1.00	0.95
	39	Shahjalal Bank Ltd.	0.480	0.615	0.780	drs	Min.	0.42	0.60	0.58
FCBs	40	American Express Bank	0.433	0.484	0.895	drs				
	41	Standard Chart Bank U.K.	0.819	1.000	0.819	drs				
	42	Habib Bank Ltd.	0.742	1.000	0.742	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.455	0.600	0.758	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.586	0.811	0.723	drs	Mean	0.737	0.890	0.827
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.22	0.19	0.14
	48	The HSBC Ltd.	0.699	1.000	0.699	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain	0.638	1.000	0.638	irs	Min.	0.43	0.48	0.64
		Mean Efficiency	0.648	0.879	0.736					
		Standard Deviation	0.204	0.171	0.161					
		Maximum	1.000	1.000	1.000					
		Minimum	0.298	0.438	0.469					

Appendix 8.1.6 Input Oriented DEA Efficiency Score for the Year 2004

Bank		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
	1	Sonali Bank	0.731	1.000	0.731	drs	Mean	0.70	1.00	0.70
NCBs	2	Janata Bank	0.702	1.000	0.702	drs	SD	0.048	0.001	0.047
	3	Agrani Bank	0.742	1.000	0.742	drs	Max.	0.74	1.00	0.74
	4	Rupali Bank	0.636	0.999	0.637	drs	Min.	0.64	1.00	0.64
	5	Pubali Bank Ltd.	0.529	1.000	0.529	drs				
	6	Uttara Bank Ltd.	0.746	1.000	0.746	drs				
	7	AB Bank Ltd.	0.420	0.789	0.533	drs				
	8	National Bank Ltd.	0.776	1.000	0.776	drs				
	9	The City Bank Ltd.	0.697	0.970	0.718	drs				
	10	IFIC Bank Ltd.	0.781	1.000	0.781	drs				
	11	UCBL	0.762	1.000	0.762	drs				
	12	Eastern Bank Ltd.	0.809	1.000	0.809	drs				
	13	NCCBL	0.874	0.961	0.910	drs				
	14	Prime Bank Ltd.	0.655	0.954	0.687	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.604	1.000	0.604	drs	Mean	0.71	0.93	0.76
	16	Dhaka Bank Ltd.	0.614	1.000	0.614	drs	SD	0.12	0.11	0.12
PCBs	17	Dutch-Bangla Bank Ltd.	0.685	0.777	0.882	drs	Max.	0.92	1.00	0.97
	18	Mercantile Bank Ltd.	0.841	1.000	0.841	drs	Min.	0.42	0.62	0.53
	19	Standard Bank Ltd.	0.703	1.000	0.703	drs				
	20	One Bank Ltd.	0.662	0.930	0.712	drs				
	21	EXIM Bank of BD. Ltd.	0.866	1.000	0.866	drs				
	22	BD. Commerce Bank Ltd.	0.585	0.619	0.945	drs				
	23	Mutual Trust Bank Ltd.	0.918	1.000	0.918	drs				
	24	First Security Bank Ltd.	0.729	0.976	0.746	drs				
	25	The Premier Bank Ltd.	0.793	1.000	0.793	drs				
	26	Bank-Asia Ltd.	0.662	1.000	0.662	drs				
	27	The Trust Bank Ltd.	0.639	0.660	0.969	drs				
	28	Jamuna Bank Ltd.	0.752	0.873	0.861	drs				
	29	Brac Bank Ltd.	0.581	0.786	0.739	drs				
	30	BD. Krishi Bank	0.617	0.937	0.658	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.706	1.000	0.706	drs	Mean	0.85	0.99	0.86
SCBs	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.18	0.03	0.17
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.939	1.000	0.939	drs	Min.	0.62	0.94	0.658
	35	Islami Bank of BD. Ltd.	0.901	1.000	0.901	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.613	0.815	0.752	drs	Mean	0.75	0.91	0.81
IPCBs	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.20	0.12	0.13
	38	The Oriental Bank Ltd.	0.693	1.000	0.693	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.528	0.746	0.708	drs	Min.	0.53	0.75	0.69
	40	American Express Bank	0.474	0.564	0.840	drs				
	41	Standard Chart Bank U.K.	0.997	1.000	0.997	drs				
	42	Habib Bank Ltd.	0.643	1.000	0.643	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
FCBs	44	Credit Agricole Indosuez	0.650	0.750	0.867	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.756	1.000	0.756	drs	Mean	0.790	0.926	0.852
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.19	0.15	0.14
	48	The HSBC Ltd.	0.727	0.945	0.770	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.651	1.000	0.651	irs	Min.	0.47	0.56	0.64
		Mean Efficiency	0.743	0.940	0.792					
		Standard Deviation	0.150	0.115	0.133					
		Maximum	1.000	1.000	1.000					ok
		Minimum	0.420	0.564	0.529					

Appendix 8.1.7 Input Oriented DEA Efficiency Score for the Year 2005

Bank		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
	1	Sonali Bank	0.847	1.000	0.847	drs	Mean	0.76	0.99	0.76
NCBs	2	Janata Bank	0.746	1.000	0.746	drs	SD	0.070	0.028	0.057
	3	Agrani Bank	0.749	1.000	0.749	drs	Max.	0.85	1.00	0.85
	4	Rupali Bank	0.678	0.945	0.717	drs	Min.	0.68	0.95	0.72
	5	Pubali Bank Ltd.	0.634	1.000	0.634	drs				
	6	Uttara Bank Ltd.	0.724	0.979	0.739	drs				
	7	AB Bank Ltd.	0.250	0.295	0.846	drs				
	8	National Bank Ltd.	0.588	0.768	0.766	drs				
	9	The City Bank Ltd.	0.639	0.852	0.750	drs				
	10	IFIC Bank Ltd.	0.584	0.635	0.919	drs				
	11	UCBL	0.720	0.857	0.840	drs				
	12	Eastern Bank Ltd.	0.767	0.893	0.860	drs				
	13	NCCBL	0.806	0.957	0.842	drs				
	14	Prime Bank Ltd.	0.659	0.850	0.776	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.714	0.920	0.776	drs	Mean	0.70	0.86	0.82
	16	Dhaka Bank Ltd.	1.000	1.000	1.000	-	SD	0.17	0.17	0.12
PCBs	17	Dutch-Bangla Bank Ltd.	0.604	0.692	0.872	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.653	0.924	0.706	drs	Min.	0.25	0.30	0.54
	19	Standard Bank Ltd.	0.754	0.976	0.772	drs				
	20	One Bank Ltd.	0.584	0.587	0.996	irs				
	21	EXIM Bank of BD. Ltd.	1.000	1.000	1.000	-				
	22	BD. Commerce Bank Ltd.	0.753	0.772	0.976	irs				
	23	Mutual Trust Bank Ltd.	0.899	1.000	0.899	drs				
	24	First Security Bank Ltd.	0.538	1.000	0.538	drs				
	25	The Premier Bank Ltd.	0.705	1.000	0.705	drs				
	26	Bank-Asia Ltd.	0.627	0.938	0.669	drs				
	27	The Trust Bank Ltd.	1.000	1.000	1.000	-				
	28	Jamuna Bank Ltd.	0.676	0.815	0.830	drs				
	29	Brac Bank Ltd.	0.534	0.673	0.792	drs				
	30	BD. Krishi Bank	0.471	0.725	0.649	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.778	0.856	0.909	drs	Mean	0.77	0.86	0.87
SCBs	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.22	0.11	0.15
	33	BD. Shilpa Rin Shangstha	na	na	na	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.814	0.875	0.930	drs	Min.	0.47	0.94	0.658
	35	Islami Bank of BD. Ltd.	0.903	1.000	0.903	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.206	0.219	0.937	irs	Mean	0.62	0.73	0.85
IPCBs	37	Social Investment Bank Ltd.	0.653	0.798	0.818	drs	SD	0.29	0.35	0.08
	38	The Oriental Bank Ltd.	na	na	na	drs	Max.	0.90	1.00	0.94
	39	Shahjalal Bank Ltd.	0.698	0.918	0.760	drs	Min.	0.21	0.22	0.76
	40	American Express Bank	na	na	na	na				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.720	1.000	0.720	irs				
	43	State Bank of India Ltd.	0.946	1.000	0.946	irs				
FCBs	44	Credit Agricole Indosuez	0.691	0.708	0.976	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.910	1.000	0.910	drs	Mean	0.857	0.968	0.888
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.14	0.10	0.13
	48	The HSBC Ltd.	0.798	1.000	0.798	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain	0.644	1.000	0.644	irs	Min.	0.64	0.71	0.64
		Mean Efficiency	0.732	0.879	0.836					
		Standard Deviation	0.181	0.178	0.121					
		Maximum	1.000	1.000	1.000					
		Minimum	0.206	0.219	0.538					

Appendix 8.1.8 Input Oriented CRS DEA Efficiency Estimates 1999-2005

Type		Name of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	0.670	0.731	0.847	0.893	0.144
	2	Janata Bank	1.000	1.000	0.875	0.985	0.593	0.702	0.746	0.843	0.164
	3	Agrani Bank	1.000	1.000	0.916	0.962	0.485	0.742	0.749	0.836	0.190
	4	Rupali Bank	0.923	1.000	0.877	1.000	1.000	0.636	0.678	0.873	0.156
PCBs	5	Pubali Bank Ltd.	0.665	0.807	0.683	0.760	0.411	0.529	0.634	0.641	0.135
	6	Uttara Bank Ltd.	0.826	0.988	0.889	0.849	0.405	0.746	0.724	0.775	0.186
	7	AB Bank Ltd.	0.609	0.635	0.662	0.485	0.298	0.420	0.250	0.480	0.165
	8	National Bank Ltd.	0.864	0.878	0.847	0.796	0.470	0.776	0.588	0.746	0.156
	9	The City Bank Ltd.	0.876	0.771	0.814	0.826	0.401	0.697	0.639	0.718	0.161
	10	IFIC Bank Ltd.	1.000	0.987	0.963	0.993	0.397	0.781	0.584	0.815	0.240
	11	UCBL	0.787	0.800	0.745	0.768	0.509	0.762	0.720	0.727	0.100
	12	Eastern Bank Ltd.	0.902	1.000	0.911	0.866	0.635	0.809	0.767	0.841	0.118
	13	NCCBL	1.000	1.000	1.000	0.869	0.565	0.874	0.806	0.873	0.157
	14	Prime Bank Ltd.	0.759	0.969	0.847	0.767	0.503	0.655	0.659	0.737	0.150
	15	South East Bank Ltd.	0.726	0.910	0.924	0.708	0.652	0.604	0.714	0.748	0.123
	16	Dhaka Bank Ltd.	1.000	0.974	0.776	0.962	0.816	0.614	1.000	0.877	0.147
	17	Dutch-Bangla Bank Ltd.	1.000	0.853	0.936	0.775	0.464	0.685	0.604	0.760	0.189
	18	Mercantile Bank Ltd.	0.591	0.903	0.987	0.938	0.702	0.841	0.653	0.802	0.153
	19	Standard Bank Ltd.	0.793	0.866	1.000	0.801	0.730	0.703	0.754	0.807	0.100
	20	One Bank Ltd.	0.657	0.649	1.000	0.869	0.814	0.662	0.584	0.748	0.150
	21	EXIM Bank of BD. Ltd.	0.769	0.667	0.783	0.817	0.729	0.866	1.000	0.804	0.107
	22	BD. Commerce Bank Ltd.	0.752	0.566	0.695	0.712	0.383	0.585	0.753	0.635	0.134
	23	Mutual Trust Bank Ltd.	0.901	1.000	1.000	0.870	0.900	0.918	0.899	0.927	0.052
	24	First Security Bank Ltd.	0.585	0.578	0.583	0.830	0.653	0.729	0.538	0.642	0.104
	25	The Premier Bank Ltd.	0.354	0.686	0.902	0.902	0.714	0.793	0.705	0.722	0.186
	26	Bank-Asia Ltd.	0.720	1.000	1.000	1.000	0.750	0.662	0.627	0.823	0.170
	27	The Trust Bank Ltd.	1.000	0.724	0.975	0.668	0.425	0.639	1.000	0.776	0.222
	28	Jamuna Bank Ltd.	na	na	1.000	0.656	0.707	0.752	0.676	0.758	0.140
	29	Brac Bank Ltd.	na	na	0.605	0.390	0.840	0.581	0.534	0.590	0.163
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	0.978	0.510	0.617	0.471	0.797	0.251
	31	Raj. Krishi Unnayan Bank	0.645	1.000	0.848	1.000	0.474	0.706	0.778	0.779	0.191
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	33	BD. Shilpa Rin	0.613	0.912	1.000	1.000	1.000	1.000	na	0.921	0.155
	34	BASIC Bank Ltd.	0.997	0.890	0.945	1.000	0.623	0.939	0.814	0.887	0.133
IPCBs	35	Islami Bank of BD. Ltd.	0.945	1.000	0.992	0.831	0.743	0.901	0.903	0.902	0.091
	36	Al- Arafa Islami Bank	1.000	0.771	1.000	0.591	0.415	0.613	0.206	0.657	0.293
	37	Social Investment Bank	1.000	0.947	1.000	1.000	0.950	1.000	0.653	0.936	0.127
	38	The Oriental Bank Ltd.	0.888	0.969	0.830	0.461	0.572	0.693	na	0.736	0.195
	39	Shahjalal Bank Ltd.	na	na	0.523	0.669	0.480	0.528	0.698	0.580	0.097
FCBs	40	American Express Bank	0.561	0.776	0.827	0.714	0.433	0.474	na	0.631	0.164
	41	Standard Chart Bank	1.000	1.000	1.000	1.000	0.819	0.997	1.000	0.974	0.068
	42	Habib Bank Ltd.	0.729	1.000	0.857	0.867	0.742	0.643	0.720	0.794	0.120
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.946	0.992	0.020
	44	Credit Agricole Indosuez	0.983	1.000	0.945	0.375	0.455	0.650	0.691	0.728	0.256
	45	National Bank of PAK.	0.856	1.000	0.660	1.000	1.000	1.000	1.000	0.931	0.131
	46	City Bank n.a.	1.000	0.830	0.775	0.894	0.586	0.756	0.910	0.822	0.134
	47	Woori Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	48	The HSBC Ltd.	0.377	0.682	0.682	0.743	0.699	0.727	0.798	0.673	0.137
	49	Shamil Bank of Bahrain	0.555	1.000	0.835	0.768	0.638	0.651	0.644	0.727	0.152
		Mean Efficiency	0.831	0.891	0.876	0.743	0.648	0.743	0.732	0.780	0.088
		Standard Deviation	0.182	0.135	0.131	0.768	0.204	0.150	0.181	0.250	0.230
		Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.293
		Minimum	0.354	0.566	0.523	0.375	0.298	0.420	0.206	0.480	0.000

Appendix 8.1.9 Input Oriented VRS DEA Efficiency Estimates 1999-2005

		Name of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	2	Janata Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	3	Agrani Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	4	Rupali Bank	1.000	1.000	1.000	1.000	1.000	0.999	0.945	0.992	0.021
PCBs	5	Pubali Bank Ltd.	1.000	1.000	1.000	1.000	0.801	1.000	1.000	0.972	0.075
	6	Uttara Bank Ltd.	0.989	1.000	1.000	1.000	0.863	1.000	0.979	0.976	0.050
	7	AB Bank Ltd.	0.932	0.845	0.924	0.850	0.576	0.789	0.295	0.744	0.231
	8	National Bank Ltd.	1.000	1.000	0.950	0.935	0.893	1.000	0.768	0.935	0.084
	9	The City Bank Ltd.	0.916	0.786	0.875	0.946	0.710	0.970	0.852	0.865	0.092
	10	IFIC Bank Ltd.	1.000	1.000	1.000	1.000	0.829	1.000	0.635	0.923	0.142
	11	UCBL	1.000	0.956	0.829	0.912	0.832	1.000	0.857	0.912	0.075
	12	Eastern Bank Ltd.	1.000	1.000	1.000	1.000	0.869	1.000	0.893	0.966	0.058
	13	NCCBL	1.000	1.000	1.000	1.000	0.718	0.961	0.957	0.948	0.103
	14	Prime Bank Ltd.	1.000	1.000	1.000	0.936	0.875	0.954	0.850	0.945	0.062
	15	South East Bank Ltd.	1.000	1.000	1.000	0.731	1.000	1.000	0.920	0.950	0.101
	16	Dhaka Bank Ltd.	1.000	1.000	0.939	1.000	1.000	1.000	1.000	0.991	0.023
	17	Dutch-Bangla Bank Ltd.	1.000	0.892	0.983	1.000	0.631	0.777	0.692	0.854	0.154
	18	Mercantile Bank Ltd.	0.637	0.925	1.000	0.996	1.000	1.000	0.924	0.926	0.132
	19	Standard Bank Ltd.	0.935	0.959	1.000	0.805	1.000	1.000	0.976	0.954	0.070
	20	One Bank Ltd.	0.920	0.720	1.000	1.000	0.910	0.930	0.587	0.867	0.155
	21	EXIM Bank of BD. Ltd.	1.000	0.715	0.865	0.904	1.000	1.000	1.000	0.926	0.108
	22	BD. Commerce B. Ltd.	0.923	0.608	0.728	0.756	0.450	0.619	0.772	0.694	0.151
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	0.888	1.000	1.000	1.000	0.984	0.042
	24	First Security Bank Ltd.	1.000	0.598	0.610	0.878	0.974	0.976	1.000	0.862	0.181
	25	The Premier Bank Ltd.	0.667	0.741	0.909	0.936	1.000	1.000	1.000	0.893	0.136
	26	Bank-Asia Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.938	0.991	0.023
	27	The Trust Bank Ltd.	1.000	1.000	1.000	0.755	0.438	0.660	1.000	0.836	0.225
	28	Jamuna Bank Ltd.	na	na	1.000	0.676	0.970	0.873	0.815	0.867	0.130
	29	Brac Bank Ltd.	na	na	1.000	0.420	1.000	0.786	0.673	0.776	0.244
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	1.000	0.936	0.937	0.725	0.943	0.101
	31	RUKUB	0.647	1.000	1.000	1.000	0.863	1.000	0.856	0.909	0.133
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	33	BSRS	0.615	0.916	1.000	1.000	1.000	1.000	na	0.922	0.154
	34	BASIC Bank Ltd.	1.000	0.937	1.000	1.000	0.806	1.000	0.875	0.945	0.078
IPCBs	35	Islami Bank of BD. Ltd.	0.996	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.002
	36	Al- Arafa Islami B. Ltd.	1.000	0.797	1.000	0.693	0.599	0.815	0.219	0.732	0.270
	37	Social Investment B.	1.000	1.000	1.000	1.000	1.000	1.000	0.798	0.971	0.076
	38	The Oriental Bank Ltd.	1.000	0.991	1.000	0.462	0.994	1.000	na	0.908	0.218
	39	Shahjalal Bank Ltd.	na	na	0.865	0.709	0.615	0.746	0.918	0.771	0.122
FCBs	40	American Express Bank	1.000	0.948	0.995	0.856	0.484	0.564	na	0.808	0.227
	41	Standard Chart B. U.K.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	42	Habib Bank Ltd.	0.729	1.000	0.882	0.884	1.000	1.000	1.000	0.928	0.104
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	44	Credit Agricole	1.000	1.000	1.000	0.375	0.600	0.750	0.708	0.776	0.241
	45	National B. of Pakistan.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	46	City Bank n.a.	1.000	0.846	0.798	0.917	0.811	1.000	1.000	0.910	0.092
	47	Woori Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	48	The HSBC Ltd.	0.497	0.825	0.695	0.794	1.000	0.945	1.000	0.822	0.183
	49	Shamil B. of Bahrain	0.564	1.000	0.915	0.848	1.000	1.000	1.000	0.904	0.161
		Mean Efficiency	0.934	0.935	0.954	0.794	0.879	0.940	0.879	0.902	0.082
		Standard Deviation	0.110	0.111	0.082	0.848	0.171	0.115	0.178	0.914	0.274
		Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
		Minimum	0.497	0.598	0.610	0.375	0.438	0.564	0.219	0.694	0.141

Appendix 8.1.10 Input Oriented DEA Scale Efficiency Scores, 1999 - 2005

Type		Name of banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	0.670	0.731	0.847	0.893	0.144
	2	Janata Bank	1.000	1.000	0.875	0.985	0.593	0.702	0.746	0.843	0.164
	3	Agrani Bank	1.000	1.000	0.916	0.962	0.485	0.742	0.749	0.836	0.190
	4	Rupali Bank	0.923	1.000	0.877	1.000	1.000	0.637	0.717	0.879	0.148
PCBs	5	Pubali Bank Ltd.	0.665	0.807	0.683	0.760	0.513	0.529	0.634	0.656	0.109
	6	Uttara Bank Ltd.	0.835	0.988	0.889	0.849	0.469	0.746	0.739	0.788	0.164
	7	AB Bank Ltd.	0.654	0.751	0.717	0.571	0.517	0.533	0.846	0.656	0.123
	8	National Bank Ltd.	0.864	0.878	0.891	0.852	0.526	0.776	0.766	0.793	0.128
	9	The City Bank Ltd.	0.957	0.982	0.930	0.873	0.564	0.718	0.750	0.825	0.153
	10	IFIC Bank Ltd.	1.000	0.987	0.963	0.993	0.479	0.781	0.919	0.875	0.190
	11	UCBL	0.787	0.837	0.899	0.842	0.612	0.762	0.840	0.797	0.093
	12	Eastern Bank Ltd.	0.902	1.000	0.911	0.866	0.731	0.809	0.860	0.868	0.084
	13	NCCBL	1.000	1.000	1.000	0.869	0.786	0.910	0.842	0.915	0.087
	14	Prime Bank Ltd.	0.759	0.969	0.847	0.819	0.575	0.687	0.776	0.776	0.124
	15	South East Bank Ltd.	0.726	0.910	0.924	0.968	0.652	0.604	0.776	0.794	0.143
	16	Dhaka Bank Ltd.	1.000	0.974	0.826	0.962	0.816	0.614	1.000	0.885	0.143
	17	Dutch-Bangla Bank Ltd.	1.000	0.957	0.952	0.775	0.735	0.882	0.872	0.882	0.098
	18	Mercantile Bank Ltd.	0.928	0.976	0.987	0.942	0.702	0.841	0.706	0.869	0.122
	19	Standard Bank Ltd.	0.849	0.903	1.000	0.996	0.730	0.703	0.772	0.850	0.122
	20	One Bank Ltd.	0.714	0.902	1.000	0.869	0.894	0.712	0.996	0.870	0.118
	21	EXIM Bank of BD. Ltd.	0.769	0.933	0.906	0.904	0.729	0.866	1.000	0.872	0.094
	22	BD. Commerce Bank Ltd.	0.815	0.930	0.955	0.942	0.851	0.945	0.976	0.916	0.060
	23	Mutual Trust Bank Ltd.	0.901	1.000	1.000	0.980	0.900	0.918	0.899	0.943	0.048
	24	First Security Bank Ltd.	0.585	0.967	0.956	0.945	0.671	0.746	0.538	0.773	0.184
	25	The Premier Bank Ltd.	0.530	0.926	0.992	0.964	0.714	0.793	0.705	0.803	0.168
	26	Bank-Asia Ltd.	0.720	1.000	1.000	1.000	0.750	0.662	0.669	0.829	0.163
	27	The Trust Bank Ltd.	1.000	0.724	0.975	0.884	0.970	0.969	1.000	0.932	0.100
	28	Jamuna Bank Ltd.	na	na	1.000	0.969	0.729	0.861	0.830	0.878	0.109
	29	Brac Bank Ltd.	na	na	0.605	0.931	0.840	0.739	0.792	0.781	0.121
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	0.978	0.545	0.658	0.649	0.833	0.205
	31	Raj. Krishi Unnayan Bank	0.996	1.000	0.848	1.000	0.549	0.706	0.909	0.858	0.174
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	33	BD. Shilpa Rin Shangstha	0.997	0.996	1.000	1.000	1.000	1.000	na	0.999	0.002
	34	BASIC Bank Ltd.	0.997	0.950	0.945	1.000	0.772	0.939	0.930	0.933	0.076
IPCBs	35	Islami Bank of BD. Ltd.	0.948	1.000	0.992	0.831	0.743	0.901	0.903	0.903	0.091
	36	Al- Arafa Islami Bank Ltd.	1.000	0.967	1.000	0.853	0.693	0.752	0.937	0.886	0.123
	37	Social Investment Bank Ltd.	1.000	0.947	1.000	1.000	0.950	1.000	0.818	0.959	0.067
	38	The Oriental Bank Ltd.	0.888	0.978	0.830	0.996	0.576	0.693	na	0.827	0.165
	39	Shahjalal Bank Ltd.	na	na	0.605	0.943	0.780	0.708	0.760	0.759	0.123
FCBs	40	American Express Bank	0.561	0.818	0.832	0.834	0.895	0.840	na	0.797	0.118
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	1.000	0.819	0.997	1.000	0.974	0.068
	42	Habib Bank Ltd.	0.999	1.000	0.972	0.981	0.742	0.643	0.720	0.865	0.156
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.946	0.992	0.020
	44	Credit Agricole Indosuez	0.983	1.000	0.945	1.000	0.758	0.867	0.976	0.933	0.090
	45	National Bank of PAK. Ltd.	0.856	1.000	0.660	1.000	1.000	1.000	1.000	0.931	0.131
	46	City Bank n.a.	1.000	0.981	0.972	0.976	0.723	0.756	0.910	0.903	0.115
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	48	The HSBC Ltd.	0.759	0.826	0.981	0.936	0.699	0.770	0.798	0.824	0.101
	49	Shamil Bank of Bahrain E.C.	0.984	1.000	0.912	0.906	0.638	0.651	0.644	0.819	0.167
		Mean Efficiency	0.888	0.951	0.918	0.936	0.736	0.792	0.836	0.865	0.080
		Standard Deviation	0.140	0.070	0.107	0.906	0.161	0.133	0.121	0.234	0.298
		Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
		Minimum	0.530	0.724	0.605	0.571	0.469	0.529	0.538	0.567	0.081

Appendix 8.1.11 Input Oriented DEA returns to Scale Rating 1999-2005

Type	Sl.	Name of Banks	1999	2000	2001	2002	2003	2004	2005
NCBs	1	Sonali Bank	-	-	-	-	drs	drs	drs
	2	Janata Bank	-	-	drs	drs	drs	drs	drs
	3	Agrani Bank	-	-	drs	drs	drs	drs	drs
	4	Rupali Bank	drs	-	drs	-	-	drs	drs
PCBs	5	Pubali Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	6	Uttara Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	7	AB Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	8	National Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	9	The City Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	10	IFIC Bank Ltd.	-	drs	drs	drs	drs	drs	drs
	11	UCBL	drs	drs	drs	drs	drs	drs	drs
	12	Eastern Bank Ltd.	drs	-	drs	drs	drs	drs	drs
	13	NCCBL	-	-	-	drs	drs	drs	drs
	14	Prime Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	15	South East Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	16	Dhaka Bank Ltd.	-	drs	drs	drs	drs	drs	-
	17	Dutch-Bangla Bank Ltd.	-	drs	drs	drs	drs	drs	drs
	18	Mercantile Bank Ltd.	irs	drs	drs	drs	drs	drs	drs
	19	Standard Bank Ltd.	irs	irs	-	irs	drs	drs	drs
	20	One Bank Ltd.	irs	irs	-	drs	drs	drs	irs
	21	EXIM Bank of BD. Ltd.	irs	drs	drs	drs	drs	drs	-
	22	BD. Commerce Bank Ltd.	drs	irs	irs	drs	drs	drs	irs
	23	Mutual Trust Bank Ltd.	irs	-	-	drs	drs	drs	drs
	24	First Security Bank Ltd.	irs	drs	drs	drs	drs	drs	drs
	25	The Premier Bank Ltd.	irs	irs	irs	drs	drs	drs	drs
	26	Bank-Asia Ltd.	irs	-	-	-	drs	drs	drs
	27	The Trust Bank Ltd.	-	irs	irs	irs	irs	drs	-
	28	Jamuna Bank Ltd.	na	na	-	drs	drs	drs	drs
	29	Brac Bank Ltd.	na	na	irs	irs	drs	drs	drs
SCBs	30	BD. Krishi Bank	-	-	-	drs	drs	drs	drs
	31	Raj. Krishi Unnayan Bank	drs	-	drs	-	drs	drs	drs
	32	BD. Shilpa Bank	-	-	-	-	-	-	-
	33	BD. Shilpa Rin Shangstha	irs	irs	-	-	-	-	-
	34	BASIC Bank Ltd.	drs	drs	drs	-	drs	drs	drs
IPCBs	35	Islami Bank of BD. Ltd.	drs	-	drs	drs	drs	drs	drs
	36	Al- Arafa Islami Bank Ltd.	-	drs	-	drs	drs	drs	irs
	37	Social Investment Bank Ltd.	-	irs	-	-	drs	-	drs
	38	The Oriental Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	39	Shahjalal Bank Ltd.	na	na	irs	drs	drs	drs	drs
FCBs	40	American Express Bank	drs	drs	drs	drs	drs	drs	na
	41	Standard Chart Bank U.K.	-	-	-	-	drs	drs	-
	42	Habib Bank Ltd.	-	-	irs	irs	irs	irs	irs
	43	State Bank of India Ltd.	-	-	-	-	-	-	irs
	44	Credit Agricole Indosuez	drs	-	drs	-	drs	drs	drs
	45	National Bank of PAK. Ltd.	irs	-	irs	-	-	-	-
	46	City Bank n.a.	-	irs	drs	drs	drs	drs	drs
	47	HANVIT (Woori) Bank Ltd.	-	-	-	-	-	-	-
	48	The HSBC Ltd.	drs	drs	drs	drs	drs	drs	drs
	49	Shamil Bank of Bahrain	irs	-	irs	drs	irs	irs	irs

Appendix 8.2.1 Output Oriented DEA Efficiency Score for the Year 1999

		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.98	1.00	0.98
	2	Janata Bank	1.000	1.000	1.000	-	SD	0.039	0.000	0.039
	3	Agrani Bank	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	4	Rupali Bank	0.923	1.000	0.923	drs	Min.	0.923	1.00	0.923
PCBs	5	Pubali Bank Ltd.	0.665	1.000	0.665	drs				
	6	Uttara Bank Ltd.	0.826	0.990	0.834	drs				
	7	AB Bank Ltd.	0.609	0.938	0.650	drs				
	8	National Bank Ltd.	0.864	1.000	0.864	drs				
	9	The City Bank Ltd.	0.876	0.923	0.950	drs				
	10	IFIC Bank Ltd.	1.000	1.000	1.000	-				
	11	UCBL	0.787	1.000	0.787	drs				
	12	Eastern Bank Ltd.	0.902	1.000	0.902	drs				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.759	1.000	0.759	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.726	1.000	0.726	drs	Mean	0.79	0.94	0.84
	16	Dhaka Bank Ltd.	1.000	1.000	1.000	-	SD	0.17	0.13	0.13
	17	Dutch-Bangla Bank Ltd.	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.591	0.604	0.978	irs	Min.	0.35	0.48	0.59
	19	Standard Bank Ltd.	0.793	0.917	0.865	irs				
	20	One Bank Ltd.	0.657	0.888	0.740	irs				
	21	EXIM Bank of BD. Ltd.	0.769	1.000	0.769	irs				
	22	BD. Commerce Bank Ltd.	0.752	0.939	0.801	drs				
	23	Mutual Trust Bank Ltd.	0.901	1.000	0.901	irs				
	24	First Security Bank Ltd.	0.585	1.000	0.585	irs				
	25	The Premier Bank Ltd.	0.354	0.481	0.735	irs				
	26	Bank-Asia Ltd.	0.720	1.000	0.720	irs				
	27	The Trust Bank Ltd.	1.000	1.000	1.000	-				
	28	Jamuna Bank Ltd.	na	na	na	na				
	29	Brac Bank Ltd.	na	na	na	na				
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.645	0.653	0.987	drs	Mean	0.85	0.89	0.95
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.20	0.16	0.10
	33	BD. Shilpa Rin Shangstha	0.613	0.783	0.783	drs	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.997	1.000	0.997	drs	Min.	0.61	0.94	0.658
IPCBs	35	Islami Bank of BD. Ltd.	0.945	0.996	0.948	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	1.000	1.000	1.000	-	Mean	0.96	1.00	0.96
	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.05	0.00	0.05
	38	The Oriental Bank Ltd.	0.888	1.000	0.888	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	na	na	na	na	Min.	0.89	1.00	0.89
FCBs	40	American Express Bank	0.561	1.000	0.561	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.729	0.758	0.961	drs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.983	1.000	0.983	drs				
	45	National Bank of PAK. Ltd.	0.856	1.000	0.856	irs		crste	vrste	scale
	46	City Bank n.a.	1.000	1.000	1.000	-	Mean	0.806	0.900	0.886
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.235	0.165	0.170
	48	The HSBC Ltd.	0.377	0.637	0.592	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.555	0.609	0.911	drs	Min.	0.38	0.61	0.56
		Mean Efficiency	0.831	0.937	0.883					
		Standard Deviation	0.182	0.116	0.130					
		Maximum	1.000	1.000	1.000					
		Minimum	0.354	0.481	0.561					0k

Appendix 8.2.2 Output Oriented DEA Efficiency Score for the Year 2000

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	1.000	1.000	1.000	-	Mean	1.00	1.00	1.00
	2	Janata Bank	1.000	1.000	1.000	-	SD	0.00	0.00	0.000
	3	Agrani Bank	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	1.00	1.00	1.00
PCBs	5	Pubali Bank Ltd.	0.807	1.000	0.807	drs				
	6	Uttara Bank Ltd.	0.988	1.000	0.988	drs				
	7	AB Bank Ltd.	0.635	0.857	0.740	drs				
	8	National Bank Ltd.	0.878	1.000	0.878	drs				
	9	The City Bank Ltd.	0.771	0.793	0.973	drs				
	10	IFIC Bank Ltd.	0.987	1.000	0.987	drs				
	11	UCBL	0.800	0.957	0.836	drs				
	12	Eastern Bank Ltd.	1.000	1.000	1.000	-				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.969	1.000	0.969	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.910	1.000	0.910	drs	Mean	0.84	0.90	0.93
	16	Dhaka Bank Ltd.	0.974	1.000	0.974	drs	SD	0.15	0.14	0.08
	17	Dutch-Bangla Bank Ltd.	0.853	0.899	0.950	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.903	0.930	0.971	drs	Min.	0.57	0.58	0.72
	19	Standard Bank Ltd.	0.866	0.947	0.915	irs				
	20	One Bank Ltd.	0.649	0.665	0.976	irs				
	21	EXIM Bank of BD. Ltd.	0.667	0.739	0.903	drs				
	22	BD. Commerce Bank Ltd.	0.566	0.580	0.977	drs				
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	-				
	24	First Security Bank Ltd.	0.578	0.619	0.934	drs				
	25	The Premier Bank Ltd.	0.686	0.686	1.000	-				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.724	1.000	0.724	irs				
	28	Jamuna Bank Ltd.	na	na	na	na				
	29	Brac Bank Ltd.	na	na	na	na				
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	1.000	1.000	1.000	-	Mean	0.96	0.97	0.99
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.05	0.04	0.02
	33	BD. Shilpa Rin Shangstha	0.912	0.914	0.998	drs	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.890	0.939	0.948	drs	Min.	0.89	0.94	0.658
IPCBs	35	Islami Bank of BD. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.771	0.814	0.947	drs	Mean	0.92	0.95	0.97
	37	Social Investment Bank Ltd.	0.947	1.000	0.947	irs	SD	0.10	0.09	0.03
	38	The Oriental Bank Ltd.	0.969	0.991	0.978	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	na	na	na	na	Min.	0.77	0.81	0.95
FCBs	40	American Express Bank	0.776	0.955	0.813	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	1.000	1.000	1.000	-				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	1.000	1.000	1.000	-				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.830	0.842	0.986	irs	Mean	0.92	0.96	0.960
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.12	0.06	0.081
	48	The HSBC Ltd.	0.682	0.854	0.799	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	1.000	1.000	1.000	-	Min.	0.68	0.84	0.799
		Mean Efficiency	0.891	0.934	0.953					
		Standard Deviation	0.135	0.115	0.071					
		Maximum	1.000	1.000	1.000					
		Minimum	0.566	0.580	0.724					ok

Appendix 8.2.3 Output Oriented DEA Efficiency Score for the Year 2001

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.92	1.00	0.92
	2	Janata Bank	0.875	1.000	0.875	drs	SD	0.058	0.000	0.058
	3	Agrani Bank	0.916	1.000	0.916	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	0.877	1.000	0.877	drs	Min.	0.88	1.00	0.88
PCBs	5	Pubali Bank Ltd.	0.683	1.000	0.683	drs				
	6	Uttara Bank Ltd.	0.889	1.000	0.889	drs				
	7	AB Bank Ltd.	0.662	0.943	0.702	drs				
	8	National Bank Ltd.	0.847	0.956	0.886	drs				
	9	The City Bank Ltd.	0.814	0.882	0.923	drs				
	10	IFIC Bank Ltd.	0.963	1.000	0.963	drs				
	11	UCBL	0.745	0.841	0.887	drs				
	12	Eastern Bank Ltd.	0.911	1.000	0.911	drs				
	13	NCCBL	1.000	1.000	1.000	-				
	14	Prime Bank Ltd.	0.847	1.000	0.847	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.924	1.000	0.924	drs	Mean	0.86	0.95	0.91
	16	Dhaka Bank Ltd.	0.776	0.951	0.816	drs	SD	0.14	0.10	0.11
	17	Dutch-Bangla Bank Ltd.	0.936	0.985	0.950	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.987	1.000	0.987	drs	Min.	0.58	0.64	0.61
	19	Standard Bank Ltd.	1.000	1.000	1.000	-				
	20	One Bank Ltd.	1.000	1.000	1.000	-				
	21	EXIM Bank of BD. Ltd.	0.783	0.875	0.895	drs				
	22	BD. Commerce Bank Ltd.	0.695	0.708	0.982	irs				
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	-				
	24	First Security Bank Ltd.	0.583	0.638	0.913	drs				
	25	The Premier Bank Ltd.	0.902	0.903	0.998	irs				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.975	1.000	0.975	irs				
	28	Jamuna Bank Ltd.	1.000	1.000	1.000	-				
	29	Brac Bank Ltd.	0.605	1.000	0.605	irs				
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	-		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.848	1.000	0.848	drs	Mean	0.96	1.00	0.96
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.07	0.00	0.07
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.945	1.000	0.945	drs	Min.	0.85	0.94	0.66
IPCBs	35	Islami Bank of BD. Ltd.	0.992	1.000	0.992	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	1.000	1.000	1.000	-	Mean	0.87	0.94	0.92
	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.21	0.14	0.11
	38	The Oriental Bank Ltd.	0.830	1.000	0.830	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.523	0.680	0.769	irs	Min.	0.52	0.68	0.77
FCBs	40	American Express Bank	0.827	0.995	0.831	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.857	0.872	0.983	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.945	1.000	0.945	drs				
	45	National Bank of PAK. Ltd.	0.660	1.000	0.660	irs		crste	vrste	scale
	46	City Bank n.a.	0.775	0.822	0.943	drs	Mean	0.858	0.929	0.926
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.128	0.102	0.106
	48	The HSBC Ltd.	0.682	0.710	0.960	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.835	0.886	0.942	irs	Min.	0.660	0.710	0.660
		Mean Efficiency	0.876	0.952	0.919					
		Standard Deviation	0.132	0.088	0.101					
		Maximum	1.000	1.000	1.000					
		Minimum	0.523	0.638	0.605					ok

Appendix 8.2.4 Output Oriented DEA Efficiency Score for the Year 2002

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	1.000	1.000	1.000	-	Mean	0.99	1.00	0.99
	2	Janata Bank	0.985	1.000	0.985	drs	SD	0.018	0.000	0.018
	3	Agrani Bank	0.962	1.000	0.962	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	0.96	1.00	0.96
PCBs	5		0.760	1.000	0.760	drs				
	6	Uttara Bank Ltd.	0.849	1.000	0.849	drs				
	7	AB Bank Ltd.	0.485	0.885	0.548	drs				
	8	National Bank Ltd.	0.796	0.942	0.845	drs				
	9	The City Bank Ltd.	0.826	0.953	0.867	drs				
	10	IFIC Bank Ltd.	0.993	1.000	0.993	drs				
	11	UCBL	0.768	0.920	0.835	drs				
	12	Eastern Bank Ltd.	0.866	1.000	0.866	drs				
	13	NCCBL	0.869	1.000	0.869	drs				
	14	Prime Bank Ltd.	0.767	0.944	0.812	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.708	0.792	0.894	drs	Mean	0.80	0.90	0.89
	16	Dhaka Bank Ltd.	0.962	1.000	0.962	drs	SD	0.14	0.14	0.10
	17	Dutch-Bangla Bank Ltd.	0.775	1.000	0.775	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.938	0.996	0.941	drs	Min.	0.39	0.39	0.55
	19	Standard Bank Ltd.	0.801	0.802	0.999	-				
	20	One Bank Ltd.	0.869	1.000	0.869	drs				
	21	EXIM Bank of BD. Ltd.	0.817	0.911	0.897	drs				
	22	BD. Commerce Bank Ltd.	0.712	0.766	0.929	drs				
	23	Mutual Trust Bank Ltd.	0.870	0.906	0.961	drs				
	24	First Security Bank Ltd.	0.830	0.889	0.934	drs				
	25	The Premier Bank Ltd.	0.902	0.940	0.960	drs				
	26	Bank-Asia Ltd.	1.000	1.000	1.000	-				
	27	The Trust Bank Ltd.	0.668	0.714	0.936	irs				
	28	Jamuna Bank Ltd.	0.656	0.684	0.959	drs				
	29	Brac Bank Ltd.	0.390	0.391	0.997	irs				
SCBs	30	BD. Krishi Bank	0.978	1.000	0.978	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	1.000	1.000	1.000	-	Mean	1.00	1.00	1.00
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.01	0.00	0.01
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	1.000	1.000	1.000	-	Min.	0.98	0.94	0.658
IPCBs	35	Islami Bank of BD. Ltd.	0.831	1.000	0.831	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.591	0.718	0.823	drs	Mean	0.71	0.79	0.90
	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.21	0.22	0.08
	38	The Oriental Bank Ltd.	0.461	0.494	0.933	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.669	0.719	0.930	drs	Min.	0.46	0.49	0.82
FCBs	40	American Express Bank	0.714	0.874	0.817	drs				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.867	0.879	0.985	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.375	0.402	0.933	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.894	0.923	0.969	drs	Mean	0.836	0.876	0.950
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.198	0.180	0.063
	48	The HSBC Ltd.	0.743	0.818	0.909	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.768	0.867	0.886	drs	Min.	0.375	0.402	0.817
		Mean Efficiency	0.831	0.901	0.922					
		Standard Deviation	0.171	0.156	0.090					
		Maximun	1.000	1.000	1.000					
		Minimum	0.375	0.391	0.548					

Appendix 8.2.5 Output Oriented DEA Efficiency Score for the Year 2003

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	0.670	1.000	0.670	drs	Mean	0.69	1.00	0.69
	2	Janata Bank	0.593	1.000	0.593	drs	SD	0.222	0.000	0.222
	3	Agrani Bank	0.485	1.000	0.485	drs	Max.	1.00	1.00	1.00
	4	Rupali Bank	1.000	1.000	1.000	-	Min.	0.49	1.00	0.49
PCBs	5	Pubali Bank Ltd.	0.411	0.854	0.481	drs				
	6	Uttara Bank Ltd.	0.405	0.913	0.444	drs				
	7	AB Bank Ltd.	0.298	0.664	0.449	drs				
	8	National Bank Ltd.	0.470	0.931	0.505	drs				
	9	The City Bank Ltd.	0.401	0.847	0.473	drs				
	10	IFIC Bank Ltd.	0.397	0.897	0.442	drs				
	11	UCBL	0.509	0.895	0.569	drs				
	12	Eastern Bank Ltd.	0.635	0.885	0.718	drs				
	13	NCCBL	0.565	0.803	0.703	drs				
	14	Prime Bank Ltd.	0.503	0.910	0.553	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.652	1.000	0.652	drs	Mean	0.59	0.89	0.66
	16	Dhaka Bank Ltd.	0.816	1.000	0.816	drs	SD	0.17	0.14	0.14
	17	Dutch-Bangla Bank Ltd.	0.464	0.775	0.599	drs	Max.	0.90	1.00	0.90
	18	Mercantile Bank Ltd.	0.702	1.000	0.702	drs	Min.	0.30	0.50	0.44
	19	Standard Bank Ltd.	0.730	1.000	0.730	drs				
	20	One Bank Ltd.	0.814	0.929	0.876	drs				
	21	EXIM Bank of BD. Ltd.	0.729	1.000	0.729	drs				
	22	BD. Commerce Bank Ltd.	0.383	0.533	0.719	drs				
	23	Mutual Trust Bank Ltd.	0.900	1.000	0.900	drs				
	24	First Security Bank Ltd.	0.653	0.977	0.668	drs				
	25	The Premier Bank Ltd.	0.714	1.000	0.714	drs				
	26	Bank-Asia Ltd.	0.750	1.000	0.750	drs				
	27	The Trust Bank Ltd.	0.425	0.495	0.859	drs				
	28	Jamuna Bank Ltd.	0.707	0.973	0.726	drs				
	29	Brac Bank Ltd.	0.840	1.000	0.840	drs				
SCBs	30	BD. Krishi Bank	0.510	0.939	0.544	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.474	0.874	0.543	drs	Mean	0.72	0.93	0.77
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.26	0.08	0.23
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.623	0.821	0.758	drs	Min.	0.47	0.94	0.658
IPCBs	35	Islami Bank of BD. Ltd.	0.743	1.000	0.743	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.415	0.633	0.655	drs	Mean	0.63	0.86	0.73
	37	Social Investment Bank Ltd.	0.950	1.000	0.950	drs	SD	0.22	0.20	0.14
	38	The Oriental Bank Ltd.	0.572	0.995	0.575	drs	Max.	0.95	1.00	0.95
	39	Shahjalal Bank Ltd.	0.480	0.649	0.739	drs	Min.	0.42	0.63	0.58
FCBs	40	American Express Bank	0.433	0.573	0.755	drs				
	41	Standard Chart Bank U.K.	0.819	1.000	0.819	drs				
	42	Habib Bank Ltd.	0.742	1.000	0.742	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.455	0.635	0.716	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.586	0.829	0.707	drs	Mean	0.737	0.904	0.808
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.216	0.167	0.140
	48	The HSBC Ltd.	0.699	1.000	0.699	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.638	1.000	0.638	irs	Min.	0.43	0.57	0.64
		Mean Efficiency	0.648	0.903	0.713					
		Standard Deviation	0.200	0.144	0.166					
		Maximun	1.000	1.000	1.000					
		Minimum	0.298	0.495	0.442					ok

Appendix 8.2.6 Output Oriented DEA Efficiency Score for the Year 2004

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	0.731	1.000	0.731	drs	Mean	0.70	1.00	0.70
	2	Janata Bank	0.702	1.000	0.702	drs	SD	0.048	0.001	0.047
	3	Agrani Bank	0.742	1.000	0.742	drs	Max.	0.74	1.00	0.74
	4	Rupali Bank	0.636	0.999	0.637	drs	Min.	0.64	1.00	0.64
PCBs	5	Pubali Bank Ltd.	0.529	1.000	0.529	drs				
	6	Uttara Bank Ltd.	0.746	1.000	0.746	drs				
	7	AB Bank Ltd.	0.420	0.815	0.516	drs				
	8	National Bank Ltd.	0.776	1.000	0.776	drs				
	9	The City Bank Ltd.	0.697	0.973	0.716	drs				
	10	IFIC Bank Ltd.	0.781	1.000	0.781	drs				
	11	UCBL	0.762	1.000	0.762	drs				
	12	Eastern Bank Ltd.	0.809	1.000	0.809	drs				
	13	NCCBL	0.874	0.964	0.907	drs				
	14	Prime Bank Ltd.	0.655	0.961	0.682	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.604	1.000	0.604	drs	Mean	0.71	0.94	0.75
	16	Dhaka Bank Ltd.	0.614	1.000	0.614	drs	SD	0.12	0.10	0.11
	17	Dutch-Bangla Bank Ltd.	0.685	0.804	0.852	drs	Max.	0.92	1.00	0.92
	18	Mercantile Bank Ltd.	0.841	1.000	0.841	drs	Min.	0.42	0.67	0.52
	19	Standard Bank Ltd.	0.703	1.000	0.703	drs				
	20	One Bank Ltd.	0.662	0.937	0.706	drs				
	21	EXIM Bank of BD. Ltd.	0.866	1.000	0.866	drs				
	22	BD. Commerce Bank Ltd.	0.585	0.673	0.870	drs				
	23	Mutual Trust Bank Ltd.	0.918	1.000	0.918	drs				
	24	First Security Bank Ltd.	0.729	0.980	0.744	drs				
	25	The Premier Bank Ltd.	0.793	1.000	0.793	drs				
	26	Bank-Asia Ltd.	0.662	1.000	0.662	drs				
	27	The Trust Bank Ltd.	0.639	0.698	0.917	drs				
	28	Jamuna Bank Ltd.	0.752	0.888	0.846	drs				
	29	Brac Bank Ltd.	0.581	0.826	0.703	drs				
SCBs	30	BD. Krishi Bank	0.617	0.940	0.657	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.706	1.000	0.706	drs	Mean	0.85	0.99	0.86
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.18	0.03	0.17
	33	BD. Shilpa Rin Shangstha	1.000	1.000	1.000	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.939	1.000	0.939	drs	Min.	0.62	0.94	0.66
IPCBs	35	Islami Bank of BD. Ltd.	0.901	1.000	0.901	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.613	0.834	0.735	drs	Mean	0.75	0.92	0.80
	37	Social Investment Bank Ltd.	1.000	1.000	1.000	-	SD	0.20	0.11	0.14
	38	The Oriental Bank Ltd.	0.693	1.000	0.693	drs	Max.	1.00	1.00	1.00
	39	Shahjalal Bank Ltd.	0.528	0.780	0.676	drs	Min.	0.53	0.78	0.68
FCBs	40	American Express Bank	0.474	0.634	0.748	drs				
	41	Standard Chart Bank U.K.	0.997	1.000	0.997	drs				
	42	Habib Bank Ltd.	0.643	1.000	0.643	irs				
	43	State Bank of India Ltd.	1.000	1.000	1.000	-				
	44	Credit Agricole Indosuez	0.650	0.783	0.830	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.756	1.000	0.756	drs	Mean	0.790	0.937	0.839
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.195	0.126	0.148
	48	The HSBC Ltd.	0.727	0.949	0.766	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.651	1.000	0.651	irs	Min.	0.474	0.634	0.643
		Mean Efficiency	0.743	0.948	0.783					
		Standard Deviation	0.150	0.099	0.131					
		Maximun	1.000	1.000	1.000					
		Minimum	0.420	0.634	0.516					ok

Appendix 8.2.7 Output Oriented DEA Efficiency Score for the Year 2005

Type		Name of Banks	crste	vrste	scale	rs		crste	vrste	scale
NCBs	1	Sonali Bank	0.847	1.000	0.847	drs	Mean	0.76	0.99	0.76
	2	Janata Bank	0.746	1.000	0.746	drs	SD	0.070	0.027	0.057
	3	Agrani Bank	0.749	1.000	0.749	drs	Max.	0.85	1.00	0.85
	4	Rupali Bank	0.678	0.947	0.716	drs	Min.	0.68	0.95	0.72
PCBs	5	Pubali Bank Ltd.	0.634	1.000	0.634	drs				
	6	Uttara Bank Ltd.	0.724	0.984	0.736	drs				
	7	AB Bank Ltd.	0.250	0.345	0.724	drs				
	8	National Bank Ltd.	0.588	0.808	0.728	drs				
	9	The City Bank Ltd.	0.639	0.888	0.720	drs				
	10	IFIC Bank Ltd.	0.584	0.722	0.808	drs				
	11	UCBL	0.720	0.893	0.807	drs				
	12	Eastern Bank Ltd.	0.767	0.898	0.854	drs				
	13	NCCBL	0.806	0.960	0.840	drs				
	14	Prime Bank Ltd.	0.659	0.885	0.745	drs		crste	vrste	scale
	15	South East Bank Ltd.	0.714	0.943	0.757	drs	Mean	0.70	0.87	0.80
	16	Dhaka Bank Ltd.	1.000	1.000	1.000	-	SD	0.17	0.16	0.12
	17	Dutch-Bangla Bank Ltd.	0.604	0.754	0.801	drs	Max.	1.00	1.00	1.00
	18	Mercantile Bank Ltd.	0.653	0.931	0.701	drs	Min.	0.25	0.35	0.54
	19	Standard Bank Ltd.	0.754	0.979	0.770	drs				
	20	One Bank Ltd.	0.584	0.584	1.000	-				
	21	EXIM Bank of BD. Ltd.	1.000	1.000	1.000	-				
	22	BD. Commerce Bank Ltd.	0.753	0.762	0.988	drs				
	23	Mutual Trust Bank Ltd.	0.899	1.000	0.899	drs				
	24	First Security Bank Ltd.	0.538	1.000	0.538	drs				
	25	The Premier Bank Ltd.	0.705	1.000	0.705	drs				
	26	Bank-Asia Ltd.	0.627	0.945	0.664	drs				
	27	The Trust Bank Ltd.	1.000	1.000	1.000	-				
	28	Jamuna Bank Ltd.	0.676	0.829	0.816	drs				
	29	Brac Bank Ltd.	0.534	0.726	0.735	drs				
SCBs	30	BD. Krishi Bank	0.471	0.744	0.632	drs		crste	vrste	scale
	31	Raj. Krishi Unnayan Bank	0.778	0.865	0.899	drs	Mean	0.77	0.87	0.86
	32	BD. Shilpa Bank	1.000	1.000	1.000	-	SD	0.22	0.11	0.16
	33	BD. Shilpa Rin Shangstha	na	na	na	-	Max.	1.00	1.00	1.00
	34	BASIC Bank Ltd.	0.814	0.889	0.916	drs	Min.	0.47	0.94	0.66
IPCBs	35	Islami Bank of BD. Ltd.	0.903	1.000	0.903	drs		crste	vrste	scale
	36	Al- Arafa Islami Bank Ltd.	0.206	0.269	0.764	drs	Mean	0.62	0.76	0.80
	37	Social Investment Bank Ltd.	0.653	0.819	0.798	drs	SD	0.29	0.33	0.07
	38	The Oriental Bank Ltd.	na	na	na	na	Max.	0.90	1.00	0.90
	39	Shahjalal Bank Ltd.	0.698	0.933	0.748	drs	Min.	0.21	0.27	0.75
FCBs	40	American Express Bank	na	na	na	na				
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	-				
	42	Habib Bank Ltd.	0.720	1.000	0.720	irs				
	43	State Bank of India Ltd.	0.946	1.000	0.946	irs				
	44	Credit Agricole Indosuez	0.691	0.730	0.947	drs				
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	-		crste	vrste	scale
	46	City Bank n.a.	0.910	1.000	0.910	drs	Mean	0.857	0.970	0.885
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	-	SD	0.145	0.090	0.133
	48	The HSBC Ltd.	0.798	1.000	0.798	drs	Max.	1.00	1.00	1.00
	49	Shamil Bank of Bahrain E.C.	0.644	1.000	0.644	irs	Min.	0.644	0.730	0.644
		Mean Efficiency	0.732	0.892	0.819					
		Standard Deviation	0.181	0.166	0.123					
		Maximun	1.000	1.000	1.000					
		Minimum	0.206	0.269	0.538					

Appendix 8.2.8 Output Oriented CRS DEA Efficiency Scores Over the Years 1999-2005

Type		Name of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	0.670	0.731	0.847	0.893	0.144
	2	Janata Bank	1.000	1.000	0.875	0.985	0.593	0.702	0.746	0.843	0.164
	3	Agrani Bank	1.000	1.000	0.916	0.962	0.485	0.742	0.749	0.836	0.190
	4	Rupali Bank	0.923	1.000	0.877	1.000	1.000	0.636	0.678	0.873	0.156
PCBs	5	Pubali Bank Ltd.	0.665	0.807	0.683	0.760	0.411	0.529	0.634	0.641	0.135
	6	Uttara Bank Ltd.	0.826	0.988	0.889	0.849	0.405	0.746	0.724	0.775	0.186
	7	AB Bank Ltd.	0.609	0.635	0.662	0.485	0.298	0.420	0.250	0.480	0.165
	8	National Bank Ltd.	0.864	0.878	0.847	0.796	0.470	0.776	0.588	0.746	0.156
	9	The City Bank Ltd.	0.876	0.771	0.814	0.826	0.401	0.697	0.639	0.718	0.161
	10	IFIC Bank Ltd.	1.000	0.987	0.963	0.993	0.397	0.781	0.584	0.815	0.240
	11	UCBL	0.787	0.800	0.745	0.768	0.509	0.762	0.720	0.727	0.100
	12	Eastern Bank Ltd.	0.902	1.000	0.911	0.866	0.635	0.809	0.767	0.841	0.118
	13	NCCBL	1.000	1.000	1.000	0.869	0.565	0.874	0.806	0.873	0.157
	14	Prime Bank Ltd.	0.759	0.969	0.847	0.767	0.503	0.655	0.659	0.737	0.150
	15	South East Bank Ltd.	0.726	0.910	0.924	0.708	0.652	0.604	0.714	0.748	0.123
	16	Dhaka Bank Ltd.	1.000	0.974	0.776	0.962	0.816	0.614	1.000	0.877	0.147
	17	Dutch-Bangla Bank Ltd.	1.000	0.853	0.936	0.775	0.464	0.685	0.604	0.760	0.189
	18	Mercantile Bank Ltd.	0.591	0.903	0.987	0.938	0.702	0.841	0.653	0.802	0.153
	19	Standard Bank Ltd.	0.793	0.866	1.000	0.801	0.730	0.703	0.754	0.807	0.100
	20	One Bank Ltd.	0.657	0.649	1.000	0.869	0.814	0.662	0.584	0.748	0.150
	21	EXIM Bank of BD. Ltd.	0.769	0.667	0.783	0.817	0.729	0.866	1.000	0.804	0.107
	22	BD. Commerce Bank Ltd.	0.752	0.566	0.695	0.712	0.383	0.585	0.753	0.635	0.134
	23	Mutual Trust Bank Ltd.	0.901	1.000	1.000	0.870	0.900	0.918	0.899	0.927	0.052
	24	First Security Bank Ltd.	0.585	0.578	0.583	0.830	0.653	0.729	0.538	0.642	0.104
	25	The Premier Bank Ltd.	0.354	0.686	0.902	0.902	0.714	0.793	0.705	0.722	0.186
	26	Bank-Asia Ltd.	0.720	1.000	1.000	1.000	0.750	0.662	0.627	0.823	0.170
	27	The Trust Bank Ltd.	1.000	0.724	0.975	0.668	0.425	0.639	1.000	0.776	0.222
	28	Jamuna Bank Ltd.	na	na	1.000	0.656	0.707	0.752	0.676	0.758	0.140
	29	Brac Bank Ltd.	na	na	0.605	0.390	0.840	0.581	0.534	0.590	0.163
SCBs	30	BD. Krishi Bank	1.000	1.000	1.000	0.978	0.510	0.617	0.471	0.797	0.251
	31	Raj. Krishi Unnayan Bank	0.645	1.000	0.848	1.000	0.474	0.706	0.778	0.779	0.191
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	33	BD. Shilpa Rin Shangstha	0.613	0.912	1.000	1.000	1.000	1.000	na	0.921	0.155
	34	BASIC Bank Ltd.	0.997	0.890	0.945	1.000	0.623	0.939	0.814	0.887	0.133
IPCBs	35	Islami Bank of BD. Ltd.	0.945	1.000	0.992	0.831	0.743	0.901	0.903	0.902	0.091
	36	Al- Arafa Islami Bank Ltd.	1.000	0.771	1.000	0.591	0.415	0.613	0.206	0.657	0.293
	37	Social Investment Bank Ltd.	1.000	0.947	1.000	1.000	0.950	1.000	0.653	0.936	0.127
	38	The Oriental Bank Ltd.	0.888	0.969	0.830	0.461	0.572	0.693	na	0.736	0.195
	39	Shahjalal Bank Ltd.	na	na	0.523	0.669	0.480	0.528	0.698	0.580	0.097
FCBs	40	American Express Bank	0.561	0.776	0.827	0.714	0.433	0.474	na	0.631	0.164
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	1.000	0.819	0.997	1.000	0.974	0.068
	42	Habib Bank Ltd.	0.729	1.000	0.857	0.867	0.742	0.643	0.720	0.794	0.120
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.946	0.992	0.020
	44	Credit Agricole Indosuez	0.983	1.000	0.945	0.375	0.455	0.650	0.691	0.728	0.256
	45	National Bank of PAK. Ltd.	0.856	1.000	0.660	1.000	1.000	1.000	1.000	0.931	0.131
	46	City Bank n.a.	1.000	0.830	0.775	0.894	0.586	0.756	0.910	0.822	0.134
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	48	The HSBC Ltd.	0.377	0.682	0.682	0.743	0.699	0.727	0.798	0.673	0.137
	49	Shamil Bank of Bahrain E.C.	0.555	1.000	0.835	0.768	0.638	0.651	0.644	0.727	0.152
		Mean Efficiency	0.831	0.891	0.876	0.831	0.648	0.743	0.732		
		Standard Deviation	0.182	0.135	0.132	0.168	0.200	0.150	0.181		
		Maximun	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
		Minimum	0.354	0.566	0.523	0.375	0.298	0.420	0.206		

Appendix 8.2.9 Output Oriented DEA Returns to Scale Rating 1999-2005

Bank Type		Name of Banks	1999	2000	2001	2002	2003	2004	2005
NCBs	1	Sonali Bank	-	-	-	-	drs	drs	drs
	2	Janata Bank	-	-	drs	drs	drs	drs	drs
	3	Agrani Bank	-	-	drs	drs	drs	drs	drs
	4	Rupali Bank	drs	-	drs	-	-	drs	drs
PCBs	5	Pubali Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	6	Uttara Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	7	AB Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	8	National Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	9	The City Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	10	IFIC Bank Ltd.	-	drs	drs	drs	drs	drs	drs
	11	UCBL	drs	drs	drs	drs	drs	drs	drs
	12	Eastern Bank Ltd.	drs	-	drs	drs	drs	drs	drs
	13	NCCBL	-	-	-	drs	drs	drs	drs
	14	Prime Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	15	South East Bank Ltd.	drs	drs	drs	drs	drs	drs	drs
	16	Dhaka Bank Ltd.	-	drs	drs	drs	drs	drs	-
	17	Dutch-Bangla Bank Ltd.	-	drs	drs	drs	drs	drs	drs
	18	Mercantile Bank Ltd.	irs	drs	drs	drs	drs	drs	drs
	19	Standard Bank Ltd.	irs	irs	-	-	drs	drs	drs
	20	One Bank Ltd.	irs	irs	-	drs	drs	drs	-
	21	EXIM Bank of BD. Ltd.	irs	drs	drs	drs	drs	drs	-
	22	BD. Commerce Bank Ltd.	drs	drs	irs	drs	drs	drs	drs
	23	Mutual Trust Bank Ltd.	irs	-	-	drs	drs	drs	drs
	24	First Security Bank Ltd.	irs	drs	drs	drs	drs	drs	drs
	25	The Primier Bank Ltd.	irs	-	irs	drs	drs	drs	drs
	26	Bank-Asia Ltd.	irs	-	-	-	drs	drs	drs
	27	The Trust Bank Ltd.	-	irs	irs	irs	drs	drs	-
	28	Jamuna Bank Ltd.	na	na	-	drs	drs	drs	drs
	29	Brac Bank Ltd.	na	na	irs	irs	drs	drs	drs
SCBSs	30	BD. Krishi Bank	-	-	-	drs	drs	drs	drs
	31	Raj. Krishi Unnayan Bank	drs	-	drs	-	drs	drs	drs
	32	BD. Shilpa Bank	-	-	-	-	-	-	-
	33	BD. Shilpa Rin Shangstha	drs	drs	-	-	-	-	-
	34	BASIC Bank Ltd.	drs	drs	drs	-	drs	drs	drs
IPCBs	35	Islami Bank of BD. Ltd.	drs	-	drs	drs	drs	drs	drs
	36	Al- Arafa Islami Bank Ltd.	-	drs	-	drs	drs	drs	drs
	37	Social Investment Bank Ltd.	-	irs	-	-	drs	-	drs
	38	The Oriental Bank Ltd.	drs	drs	drs	drs	drs	drs	na
	39	Shahjalal Bank Ltd.	na	na	irs	drs	drs	drs	drs
FCBs	40	American Express Bank	drs	drs	drs	drs	drs	drs	na
	41	Standard Chart Bank U.K.	-	-	-	-	drs	drs	-
	42	Habib Bank Ltd.	drs	-	irs	irs	irs	irs	irs
	43	State Bank of India Ltd.	-	-	-	-	-	-	irs
	44	Credit Agricole Indosuez	drs	-	drs	drs	drs	drs	drs
	45	National Bank of PAK. Ltd.	irs	-	irs	-	-	-	-
	46	City Bank n.a.	-	irs	drs	drs	drs	drs	drs
	47	HANVIT (Woori) Bank Ltd.	-	-	-	-	-	-	-
	48	The HSBC Ltd.	drs	drs	drs	drs	drs	drs	drs
	49	Shamil Bank of Bahrain E.C.	drs	-	irs	drs	irs	irs	irs

Appendix 8.2.10 Output Oriented Scale DEA Technical Efficiency Scores 1999-2005

Type		Name of banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	0.670	0.731	0.847	0.893	0.144
	2	Janata Bank	1.000	1.000	0.875	0.985	0.593	0.702	0.746	0.843	0.164
	3	Agrani Bank	1.000	1.000	0.916	0.962	0.485	0.742	0.749	0.836	0.19
	4	Rupali Bank	0.923	1.000	0.877	1.000	1.000	0.637	0.716	0.879	0.148
PCBs	5	Pubali Bank Ltd.	0.665	0.807	0.683	0.760	0.481	0.529	0.634	0.651	0.117
	6	Uttara Bank Ltd.	0.834	0.988	0.889	0.849	0.444	0.746	0.736	0.784	0.173
	7	AB Bank Ltd.	0.650	0.740	0.702	0.548	0.449	0.516	0.724	0.618	0.114
	8	National Bank Ltd.	0.864	0.878	0.886	0.845	0.505	0.776	0.728	0.783	0.136
	9	The City Bank Ltd.	0.950	0.973	0.923	0.867	0.473	0.716	0.720	0.803	0.179
	10	IFIC Bank Ltd.	1.000	0.987	0.963	0.993	0.442	0.781	0.808	0.853	0.203
	11	UCBL	0.787	0.836	0.887	0.835	0.569	0.762	0.807	0.783	0.103
	12	Eastern Bank Ltd.	0.902	1.000	0.911	0.866	0.718	0.809	0.854	0.866	0.088
	13	NCCBL	1.000	1.000	1.000	0.869	0.703	0.907	0.840	0.903	0.111
	14	Prime Bank Ltd.	0.759	0.969	0.847	0.812	0.553	0.682	0.745	0.767	0.131
	15	South East Bank Ltd.	0.726	0.910	0.924	0.894	0.652	0.604	0.757	0.781	0.13
	16	Dhaka Bank Ltd.	1.000	0.974	0.816	0.962	0.816	0.614	1.000	0.883	0.143
	17	Dutch-Bangla Bank Ltd.	1.000	0.950	0.950	0.775	0.599	0.852	0.801	0.847	0.138
	18	Mercantile Bank Ltd.	0.978	0.971	0.987	0.941	0.702	0.841	0.701	0.874	0.128
	19	Standard Bank Ltd.	0.865	0.915	1.000	0.999	0.730	0.703	0.770	0.855	0.123
	20	One Bank Ltd.	0.740	0.976	1.000	0.869	0.876	0.706	1.000	0.881	0.121
	21	EXIM Bank of BD. Ltd.	0.769	0.903	0.895	0.897	0.729	0.866	1.000	0.866	0.091
	22	BD. Commerce Bank Ltd.	0.801	0.977	0.982	0.929	0.719	0.870	0.988	0.895	0.104
	23	Mutual Trust Bank Ltd.	0.901	1.000	1.000	0.961	0.900	0.918	0.899	0.940	0.046
	24	First Security Bank Ltd.	0.585	0.934	0.913	0.934	0.668	0.744	0.538	0.759	0.17
	25	The Premier Bank Ltd.	0.735	1.000	0.998	0.960	0.714	0.793	0.705	0.844	0.137
	26	Bank-Asia Ltd.	0.720	1.000	1.000	1.000	0.750	0.662	0.664	0.828	0.164
	27	The Trust Bank Ltd.	1.000	0.724	0.975	0.936	0.859	0.917	1.000	0.916	0.098
	28	Jamuna Bank Ltd.	na	na	1.000	0.959	0.726	0.846	0.816	0.869	0.111
	29	Brac Bank Ltd.	na	na	0.605	0.997	0.840	0.703	0.735	0.776	0.149
SCBSs	30	BD. Krishi Bank	1.000	1.000	1.000	0.978	0.544	0.657	0.632	0.830	0.208
	31	Raj. Krishi Unnayan Bank	0.987	1.000	0.848	1.000	0.543	0.706	0.899	0.855	0.174
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0
	33	BD. Shilpa Rin Shangstha	0.783	0.998	1.000	1.000	1.000	1.000	na	0.964	0.088
	34	BASIC Bank Ltd.	0.997	0.948	0.945	1.000	0.758	0.939	0.916	0.929	0.081
IPCBs	35	Islami Bank of BD. Ltd.	0.948	1.000	0.992	0.831	0.743	0.901	0.903	0.903	0.091
	36	Al- Arafa Islami Bank Ltd.	1.000	0.947	1.000	0.823	0.655	0.735	0.764	0.846	0.138
	37	Social Investment Bank Ltd.	1.000	0.947	1.000	1.000	0.950	1.000	0.798	0.956	0.074
	38	The Oriental Bank Ltd.	0.888	0.978	0.830	0.933	0.575	0.693	na	0.816	0.154
	39	Shahjalal Bank Ltd.	na	na	0.769	0.930	0.739	0.676	0.748	0.772	0.095
FCBs	40	American Express Bank	0.561	0.813	0.831	0.817	0.755	0.748	na	0.754	0.101
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	1.000	0.819	0.997	1.000	0.974	0.068
	42	Habib Bank Ltd.	0.961	1.000	0.983	0.985	0.742	0.643	0.720	0.862	0.153
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.946	0.992	0.02
	44	Credit Agricole Indosuez	0.983	1.000	0.945	0.933	0.716	0.830	0.947	0.908	0.1
	45	National Bank of PAK. Ltd.	0.856	1.000	0.660	1.000	1.000	1.000	1.000	0.931	0.131
	46	City Bank n.a.	1.000	0.986	0.943	0.969	0.707	0.756	0.910	0.896	0.117
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0
	48	The HSBC Ltd.	0.592	0.799	0.960	0.909	0.699	0.766	0.798	0.789	0.123
	49	Shamil Bank of Bahrain E.C.	0.911	1.000	0.942	0.886	0.638	0.651	0.644	0.810	0.159
		Mean Efficiency	0.883	0.953	0.919	0.922	0.713	0.783	0.819		
		Standard Deviation	0.130	0.071	0.101	0.090	0.166	0.131	0.123		
		Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
		Minimum	0.561	0.724	0.605	0.548	0.442	0.516	0.538		

Appendix 8.2.11 Output Oriented VRS DEA Technical Efficiency Scores, 1999-2005

Type		Name of Banks	1999	2000	2001	2002	2003	2004	2005	Mean	SD
NCBs	1	Sonali Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	2	Janata Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	3	Agrani Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	4	Rupali Bank	1.000	1.000	1.000	1.000	1.000	0.999	0.947	0.992	0.020
PCBs	5	Pubali Bank Ltd.	1.000	1.000	1.000	1.000	0.854	1.000	1.000	0.979	0.055
	6	Uttara Bank Ltd.	0.990	1.000	1.000	1.000	0.913	1.000	0.984	0.984	0.032
	7	AB Bank Ltd.	0.938	0.857	0.943	0.885	0.664	0.815	0.345	0.778	0.213
	8	National Bank Ltd.	1.000	1.000	0.956	0.942	0.931	1.000	0.808	0.948	0.068
	9	The City Bank Ltd.	0.923	0.793	0.882	0.953	0.847	0.973	0.888	0.894	0.062
	10	IFIC Bank Ltd.	1.000	1.000	1.000	1.000	0.897	1.000	0.722	0.946	0.106
	11	UCBL	1.000	0.957	0.841	0.920	0.895	1.000	0.893	0.929	0.059
	12	Eastern Bank Ltd.	1.000	1.000	1.000	1.000	0.885	1.000	0.898	0.969	0.053
	13	NCCBL	1.000	1.000	1.000	1.000	0.803	0.964	0.960	0.961	0.072
	14	Prime Bank Ltd.	1.000	1.000	1.000	0.944	0.910	0.961	0.885	0.957	0.047
	15	South East Bank Ltd.	1.000	1.000	1.000	0.792	1.000	1.000	0.943	0.962	0.078
	16	Dhaka Bank Ltd.	1.000	1.000	0.951	1.000	1.000	1.000	1.000	0.993	0.019
	17	Dutch-Bangla Bank Ltd.	1.000	0.899	0.985	1.000	0.775	0.804	0.754	0.888	0.110
	18	Mercantile Bank Ltd.	0.604	0.930	1.000	0.996	1.000	1.000	0.931	0.923	0.144
	19	Standard Bank Ltd.	0.917	0.947	1.000	0.802	1.000	1.000	0.979	0.949	0.072
	20	One Bank Ltd.	0.888	0.665	1.000	1.000	0.929	0.937	0.584	0.858	0.166
	21	EXIM Bank of BD. Ltd.	1.000	0.739	0.875	0.911	1.000	1.000	1.000	0.932	0.100
	22	BD. Commerce Bank Ltd.	0.939	0.580	0.708	0.766	0.533	0.673	0.762	0.709	0.134
	23	Mutual Trust Bank Ltd.	1.000	1.000	1.000	0.906	1.000	1.000	1.000	0.987	0.036
	24	First Security Bank Ltd.	1.000	0.619	0.638	0.889	0.977	0.980	1.000	0.872	0.171
	25	The Premier Bank Ltd.	0.481	0.686	0.903	0.940	1.000	1.000	1.000	0.859	0.200
	26	Bank-Asia Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.945	0.992	0.021
	27	The Trust Bank Ltd.	1.000	1.000	1.000	0.714	0.495	0.698	1.000	0.844	0.207
	28	Jamuna Bank Ltd.	na	na	1.000	0.684	0.973	0.888	0.829	0.875	0.126
	29	Brac Bank Ltd.	na	na	1.000	0.391	1.000	0.826	0.726	0.789	0.251
SCBSs	30	BD. Krishi Bank	1.000	1.000	1.000	1.000	0.939	0.940	0.744	0.946	0.094
	31	Raj. Krishi Unnayan Bank	0.653	1.000	1.000	1.000	0.874	1.000	0.865	0.913	0.130
	32	BD. Shilpa Bank	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	33	BD. Shilpa Rin Shangstha	0.783	0.914	1.000	1.000	1.000	1.000	na	0.950	0.089
	34	BASIC Bank Ltd.	1.000	0.939	1.000	1.000	0.821	1.000	0.889	0.950	0.071
IPCBs	35	Islami Bank of BD. Ltd.	0.996	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.002
	36	Al- Arafa Islami Bank Ltd.	1.000	0.814	1.000	0.718	0.633	0.834	0.269	0.753	0.252
	37	Social Investment Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	0.819	0.974	0.068
	38	The Oriental Bank Ltd.	1.000	0.991	1.000	0.494	0.995	1.000	na	0.913	0.205
	39	Shahjalal Bank Ltd.	na	na	0.680	0.719	0.649	0.780	0.933	0.752	0.112
FCBs	40	American Express Bank	1.000	0.955	0.995	0.874	0.573	0.634	na	0.839	0.189
	41	Standard Chart Bank U.K.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	42	Habib Bank Ltd.	0.758	1.000	0.872	0.879	1.000	1.000	1.000	0.930	0.096
	43	State Bank of India Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	44	Credit Agricole Indosuez	1.000	1.000	1.000	0.402	0.635	0.783	0.730	0.793	0.227
	45	National Bank of PAK. Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	46	City Bank n.a.	1.000	0.842	0.822	0.923	0.829	1.000	1.000	0.917	0.085
	47	HANVIT (Woori) Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
	48	The HSBC Ltd.	0.637	0.854	0.710	0.818	1.000	0.949	1.000	0.853	0.142
	49	Shamil Bank of Bahrain E.C.	0.609	1.000	0.886	0.867	1.000	1.000	1.000	0.909	0.145
		Mean Efficiency	0.937	0.934	0.952	0.901	0.903	0.948	0.892	0.924	0.025
		Standard Deviation	0.116	0.115	0.088	0.156	0.144	0.099	0.166	0.126	0.029
		Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000
		Minimum	0.481	0.580	0.638	0.391	0.495	0.634	0.269	0.498	0.135

Chapter 9

Conclusions and Recommendations

9.1 Introduction

This study examines the technical efficiency scores of the commercial banks of Bangladesh over the period 1999-2005 on the background of reform deregulation and technological changes that have been taken place during the last two decades. As such it provides a contribution to the discussion of banking performance in Bangladesh. This study explores banking productivity in terms of technical efficiency estimates over a seven year time period to see the efficiency changes of the individual commercial banks and within their categories as well as the whole of the banking sector. In this connection we like to mention a brief story of the commercial banks of Bangladesh. In 1972, immediately after liberation of Bangladesh, the banking sector starts functioning with organising the leftover bank branches of the Pakistani owners. Mainly, those branches constitute some new banks. The leftover local branches of the State Bank of Pakistan located in East Pakistan (Bangladesh) region together formed the central bank for the newly born Bangladesh. At that time two private banks under Bengali ownership naming Uttara and Pubali start banking operation. The entire banking system excluding a few foreign banks branches are restructured and nationalised in 1972, which can be termed as a major reform and basic change in the banking sector. During the 70's the main characteristics of the banking activities are to expand bank branches in the far-reaching areas. Most of the present banking problems have been implanted during mid 75 to 80's. The main cause may be noted that the nationalised banking sector had been utilised for political patronage. Khaled (2003) indicates that lack of proper planning before nationalisation and failure to undertake proper reform measures after nationalisation are major reasons for poor performance of nationalisation regime (1972-1982) of the banks. Eventually the banking sector has been subject to and reform. Results of the reform measures imply that failures to identify the inefficiency factors are essentially responsible for wastefulness in the country's banking sector. However, in the context of global reform, deregulation and liberalisation in the financial sector, Bangladesh adopted liberalisation, deregulation policies to make her financial sector more competitive.

In these circumstances the banking sector of Bangladesh needs a through investigation of the efficiency criteria. This study examines the productive efficiencies of the commercial banks of Bangladesh. We give in the next Section a brief account of the Chapters described in the meantime. Conclusion and some recommendations are made in the final section.

9.2. Summary

In the second chapter, we have reviewed in detail literature related to productivity, performance and efficiency of banking sector of Bangladesh. Since objectives of this study is to measure technical efficiency of the commercial banks of Bangladesh, during the period 1999-2005 on the ground of liberalized banking policies. While many similar studies have evaluation the performance of banking sector in the US and other advanced countries, very few studies have evaluated the performance of banking sector of Bangladesh. Although saha et. al.(1994), Choudhuri and Choudhury (1993), Choudhury (1988), Bhuiyan and Akhtaruddin (1989), Cookson(1989), Shakoor (1989) have examine various issues relating to the performance of commercial banks of Bangladesh, none of these studies have examined the technical, overall, pure technical efficiency and scale efficiencies of commercial banks of Bangladesh and used frontier analysis. Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis have been popular since Aigner, Lovell and Schmidt (1977) and Charnes, Coopers and Rhodes (1978). In an influential article, Farrell (1957) proposes two ways to estimate efficiency of firms in production. Farrell's presentation is outstanding and pioneering in finding two distinct and methodologically different ways to obtain measures of efficiency. We have discussed the pioneering works of Ferrier and Lovell (1990), Berger and Humphrey (1997), Bhattacharyya et. al.(1998) who applied production frontier analysis to measures productive efficiencies of banks. Our study in this field is justified by the sense that none attempt to measure productivity efficiencies of commercial banks in Bangladesh.

In chapter 3 we have made a through assessment on the banking sector of Bangladesh on the basis of collected data. We provided description for various characterisations of the banking variables. In various tables we examine relative shares and growth rates of the variables over time. We construct tables for changes of banks and branches by categories and over time, static picture on status of banking sector, magnitude of the banking sector to the economy, shares banking sector to financial system and to GDP. We discussed structure of banking sector of Bangladesh and categorisation. We discussed the components of the income and expenditure variables and its magnitudes. A brif discussion is made on the reforms and basic changes of the banking sector. Due to initiation of reforms and gradual deregulation policies private banks are allowed to start functioning in sector, parallel to NCBs and competitions increase among the various categories of banks. Due to reforms and deregulation banking activities further geared up. As reform is a continuous process and additional up dating on reform measures during the study period could well be perceived from the behaviour of variables. Various table are prepared to understand the magnitude of the banking variables. The behaviours of the variable are shown in different presentations. Relative shares, growth rates, portion as fractions of the components to the total value of variables are constructed over the period. We understand the behaviour and responses of the variables from the over years behaviour for all category of banks from the tables constructed. This Chapter provides an overall description of the commercial banks of Bangladesh mostly based on the data during 1999-2005.

In Chapter 4, we have discussed different issues relating to production function and efficiencies. Farrell (1957) article on efficiency measurement based on production function provide the concept of technical efficiency. Technical efficiency reveals the ability of a firm to obtain maximum output from a given set of input or ability to minimize input use in the production of a given vector. Since technical efficiency is the core of Farrell's (1957) productive efficiency, the focus of the study is centered on the fundamentals of the technical efficiency. According to Farrell (1957) technical efficiency can be obtained for input orientations and output orientations. Accordingly this Chapter discusses the notion of production function, marginal productivity, output elasticity, marginal rate of technical substitution and returns to scale. The output elasticity is a unit free measure of marginal productivity and estimates the degree of substitution between inputs. The efficiency implies that a firm produces maximum output by utilising its available inputs with minimum cost. If the firm fails to achieve optimal output by using minimum quantities of inputs under existing technical support then the firm is inefficient. Thus the concept of technical efficiency arises as the ability to produce maximum output by minimum input mix with existing technology.

In Chapter 5 Stochastic frontier analysis is discussed theoretically. We discussed the evolution of the concept stochastic production frontier. The analytical foundation for the definition of efficiency goes to Farrell (1957). The major econometric approach to estimation of frontier efficiency involves deterministic frontier model and stochastic econometric frontier model. Econometric SFA approach needs to impose an explicit functional form for the underlying technology and distributional assumptions for the inefficiency term. The great merit of stochastic production frontier model is that impact on output due to internal or external shocks can be separated. Exogenous shocks on output can be separated from the contribution of variation in technical efficiency by incorporating an additional random error term. Therefore, in SFA the error term is segmented into two components. Since the error term has two components, the stochastic production frontier model is often called as composed error model. Stochastic frontier analysis is introduced by Meeusen and vanden Broeck (1977). At the same time Aigner, Lovell and Schmidt (1977) have introduced independently and separately the stochastic production frontier model. The stochastic production frontier model permits the estimation of estimation of standard errors and tests of hypothesis by using maximum likelihood method, which has been impossible under deterministic production frontier. It has been discussed that we need a specific functional form of a production function to fit stochastic model. In our study, the stochastic frontier production model is specified by the Cobb-Douglas production model.

In Chapter 6 we describe the technical efficiency results obtained by using stochastic Cobb-Douglas production model. We obtain technical efficiency estimates (TE scores) for 49 commercial banks of Bangladesh in a single output and multiple input framework for the period 1999-2005 as per the objectives set in Chapter 1. We have categorised the banks to compare technical efficiency scores. We have obtained average technical efficiency scores for NCBs, PCBs. SCBs, IPCBs and FCBs. We have obtained overall banking sector technical efficiency scores as average of the all 49 commercial banks' technical efficiency scores, according to objectives of our study. We then compare the results of the technical efficiency scores achieved by different category of banks. Individual technical efficiency for each of the banks can be found in the year wise cross-section in Chapter 6. Comparative performance is shown in Figure 6.1 – 6.7. However, we describe in brief the findings.

According to intra-category comparison over the year of study, the NCBs are found most efficient. This finding is consistent with the findings of Bhattacharyya et al. (1998) and Mahesh and Meenakshi (2006) in the event of Indian commercial banks. The performances of SCBs are found occupying the second position in relation to technical efficiency scores.

SCBs having specialised objectives for providing banking services in the country to boost agricultural productivity and industrial productivity, are found surpassing the rest of the PCBs and IPCBs in raking. FCBs performances are mentionable, because the follow the line of average banking sector's efficiency scores and secure third position.

Then appear the rank of PCBs and IPCBs. In the beginning of the study period in 1999 and in 2000 IPCBs performance are better than pure PCBs but after 2000 and onward PCBs improved beyond the IPCBs. We are giving the average scores of the banks according to to category obtained for 1999-2005 in Table 9.1.

Table 9.1: Average TE scores

Category of Banks	NCBs	PCBs	SCBs	IPCBs	FCBs	All Banks
TE Scores	0.873	0.728	0.744	0.709	0.742	0.743

From Table 9.1 we a clear picture about the performance of different types of banks as an average for the period 1999-2005. Obviously, the NCBs are highest scorer with average technical efficiency score 0.873 while IPCBs attains the least position with score 0.709.

Table 9.2 shows that if current resources are utilised at full efficiency, the banking sector would increase their efficiency by 25 percent on an average according to stochastic frontier methodology. Banking sector's efficiency performance is shown. Overall banking sector experiences 82 percent efficiency in 2001, then it declined to 67 percent in 2004, and then it restored in 2005 at 77 percent.

Table 9.2: Average TE of the Banking Sector and Efficiency Change

Year	1999	2000	2001	2002	2003	2004	2005	Mean
SFA Technical Efficiency	75	77	82	70	76	67	77	75
Changes in Efficiency	-	2.67	6.49	-14.63	8.57	-11.84	14.93	1.03

Table 9.2 shows that average banking sector technical efficiency increases gradually from 75 percent in 1999 to 85 percent in 2002. we find that growth rate is increasing with positive sign but in 2002 average technical efficiency came dowg to 70 percent with growth rate –14.63. Thereafter, average technical efficiency of the banking sector fluctuates and finally it started to move upward.

In Chapter 7 we have discussed methodology of Data Envelopment Analysis (DEA). Application of DEA as an empirical methodology is discussed under several sections. DEA is a non-parametric mathematical programming approach to estimate production unit. DEA can handle multiple outputs and multiple inputs at the same time. Measures of efficiencies obtained from DEA calculation are considered as Pareto optimal. This approach is formulated for two types of orientations such as input orientation and output orientation. Method of estimating of productive efficiency of the commercial banks with nonparametric methods is obtained. Empirical investigations have been conducted on the efficiency scores that varied over the timeTechnical efficiency is divided into two types of efficiency under DEA

Constant returns to scale (CRS) frontier produces overall technical efficiency and the variable returns to scale produces the measure of overall technical efficiency. Scale efficiency is calculated as a ratio of CRS technical efficiency and VRS technical efficiency. Comparing efficiency estimates from CRS technical efficiency and VRS technical efficiency and non-increasing returns to scale (NIRS) technologies economies of operation level is found for individual firm. These measures are found for both input-oriented DEA and output-oriented DEA for individual firms. Empirical results shows that there is not much difference in the results as far as orientation is concerned. The issues have been discussed in this Chapter.

In Chapter 8 we have discussed the results obtained for 49 commercial banks in Bangladesh with the applications of DEA first under input orientations and then under output orientation. We compare the results of DEA with those obtained from stochastic frontier model. We find that though DEA produces efficiency scores higher than those obtained from SFA method, the results are consistent. We find in Table 9.3 that if current resources could be used fully banking sector could increase its output by 22 percent according to constant returns to scale efficiency estimates. Overall inefficiency is higher than pure inefficiency. We find that average crste score over year under input-oriented DEA is 10 percent. Average banking sector efficiencies have been put in Table 9.3 below according to orientations. The DEA results show that the average overall technical efficiency scores the banking sector over our study period under crste is 78 percent, input-oriented vrste 90 percent, output-oriented vrste 92 percent, input-oriented scale efficiency 87 percent, output-oriented scale efficiency 86 percent.

Table 9.3: DEA Summary Results for banking sector of Bangladesh. (percent)

DEA Results	1999	2000	2001	2002	2003	2004	2005	Mean
DEA crste	83	89	88	74	65	74	73	78
Input-oriented vrste	93	94	95	79	88	94	88	90
Output-oriented vrste	94	93	95	90	90	95	89	92
Input-oriented scale efficiency	89	95	92	94	74	79	84	87
Output-oriented scale efficiency	88	95	92	92	71	78	82	85

Note: crste indicates constant returns to scale to scale; vrste indicates variable returns to scale.

Table 9.3 shows that if current resources are utilised at full efficiency, the banking sector would increase their efficiency by 22 percent on an average according to crste DEA.

9.3 Conclusions and Recommendations

This study assesses the different efficiencies of commercial banks operations on the basis of production frontier and mathematical programming frontier. One of the contributions of this paper is that Stochastic Frontier Analysis and Data Envelopment Analysis is applied to analyse technical efficiency of commercial banks in Bangladesh. We have measured overall technical efficiency, pure technical efficiency, scale efficiency and economies of operation of the banking sector. We have compared commercial banks efficiency across their categories under stochastic econometric frontier and Data Envelopment Analysis. Each method has its strength and weaknesses. The stochastic frontier model imposes a functional form on technology and a distributional assumption on inefficiency effects. It distinguishes the effects of noise from the effects of inefficiency. Cobb-Douglas stochastic functional form allows for frontier. Under stochastic frontier approach, we have used Cobb-Douglas production frontier to estimate technical efficiency. The stochastic frontier results show that parameters of the Cobb-Douglas frontier are holding positive sign except for a few cases. Some peculiarities in case of salaries and wages variable, occupancy expenditure variable and depreciation and repair variables are observed. Since the variables contain negative value in different years, it requires a mention. In year 1999 salaries and wages variable is found negative, it is reasonable because this year national pay scale shifted vertically upward, as such additional increase in salaries and wages are likely to produce negative impact on banking output. Estimates of 'Occupancy expenditure' variable parameter appear negative three times in 2001, 2003 and 2004. It implies there may be excessive amount of expenditure or misuse of input on this component. This requires further investigation and a through scrutiny as to the fact that whether banks premises rent reflect the market price. The same can be checked for depreciation and repair expenditures also, since this parameter appear negative in 2002.

According to DEA results, we find that the banking sector is experiencing a trend of decreasing returns to scale economies of operation. The number of banks enjoying increasing returns to scale and constant returns to scale declines while the number of banks under decreasing returns to scale increases. It implies overall banking sector's weaknesses in economies of operation. However, this trend starts upturn from 2004 and further increases in 2005. We view this finding as an important one. However, the reasons can be external imposition of policies.

One of the probable grounds for declining trends of the technical efficiency scores can be attributed to intervention in interest rates during 2001 and 2002. During this period interest rates are reduced remarkably. Sometimes deregulation and liberalisation policies yield the opposite results as it is originally intended for. However, there may be more other grounds.

Our stochastic frontier results suggests that that private banks performance do not indicate significant improvement in efficiency in the banking sector and hence to move further for privatising the nationalised banks is likely to aggravate banking sector performance. Productivity growth involves two major components: technological change and change in technical efficiency. It would be interesting to study whether the efficiency gains introduced by FCBs are due to better management controlling or to the transfer of technology from the owners. There is already a sign of technological changes in the banking sector of Bangladesh. Later study can reveal the fact whether efficiency gains of the FCBs are due to technological change or technical efficiency.

It might be expected that banks would show low efficiency scores prior to failure and that management quality would be positively related to low efficiency. Some international studies report that banks with low efficiency fail at greater rates than with higher efficiency levels (Berger and Humphrey, 1992a; Cebenoyan et al.1993a and

Hermalin and Wallace, 1994). Examples are also available in our study. In 2007, Oriental bank Ltd has been taken over by Bangladesh Bank due to mismanagement and poor performance. In our stochastic frontier results, we examine that this bank's efficiency estimates are 42 percent in 2002; 58 percent in 2003; 52 percent in 2004. Data for the bank in the year 2005 is restricted to access during our study and hence no score for 2005. Therefore Berger and Humphrey's (1992a) comment regarding low efficiency scores of the banks are consistent, we can remark.

Therefore, we recommend utilising efficiency results for examining soundness of the individual commercial banks in Bangladesh. Results of stochastic frontier and DEA models can be great use to policy makers in these areas. We further suggest carrying out such studies of frontier efficiencies more frequently for all the individual commercial banks of Bangladesh to diagnose efficiency status of the banks to sustain sound health of the banking sector.

9.4. Further Research

We have examined technical efficiency, overall technical efficiency, pure technical efficiency, scale efficiency and economies of operation of the commercial banks of Bangladesh. We have used Stochastic Frontier model to obtain estimates of technical efficiency. We again use Data Envelopment Analysis to obtain estimates of overall technical efficiency, pure technical efficiency and scale efficiencies of the 49 banks using input-oriented and output-oriented DEA. We make some comparison of efficiency estimates obtained from the two approaches. We find two approaches are in substantial agreement in efficiency results. We estimate technical efficiency by specifying Cobb-Douglas stochastic production frontier model. There are scopes for further research to assess technical efficiency by using stochastic Translog production function. Since technical efficiency is the heart of Farrell's (1957) productive efficiency, we have just examined technical efficiency only but one can further investigate allocative efficiency and economic efficiency of Commercial banks calculated from technical efficiency estimates. Time and space constraint do not allow the researcher to perform much research on this particular point. Hence there remains adequate scope to carry out further research on banks to find allocative and economic efficiencies. In further research stochastic cost and profit frontier efficiencies can be measured for banking sector of Bangladesh. One important issue is that we have not incorporated inefficiency effects in our model. Both Cobb-Douglas and Translog stochastic frontier model allow for inefficiency effects. Thus examining inefficiency effects with Translog or Cobb-Douglas functional form can be a further research.

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